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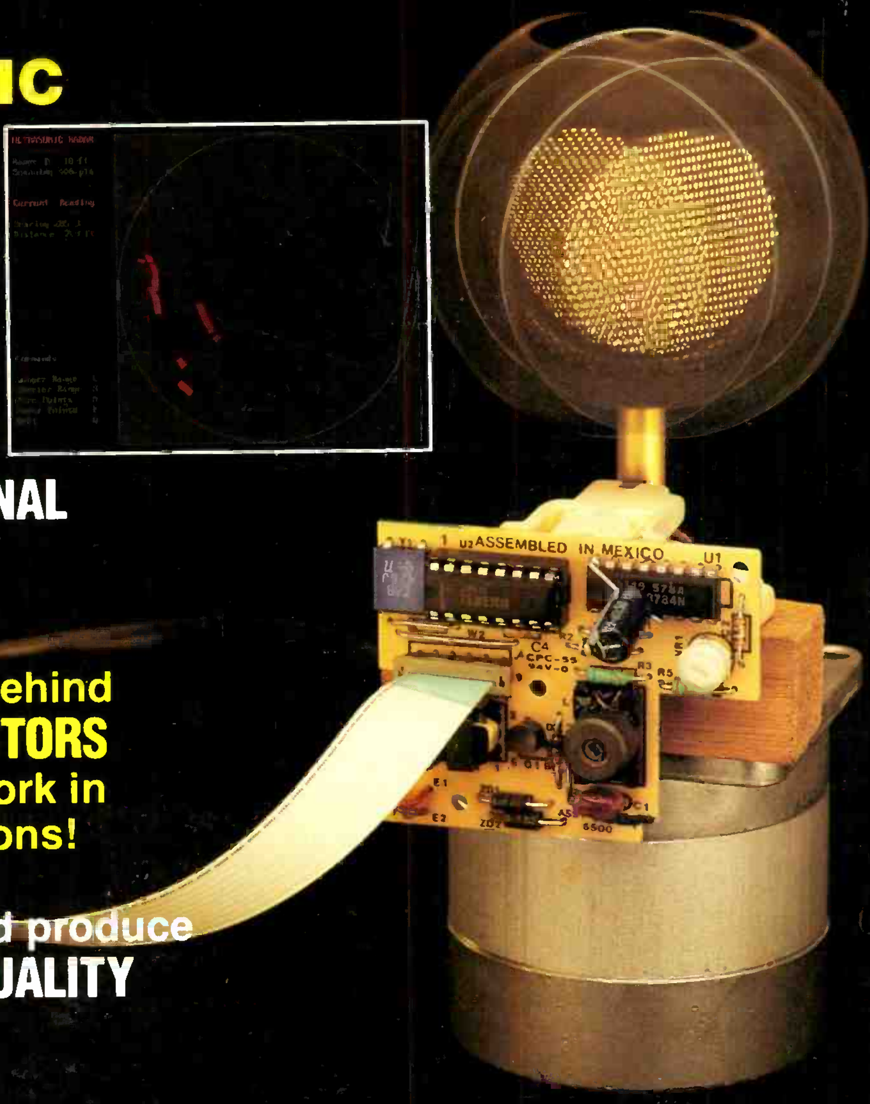

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September 1993 Electronics NOW®

Vol. 64 No. 9

ON THE COVER

Looking for a computer application that will "wow" your friends and family? This month's addition to The Experimenter project should do the trick. It adds to your computer an ultrasonic rangefinder sensor that measures the distance to surrounding objects in real time (similar to the way sonar is used). That data is translated to a live-action, radar-like display in high-resolution color graphics on your computer screen. The blips on the screen accurately portray the movements of people and pets, so you can track them as they move around the room. For all the details on the radar project, turn to page 31.

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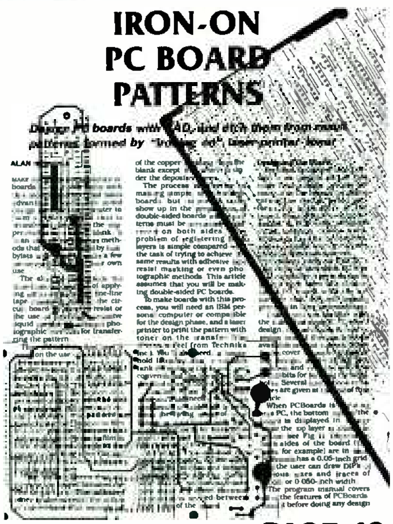

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WHAT'S NEWS

A review of the latest happenings in electronics.

Energy-saving computer

IBM has introduced a new personal computer that is said to use less energy than most desktop PC's. The IBM PS-2E includes many of the energy-saving features of a laptop computer such as a flat-panel liquid-crystal display and a 3.3-volt power supply. IBM says that the computer consumes 60 watts of electricity compared with the 150 to 220 watts consumed by most PC's. If not used continuously, the PS-2E lapses into a "sleep mode" in which it consumes less than 20 watts.

In another development, IBM introduced its first subnotebook computer, the Thinkpad 500. It weighs in at 3.8 pounds, 0.2 pounds under the weight limit for the category. Priced at $2000 and equipped with a 486 microprocessor, it will compete against subnotebooks such as Hewlett-Packard's Omnibook as well as those from Zeos, Dell, and Zenith Data Systems.

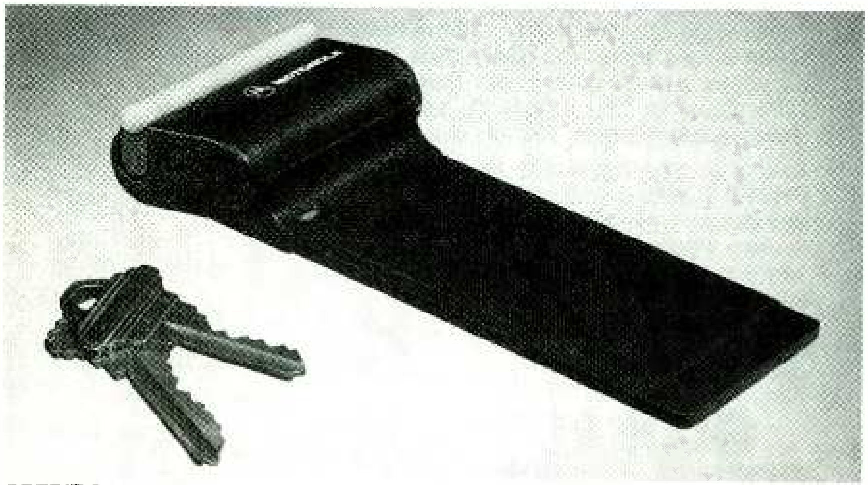
Wireless modems

Motorola Inc. has announced the technology for a new generation of wireless modems that are small enough to fit in the slots of many handheld computers and other portable communications equipment. The modem is about the size of credit card with 9-volt transistor battery on one end. However, products will not be available until early next year.

This new family of PCMCIA (Personal Computer Memory Card International Association)-format intelligent wireless modems, the first of its kind, will enable both one- and two-way, wide and local-area networking, and will operate over the most popular public and private networks. It supports credit-card-size peripheral devices that add memory and input/output capabilities to computers.

According to Motorola, the innovation is in its small package size that scales down the conventional wireless modems to a size appropriate for portable computers. The modem will be able to send electronic mail, gain access to information services, and exchange files "on the road."

Motorola has gained the support of most of the companies with a stake in wireless computing for its new product. These include Apple Computer, Compaq Computer, Dell Computer Hewlett-Packard, IBM, Microsoft, Sony and Toshiba.



CREDIT-CARD-SIZE INTELLIGENT wireless modem from Motorola.

Cable- and phone-company partnership

U.S. West (Englewood, CO), a regional Bell operating telephone company has joined in a strategic alliance with Time Warner Entertainment, the country's second-largest cable TV company. U.S. West, a company that provides phone service in the northwest region of the country, will provide telecommunications expertise for Time Warner's existing cable franchises. The intent of the agreement is to build interactive networks for communications and entertainment in homes and businesses in 36 states.

In addition to providing video-on-demand, TV shopping and games, the alliance will challenge the existing status in communications services. If FCC approval is granted, the system would allow Time-Warner cable subscribers in New York City, for instance, to bypass New York Telephone to make long-distance phone calls.

Another service contemplated, again assuming an FCC frequency allocation, is wireless personal communications services that would allow local phone calls to be made over the cable system.

U.S. West is reported to be investing $2.5 billion to in the Time Warner venture. It is expected that $1 billion will be spent in building Time Warner's two-way video, data, and voice network; the rest will reduce the debt from the 1990 merger of Time and Warner. The two companies will share equally in the design, implementation, and direction of the proposed full service networks.

Cellular personal-security service

A new cellular-radio-based service is expected to provide personal security and quickly locate and send help to persons in distress. Help Express (San Diego, CA) has proposed the system based on its proprietary mobile and handheld cellular phones and a cellular home-alarm system.

The Help Express Service is ex-

PRESS A BUTTON ON THE HELPFON (top) to get help from Help Express Service Center (bottom), to use cellular and mapping equipment to pinpoint the location subscribers in distress, and send emergency assistance.

pected to locate and respond to each subscriber. In emergency situations, such as medical emergencies, home fires, or car breakdowns in critical locations, trained personnel would be dispatched to help. The touch of a button will activate the system. This makes it especially attractive in situations where the subscriber might not have the time to dial the 911 number and explain the emergency to an operator.

In situations where there is time for conversation, the system offers duplex voice capability. Subscribers to Help Express can get assurance, first-aid advice, or directions to the nearest hospital, service station, or police station.

Help Express claims that it can instantly locate its subscribers with transmitted cellular-telephone signals. They are translated into location "fixes" on computers equipped with MapInfo desktop mapping software from MapInfo Corp. (Troy, NY).

The mapping system includes the positions of major street intersections, public buildings, shopping centers, and recognizable geographical features such as lakes and rivers. This information helps to direct the nearest emergency unit.

Complete pricing for the service has not been set, but starting rates are expected to be between $10 and $20 a month. Help Express provides a portable "Helpfon" and a cellular-based home system. The full-function, compact portable phone has all of the location circuitry built-in.

Rapid growth predicted for multimedia

Worldwide multimedia hardware and software sales will nearly quintuple over the next six years, according to a study published by Market Intelligence of Mountain View, CA. Its report "World Multimedia Hardware and Software Markets," says that the growth will occur as prices drop and potential users gain a better understanding of multimedia.

Market Intelligence projects that the market will leap from $5 billion in 1992 to more than $24 billion by 1998, at a 25% compound annual growth rate. Acceleration will occur in the mid-1990's, peaking at over 40% during the 1993–1995 period, before leveling out later in the decade.

Multimedia, is broadly defined as the computer-based integration of different media primarily used today for corporate training and education. According to the market research firm, prices will drop with increased consumer acceptance, and they will drop even further as a mass market is achieved. Interactive "shrink-wrapped" books, games, and lessons are expected to become big sellers.

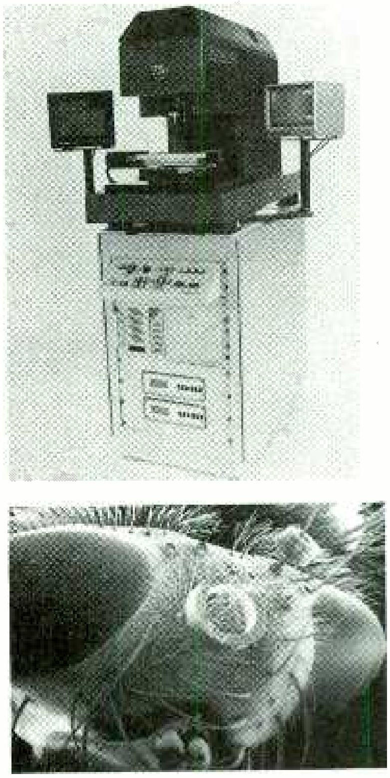
Digital signal processing is seen as the driving force behind multimedia, and networking is expected to take off rapidly. There are multimedia elements in voice-annotated spreadsheets and video electronic mail. These services are expected to achieve office acceptance before the end of the century.

As the effectiveness of voice and video transmission over local-area and wide-area networks increases, multimedia is expected to become an integral part of those networks. Market Intelligence expects that multimedia equipment will include advanced data compression for high-quality video, faster CPU's, and cheaper and larger mass data strage.

Laser-based micro-machining system

A laser-based micro-machine tool is said to be able to produce miniature commercial hardware products with a precision not previously achieved. Advanced Recording Technologies (Escondido, CA) has developed the Laserlith machine to produce rings and gears that are less than 0.002 inch in diameter.

The parts can be machined from many different materials—ceramics, metals, and glass. The manufacturer says high precision is obtained because its machine is mounted on a rigid granite foundation and is coupled to laser-controlled interferometer stages.



LASERLITH STATION (top) micro-machined these microminiature rings, shown adorning the head of a fly (bottom).

Laserlith is powered by diode-pumped YAG lasers, said to have a longer life than comparable krypton arc-pumped systems. It can also weld tiny fibers of various materials, bore microscopic holes in circuit boards and semiconductor chips, and mark miniature objects. Prospective applications include trimming resistors, trimming magnetic recording heads, and cutting tiny gears and wheels. Ω

VIDEO NEWS

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

DAVID LACHENBRUCH

• **HDTV alliance.** The three remaining proponents in the competition for a high-definition TV standard in the United States have agreed to form a "grand alliance," pooling aspects of their various systems into what will eventually be a single system (**Electronics Now**, June 1993). It could take as long as a year for components of the four proposed systems to be meshed into one system.

The proponents say that, in the long run, the compromise could save time by eliminating court challenges by proponents for the losing systems.

The merged system appears to combine a bundle of semi-compatible components. For example, it permits either interlaced or progressive scan, but encourages a fairly quick transition to the all-progressive scan. Stations would be permitted to transmit in either interlaced or several varieties of progressive scan, leaving it up to the receiver to cope with the different scanning systems. However, all HDTV sets with screens 34 inches or larger would be required to handle both progressive and interlaced signals.

Initial estimates indicate that providing that capability would add about 10% to the cost of receivers at first. The goal is to move eventually to a 1050-line, 60-Hz progressive-scan system when compression makes it possible to do so in a single 6-MHz channel.

Progressive scanning and square pixels are designed to ensure that the HDTV system will be compatible with computers, in preparation for a wide variety of interactive TV systems. The digital audio system is still to be selected. After the parameters are selected for the final system, another six to eight weeks will be required for testing, permitting the FCC to ratify a final standard by mid-1994. But, as we have seen in the past, all such timetables are subject to slippage.

• **Multimedia fever.** Nobody knows exactly which system, if any, will finally take off, but it seems that everybody and his brother is introducing something described as "multimedia." Among the major contenders is 3DO, whose owners include AT&T and Matsushita. 3DO's "interactive multiplayer" is scheduled for market this year. Panasonic, AT&T, and Sanyo have been announced as hardware makers. In the home version, 3DO is a sophisticated compact-disc-based system. A version that could be networked by cable is also reported to be in the works.

Meanwhile, one multimedia system already on the market—CD-I, backed most avidly by Philips—is sporting some attractive enhancements. A full-motion, full-screen video module, based on the Motion Picture Experts Group's MPEG-1 standard, will be offered as a plug-in attachment. Its suggested list price is $250.

The module will not only make possible more attractive and realistic interactive programs and games, but it will make CD-I a movie carrier as well. Philips has announced that Paramount will be releasing 50 movies on standard 5-inch CD-I discs over the next two years, with more companies expected to sign up soon. Full-motion video using the MPEG-1 algorithm is designed to provide a picture at least as good as standard VHS.

• **On-screen program guide.** A line in TV's vertical blanking interval between picture fields provides material for StarSight Telecast's interactive program guide and VCR programmer. Using the blanking intervals of PBS stations and various cable networks, StarSight (formerly called Insight Telecast) makes it possible for owners of specially equipped sets—who subscribe to StarSight services—to call up a variety of on-screen programming grids and select programs by content or category. It also provides on-screen summaries of programs, as well as program titles and other material, which can be called up on the screen as subtitles while the program is running. It lets viewers program their VCR's by moving a cursor to on-screen program titles on the grid. So far, Zenith has agreed to build StarSight into its TV's, and Mitsubishi will be including it in selected models of VCR's. Other brands will be announced soon, according to StarSight, which says that its service, to be offered for both broadcast and cable reception, will cost less than $5 a month.

A number of other on-screen electronic program guides (or EPG's) are reported to be ready for cable system use. Those include systems called Trakker, Prevue Networks, Your Choice TV, and TV Guide On Screen, all using newly developed "smart" cable boxes.

• **Micromirror TV projector.** By the end of this year, Texas Instruments plans to complete development of a unique HDTV projection-TV system using millions of microscopic mirrors mounted on three tiny silicon chips. TI is already demonstrating an NTSC version with 307,200 mirrors on a chip ⅝ inches square. Extremely bright pictures are said to be possible because the tiny pivoting mirrors reflect light rays from an external source (a xenon lamp is currently used) into an imaging lens, which projects the image onto the screen. Because the system is entirely digital, TI says it's ideally suited for the digital HDTV. The company is demonstrating a system, using a single chip, to TV manufacturers for possible use with the existing TV system. The HDTV version will use three chips, each with 2.3 million micromirrors. Development of the system is being financed, in part, by a $10 million research grant from the Defense Department's High Definition Display program. Ω

Q & A

Write to Q & A, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

VOLTAGE MONITOR

I built a robot machine using a 12-volt battery as the main power supply. I'd like to know if you have a circuit that would monitor the battery voltage and trigger a warning when the voltage is either above or below 12 volts.—R. Santerre, Bathurst, NB Canada

It's always a good idea to keep a careful eye on operating voltages, particularly when you're using batteries, because they have a habit of dying at inconvenient times. You didn't go into a lot of details about the circuit being powered, but the circuit shown in Fig. 1 should be easy to adapt to your needs. As you requested, it will let you know when the battery falls below or rises above a particular voltage value. One nice thing about the circuit that makes it quite versatile is that it can easily be set to trigger on whatever voltage you want for your particular application.

The undervoltage section compares the unregulated voltage input (from the battery) to the regulated voltage output from IC1. It will trigger whenever the unregulated voltage falls below about one and a half volts above the regulated voltage. When that happens, transistor Q2 turns off, and the collector voltage level goes high. That can then trigger an undervoltage alarm. The alarm can be as simple as an LED connected directly to Q2, or Q2 can trigger a relay that can then power some obnoxious buzzer. Most voltage regulators can supply their rated output voltage as long as the unregulated voltage input is at least one volt higher. Since the alarm is triggering at a voltage slightly higher than that, you'll still have time to switch batteries before the regulated output drops below the desired threshold.

In the overvoltage section, a portion of the unregulated voltage is applied to zener diode D2 connected to the base of Q1. If the unregulated voltage rises above a preset value (determined by potentiometer R2), Q1 will begin to conduct, and you'll get a low at its collector. That low can then be used to trigger an alarm. Note that the overvoltage alarm's low trigger is opposite that of the undervoltage alarm's high trigger.

The only critical component in the circuit is diode D2 and its zener voltage. Because the voltage applied to the zener diode is coming from a voltage divider, you should use a zener diode that's rated about two volts lower than the voltage you want the circuit to trigger on. The exact voltage of the zener diode is unimportant because the trigger level can be precisely set with potentiometer R2.

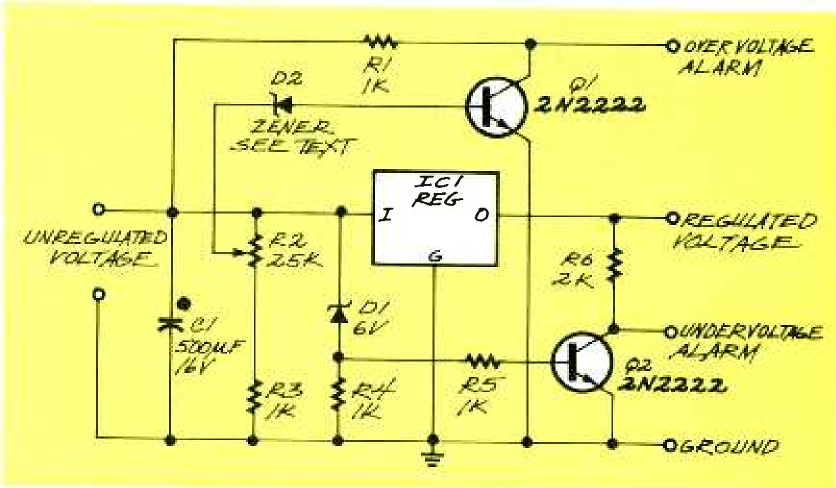


FIG. 1—THIS CIRCUIT CAN INDICATE when a voltage level falls below or rises above a particular value. It can easily be set to trigger on whatever voltage you want.

CABLE READY OR NOT

I have several TV's in my home all fed with a signal from my local cable company. Since several of the TV's are older ones that can't get the cable channels, I am thinking of buying two cable boxes from the ads in the back of your magazine. My question is, how do I know if they will be able to receive the basic channels (standard networks) that are sent by the cable company?—R. Olivo, Aspen, CO

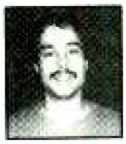
The cable boxes supplied by the majority of cable companies are made by a handful of companies such as Oak and Jerrold, and not by the cable companies themselves. Many cable companies charge a fee for each cable drop to your home. If you have two TV sets, you might be required to pay extra for the second one.

If you were to split the signal yourself and connect a second TV, what you would get on it depends entirely on the policy of your local cable company. You might be able to get all the basic channels, some of them, or none at all, if you find that all programming is scrambled on your cable.

When you buy a standard cable box, you're basically getting a cable-ready, remote-controlled TV tuner—you don't get a decoder for all the scrambled channels. If your cable company scrambles everything, you won't be able to watch anything. However, on a happier note, I know that a lot of cable companies that tried scrambling everything have been compelled to stop doing so.

If you can use the tuner in your TV

Just like these Fully Trained Electronics Professionals



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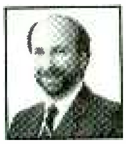

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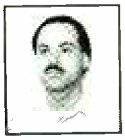

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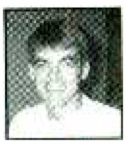

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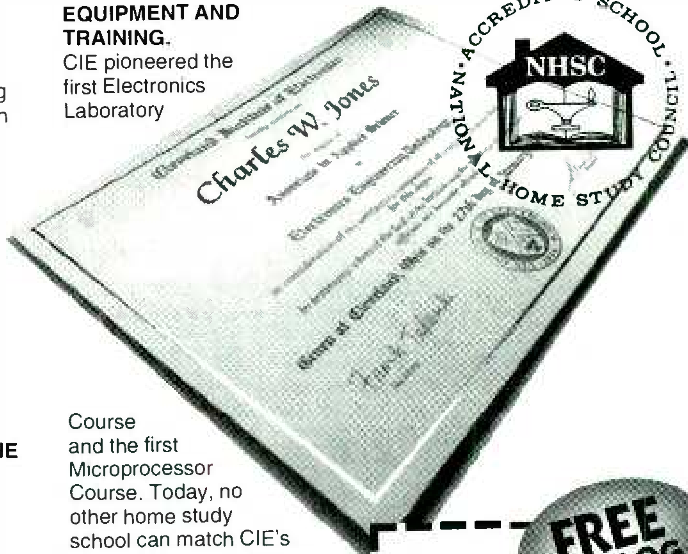

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and see unscrambled reception for the major networks and local stations, chances are that a mail-order cable box will do the same. I know that it was once possible to get VHF/UHF converters. These are retransmitters that take everything on the cable and retransmit on UHF. If you find one of these, they should be less expensive than cable boxes and, because you're not interested in receiving any of the premium cable stations (the scrambled ones), a converter might be a reasonable alternative for you.

IBM VERSUS CLONES

I am considering the purchase of a computer and, because my company uses IBM's, I want something similar so I can take work back and forth from the office. Several friends at the office have told me that I have to buy a real IBM if I want full compatibility with the computers at my office. This is my very first computer and I'm not sure what to do. Do I have to buy a real IBM as I've been told by my co-workers, or can I get by with something else?—B. Genfish, Burlington, VT

I understand your confusion but, no matter how well intentioned your friends at work are, I suspect that they don't have any more experience with computers than you do. Either that or they've been buying IBM stock and are watching the market.

The reason you buy computer hardware is to be able to run software. The hardware is sealed in a box and, for most people, what's inside the box is unimportant as long as it can properly run the software package.

In the early days of the PC industry, it was not uncommon to find certain computers that couldn't run all software. The manufacturers of those PC's used cheap parts that weren't 100% IBM-compatible. However, competition has forced almost all of the disreputable companies out of business. Today, it's highly unlikely that you'll find an IBM-compatible PC that's not 100% IBM compatible—at least from a well-known manufacturer.

The bottom line is that there's no reason whatsoever for you to think that you're required to buy a real IBM. Any software you have in your office running on an IBM will be able to run on any computer built around the Intel series of microprocessors. Any computer manufacturer who wants to stay in business for more than a few weeks has to make sure that this is true.

Far from being a risk, you can actually save a lot of money by buying something other than a real IBM.

RING AMPLIFIER

Do you have any circuit that can increase the level of the ring on a telephone? My mother is hard of hearing and I'd like to hook up an external bell or strobe light so the ringing phone will be able to catch her attention. Any help would be appreciated.—M. Mitchell, Kansas City, MO

There's no doubt that you could build a circuit that would enable you to turn on anything from an air raid siren to an aircraft landing light when the phone rings. There are even stand-alone IC's that will detect the ring and give you an active output that can be coupled, using suitable triacs and other drivers, to any device you might want to use.

Before you think about doing that, however, I'm not sure you're aware that there are lots of companies, including AT&T, whatever TELCO offshoot services your local area, and many others who make bells that are directly triggered by the standard ring voltage. I don't know any of them offhand but a trip to your local auto bodyshop, or any other business that has a very high ambient noise level will probably put you face to face with the answer to your problem. Chances are you'll see exactly what you need hanging on the wall.

If you still want to be able to build something, you'll find that some manufacturers make IC's and support components to build the circuit you have in mind. As an example, look into Motorola's MC34012-1 telephone tone ringer. Ω

Countersurveillance

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what was to be an embassy and private residence into the most sophisticated recording studio the world had ever known. The building had to be torn down in order to remove all the bugs.

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The open taps from where the information pours out may be from FAX's, computer communications, telephone calls, and everyday business meetings and lunchtime encounters. Businessmen need counselling on how to eliminate this information drain. Basic telephone use coupled with the user's understanding that someone may be listening or recording vital data and information greatly reduces the opportunity for others to purloin meaningful information.

EN

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The professional discussions seen on the TV screen in your home reveals how to detect and disable wiretaps, midget radio-frequency transmitters, and other bugs, plus when to use disinformation to confuse the unwanted listener, and the technique of voice scrambling telephone communications. In fact, do you know how to look for a bug, where to look for a bug, and what to do when you find it?

Bugs of a very small size are easy to build and they can be placed quickly in a matter of seconds, in any object or room. Today you may have used a telephone handset that was bugged. It probably contained three bugs. One was a phony bug to fool you into believing you found a bug and secured the telephone. The second bug placates the investigator when he finds the real thing! And the third bug is found only by the professional, who continued to search just in case there were more bugs.

The professional is not without his tools. Special equipment has been designed so that the professional can sweep a room so that he can detect voice-activated (VOX) and remote-activated bugs. Some of this equipment can be operated by novices, others require a trained countersurveillance professional.

The professionals viewed on your television screen reveal information on the latest technological advances like laser-beam snoopers that are installed hundreds of feet away from the room they snoop on. The professionals disclose that computers yield information too easily.

This advertisement was not written by a countersurveillance professional, but by a beginner whose only experience came from viewing the video tape in the privacy of his home. After you review the video carefully and understand its contents, you have taken the first important step in either acquiring professional help with your surveillance problems, or you may very well consider a career as a countersurveillance professional.

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To obtain the information contained in the video VHS cassette, you would attend a professional seminar costing $350-750 and possibly pay hundreds of dollars more if you had to travel to a distant city to attend. Now, for only $49.95 (plus $4.00 P&H) you can view ***Countersurveillance Techniques*** at home and take refresher views often. To obtain your copy, complete the coupon or call.

Write to Letters, Electronics Now, 500-B Bi-County Blvd., Farmingdale, NY 11735

50% DUTY CYCLE FROM A 555

50% duty cycle from a 555 timer circuit?

I'm responding to the letter in *Q&A* (**Electronics Now**, May 1993) asking for a simple square-wave circuit. As the response stated, the 555 timer set up as an astable multivibrator can approach a 50% duty cycle.

That 50% can also be achieved when the circuit is "tricked" with the addition of diodes. I have shown here (Fig. 1) an external circuit for the 555 timer with only two resistors and one capacitor that will provide true 50% duty-cycle output.

The circuit is capable of charging and discharging the capacitor over a specified range. It is even capable of cycling the capacitor voltage between ⅔ and ⅓ supply voltage, as long as the value of R2 is less than half the value of R1.

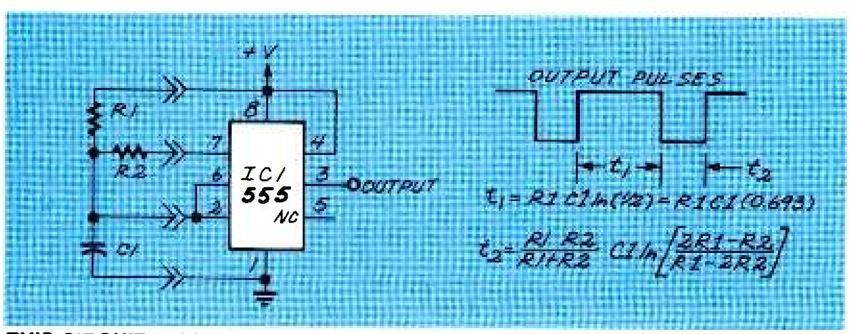
For a 50% duty cycle: $t_1 = t_2$, f = 1/[R1 = XC1 × (1.386)], and R2/R1 = 0.4233. To apply this circuit, pick R1 and C1 to give the frequency you want. Then calculate R2. Resistor R2 could be a PC-board-mounted trimmer so you can adjust for a true 50% duty cycle.

Convenient resistor values are R1 = 51 kilohms and R2 = 22 kilohms. A capacitor value of 0.01 µF then provides f = 1.4 kHz. To scale the frequency up by a factor of 10, scale the capacitor down by a factor of 10.

This circuit is often overlooked in most discussions of 555 timer circuits, although square-wave generation is one of its most popular applications. Another overlooked (or rarely mentioned) fact is that the TLC555 is *not* a one-for-one replacement for the 555. Its output is inverted from that of the industry-standard 555. Thus, the TLC555 is capable of a 50% duty cycle with only one resistor and one capacitor. That circuit was shown in *Letters* in the February 1993 issue of **Electronics Now**.

I enjoyed your series on 555 timer circuits in the September 1992 through February 1993 issues. The series included many clever circuits, but I think the one shown here belongs in everyone's "nuts and bolts" notebook.

KEVIN NEWMAN
Billings, MT



THIS CIRCUIT WILL PRODUCE a 50% duty cycle from a 555.

I don't know why, but many publications seem to be unaware of the CMOS version of the 555. The easiest way to get a 50% duty cycle is to use a Texas Instruments TLC7555, or equivalent, available in small quantities from Radio Shack and other distributors. Just connect the timing resistor to OUTPUT pin 3.

As long as the output is not loaded asymmetrically, the square wave will have a duty cycle close to 50%. That occurs because the TLC7555's output goes from +V to ground. The formula for calculating timing relationships is also easier (0.7/R × C).

Other benefits of the TLC7555 are lower power drain, higher speed, larger timing resistor capability, and no problems on the power supply. There are other sources for CMOS 555's in addition to Texas Instruments.

DON LEWIS
Monrovia, CA

I was surprised that you did not suggest doubling the clock speed and feeding the output to a flip-flop—an old and common (I thought!) solution. At any rate, it's the solution I was using 20 years ago.

TOM KLEINER, N9HWC

THE POWER OF MOV's

The article "Inrush Current Limiter" (**Electronics Now**, December 1992) used a metal-oxide varistor (MOV), and I just wanted to write and add a few more positives for the mighty MOV.

A few years ago, I had the opportunity to do extensive comparison testing between MOV's and other transient suppression devices, using a KeyTek transient generator (KeyTek Instrument Corp., Wilmington, MA). KeyTek instruments can produce selectable waveshapes and measure and display peak voltage and current across a test device.

I found that MOV's were clearly superior to other protective devices when it came to power absorption and speed. Although zener devices are specified as having faster clamping speed, that difference is all but erased by the lead inductance of those devices. Gas-filled tubes, also included in my comparison, will absorb large amounts of power, but they are inherently slow when it comes to clamping speed and are often unsuitable.

In my tests, I was comparing a General Electric GE-MOV 150LA20A against a number of different zener-type suppressors. The General Electric or GE-MOV is now made by Harris Semiconductor. Both Siemens and Panasonic (Matsushita) offer comparable products.

I chose a device rated for 150 volts AC to give me some voltage margin in parts of the country where there are excessively high line voltages (135 volts AC and up). I found that a 130-volt MOV would start to conduct at these excessive line voltages and fail prematurely.

During my tests I applied ring waves and exponential waves to the MOV's. Their characteristics were defined by the IEEE 587 transient specification. Peak voltages were limited to 5000 volts. (Contacts on a typical wall outlet will arc over between 5000 and 6000 volts.)

The GE-MOV was able to absorb thousands of strikes from the Key-Tek generator, while the zener devices usually burned out after a few hundred strikes. A zener device would fail shorted and then crack. A GE-MOV would also fail shorted and then blow open. However, both devices appeared to be intact.

If you want to do some serious voltage clamping without the expense of a computer-regulated line conditioner, the ideal setup will include gas tubes on the front end of a power filter and MOV's on the secondary side. The filter slows up the rise time of the spike, the MOV's clamp the voltage across the filter, and finally the gas tubes arc over.

A MOV should be placed from line to ground, neutral to ground, and, preferably, from line to neutral. The same applies for the gas tubes, which can be rated at a much higher turn-on voltage (more than 300 volts). It's also a good idea to put some resistance in series with the tubes to limit excessive follow-on current when the tubes ionize.

The tubes will de-ionize at the zero crossing of the line voltage wave, assuming the transient is gone by then. It is also a good idea to put a slow-acting dual circuit breaker in front of the whole setup (gas tubes and all). The breaker will trip only during massive overvoltages and will stay on during short-term transients.

Keep lead lengths on the MOV's as short as possible, and be certain that the power wires coming into your system on the primary side of the filter are kept isolated from the wires coming from the secondary side of the filter. This will keep the noise coupling around the filter to a minimum.

PHILIP RILINGER
Columbus, OH

UNCOVERING "AUDIO-PHOOLISHNESS"

I enjoy Larry Klein's *Audio Update* column. His straightforward, unmystical approach to audio reproduction is a quiet beacon of reason among the babble of fog-bound, clamorous natterings.

A major attribute of Mr. Klein's work is its freedom from the endless blathering of those who are persuaded that Zen-like mysticism somehow transcends the laws of physics in the recording and reproduction of sound.

In the June 1993 "Letters" column, John Berglund launched an assault on Larry Klein, giving him a resounding vote of no confidence. It is not entirely clear to me whether his real purpose was to attack Klein, which he did quite personally and viciously, or to boast about his own many attributes as an accomplished listener.

Mr. Berglund described himself as "an electrical engineer and a devoted enthusiast." I could use the same terms to describe myself. However, as an engineer, I would have to conclude that Mr. Berglund is not a very good one. After proclaiming his credentials, he then proceeded, step-by-step, to deny many of the principles that underlie engineering.

In reference to Klein's ability to perceive the quality of sound, Mr. Berglund made a statement that I found intriguing. He said, "... he [Klein] doesn't listen to it with the audio receptors that are in the space between my ears."

I agree, Mr. Berglund. Maybe if that space were more fully occupied, one would not be able to distinguish between the emotional, entirely subjective experience of listening to music, and the technological challenge of recording and reproducing it.

(continued on page 29)

How to Buy a Speaker System—Part II

LARRY KLEIN

Small speaker systems—including those in the new subwoofer/satellite combos—can sound almost as good as large ones. A knowledgeable designer, although constrained by parts costs and box size, will nevertheless be able to produce small, inexpensive systems with the same overall sound quality as his larger systems. In general, the smaller systems simply will not be able to play as loudly or reach the low frequencies of a big system.

Check the power ratings

As I wrote several months ago, loudspeakers come with two power ratings, usually listed as *minimum required power* and *maximum power capability*. Unfortunately, neither specification has an officially sanctioned definition in the U.S.

Let's look at minimum power first. In general, if a manufacturer states that his speaker requires a minimum amplifier power of, say, 15 watts, you can take him at his word. In effect, the minimum rating is an oblique but more easily comprehended way of stating a speaker's relative efficiency or sensitivity.

Sensitivity ratings are a fairly standardized way of specifying how much sound a speaker will put out with a given input signal. The rating usually appears in the specification sheets as something like "88 dB SPL/W/m." That means that a speaker will produce a sound-pressure level of 88 decibels when fed 1 watt of audio signal and measured with a sound-pressure level (SPL) meter located 1 meter in front of the speaker. Today's speaker sensitivities range from a low of perhaps 80 dB to a high (for a few large horn-loaded models) of 104 dB. A speaker that produces about 94 dB is said to have high sensitivity, 87 dB is medium sensitivity, and 81 dB is considered low sensitivity.

To put those figures in perspective, keep in mind that every 3-dB increase in speaker sensitivity is the equivalent of doubling the available power from the driving amplifier. Although amplifier power is relatively cheap these days, when you want a lot of it the cost goes up fast! If you can get a speaker with greater sensitivity, all other specifications being equal, then you can use a smaller amplifier without running into overload problems. Unfortunately, all other specifications seldom are equal, and unless the speaker is in a large box, its extra sensitivity has probably been achieved by trading-off of its low bass (below 60 Hz) performance. So when auditioning speakers with claimed high sensitivity, make sure that their low-bass performance is up to your expectations.

The maximum power rating is the other side of the speaker-power coin. One might imagine that a speaker's rated maximum power would simply indicate the amount of input it can sustain without damage. But the situation turns out to be far more complex because (1) damage can also result from long-term heating and/or short-term mechanical stress, (2) the various drivers within a speaker are able to handle different amounts of power, and (3) different kinds of test signals (and program material) cause different kinds of stress.

Given that situation, it is impossible to specify accurately a single number for a speaker's maximum power rating. Nevertheless, manufacturers do provide numbers as a rough guide, much to the confusion of the consumer. This brings us to the matter of ...

Avoiding speaker overload

Many listeners are understandably nervous about connecting speakers to an amplifier whose power output rating exceeds their speakers' maximum power capability. In most cases the concern is unwarranted, as long as normal precautions are observed, such as not dropping the tone arm (if your system still has one) on the record, not changing shielded cables when the system is switched on, and not trying to play "The 1812 Overture" at 120 dB. Also keep in mind that just as many tweeters are blown out by overdriving an underpowered amplifier (which then produces dangerous high-frequency waveforms) as by excessive power from a large amplifier.

Placement can be critical

If your speakers don't seem to sound as good at home as they did in the showroom—and your listening room acoustics have a reasonable balance between absorption and reflection—you probably have a placement problem. Unless the manufacturer recommends otherwise, most speakers will sound best when installed at listening ear level and at least several feet away from adjacent side and rear walls. In general, those systems that radiate from their front, rear, and sides are more sensitive to placement than conventional forward-radiating speakers simply because the sound reaching the listener's ears has a larger reflected component. But whatever the speaker system, you can usually achieve an enormous improvement in overall tonal quality and stereo imaging by proper positioning. Unfortunately, because of the many variables involved, finding the optimum system locations can be a tedious trial-and-error process. Your dealer may or may not have helpful suggestions.

Beware of "accessories"

Apparently there are some other-

Continued on page 89

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Only NRI walks you through the step-by-step assembly of a powerful 486sx computer system you train with and keep—giving you the hands-on experience you need to work with, troubleshoot, and service today's most widely used computer systems. Only NRI gives you everything you need to start a money-making career, even a business of your own, in computer service.

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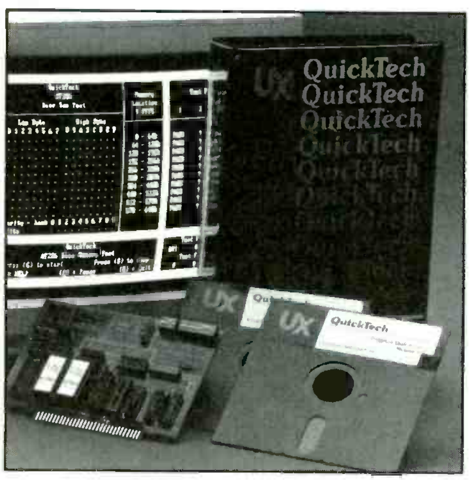

dramatically increase your computer's data storage capacity while giving you lightning-quick data access. But that's not all!

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Your NRI training now includes a remarkable diagnostic package that allows you to quickly locate and correct defects in IBM XT, AT 80286/80386/80486,

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IC MASTER ON CD-ROM. The entire *1993 IC Master* has now been recorded on a single CD-ROM—with room to spare. *Hearst Business Publishing* has also included the *1993 Directory of IC Manufacturers' Data Pages* and the *1993 Alternate Source Directory* in that "spare room."

Integrated circuits from 242 manufacturers are listed in the 1993 IC Master. The listings include 21,164 new memory, linear, digital, microprocessor, and interface devices. The data-pages directory is a cross-reference index, by device number, to the data books of 586 integrated circuit manufacturers.

The disc also includes an Inquiry Generating and Tracking System, which allows the user to perform searches for specific device specifications in minutes and print out the results on a computer printer. It also permits the review of hundreds of pages from manufacturers' data books, to compare specifications, and identify alternate sources.

The *CD-ROM Plus* disc will run on any ISO9660 CD-ROM reader coupled to any IBM AT-compatible computer. A VGA monitor is recommended, but an EGA monitor will generate acceptable images. Basic specifications can be printed on a dot-matrix printer, but a 300-dpi laser printer is required to copy image pages. A multi-user network version of the CD-ROM is available.

The *1993 IC Master CD-ROM Plus* is priced $395. If you would like to get your hands on one of these CD-ROM's, contact

Hearst Business Publishing/UTP Division
645 Stewart Avenue
Garden City, NY 11530
Phone: 516-227-1300
Fax: 516-227-1901.

CIRCLE 20 ON FREE INFORMATION CARD

RGB-TO-NTSC/PALL ENCODER. *Analog Devices* has introduced its *AD720*, said to be the first red, green, blue (RGB)-to-NTSC/PAL encoder on a single integrated circuit. No external low-pass filters or delay lines are required to use the chip.

AD720 produces a composite video output with a differential gain of 0.1%, and differential phase of 0.1%. According to *Analog Devices*, that performance level results in smear-free NTSC/PAL video outputs capable of generating type faces as small as 9-point. The IC is intended for PC video add-in cards, multimedia systems, CATV converter boxes, and other video-imaging systems.

The *AD720* converts red, green, and blue video signals into their corresponding luminance (baseband amplitude), chrominance (subcarrier amplitude and phase), and composite (combined luminance and chrominance) video signals. The three separate outputs are DC coupled, providing S-Video output.

Thin-film resistors in the RGB-to-YUV matrix, calibrated on-board low-pass filters and delay line, and digitally generated quadrature signals are all said to contribute to overall picture quality.


CIRCLE 21 ON FREE INFORMATION CARD

The *AD720* is priced at $18.39 each in thousands quantity.

Analog Devices, Inc.
181 Ballardville Street
Wilmington, MA 01887
Phone: 617-937-1428
Fax: 617-821-4273.

SOLAR-POWERED DMM. This handheld multimeter is powered by a lithium battery that can be kept continuously charged by an amorphous silicon solar cell. It is said to work up to ten hours on a one-hour charge. Energy from direct sunlight, daylight, or even normal home lighting can activate the solar cell.

The *Solar-Powered Digital Multimeter* offers 1 microampere resolution on both 2 milliampere DC and AC ranges. It has a 3½-digit LCD display and 12-ampere ranges for both alternating and direct current. Its features include data and range hold, and an audible continuity and diode check function. It measures up to 1000 volts DC, 750 volts AC, and 20 megohms.

CIRCLE 22 ON FREE INFORMATION CARD

The handheld meter has a battery-charge monitor and automatic voltage and resistance ranging. It will turn off automatically if not in continuous use.

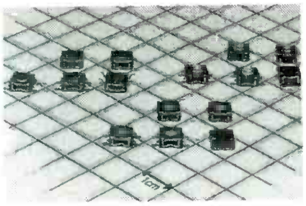
The *Solar-Powered Digital Multimeter* has a price of $95. Add $4.50 for shipping and handling. (California residents add sales tax.)

Front Row Experience
540 Discovery Bay Blvd.
Byron, CA 94514-9454
Phone: 800-524-9091.

SURFACE-MOUNTED KEY SWITCH. Three different surface-mounting switch configurations are now available from *ITT Schadow. The KSC Key Switch* is available without an actuator, with a silicone rubber actuator, and with a hard thermoplastic actuator.

The switches measure 6 mm square and are available in two heights: 2.5 mm for the actuator-less version and 3.5 mm for the other two. There is a choice of three different operating forces—160, 300, and 500 grams—and two terminal styles—tin-, silver, or gold-plated G-wing or J-wing.

KSC key switches are sealed in accordance with EIA RS 448-2. The switches are suitable for soldering by double-wave, infrared, or vapor-phase surface-mount methods.



CIRCLE 23 ON FREE INFORMATION CARD

KSC Key Switch are available on 2000-unit reels from $0.15 to $0.50 per key, depending on quantity and configuration.

ITT Schadow, Inc.
8081 Wallace Road
Eden Prairie, MN 55344
Phone: 612-934-4400
800-255-5896
Fax: 612-934-9121.

NON-CONTACT CURRENT METER. This non-contact, clamp-on current meter provides non-invasive current measurement in two- and three-wire flat cables. The *Electrascan Model VIP-100* is especially useful in situations where it is impossible or undesirable to cut or separate the cable wires.

CIRCLE 24 ON FREE INFORMATION CARD

The sensor snaps over cables and senses the current. It connects to any solid-state AC multimeter to provide a scaled reading of the current. Factory-calibrated to read one millivolt per ampere in standard 12-2 Romex cable, it can be readjusted in the field to measure most cable sizes.

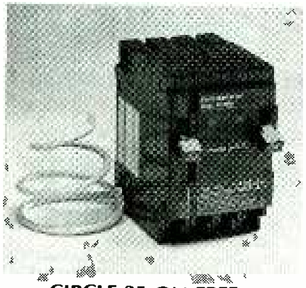
The current range of the *VIP-100* is up to 100 amperes, and its frequency range is 15 Hz to 100 kHz.

Currents in round cables can also be measured with the meter non-invasively, but not as readily.

The *VIP-100* clamp-on sensor has a price of $97.50.

Electrascan, Inc.
2917 Avalon Avenue
Berkeley, CA 94705
Phone: 510-548-1878.

CIRCUIT BREAKER/SURGE ARRESTER. The *Circuit Breaker/Surge Arrester* from *Siemens* safeguards outlets, fixtures, appliances, and electronic equipment from lightning strikes, utility switching surges, and in-home generated voltage surges.



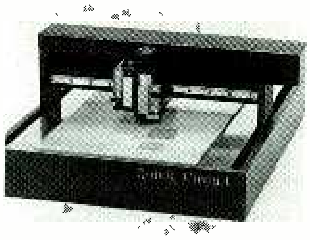
CIRCLE 25 ON FREE INFORMATION CARD

Offering the convenience of a snap-in circuit breaker, the protective device can easily be installed in any standard residential circuit-breaker panel box. (The manufacturer recommends that it be installed by a locally licensed electrician.)

The *Circuit Breaker/Surge Arrester*, available in 15- and 20-ampere ratings, is priced under $100.

Siemens Energy & Automation, Inc.
P.O. Box 2407
Norcross, GA
30091-9828.

PCB PROTOTYPING SYSTEM. The *Model 7000* is an updated version of *T-Tech's Model 6000 Quick Circuit* circuit-board prototyping system. The new model includes a 68332 micro-



CIRCLE 26 ON FREE INFORMATION CARD

controller, which permits the introduction of a serial RS-232C interface.

The *Quick Circuit* is essentially an X-Y milling machine that mills and drills prototype circuit boards under computer control. A mill path is created from computer-aided design files to isolate the conductive paths from the board material. The board is drilled, and then the isolation path is milled. Finally, the circuit board is cut from the material sheet.

The *Model 7000* also includes new versions of Quick Circuit Isolator, CAM software, and new documentation. It can be driven from any IBM-AT-compatible computers. This new system is no longer driven by a proprietary parallel circuit card in the host computer, so the user need not open his computer to insert the board.

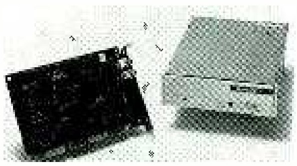
Quick Circuit Model 6000 users can upgrade to *Model 7000* for less than $2495.

T-Tech, Inc.
5591-B New Peachtree Road
Atlanta, GA 30341
Phone: 404-455-0676

CD-ROM PACKAGE. *JDR Microdevices' CD-ROM Package*, makes it possible to play CD-ROM's through a personal computer for multimedia applications. It includes a 16-bit interface card with the appropriate drivers.

The MPC- and Photo CD-compatible package is also fully compatible with industry standards including High Sierra and ISO 9660 formats. The internal drive fits in a standard half-height computer drive slot. The package offers a fast 350-millisecond access rate and a 150-kilobit per second transfer rate to reduce motion "jump" in multimedia presentations.

The front panel has a



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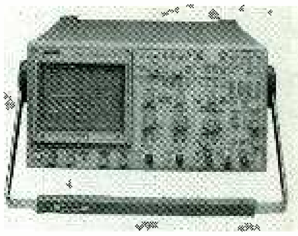
headphone jack and a volume control for private listening to audio selections. Powered speakers can be plugged into the headphone jack, and the system is compatible with many game sound effects audio cards.

The *CD-ROM Package* costs $295.95.

JDR Microdevices
2233 Samaritan Drive
San Jose, CA 95124
Phone: 408-559-1200

FOUR-CHANNEL OSCILLOSCOPE. *Leader Instruments* is now offering a new 250-MHz, four-channel analog oscilloscope. The *2250* oscilloscope offers automatic calibration and interchannel time matching. It features menu-driven setup choices, automatic sensitivity and time base setup, a four-digit, on-screen, frequency-counter display, and full cursor operations.

Trigger options include sync sourcing from one of the four channels and peak-to-peak auto sync to maintain positive triggering despite wide amplitude changes. Delayed sweep operations include TV-line



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select operations referenced to either field and applicable to 525, 625, and 1125 video systems.

Event-counter delay triggers the delayed sweep from a setable number of sync pulses following the start of the A time-base. Cursor measurements include voltage, time, frequency, and voltage ratio. Up to three titles or labels can be put on-screen for photo documentation.

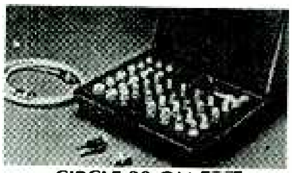
The *2250* oscilloscope is priced at $6000.

Leader Instruments Corporation
380 Oser Avenue
Hauppauge, NY 11788
Phone: 516-321-6900

ADAPTER KIT. Aimed at lab and field-service technicians in telecommunications, data communications, and broadcast industries, the *Model 5748 Maxi-Universal Adapter Kit* from ITT Pomona allows users to adapt almost any coaxial and termination type to another, including the ability to sample uninterrupted signal continuity.

The *Model 5748 Maxi-Universal Adapter Kit* costs $199.

ITT Pomona Electronics
1500 East Ninth Street
P.O. Box 2767
Pomona, CA 91769
Phone: 714-623-3463
Fax: 714-629-3317



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NEW LIT

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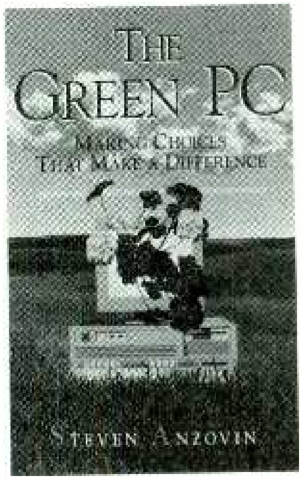
The Green PC: Making Choices That Make a Difference; by Steven Anzovin. Windcrest/McGraw-Hill, Blue Ridge Summit, PA 17294-0850; $9.95.

The computer is a threat to the environment? In the long list of sources of pollution and contamination from gas-guzzling automobiles, factory smokestacks, to plastics that give off toxic gas, one does not normally think of computers. Think again. Steve Anzovin, author of *The Green PC,* sees the proliferation of computers as having a profound impact on the environment as well as society.



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Mr. Anzovin's book, (printed on recycled paper), contains hundreds of tips on how one can reduce wasted power and trash directly related to computer use. The author provides practical advice on how to increase the life of computers and peripherals (presumably so they don't add to the growing piles of obsolete and unsalvageable hardware accumulating in dumps around the world), reduce equipment power consumption, and minimize the use of paper in the office. He writes of updating old equipment with new processor boards, and the purchase of previously owned equipment to break the cycle of junking systems that are not the fastest and latest on the market.

The book tells where to find software that conserves resources, time, and power; how to "telecommute" (shop with modems and networks) to save gas, and how to design an ergonomically sound working environment. Contained in the book is a list of "green" hardware and software vendors who consciously sell products with conservation of resources and elimination of waste in mind.

Electronic Hardware Catalog No. 93. Accurate Screw Machine Company, 19 Baltimore Street, Nutley, NJ 07110; Phone: 201-661-2600; Fax: 201-661-3408.

Accurate Screw Machine Co. is now offering its new 338-page, four-color catalog describing hundreds of different mechanical components and fasteners in its product line—screws, nuts, standoffs, washers, handles, and much, much more. The items are available in a wide range of sizes, including those with metric dimensions. All the hardware items are illustrated and described. Each product section contains an easy-to-understand sample ordering form.

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Practical Recording Techniques: The Step-by-Step Approach to Professional Audio Recording; by Bruce and Jenny Bartlett. Sams, 1171 North College, Carmel, IN 46032; Phone: 800-428-5331; $27.95.

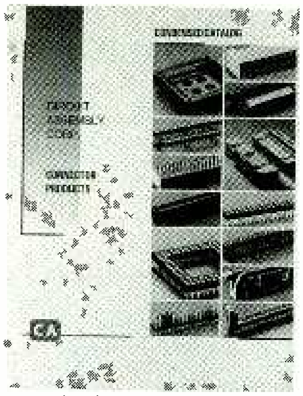
This practical book provides the reader with information that can be put to immediate use in a home hobbyist audio studio, a small professional studio, or in recoding sessions in the field. It will prove especially helpful to the entry-level audio enthusiast or professional. It provides tutorial text on the basics of sound generation and transmission, and describes available low-cost, yet effective, home-studio audio equipment.

For the professional, there is coverage of the latest digital tape recording methods and equipment, disk recording, keyboard and digital workstations, and the MIDI interface.

For readers at all levels of experience, the book explains how cost-effective equipment selection keeps costs low and quality high. Selected recording equipment is described in detail, as are control-room techniques. The section on how to organize a studio offers suggestions for improving its acoustics, choosing monitor speakers, and minimizing audio interference. A chapter on judging and improving recordings tells how to produce professional quality recordings.

Connector Products Condensed Catalog #SF9302. Circuit Assembly Corp., 18 Thomas Street, Irvine, CA 92718-2703; Phone: 714-855-7887; Fax: 714-855-4298; free.

Circuit Assembly Corp. is now offering its new condensed catalog covering the many different connectors it manufactures. The catalog is organized to permit the reader to find a desired connector quickly. Complete mechanical and electrical specifications are included for the company's



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broad selection of standard connectors. Photos and detailed drawings illustrate the products and help in the search for the "right" product. The company's custom cable and connector assembly services are described.

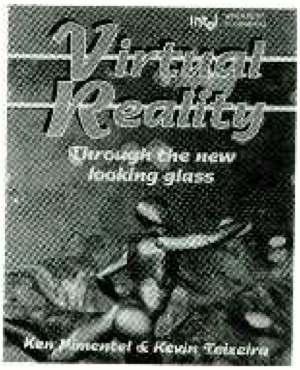
Virtual Reality: Through the New Looking Glass; by Ken Pimentel and Kevin Teixeira. Windcrest/McGraw-Hill–Intel, Blue Ridge Summit, PA 17294-0850; Phone: 800-233-1128; $22.95.

You have all seen the pictures of people wearing peculiar looking oversize goggles that make them look like bug-eyed beings from outer space. Their hands are in articulated gloves festooned with wires. The caption explains that this subject is undergoing a "virtual reality" experience—perhaps exploring a building that does not exist or driving an imaginary race car on an imaginary track.

The book *Virtual Reality,* explains that a marriage of computers, servo systems, and audio-visual equipment, permits the subject with the ungainly headset to "exert control over his environment"—look behind doors in an imaginary building, walk around to gain different perspectives, and even go up and down stairs. In the car racing scenario, the subject can change speed, and and manuever around other imaginary cars while listening to realistic sounds of a racing engine.

Virtual reality has gone beyond what would have been considered science fiction a few years ago. It has been accepted as a design and training aid in government, industrial, and academic R&D laboratories. This book explains virtual reality and how it works. It is a direct descendent of the first Link trainer flight simulators introduced more than a half century ago. You will learn how personal virtual-reality systems are built. The major components such as three-dimensional television goggles, responsive "data gloves," and sound-recognition devices are described.

The authors touch on the



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cultural and ethical questions posed by virtual reality, and its anticipated impact on education, business, medicine, architecture, science, and entertainment. Finally, the book considers the possibilities for virtual reality at the personal computer level. Appendices include a glossary, a guide to virtual-reality equipment vendors, and laboratories where significant virtual-reality R&D is now being carried out.

Now You're Talking! All You Need to Get Your First Ham Radio License: Second Edition; edited by Larry D. Wolfgang, WR1B, Jim Kearman, KR1S, and Joel P. Kleinman, N1BKE. The American Radio Relay League, Newington, CT 06111-1494; $19.

More than two million people around the world enjoy the exciting hobby of amateur radio. This book from ARRL can help you get started; it answers most of the questions you might have about amateur radio. Subjects include how amateur radio can be used in communications, public service, or just for talking to like-minded strangers all around the world.

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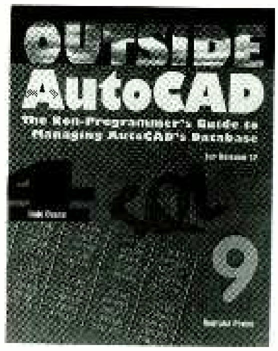
The book also explains how to use repeaters and packet radio, the radio spectrum available to amateurs, radio circuit components, and what you must know to pass the novice exam. For readers interested in taking the Technician Exam, the subject of Morse code is also covered. Sample test questions and answers are included.

Other topics of interest to the novice as well as the seasoned ham include how to select ham-radio equipment, choose the right antenna, and organize your own ham station. One chapter covers practical problem solving. Appendices include data tables, metric conversion tables, frequency and mode allocations for amateurs, a world-time finder template, and a glossary of key words.

Outside AutoCAD: The Non-programmer's Guide to Managing AutoCAD's Database; by Dale Evans. Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515; Phone: 919-942-0220; Fax: 919-942-1140; $29.95.

This book teaches techniques for using the valuable non-graphic information included in AutoCAD drawings. It explains how to get the most from the program's non-graphic information; Release 12 is said to make AutoCAD's powerful database capabilities accessible to nonprogrammers.

Evan's book explains



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guidelines for working with and customizing AutoCAD for Windows. In addition it offers tips for working with Release 12's new Dynamic Data Exchange (DDE) that ties graphics data to outside data managed by other programs. An overview of ASE, the AutoCAD SQL extension, explains how to unite SQL-based data with AutoCAD to build applications. Ω

LETTERS

continued from page 15

With unintended eloquence Mr. Berglund has come close to the essence of "audiophoolishness." Listening to music, whether a live performance or from an Edison shellac record, is an emotional, subjective experience. While many of these emotions are widely shared, they are not exactly duplicated in any two individuals regardless of hearing acuity.

If the imperfections in the recording/reproducing process are large enough, they will eventually interfere with emotional appreciation of a performance. But they cannot, by definition, *contribute* to a performance, any more than turning up the bass on a boom box "improves" the original music.

To say otherwise is to say that the original recording/reproducing system is part of the performance. That is absurd!

The underlying fallacy here is that the components of a reproducing system—the wires, resistors, capacitors, transistors —can contribute to the musical performance of the system in some mystical way that transcends their measurable properties. It is as if a capacitor can tell whether the analog signal passing through it is Rachmaninoff's second piano concerto or a reading of Shakespeare.

Perhaps because they know that the technological ice upon which they skate is perilously thin, "audiophools" will not submit their loudly proclaimed opinions for legitimately monitored A/B testing.

BURKETT FARQUHAR
New London, NH

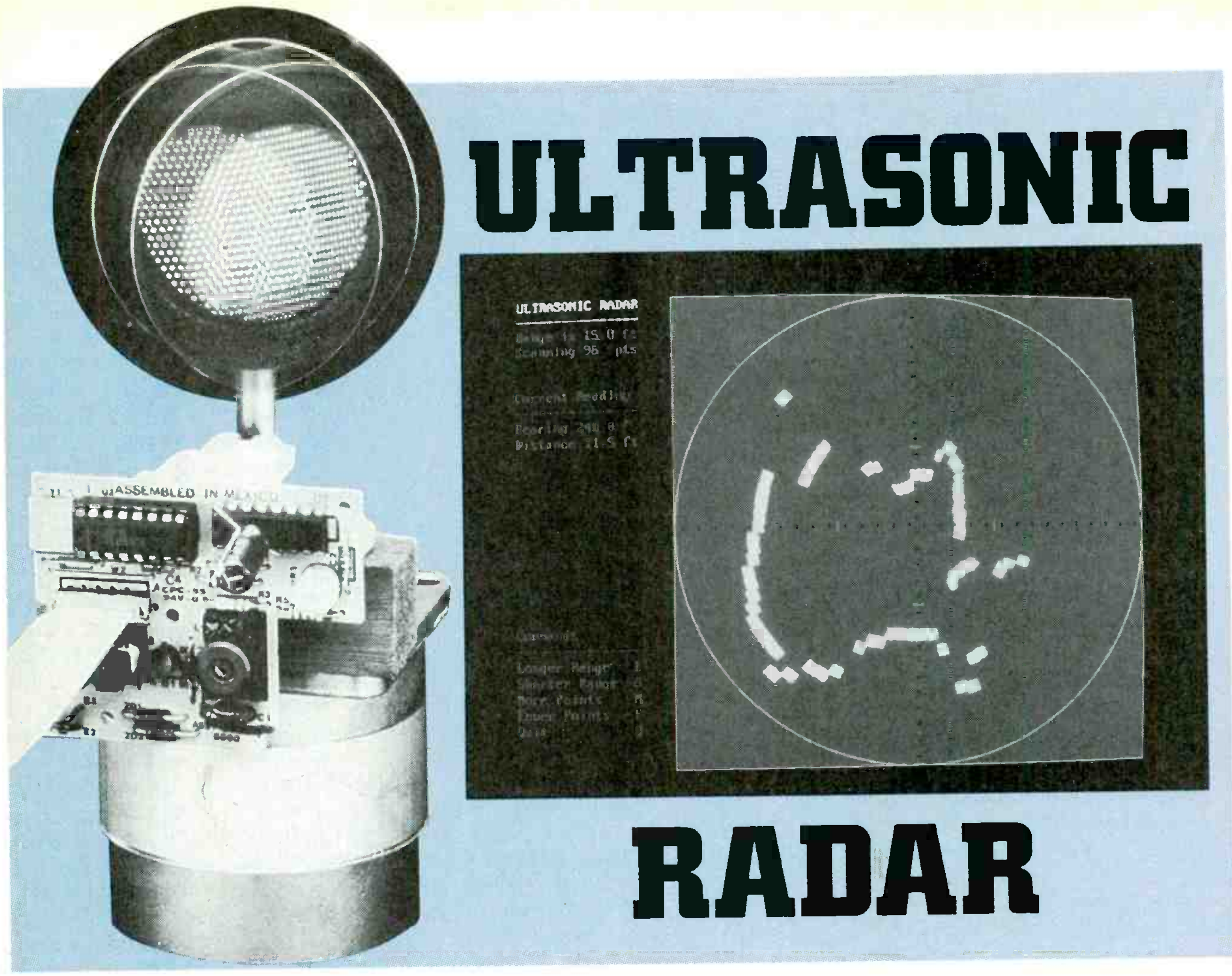
MAKING PC BOARDS

Many of my friends enjoy making PC boards, and each one claims his method is best. Does **Electronics Now** have any advice on the subject?

LENNY LEO
New York

As a matter of fact we do! This very issue contains two articles explaining two different techniques yoiu can try, and future issues will cover additional methods.—Editor. Ω

ULTRASONIC RADAR



Give your PC the ranging ability of RADAR with this month's addition to last month's Experimenter project.

RONALD M. JACKSON

IT'S DIFFICULT TO IMPRESS PEOPLE with a home computer. Even if the computer has a 486 processor running faster than blazes, from the outside it just looks like a tan box. There's not much you can bring up on the screen that will impress them either—they've seen it all before on TV. However, this month's project puts a live-action radar-like display in high-resolution color graphics on your home computer screen—and it's guaranteed to impress. People will be amazed as a blip moves about on the computer's "radar" display, following their movements about the room.

The system works as follows: An ultrasonic rangefinder measures the distances to surrounding objects. (Note that because ultrasonic energy rather than radio frequency is used, this project is more like sonar than radar.) A stepper motor rotates the transducer, giving full 360° coverage. The ultrasonic rangefinder and stepper motor are controlled and interfaced to your home computer by the Experimenter interface presented last month. The software, written in Microsoft's QuickBASIC for PC-compatible computers, is available on the *Electronics Now BBS* (516-293-2283), or on disk from the source mentioned in the Parts List. A Macintosh version is also available.

The rangefinder

Our project uses the same ultrasonic transducer that is used in Polaroid cameras. Note that we will not be building the transducer unit because it is *not* available as a kit—only as a preassembled surplus unit from the source mentioned in the Parts List. An ultrasonic rangefinder emits a brief pulse of high-frequency sound. Any object hit by the sound produces an echo. The distance to the object is determined by measuring the time delay between the transmission of the original pulse and the return of the echo, which is displayed.

The Polaroid rangefinder is made up of two parts: a transducer and a ranging board. The transducer, shown in Fig. 1, acts as both a speaker and a microphone. It emits the ultrasonic pulse and "listens" for the

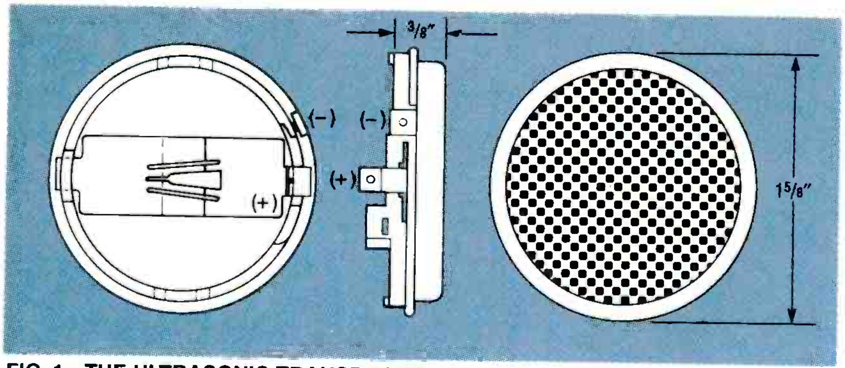


FIG. 1—THE ULTRASONIC TRANSDUCER acts as both a transmitter and receiver.

echo. The ranging board (Fig. 2) provides the high voltages required to run the transducer, sensitive amplifiers for echo detection, and control logic. The only adjustment on the ranging board, VR1, changes the sensitivity of the echo detector. The transducer is mounted on top of the output shaft of a stepper motor, which gives the transducer a 360° field of view. The ranging board mounts beside the stepper motor. Figure 3 shows the entire radar assembly.

The Experimenter controls the ranging board, measures the round-trip time of the pulses, controls the stepper motor, and communicates with your computer. Figure 4 shows the connections between the transducer, ranging board, and the Experimenter. The ranging board uses a nine-conductor flexible cable. The connector for this cable can be installed in the X1 connector mounting area on the Experimenter. The cable has a black stripe on it to indicate pin 1.

The ranging board's power requirements are normally under 100 milliamps, but peak at about 2 amps during the transmit period. Power passes through the GND (pin 1) and V+ (pin 9) signals on the flex cable to connector J1. Due to the inductance of the cable, the ranging board might experience a supply voltage drop of about 4 volts (on a 5-volt supply!) during the transmit period. That can cause the ranging board to malfunction. To prevent that, install a capacitor of 300μF or greater on the ranging board at J1 between V+ and ground. To ensure that the circuitry on the Experimenter is not affected by the sudden power demand, add a 300 μF capacitor on the Experimenter end of the cable. It can be added in the wiring grid area adjacent to X1.

Figure 5 shows a timing diagram of the ranging-board signals. When the Experimenter sets INIT high, the ranging board sends sixteen high-voltage drive pulses to the transducer. It takes about 360 microseconds to transmit the pulses. The Experimenter waits one millisecond to allow time for pulse transmission and for the transducer to settle down. Then the Experimenter sets BINH high to start the driver "listening" for an echo. If an echo is detected, the ranging board sets ECHO high. The Experimenter measures the time from BINH going high to ECHO going high. Then the Experimenter resets INIT

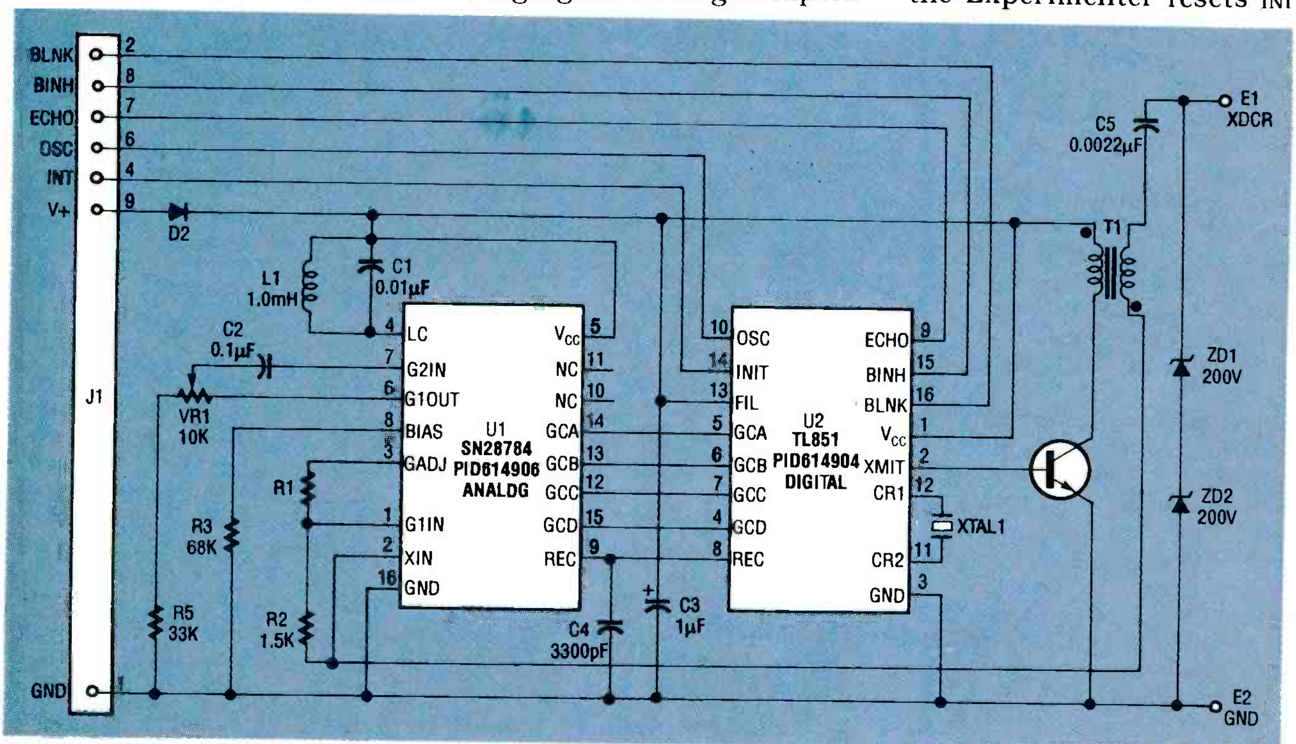


FIG. 2—RANGING BOARD SCHEMATIC. The ranging board provides the high voltages required to run the transducer, sensitive amplifiers for echo detection, and control logic.

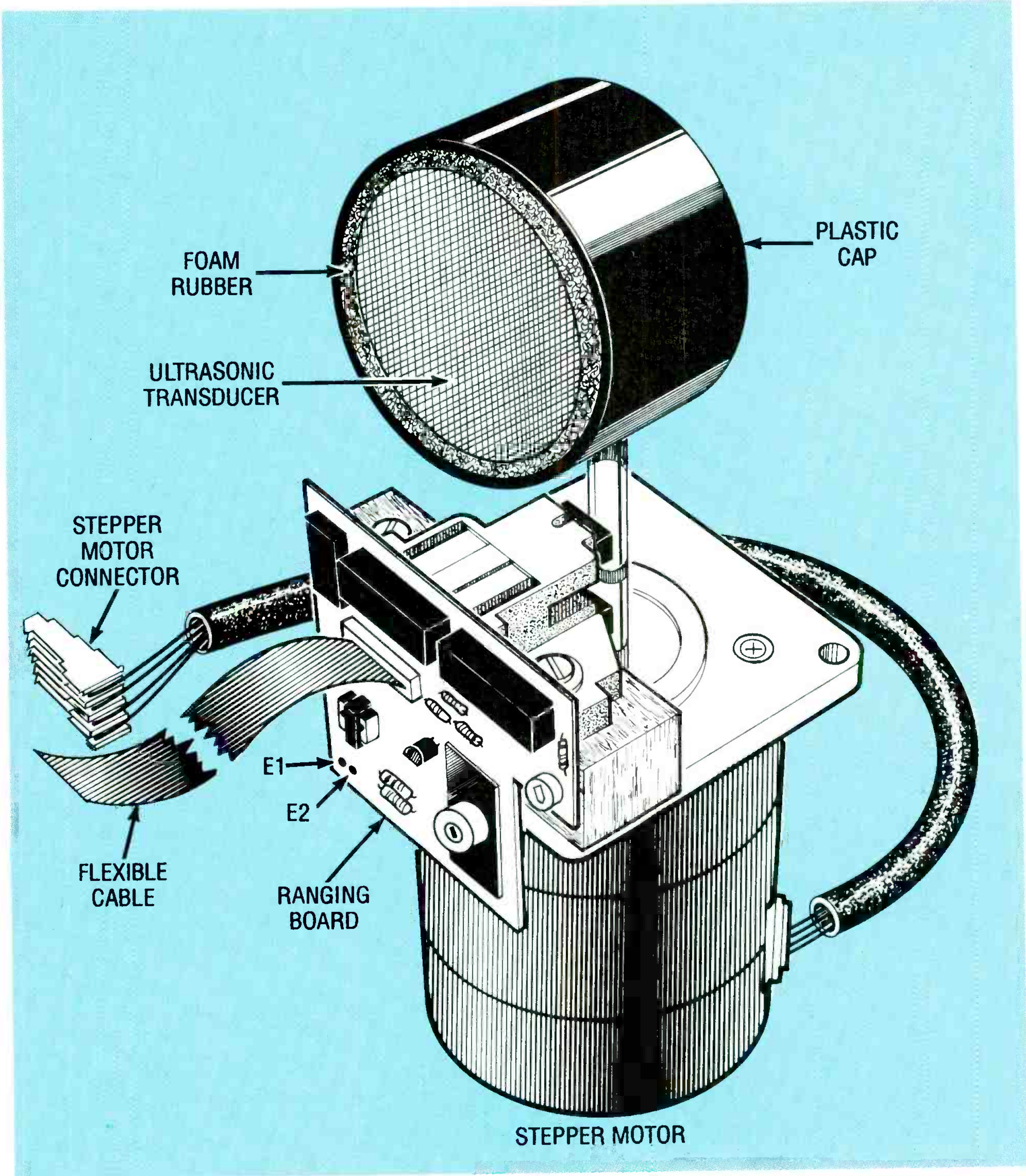


FIG. 3—THE TRANSDUCER IS MOUNTED to the stepper-motor output shaft. The ranging board is also mounted to the stepper motor.

and BINH low. If no echo is detected in about a half second, the Experimenter cancels the measurement.

The measured time is sent to the computer, which then calculates the distance based on the speed of sound. (The speed of sound in air is about 1100 feet per second, but it varies with temperature, humidity, and barometric pressure.) You can measure the speed of sound for your existing local weather conditions with the program DISTANCE.BAS, which is contained in the self-unarchiving ZIP file on the *Electronic Now BBS* (516-293-2283) called EXPER1.EXE. Since the Experimenter measures time with 10-microsecond resolution, this program can calculate distances to within about a hundredth of an inch!

The stepper motor

The project uses a stepper motor that rotates the ultrasonic transducer so it scans around the room. A stepper motor differs from an ordinary

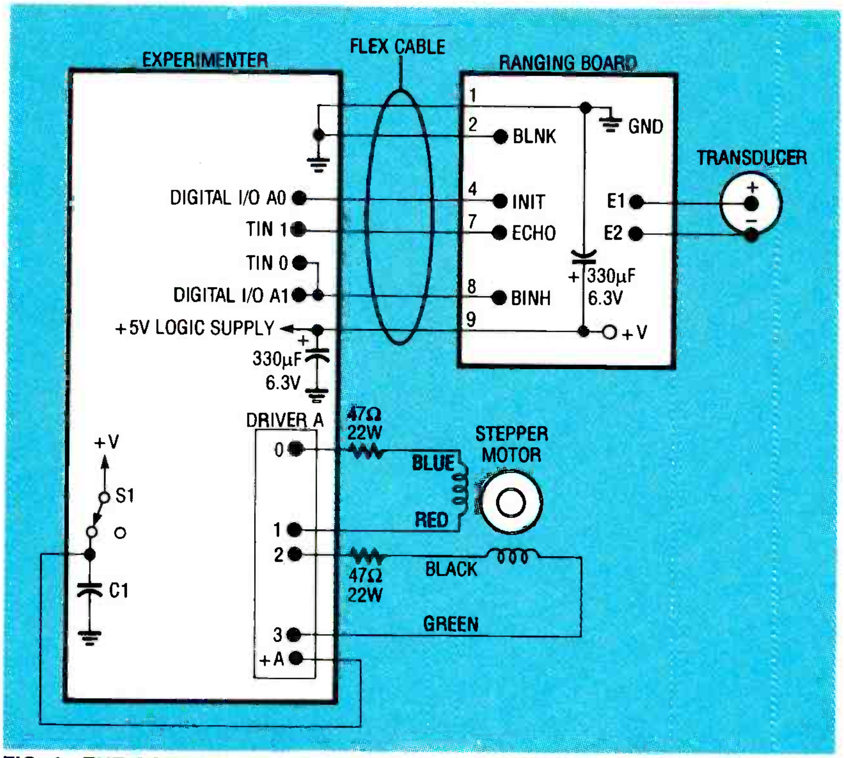


FIG. 4—THE CONNECTIONS between the transducer, ranging board, stepper motor, and the Experimenter. Capacitors must be added across the power supply on both the Experimenter and ranging boards. The power to driver A can be wired to the power switch S1 (as shown), or connected to an external power supply or battery. The choice of power source will depend on your selection of stepper motor, and the way the Experimenter is powered.

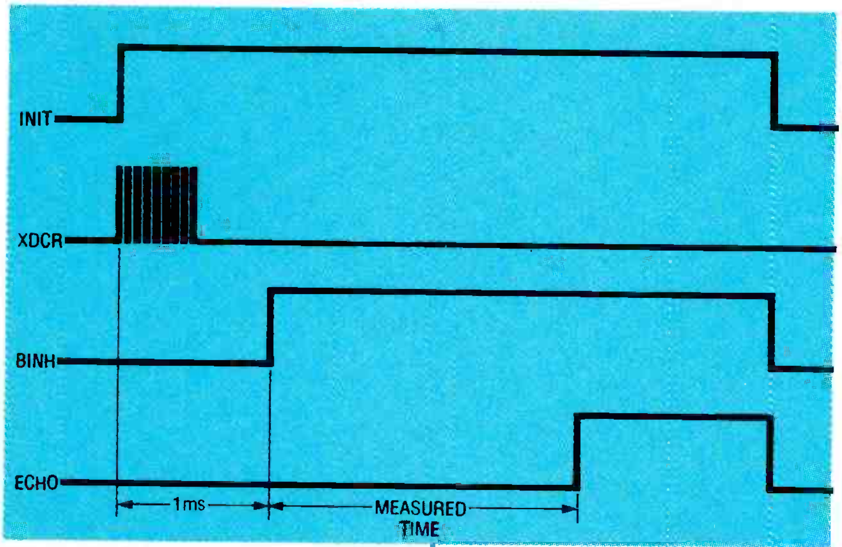


FIG. 5—TIMING DIAGRAM of the ranging-board signals for this project. The Experimenter sets INIT high, then the ranging board sends pulses to the transducer. The Experimenter waits for the pulse transmission and for the transducer to settle down. Then the Experimenter sets BINH high to start the driver listening for an echo. If an echo is detected, the ranging board sets ECHO high. The Experimenter measures the time from BINH going high to ECHO going high.

DC motor that has two wires connected to brushes inside the motor. As the armature rotates, the brushes connect successive commutator bars to windings to provide torque. The motor speed depends on how heavily it is loaded and how much voltage is supplied.

By contrast, a stepper motor has separate wires to each winding. Energizing a winding causes the armature to rotate slightly, typically a few degrees. By sequentially energizing the coils, the motor can be made to rotate through 360°. By controlling exactly when each winding is energized, the motor can be made to turn through a specified angle at a precisely controlled speed.

A stepper motor is used in this project because it gives precise control of motor-shaft location. If an ordinary DC motor were used, we couldn't control the shaft position and wouldn't be able to take the distance readings at evenly spaced positions. By controlling the number of steps and step rate, the stepper motor will turn the exact angle required between each pulse transmission.

Thanks to the Experimenter's built-in stepper-motor control, the sequencing of the stepper-motor's coils is handled automatically. Your computer tells the Experimenter how many steps it wants the motor to take between readings, and the Experimenter handles all of the timing and sequencing required to step it there.

There are many types of stepper motors available. Low-cost, light-duty stepper motors have either two coils, three coils, two coils with center taps, or four separate coils (see Fig. 6). The Experimenter can drive any of those stepper motors, with drive voltages from 4.5 to 36 volts and currents up to 1 amp. The numbers given in Fig. 6 show which driver output to connect to each wire of the stepper motor. If you don't have a data sheet for your stepper motor you will have to figure out the coil configuration with an ohmmeter.

The Experimenter must be "told" the coil configuration of the stepper motor so that it can provide the proper sequencing of outputs. Table 1 shows the available drives for the four stepper-motor coil configurations. Some configurations can be successfully driven with several different kinds of drives.

In choosing between different drives, you must make tradeoffs between the motor's power

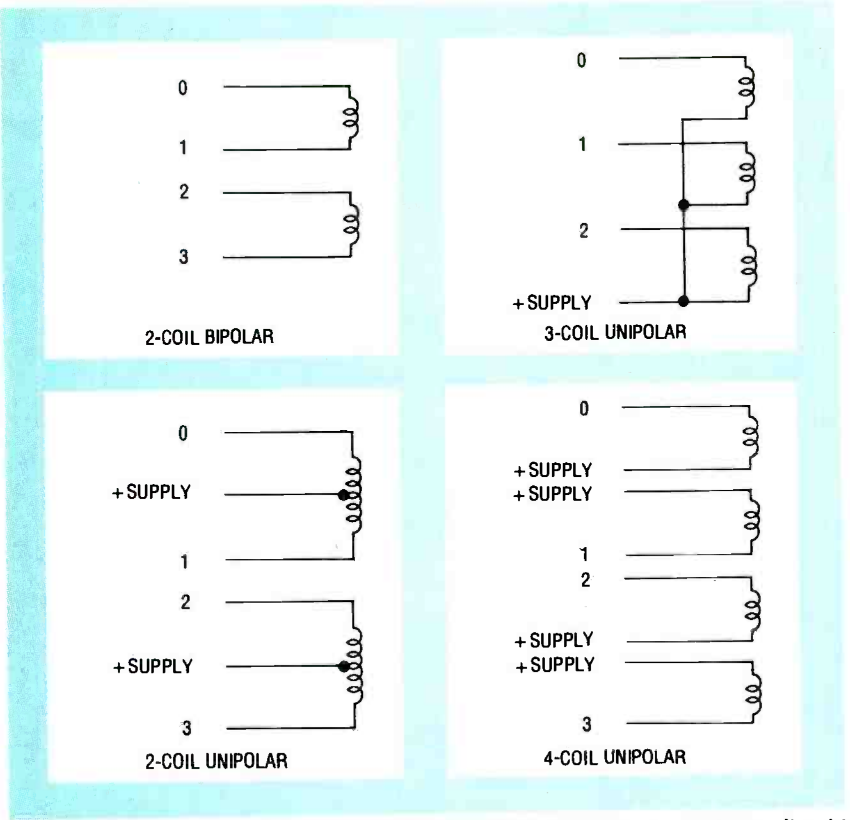


FIG. 6—COMMON STEPPER MOTORS have either two coils, three coils, two coils with center taps, or four separate coils. The Experimenter can drive all these stepper motors.

TABLE 1—STEPPER MOTOR DRIVE TYPES

Type	Coil Configuration	Common	Drive Pattern
2	3 coil unipolar	− supply	1 phase
3	3 coil unipolar	+ supply	1 phase
4	3 coil unipolar	− supply	half-step
5	3 coil unipolar	+ supply	half-step
6	4 coil unipolar	− supply	1 phase
7	4 coil unipolar	+ supply	1 phase
8	4 coil unipolar or	− supply	2 phase
	2 coil bipolar	none	2 phase
9	4 coil unipolar or	+ supply	2 phase
	2 coil bipolar	none	2 phase
10	4 coil unipolar or	− supply	half-step
	2 coil bipolar	none	half-step
11	4 coil unipolar or	+ supply	half-step
	2 coil bipolar	none	half-step

consumption, torque, and resolution. For example, a unipolar stepper motor with its common leads connected to the + supply can be driven in modes 7, 9, or 11. Mode 7 (one-phase drive) minimizes power consumption, because only one coil is active at any time, although this reduces torque. Mode 9 (two-phase drive) runs two coils simultaneously, providing maximum torque, although the power consumption is doubled. Mode 11 (half-step drive) alternates between driving two coils and one coil, doubling the number of steps per revolution.

Stepper motors are usually labeled with the step angle (or steps per revolution), maximum coil voltage, and coil resistance (or maximum current). If you use a stepper motor with coil voltages of twelve volts or less, you can run both the stepper motor and the Experimenter from the same power supply. Some stepper motors draw more current than a small power supply can provide, so a rechargeable battery pack is usually the most economical power alternative.

Let's look at one example of a suitable stepper motor. The motor has four wires terminated in a connector: blue, red, black, and green, in that order. An ohmmeter shows that the coils are arranged in a two-coil bipolar configuration; blue paired with red and black paired with green. The label says that it's a 1.8° per step motor. That corresponds to 200 steps per revolution in the two-phase drive mode (type 8), or 400 steps per revolution in the half-step drive mode (type 10).

The maximum DC voltage listed on the motor is 4.25 volts, with a current of 1.7 amps; it is a heavy-duty ball-bearing motor. We don't need the torque that this motor can produce at its full power rating for this project. We will limit the current to a reasonable level by adding series resistors to the motor leads. If we were building a project that required higher torque, we could add power transistors to the Experimenter's driver outputs, and run the motor at its full rated current.

Let's calculate the value of the series resistors. Suppose we want to run the Experimenter, ranging board, and motor from an unregulated 9-volt, 500-milliamp power supply. The Experimenter and ranging board consume about 100 milliamps each, leaving about 300 milliamps for the motor, or about 150 milliamps for each coil. That is less than a tenth the motor's rated capacity, but in this low-torque application it will be adequate. At that low current level, the voltage drop across each driver is about 0.7 volt, for a total drop of 1.4 volts. If we substitute the correct numbers into the equation:

$$R_{SERIES} = \frac{E_{SUPPLY} - E_{DROP}}{I_{CHOSEN}} - R_{MOTOR}$$

we get

$$R_{SERIES} = \frac{9 - 1.4}{0.150} - 2.5$$

With those numbers we arrive at a series resistor value of 48 ohms. The closest standard values are 47 and 51 ohms. The series resistors can be installed in the wiring grid area on the Experimenter.

Be sure to use resistors with adequate power-handling capacity. From the equation $P = I^2R$ we can calculate the required power rating ($0.15^2 \times 48$) of 1.08 watts, so 2-watt (or larger) resistors should be used. Remember to connect power to the +A input on driver A. You can obtain power from the power switch to C1. That way no power will be drawn when the Experimenter is switched off.

Assembly

In building the radar unit, two electrical contacts must be maintained while the transducer is rotating. Figure 7 shows how that was done on the prototype. Start with a brass tube with a ¼-inch inside diameter about 3 inches long. That tube will provide the ground connection between the ranging board and the ultrasonic transducer. Insulate one end of the 3-inch tube with electrical tape or heat-shrink tubing, and then slide a short ring (about ½-inch long) of slightly larger inside diameter brass tubing over the insulation. Another piece of tape or heat-shrink tubing can be used to hold the outer ring in place over the insulation—just make sure that most of the ring remains exposed. Drill a small hole in the side of the longer tube just above the shorter ring. Solder an insulated wire to the shorter ring, and run the wire through the hole and up and out the far end of the longer tube. The outer ring and the wire connected to it will provide the positive connection between the ranging board and the transducer.

Drill a hole the same diameter as the long tube in the side of a plastic jar lid, as close as possible to inner top surface of the lid. Slide the lid onto the end of the tube farthest from the outer ring, and glue it in place. (Sanding the mating plastic and brass surfaces will allow the glue to hold better.) Solder one of the two clips provided with the ultrasonic transducer to the wire from the outer ring, and slide the clip onto the inside terminal (+) of the transducer. Solder another insulated wire to a point on the longer brass tube inside the lid. Solder the other end of that wire to the unused transducer clip, and slide the clip onto the outside terminal (−) of the transducer. Pay attention to polarity! Mount the transducer in the lid by surrounding it with a strip of foam rubber for a snug fit. The longer tube can now be bonded to the shaft of the stepper motor with epoxy.

Automotive alternator brushes make excellent contacts for linking the ranging board to the long tube and ring. You can buy the brushes at most automotive stores for a few dollars, or a complete brush assembly with mounting hardware for less than $10. There are many different styles of brushes and assemblies, and some are easier to adapt than others. Choose one that has a convenient size and shape to work with. You might need to file some parts of the assembly, or remove unneeded metal fit-

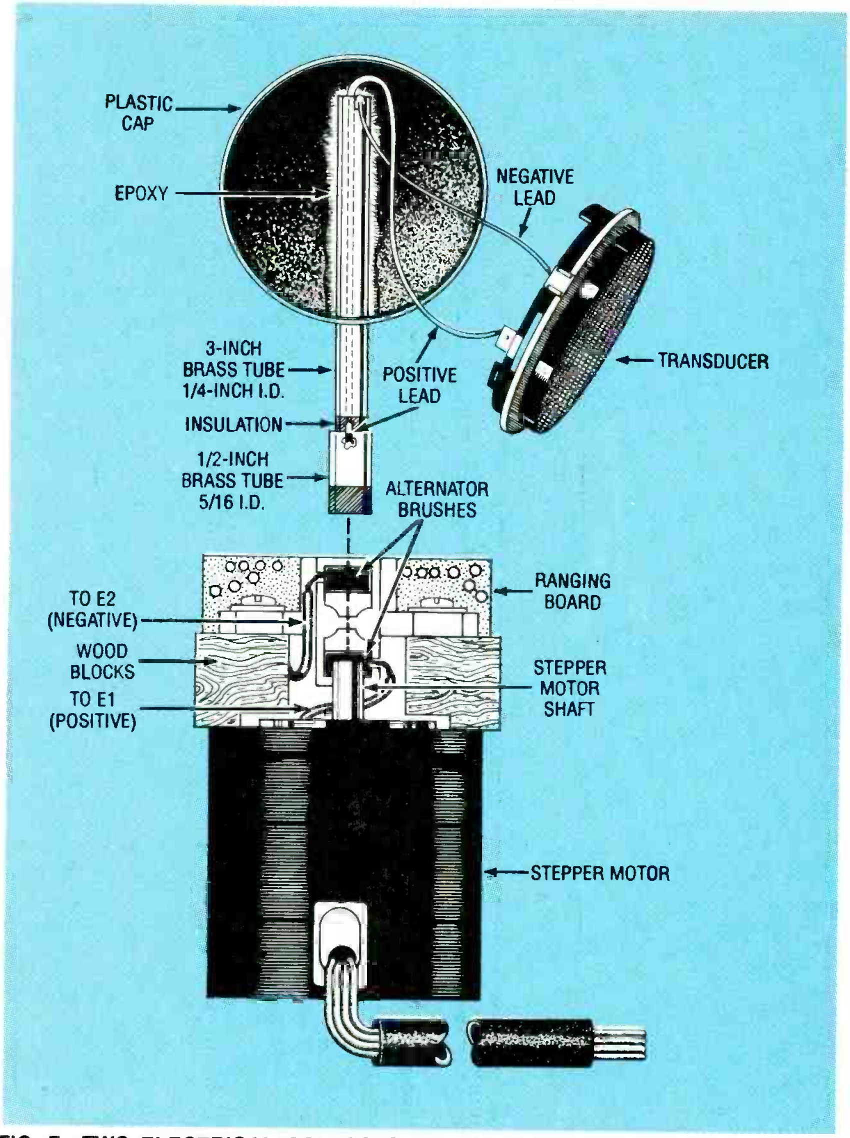


FIG. 7—TWO ELECTRICAL CONTACTS must be maintained while the transducer rotates. Here's how that was done on the prototype.

tings. The assembly can be mounted to the stepper motor with small wood blocks.

Complete the connections by running wires from the brushes to the ranging board. Again, observe the correct polarity! The longer tube is ground, and it connects to the E2 terminal on the ranging board (the black wire with the red stripe). The outer ring is positive, and it connects to the E1 terminal (the plain black wire). Although the ranging board produces 400 volts when operating, it does so only in brief pulses of current low enough so that it is not dangerous—but it will give you a mild shock if you touch the right place.

The ranging board can be glued to the wood blocks or the brush assembly. If the 300 µF capacitor installed across J1 pins 1 and 9 interferes with mounting the ranging board, move the capacitor to the front of the board on U1 between pin 16 (GND) and pin 5 (V+).

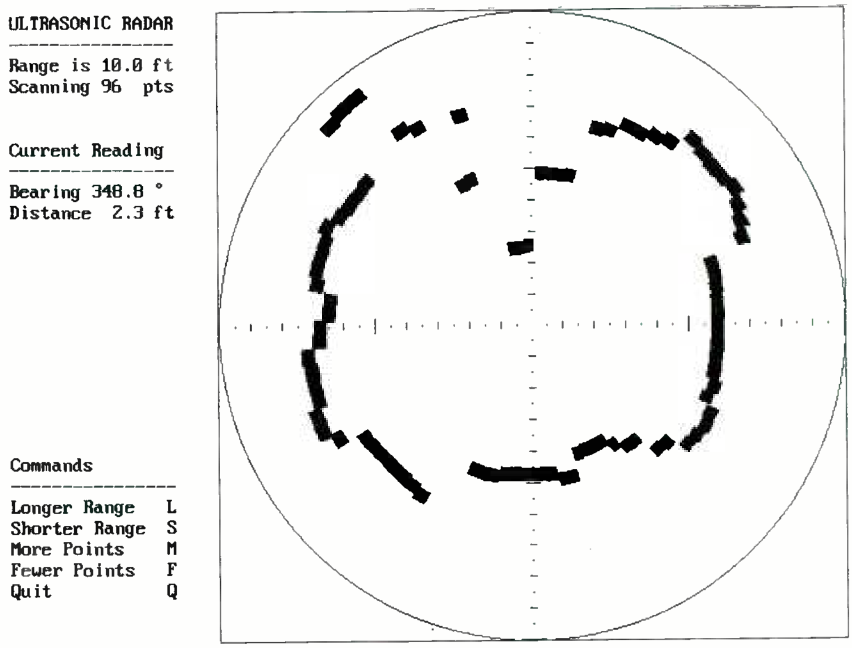


FIG. 8—THE RADAR IN OPERATION. The ultrasonic "RADAR" can detect and display objects from about 6 inches to 35 feet. Here the maximum range has been set to 15 feet.

Software

Two programs were written for the ultrasonic radar, and both are contained in the self-unarchiving ZIP file (EXPER1.EXE) on the *Electronics Now BBS*. Both programs were written in Microsoft's QuickBASIC. DISTANCE.BAS is a simple distance-measurement program. It pulses the rangefinder several times per second and reports the distance measured with 0.01-inch resolution over a range from about 6 inches to 35 feet. You can calibrate the unit for the speed of sound at your location by placing a flat object, such as a box, a carefully measured distance from the transducer. When you run the program, it will report the distance it measured, based on the default value for the speed of sound (1100 feet per second).

If the reported distance is more than the actual distance, decrease the speed of sound parameter by pressing the "1" key. It decreases the parameter by 10 feet per second. Pressing the "2" key decreases the speed by one foot per second. If the reported distance is less than the actual distance, increase the speed of sound parameter. Pressing the "4" key increases the parameter by 10 feet per second; pressing the "3" key increases the parameter by 1 foot per second.

You can include the speed-of-sound parameter you determined in the radar program to make it more accurate. The speed of sound parameter, and other initialization parameters, are read by the radar program from the file RADAR.DAT. The graphical radar program is easy to use. For a high-resolution color radar display, your computer will need EGA or VGA display electronics and a color monitor. If your computer just has CGA, the radar program will provide a lower resolution black and white display, as shown in Fig. 8.

Each rangefinder distance reading is plotted on the display in real-time. It provides scale information with bars of different colors and lengths drawn along the axes. Tens of feet are marked by long green bars; five-foot marks are red; and one-foot marks are short green bars. Half-foot marks are short black bars, and quarter-foot marks are green dots.

On the left side of the display the program reports the present range values and the number of scanning points in each revolution. The bearing and distance values are updated for each rangefinder measurement. Listed at the lower left are the commands you can give the program while it is running. Pressing the "L" key increases the displayed range (up to 35 feet). Pressing the "S" key decreases the displayed range (down to 5 feet). Pressing the "M" key causes the drive motor to scan more points per revolution (up

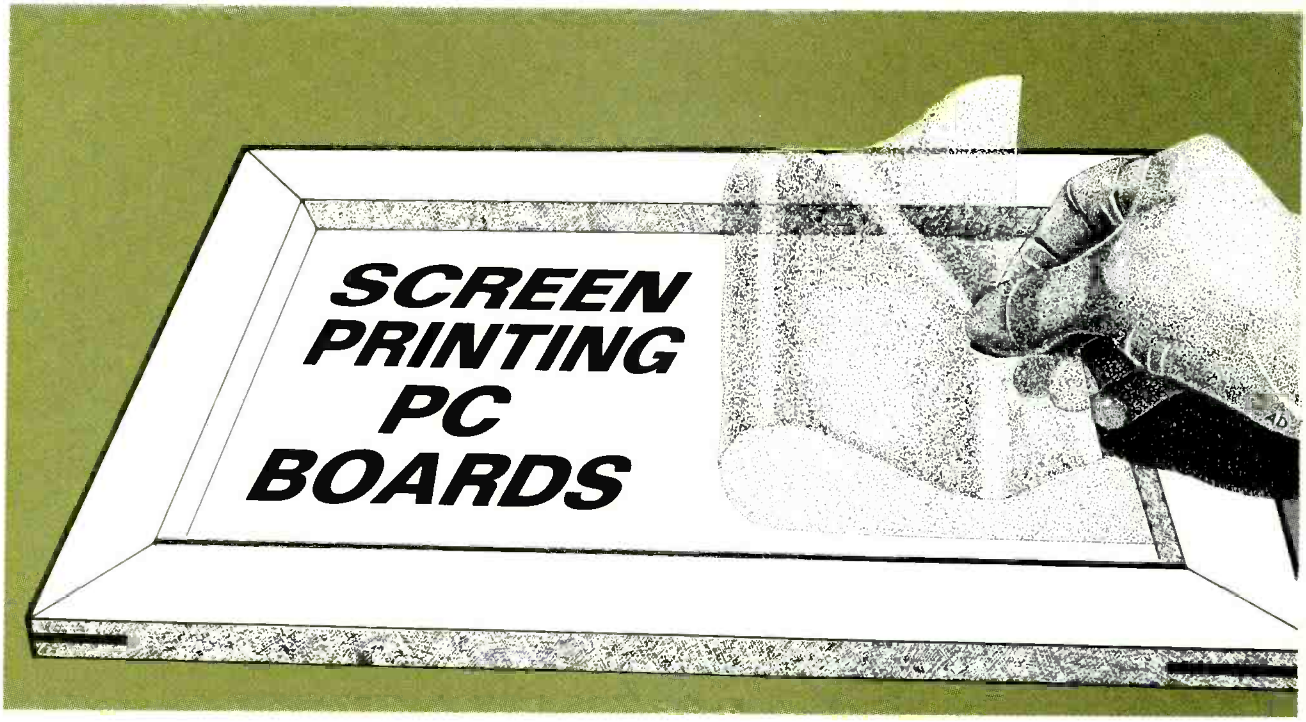
Continued on page 86

SOURCES

The following parts are available from Fascinating Electronics, PO Box 126, Beaverton, OR 97075. For VISA or Mastercard orders call 1-800-683-KITS, weekdays 10:00 AM to 5:00 PM, Pacific Time.

- Ultrasonic transducer, ranging board, cable, connector, and capacitors—$69.90
- PC-compatible or Macintosh software on either 5.25- or 3.5-inch disk (please specify machine and format)—$9.90
- Experimenter in kit form—$149.90
- Assembled and tested Experimenter—$199.90
- 9-volt 500 mA power supply—$11.90
- There is a limited quantity of the 4.25-volt, 1.7-amp, 200-step-per-revolution, surplus/used stepper motors available (includes series resistors)—$14.90

Please include $3.40 for shipping and handling with your order. Foreign orders, please inquire for prices and availability.



SCREEN PRINTING PC BOARDS

Learn how to use the commercial manufacturing process for PC boards at home.

WILLIAM ALFORD

THERE ARE MANY TECHNIQUES available for making PC boards, ranging from exposing UV-sensitive resist-coated boards to the use of heat-fused toner from copy machines. However, most of those techniques are economical only for hobbyists and small commercial prototype runs. The industrial process of choice for producing PC boards rapidly and cheaply is to print the circuit pattern onto the copper-clad board using a screen-printing process. This technique is so fundamental to the commercial manufacturing process that all serious hobbyists, students, and engineers should at least be familiar with it. Once, educated to its possibilities, they might find it to be a valuable tool in their own electronic projects.

In the screen-printing process, etchant resist is forced by a rubber squeegee through the open image area of a fine-mesh stretched stainless steel screen onto the PC board below. A blocking agent applied to the mesh in a pattern prevents the resist from passing through to areas of the substrate that are to be removed. This same process, a derivative of silk screening, can be used to label instrument panels and other flat surfaces.

Today's screen printing technology is an exacting scientific process. Instead of using silk screens stretched onto wooden frames, precisely made synthetic fabrics (or stainless steel screens) are stretched by pneumatic tensioning devices onto rigid aluminum frames. Stencil images are reproduced photographically on printing plates that can print images with resolutions to 2 mils on computer-controlled presses.

However, as sophisticated as today's screen printing industry is, the basic process itself is wonderfully simple, easy to cor-

FIG. 1—THIS IS EVERYTHING YOU NEED to produce high-quality mass-produced PC boards.

rect, and uses readily available materials.

While it's true that screen printing is best for mass-production, and there are no real advantages to it if you need only one or two boards, it costs only pennies more to produce hundreds of the same board in a very short time. That process compares favorably to individually exposing, developing, and washing several boards with the photoresist method. Moreover, meticulous cleaning and careful handling of the boards prior to processing is unnecessary; cleaning is required only if some stain or corrosion might interfere with the etching process. Also, printed boards can be stored indefinitely for etching on demand, or they can be cleaned and reprinted with a different pattern. The printing screen itself can be saved as well for future runs of the same board, or can be reclaimed and used to print other circuit designs.

Although you might think that all you'll ever need is one or two boards, you can never tell when that new electronic gadget you've invented might really be marketable—if you could only produce enough of them cheaply for the initial sales push.

Although today's inks and chemistries are much less hazardous than those used in the past, some of the products described in this article are both toxic and flammable and should only be used by trained persons in well-ventilated areas away from open flames. Figure 1 shows the materials that are used for this process. Protective gloves and clothing should be worn to prevent the chemicals from contacting the skin and eyes. Proper disposal of all waste materials in an environmentally responsible manner is crucial, just as with all other PC fabrication processes.

The printing process

The first step in the screen-printing process is to make the printing screen. Special polyester fabric is stretched onto a wooden frame and stapled in place. The fabric is classified by its mesh count; higher mesh counts provide greater print detail, but allow less ink to pass through during printing. For our purposes, a fabric of 160 to 180 threads per inch is a good choice. The fabric can be stretched and stapled by hand in much the same way as canvas is stretched for painting, as shown in Fig. 2. In fact, wooden canvas stretchers work well for light-duty use, and can be found at art-supply stores. Select a frame size that will allow a minimum two-inch clearance on all sides of the PC blank from the inside edges of the assembled frame. If canvas stretchers are to be used, the wood frame should be glued together with some good carpenter's glue, firmly clamped, and allowed to dry overnight before using it.

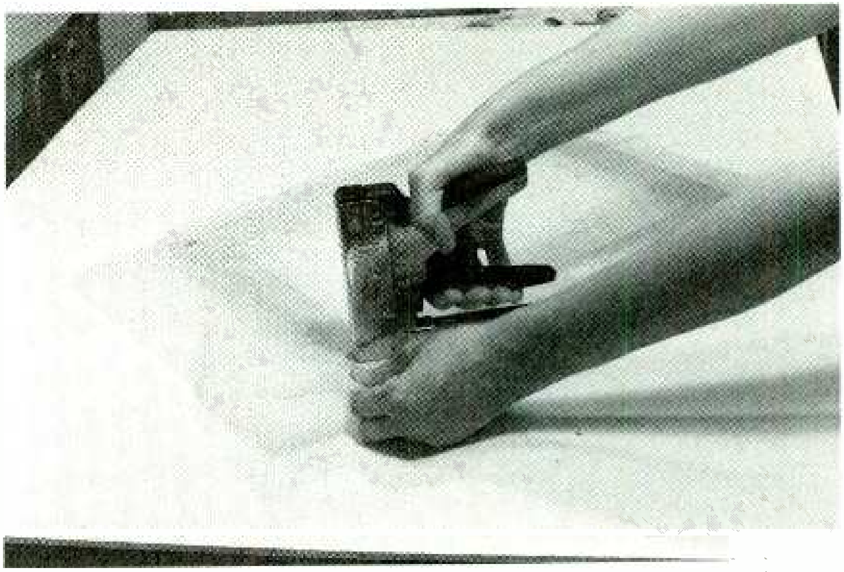


FIG. 2—THE FABRIC CAN BE STRETCHED and stapled to the frame by hand.

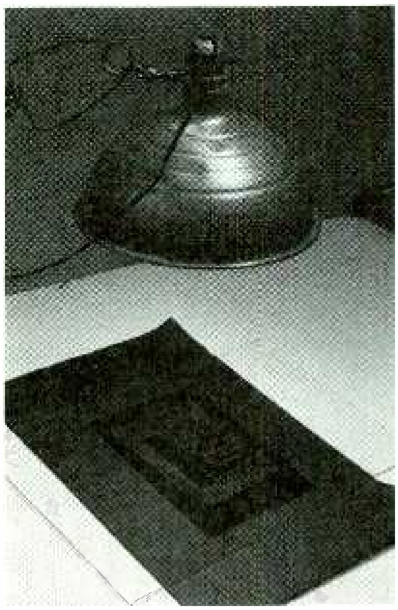


FIG. 3—A POSITIVE IMAGE is contact printed onto the stencil film using a photo flood bulb. Note the black paper beneath the film to prevent undercutting thin parts of the image.

For more demanding, long-term use, the "cord and groove" method produces a tighter, more uniformly tensioned screen, which can easily be re-tensioned if necessary. With this method, a cord is hammered into a groove in the wooden frame to capture and stretch the fabric—in much the same way a window screen is installed in a frame. This more complicated method is explained in detail in the booklet that's available from the source mentioned in the side bar.

There are many different ways to create the stencil image on the screen, but the easiest one for the beginner is the indirect film method. In that method, a piece of photo-sensitive stencil film is contact printed with the positive image transparency, developed, and adhered to the screen. The exposure step is similar to that used in the photoresist method of PC-board fabrication. The light hardens the areas of the

FIG. 4—DEVELOP THE EXPOSED STENCIL FILM in a tray of pre-mixed Ulano A+B developer.

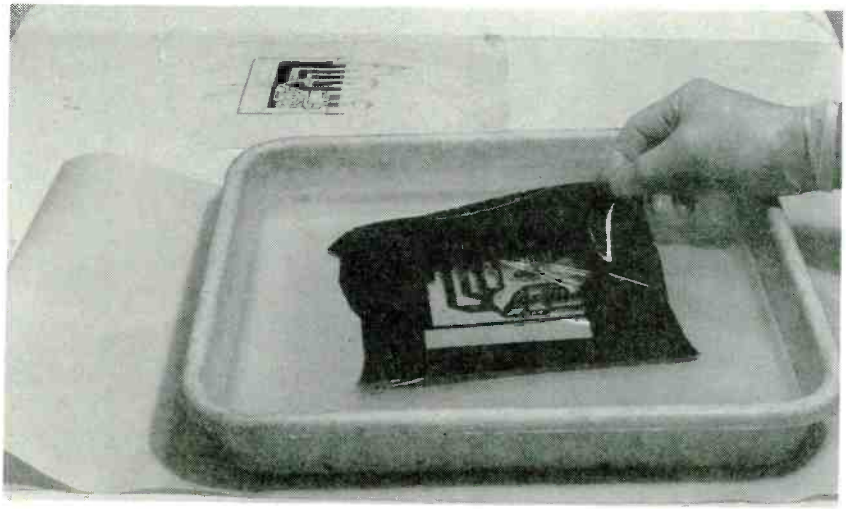


FIG. 5—WASH THE IMAGE OUT using warm water.

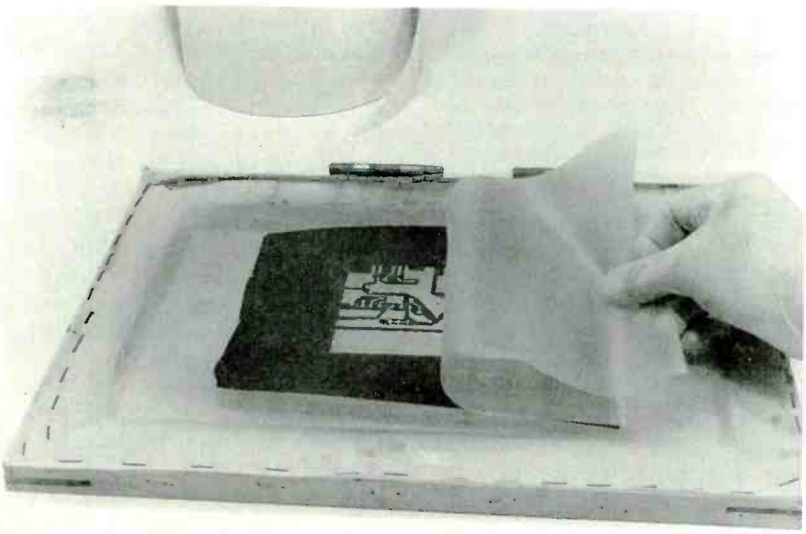


FIG. 6—WHEN COMPLETELY DRY, gently peel off the backing sheet from the stencil.

stencil film that it strikes, and the areas masked by the positive resist are washed away after developing. The author has had much experience with a line of screen-print materials from the Ulano Corporation, and their products are described in this article. The Ulano starter kits and their technical information packages contain detailed processing instructions. Although the company has a wide selection of stencil films, he used its *Blue Poly-3* film for this project.

A light source with a high UV content is necessary to expose the stencil film properly. Blacklight fluorescent tubes, daylight temperature photo floods, or just plain sunlight works well for this. A 500-watt blue photo floodlamp can be obtained from camera or lighting supply stores, and will screw directly into a reflector light housing. Be sure to use a lamp with a ceramic socket since the heat from a 500-watt bulb will soon burn out other kinds of sockets and could become a shock or fire hazard.

To expose the stencil film, place it shiny side up on a smooth flat surface. It's best to place a piece of black paper beneath it to prevent reflected light from undercutting the thin parts of the image. Then place the positive wrong-reading over the film, secure two points with clear tape to prevent movement, and cover it with a heavy piece of plate glass. Use glass with rounded edges to prevent injury while handling it. Position the light source directly over the center of the image at a distance of 20 to 24 inches (for the photo floodlamp) and expose it for 30 minutes as shown in Fig. 3.

Pre-mix the two-part developer according to the directions, and immerse the exposed stencil film in it for 90 seconds while rocking it with a gentle motion (see Fig. 4). Don't panic if you don't see an image appear at this time because it doesn't usually become visible until after the warm water wash. After the 90 second development, drain the stencil and im-

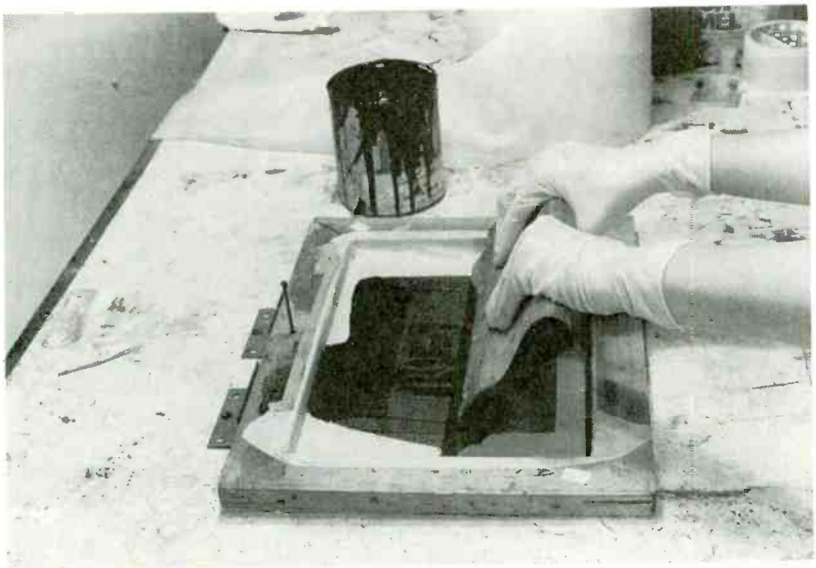


FIG. 7—**PULL THE SQUEEGEE** with a firm pressure across the image to force ink through the stencil.

FIG. 8—**PRINTED PC BOARD** positioned beneath the screen image by the register guides.

SCREEN PRINTING RESOURCES

Advance Process Supply
400 N. Noble Street
Chicago, IL 60622
(312) 829-1400
• Screen printing supplies
CIRCLE 361 ON FREE INFORMATION CARD

Atlas Screen Printing Supplies, Inc.
1733 N Milwaukee Avenue
Chicago IL 60647
(312) 278-3565
(800) 621-4173
• Screen printing supplies
CIRCLE 362 ON FREE INFORMATION CARD

Naz-Dar Co.
1087 North Branch Street
Chicago, IL 60622
(312) 943-8338
• Ink manufacturers, Circuit Black #211 resist ink
CIRCLE 363 ON FREE INFORMATION CARD

Signplex
3747 Pine Lane
Bessemer, AL 35020
(800) 631-2360
• Printed circuit screen kit
CIRCLE 364 ON FREE INFORMATION CARD

The Ulano Corporation
255 Butler Street
Brooklyn, NY 11217
(718) 237-3199
(800) 221-0616
• Complete screenmaking systems, Blue Poly-3 stencil film
CIRCLE 365 ON FREE INFORMATION CARD

Note: A kit of materials for screen printing 6 to 12 designs that includes fabric, a frame, squeegee, resist ink, stencil film and chemistry, and a detailed instruction booklet is available for $39.95 plus shipping and COD from Signplex, 1-800-631-2360. Allow three weeks for delivery. Please add appropriate state and local tax.

A detailed booklet describing double-sided printing, a user-built vacuum table, advanced screen making and printing techniques, and more is available from Alford Enterprises, 9701 Bee Branch Road, Cottondale, AL 35453 for $14.95 plus $1.50 postage and handling. Send check or money order only. Please add appropriate state and local tax.

mediately place it in a tray of warm water at a temperature between 97 and 104°F. Agitate the stencil by gently rocking the tray until the image begins to appear (see Fig. 5). Change the water frequently until no more blue color appears in the water and the image is clean and clear. Applying gentle water spray with the stencil on an inclined surface in your work sink is an even better and much faster way. When washout is complete, transfer the stencil to a tray of cold water for a few minutes to harden the surface.

The Ulano developer must be mixed fresh every time you need it, although it will last 24 hours or so. Just be sure not to store it in a sealed container since it gives off a gas and the pressure could break a glass container.

Place the film shiny-side up on the screen fabric on the back side of the screen. Then blot the inside of the screen with newsprint (unprinted newspaper stock) until no more blue color emerges, or until it begins to stick to the screen.

Air dry the screen until the stencil is a uniform, light, sky-blue color, and then gently peel off the backing sheet as shown in Fig. 6. A cold air stream from a fan will greatly speed the drying process.

Now tape the inside of the screen around the image with two-inch masking tape to prevent the resist ink from leaking through while printing, and affix the frame to your work table with small hinges so that it can be raised and lowered easily.

Locate a pre-cut, clean copper-clad board under the screen

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IRON-ON PC BOARD PATTERNS

Design PC boards with CAD, and etch them from resist patterns formed by "ironing on" laser-printer toner

ALAN NISHIOKA

MAKE SINGLE OR DOUBLE-SIDED PC boards in your own home with this modern method that takes advantage of computer- aided design and the laser printer to form a resist pattern that is transferred directly to the copper-clad circuit board blank. It is an alternative to other methods that have been used by hobbyists who want to make a few prototype boards for their own use.

The alternatives include the time-honored method of applying adhesive pads and fine-line tape masks directly to the circuit board as the etch resist or the use of ultraviolet-sensitive liquid or film resists and photographic methods for transferring the pattern.

The method described here is based on the use of copying machine/laser printer toner powder to form the resist areas to define the circuit board conductive pattern. The pattern is first drawn on the screen of a personal computer with the aid of easy-to-use circuit board design software. The pattern is then printed out on special film in a laser printer. The toner that defines the pattern on the film is then transferred directly to the copper-clad blank by the application of heat from a household laundry iron.

That toner pattern that adheres to the copper becomes the resist pattern. The adhered toner is able to resist the action of the etchant that removes all of the copper cladding from the blank except that which is under the deposited toner.

The process is effective in making simple, single-sided boards, but its merits really show up in the preparation of double-sided boards whose patterns must be accurately registered on both sides. The problem of registering both layers is simple compared with the task of trying to achieve the same results with adhesive tape resist masking or even photographic methods. This article assumes that you will be making double-sided PC boards.

To make boards with this process, you will need an IBM personal computer or compatible for the design phase, and a laser printer to print the pattern with toner on the transfer film (Press-n-Peel from Techniks Inc.). You'll also need, a household laundry iron, a suitable tank for etching the board, and conventional double-sided copper-clad circuit board stock.

Caution: When working with acid you'll also need a work area and bench or table that is away from the living areas of your house or apartment with adequate safeguards for hazardous materials and ventilation for the removal of toxic fumes.

Although this method can produce complex, double-sided PC boards, it does not include through-hole plating. Solid-wire vias or hollow machined pins make any direct electrical connections needed between both sides of the board.

Designing the board. Personal computer-aided design is an integral part of this toner heat-transfer process because it is the means for delineating the circuit board patterns for both sides of the board. The software used by the author is PCBoards, although other software can be used. PCBoards has a list price of $99, and is available from the source given in Materials Sources.

PCBoards runs on IBM PC's and compatibles with EGA or VGA capability. It permits you to lay out both sides of a double-sided PC board with the assurance that they will *register* precisely in later process steps.

Unless you are familiar with the rules that apply to PC board design, it is advisable to read or review one of the many books available on that subject. Some books cover all aspects including design, acid-etching procedures, and even the selection of drill bits for forming through-holes. Several useful book references are given at the end of this article.

When PCBoards is running on a PC, the bottom layer of the board is displayed in orange while the top layer is shown in yellow (see Fig.1). Objects on both sides of the board (DIP pads, for example) are in blue. PCBoards has a 0.05-inch grid, and the user can draw DIP's of various sizes and traces of 0.020- or 0.050-inch width.

The program manual covers all of the features of PCBoards. Read it before doing any design work. The program is menu-driven, and you can select the object you want to draw with the keyboard, and use your computer mouse to select the end points of traces and position objects on the board.

Place all objects that will have drilled holes on 0.10 inch centers (e.g., at 1.20, or 3.70 inches rather than 1.25 or 3.75 inches) so you can use a small piece of commercial phenolic circuit board with perforations 0.10-inch on centers as a drill guide. A mark located in the lower left hand corner of the computer screen as a reference for the computer mouse will help you with the layout.

Minimize the number of vias (holes that feed a signal from the top to the bottom layer) because they require drilling. Where possible, use machined socket pins as vias because holes must be drilled for them anyway. Also, minimize the number of traces between DIP pins, particularly those that will be under the DIP when it is inserted, because they are most likely to cause problems if the trace patterns on both sides are improperly registered.

The need for soldering sockets or DIP packaged components from the top surface of the board also influences component layout and trace placement. If two components are mounted too close together, it will be difficult to get the tip of a soldering pencil between them to make satisfactory soldered joints.

Material purchasing

Copper-clad circuit board blanks are available from many different electronics stores and mail-order distributors. Expect to pay about 10 cents per square inch for double-sided boards. Regardless of the source and quality of the blanks you buy, be sure to clean them thoroughly so that the toner will stick to the copper and contaminants will not impede the copper-etching process.

Any standard brand household cleaning powder is suitable for cleaning superficial wax, grime, or oil from the boards, and this can be supplemented by scouring the copper surfaces with fine steel wool. Wear rubber gloves when cleaning the boards to prevent leaving finger prints on the clean copper surfaces. The skin oil in finger prints will corrode the clean copper.

Satisfactory cleaning is indicated by complete surface wetting following a clean tap water rinse cycle. The water should not bead up, an indication of that surface contaminants are still present.

Transfer film

Use 8½× 11-inch sheets of Press-n-Peel PCB transfer film from Techniks Inc. (see Materials Sources) to transfer the image to the copper-clad blank. (It is priced at $30 for a package of 20 films). Easy-to-follow instructions are provided with each package.

The Press-n-Peel transfer sheet is a plastic film with a blue matte coating. When passed through the laser printer, toner fuses to the blue coating as it does to paper when a document

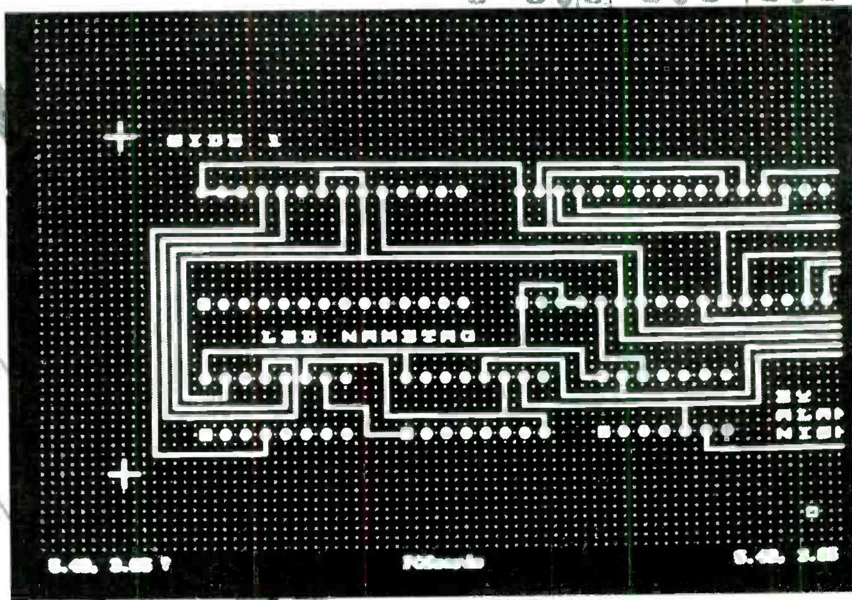

FIG. 1—LAYOUT OF ONE PC BOARD PATTERN shown on a computer screen obtained with circuit board design software. A square reference point and the coordinate readout are displayed at lower right.

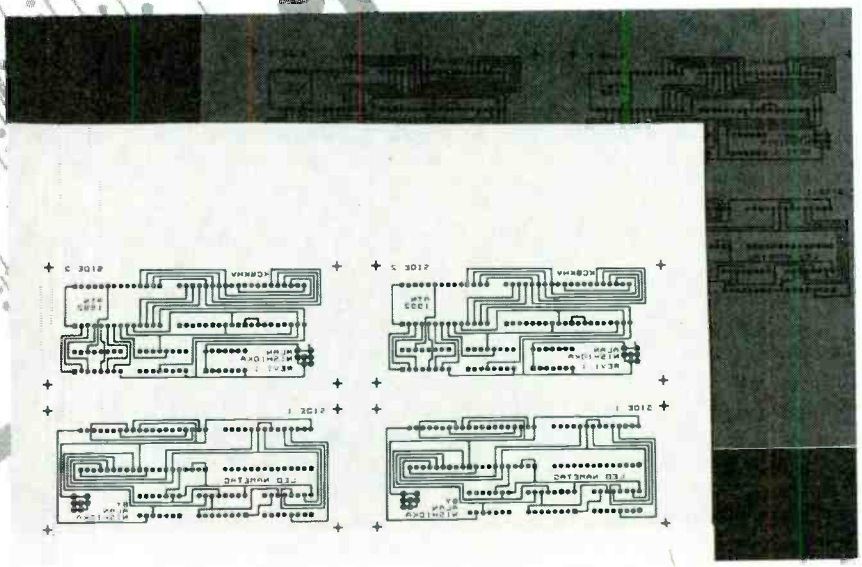

FIG. 2—PC BOARD PATTERN PRINTED ON PAPER with the printed transfer film shown in the background. Two patterns are printed on the same film to economize on film. The original patterns have been "flopped" so the toner can be ironed directly on the copper-clad blank.

FIG. 3—IRON-ON TRANSFER FILM IS FED INTO THE LASER PRINTER. A backup sheet of paper can be attached to the leading edge of the film for support, if necessary.

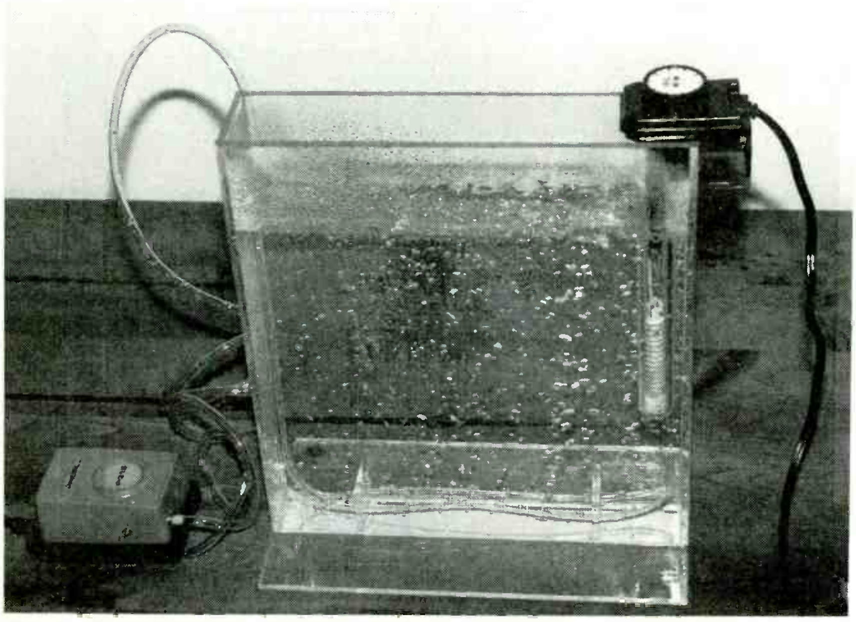

FIG. 4—CIRCUIT-BOARD ETCHING TANK with air bubbler and solution heater to speed up the etching process and provide more uniform results.

is printed. The transfer sheet is designed so that its plastic backing easily peels away after the toner has been ironed on the copper-clad board. The blue coating also thickens the resist pattern transferred to the board for improved protection against the copper etchant.

Print the layout

The output of the laser printer obtained from the computer with the PCBoards software is a drawing of the circuit board trace pattern with the toner on top as in a normal printing operation. However, to obtain a circuit board pattern that can be ironed directly on the board, the pattern must be inverted.

The author wrote a computer program that will invert the output from the computer running the PCBoards software. This is available as a self-extracting compressed file PCBFLIP.EXE in the *Electronics Now BBS* (516-293-2283; 2400 or 1200 baud.

Both top and bottom patterns can be printed on the same transfer film, assuming that the double-sided board measures less than 5×8 inches. This approach will economize on the number of transfer sheets needed.

After you have completed the design of both sides of the board, place crosses at two or three locations outside the board patterns to function as registration marks. Locate these marks with respect to the reference mark on each pattern so that when the printouts are placed together, the registration marks will match.

It is recommended that you print out a test sample on quality parchment tracing paper before printing on the actual transfer film. You can then cut apart the two patterns, place their printed sides together and align the paper printouts before you print on the transfer film. Any mismatches or errors can be corrected at that time without wasting transfer film. The use of a professional (or improvised) light table will make the registration and examination easier.

After you are satisfied that the alignment of all circuit board elements is within the expected tolerance levels, print out the transfer film. Feed the transfer film into the single-sheet feeder with the blue matte coating side

MATERIAL SOURCES
Etch Tank System
Circuit Specialists
P.O. Box 3047
Scottsdale, AZ 85271
1-800-528-1417

Iron-on transfer film
DynaArt Designs
3535 Stillmeadow Lane,
Lancaster, CA 93536
(805) 943-4746

PC board design software
PCBoards
2110 14th Avenue South
Birmingham AL 35205
(800) 473-PCBS

Press-n-Peel iron-on transfer film
Techniks Inc.
45 J. Ringo Road
PO Box 463
Ringoes NJ 085551-0463
(908) 788-8249

up. You might find it necessary to attach a paper backing to the transfer film so it will be easier to feed through the laser printer.

Attach the leading edge of the film to the paper backing by applying a narrow stripe of stick adhesive (available at stationery stores) along the leading edge of the underside of the transfer film, leaving the trailing edge free (see Fig. 3).

Iron-on process

Align the transfer sheets for the top and bottom of the board with their printed (toner) sides inward (face to face) on a light table. Staple the two sheets together in three or four places on one edge or tape them among one edge. Slip the cleaned circuit board between the fastened opposing sheets and align it correctly at the edges.

Heat the laundry iron to about 200°F and check that temperature with a mechanical thermometer. If the iron is too hot, the plastic film will melt, distorting the transferred pattern. If it is too cool, the toner will not transfer to the copper surface. You might have to experiment to find the right setting on your iron. However, once you have found it, note that setting for the next time you use this method.

Select a clean, dry, bare wooden board as an ironing surface. The easiest way to make the transfer is to start with the lower transfer sheet. Place it toner-side up on the ironing surface and put the copper-clad board on top of it. (The attached upper sheet can be folded back out of the way.) Then clamp the board to the film, and apply the iron directly to the top copper-clad surface so the heat will be conducted through the board to the lower surface.

After the film has lightly adhered to the copper, turn it over and iron on the transfer film from the back. Then fold over the upper film, toner side down, and iron it directly on the upper copper-clad surface of the board.

The movement of the iron over the surface helps to loosen the blue coating from the film. Use the tip of the iron to trace over the entire layout on both sides to ensure that all the elements to be transferred have received enough heat and pressure. Take special care with isolated pads and thin traces because they are least likely to transfer properly.

There is no sure way with this method to determine if the complete image has been transferred satisfactorily. The features will appear slightly darker when viewed through the back of the transfer film after the ironing procedure. *Caution:* Do not remove the film until the circuit board is cool to the touch.

If, for some reason, small sections of the pattern do not transfer satisfactorily, the gaps can be touched up after the film is removed. The best way to make those minor corrections is to mask them with the black tape intended for the direct-etch process. If larger areas did not transfer, or there are many gaps, the board should be cleaned and the complete process repeated.

FIG. 5—PERFORATED CIRCUIT BOARD blank serves as a drill jig to obtain holes spaced in 0.10-inch increments.

AN ALTERNATIVE METHOD

An alternative method for transferring copy-machine toner to blank copper-clad circuit boards is offered by DynaArt Designs. It makes special toner-transfer sheets that have a release agent, or "sugar-water" coating on one side of each sheet. A flopped toner image is made on the sugar-water side with a laser printer or copy machine.

The sheet is then placed, toner-side down, on the PC blank, and the toner image is fused to the board with a conventional laundry iron as described in the article. However, instead of peeling off the paper backing, the board is soaked in water until the release agent dissolves and the paper slides off. The manufacturer claims this method assures the complete transfer of all toner.

Copper etching

A suitable etching tank system is shown in Fig. 4. You can purchase a complete system from a supplier such as Circuit Specialists (see Materials Sources) or you can build your own. Figure 4 shows all the recommended elements for obtaining the best results, but neither the air bubbler nor solution heater are required.

An article entitled *Make Your Own Etching Tank* by Tony Lewis appeared in the December 1989 **Radio-Electronics** on page 45. This article gives complete directions for making a tank from Plexiglas. The article also includes useful information on the various chemical etchants.

Several different acids available commercially will etch the copper cladding satisfactorily. However ferric chloride is recommended because it is the most readily available from electronics stores and distributors and it is inexpensive. Unfortunately it is an opaque solution, so it is not possible to observe the etching process through a transparent tank. A 1-liter plastic bottle of the acid costs less than $7.00, but it should be enough to etch more than 500 square inches of copper cladding.

Alternative chemicals are sodium and ammonium persulfate. The persulfates are sold in crystal form and have several advantages over ferric chloride in that they will not attack stainless steel, and they are effective when cold. Both give an indication of copper absorption by turning blue as copper dissolves in them—a visual indication that they have lost their etching effectiveness.

Before working with any acid,

Continued on page 88

THE SPECTRUM ANALYZER

Vertical pulse height represents signal strength and horizontal pulse position represents frequency. Learn more about this important but frequently overlooked instrument

FERNANDO GARCIA VIESCA

THE SPECTRUM ANALYZER LETS YOU view the frequency domain the same way the oscilloscope lets you view the time domain. This article is a primer (or refresher) on the spectrum analyzer, an extremely powerful and versatile test instrument that is frequently overlooked by many who have never taken the time to explore its special properties.

Long considered too specialized and too expensive for general use, the spectrum analyzer has recently become an important test instrument in cable television, computer networks, digital radio, and automated component testing. However, for years it had been a well established instrument in radio and radar transmitter design and maintenance.

Government requirements mandating the control of electromagnetic interference (EMI) have made the spectrum analyzer a factory-production and quality-control tool in the manufacture of many different kinds of electrical and electronic equipment.

The selection of the appropriate spectrum analyzer for a given task will depend on such factors as the frequency sweep rate, frequency sweep range, bandwidth, and the center frequency of its intermediate frequency system. Other considerations are the bandwidth of its video amplifier and the analyzer's overall sensitivity.

Spectrum analyzers are useful in the analysis of continuous-wave (CW) signals, amplitude-modulated (AM) signals, frequency-modulated (FM) signals and pulse-modulated signals: pulse-amplitude modulated (PAM), pulse-width modulated (PWM), and pulse-position modulated (PPM) signals.

Before discussing the spectrum analyzer and how it works, a review of some of its basics will be useful. Figure 1 illustrates two different ways of looking at the same signal. The waveform viewed at the left is an instantaneous voltage plotted against time, as seen on an oscilloscope. The view at right shows the same waveform, but here the voltage is positioned with respect to frequency rather than time.

A complex signal has more than one frequency component (spectral line), which indicates the amount of energy that is present at each frequency. The more complex the waveform, the greater the number of spectral lines.

According to the French mathematician and physicist Jean Fourier, any time domain electrical signal consists of one or more sine waves, each with its own frequency, amplitude,

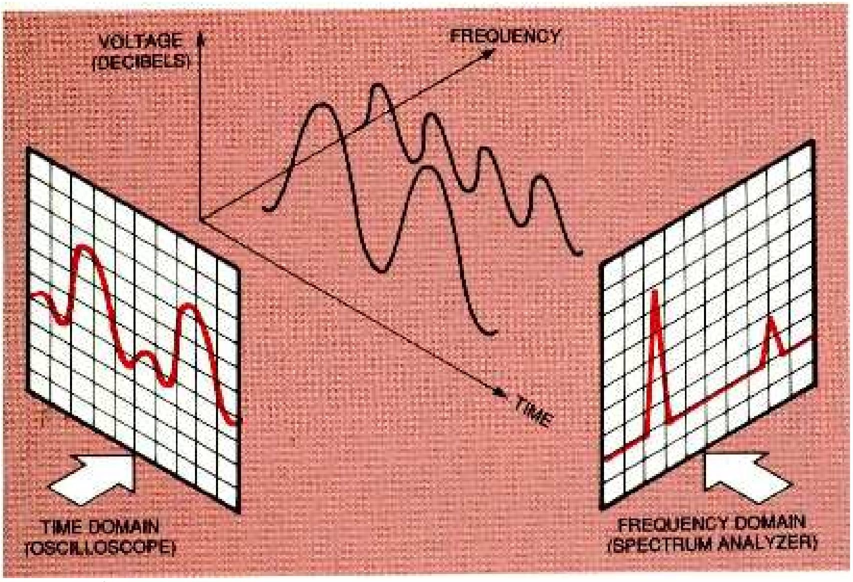

FIG. 1—TIME-DOMAIN MEASUREMENTS made with an oscilloscope (left) are compared with frequency domain measurements that can be made with a spectrum analyzer (right).

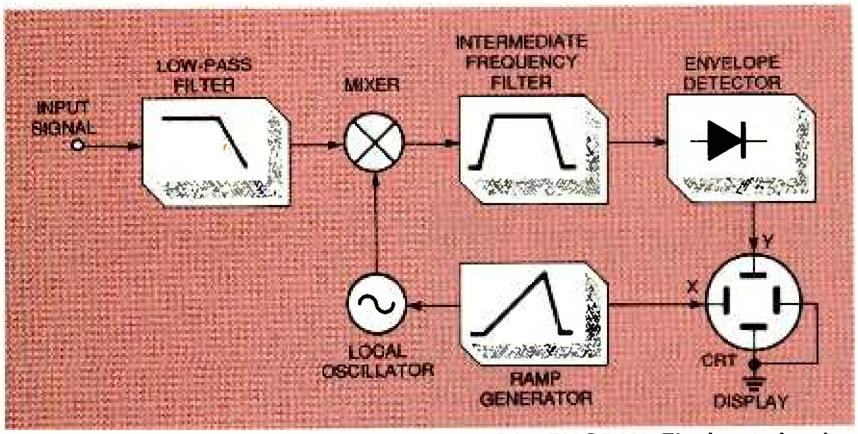

FIG. 2—SIMPLIFIED SPECTRUM ANALYZER BLOCK DIAGRAM. The input signal is mixed with local oscillator (LO) signal in the mixer. The intermediate frequency (LO) is filtered, detected and displayed on the CRT's vertical axis. The ramp generator triggers the CRT's time base and the LO.

and phase. As a result of his insight, it was found that any complex time-domain waveform can be broken down into separate sine waves that can be evaluated separately. In effect, any time domain signal can be transformed into its frequency-domain equivalent.

Theoretically, any signal must be evaluated for an infinite length of time when making a transformation from the time to the frequency domain. However, in practice, it is assumed that the behavior of a signal for time intervals ranging from milliseconds to a minute will give a reasonably accurate indication of the waveform's long-term characteristics.

Time vs. frequency domain

Time-domain measurements from an oscilloscope provide an overall view of the signal waveform, including such characteristics such as pulse rise and fall times, overshoot, and ringing. By contrast, the spectrum analyzer provides a panoramic display of the signal distribution in a selected portion of the radio frequency or microwave bands. The display can show the presence or absence of signals of interest, their frequencies or harmonic content, frequency differences, relative amplitudes, and the modulation form, if any.

In the United States and most of the advanced countries of the world, radio equipment must meet government-imposed standards for spectral purity. The spectrum analyzer permits the viewing of the bandwidth of the modulated signal, and it also gives an immediate indication of the harmonic content of a transmitter's signal.

Harmonics of the carrier signal might interfere with other systems operating at the same frequencies as the harmonics. Improper RF transmission conditions such as splatter or over modulation can be easily seen as excessive bandwidth. These deviations can be observed on a spectrum analyzer. This is helpful in making adjustments and corrections.

How does it work?

There are four basic spectrum analyzer architectures: bank of filters, fast Fourier transform (FFT), wavemeter, and swept spectrum or superheterodyne. Each has its own set of strengths and weaknesses, but in this article only the superheterodyne architecture will be discussed.

Figure 2 is a simple block diagram of a superheterodyne spectrum analyzer. It is essen-

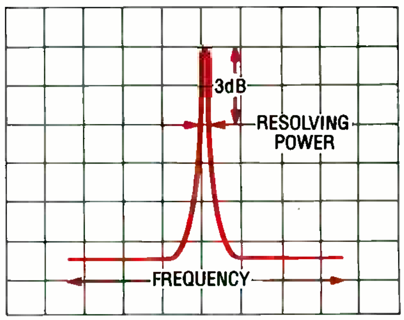

FIG. 3—TYPICAL CONTINUOUS-wave signal

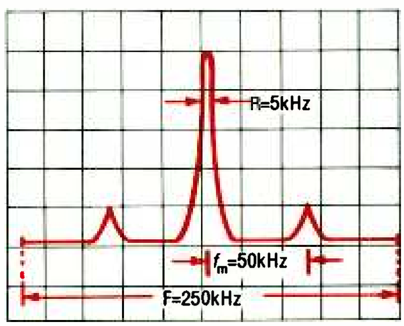

FIG. 4—SINGLE-TONE AMPLITUDE modulated signal.

tially a narrow-band superheterodyne receiver that is repeatedly swept in frequency over a selected portion of the RF band. Heterodyne means to mix signals together to produce sum and difference frequencies. Superheterodyne has the same meaning except that the signals being mixed are above the audio range.

The ramp (or sweep) generator generates a sawtooth (or ramp) waveform that tunes the local oscillator (LO). A form of frequency generator, it is swept linearly between two frequency limits. At the same time, the ramp generator also deflects the CRT beam horizontally across the screen from left to right. The local oscillator output is fed into the mixer.

The input signal is passed through a low-pass filter to the mixer, where it is mixed with the LO output. The output of the mixer includes not only the input and LO frequencies, but also their harmonics and sums and differences.

Only those mixed signals that fall within the passband of the intermediate frequency (IF) filter will be passed on to the envelope detector, represented here as a diode. The output of the envelope detector is amplified and applied to the vertical plates of the cathode-ray tube (CRT) to produce a vertical deflection on the CRT screen.

The CRT screen typically has a graticule or overlay grid of lines—ten horizontal and eight or ten major vertical divisions spaced one centimeter apart. The horizontal axis is calibrated in frequency that increases from left to right.

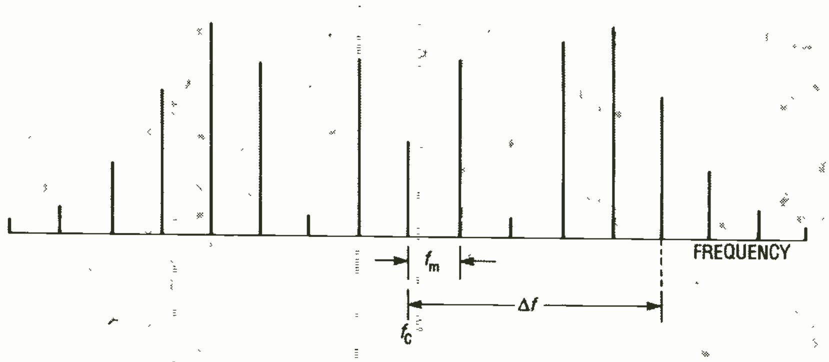

FIG. 5—SINGLE-TONE FREQUENCY-modulated tone where f_m equals the modulating frequency.

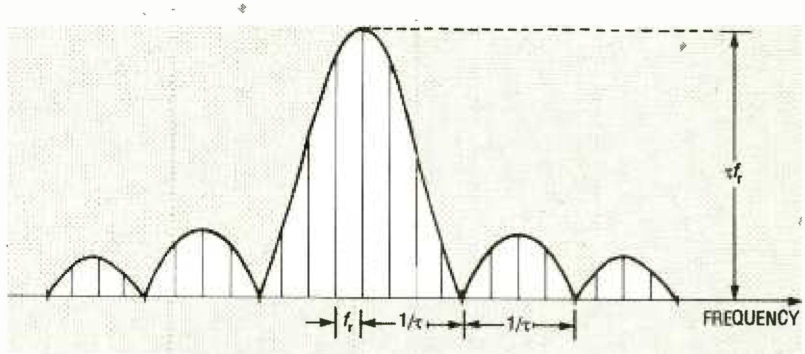

FIG. 6—PULSE-MODULATED SIGNAL where f_r equals the pulse repetition frequency and τ equals the pulse width.

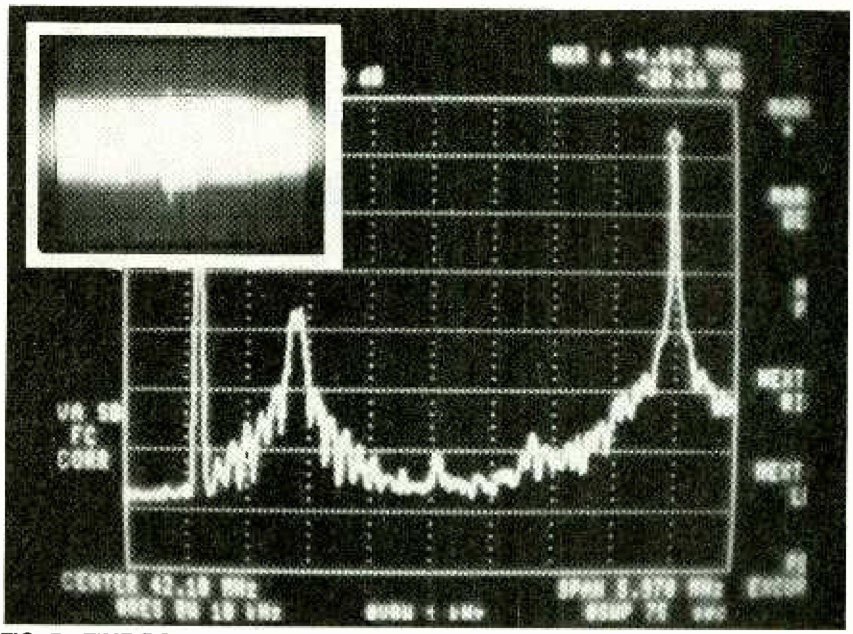

FIG. 7—TIME-DOMAIN AND FREQUENCY-DOMAIN PHOTOS: A time-domain waveform as displayed on an oscilloscope (inset), and frequency-domain waveform of the same signal as displayed on a spectrum analyzer.

Signal treatment

If a spectrum analyzer receives a continuous-wave signal, the trace is a plot of the bandpass characteristic of the intermediate-frequency amplifier, as shown in Fig. 3. A single response will show up on the screen, and the resolving power of the analyzer is equal to the 3 dB bandwidth of the intermediate-frequency amplifier.

The spectrum of a single-tone, amplitude-modulated signal will consist of the vertical response representing the original carrier frequency plus a pair of side frequencies, one above and the other below the carrier, as shown in Fig. 4. The amplitude of either sideband voltage with respect to the carrier voltage is $m/2$, where m is the percentage modulation. The frequency difference between the carrier and either sideband is equal to the modulating frequency, as shown in Fig. 4.

If the modulating wave is complex, each frequency com-

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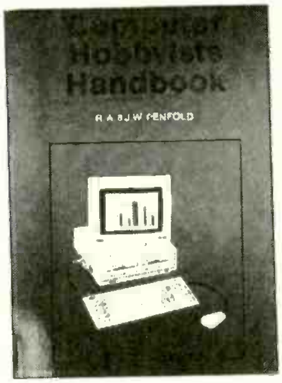

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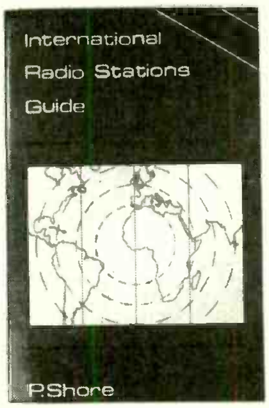

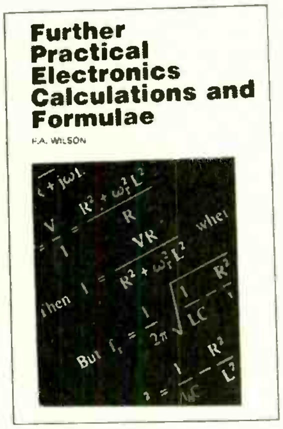

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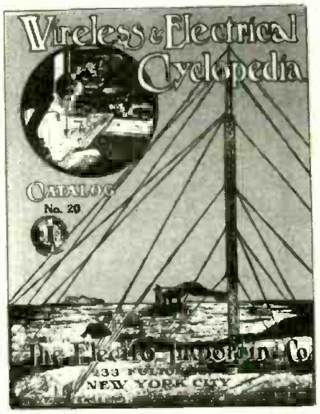

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7/31/92

CIRCLE 219 ON FREE INFORMATION CARD

CAIG Electronic Chemicals
for Manufacturing, Maintenance & Service!

DON'T JUST CLEAN CONNECTIONS; DEOXIDIZE, SEAL & PROTECT THEM!

Even the finest equipment cannot guarantee noise-free/error-free operation. One "dirty" connection anywhere in the signal path can cause unwanted noise or signal loss.

***ProGold** and **DeoxIT** increase the performance and reliability of electrical components and equipment. They provide long-lasting protection, reducing the expense of repeated cleaning with expensive ozone-depleting solvents.*

ProGold™
Gold Conditioner & Protector

ProGold is specifically formulated to improve conductivity and protect gold, base metals and other precious metal surfaces. Use on gold connectors and contacts for maximum performance and protection. A common problem with gold plated surfaces is that the base metals migrate to the surface due to gold's soft and porous nature (dendrite corrosion). Once exposed, base metals oxidize, adding unwanted resistance that impedes electrical performance. Since gold plated surfaces are thinly coated, they are susceptible to scratching & abrasion, further exposing the base metals.

ProGold is a one-step treatment that conditions gold connectors, contacts and other metal surfaces, enhancing the conductivity characteristics to efficiently transmit electrical signals. **ProGold** coats the entire contact surface and connection, providing superior protection from abrasion (insertion resistance), arcing, RFI, wear and atmospheric contamination.

DeoxIT™ & PreservIT™
Deoxidizes, Seals & Protects Electrical Connections

DeoxIT, *a one-step treatment*, is a fast-acting, deoxidizing solution that cleans, preserves, lubricates & improves conductivity on all metal surfaces. Use as a general treatment for connectors, contacts & other metal surfaces.

PreservIT seals, lubricates and preserves metal surfaces for protection from oxidation and contamination. For use on <u>clean/new</u> surfaces or those pre-cleaned with **DeoxIT**.

Both have excellent migration properties that coat the surfaces and protect them from future oxidation & contamination. These new advanced formulas contain improved deoxidizers, preservatives, conductivity enhancers, anti-tarnishing compounds, arcing & RFI inhibitors and provide extended temperature range.

OpticALL™
Effectively cleans, polishes and eliminates static electricity on optical viewing surfaces. OpticALL is also recommended as a general purpose antistatic cleaner on plastic, glass and metal surfaces.

StaticALL™
Neutralizes static build-up caused by friction & low humidity conditions.

DustALL™
Quickly & safely removes dust, lint & particles from sensitive electronic equipment, computers, lab equip., optical grade surfaces & other mechanisms & equipment.

FreezALL™
Quickly and safely cools circuits to -54°C. Locates intermittent components due to heat failure and hairline cracks on PCBs.

MechanicALL™
High Penetrating Anti-Corrosive Anti-Tarnishing Cleaner & Lubricant. Lubricates & Protects, Displaces Moisture, Stops Squeaks, Migrates & Coats Entire Surface.

ElectricALL™
Rejuvenating Solution For All Electrical Applications. Cleans, Preserves, Improves & Protects Connections, Removes Corrosion & Oxidation, Reduces Wear, Abrasion, Arcing & RFI.

DegreasALL™
For degreasing, cleaning & defluxing equipment and parts. Removes oil, grease, dirt and contaminants including rosin flux from PCBs, components and metal parts. Biodegradable.

CAEON™ 27
For sensitive equipment applications. For removal of oil, grease & dirt from surfaces. (Freon® TF).

CAEON™ 28
Degreaser and cleaning liquid removes organic contaminants including rosin flux from PCBs, components and metal parts. (Freon® TMC).

X-10S Instrument Oil
Contains silicone. Finest quality instrument oil for use on rubber, plastics and metals. Non-gumming, rust inhibiting, long lasting lubrication.

X-10 Instrument Oil
Lubricates precision instruments, fine parts & mechanisms. Use on all metals (gauges, gears, clocks, instruments, etc.). Non-gumming, rust inhibiting, long lasting lubrication.

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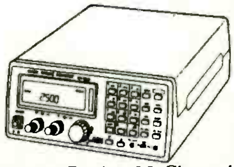
Total Coverage Radios

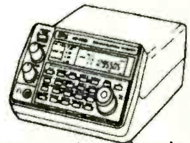
AOR AR1000XLT
$449.00
AM Broadcast to Microwave
1000 Channels

500KHz to 1300MHz coverage in a programmable hand held. Ten scan banks, ten search banks. Lockout on search and scan. AM plus narrow and broadcast FM. Priority, hold, delay and selectable search increment of 5 to 995 KHz. Permanent memory. 4 AA ni-cads and wall plus cig charger included along with belt clip, case, ant. & earphone. Size: 6 7/8 x 1 3/4 x 2 1/2. Wt 12 oz. Fax fact document # 205



AR2500
$499.00
2016 Channels
1 to 1300MHz
Computer Control

62 Scan Banks, 16 Search Banks, 35 Channels per second. Patented Computer control for logging and spectrum display. AM, NFM, WFM, & BFO for CW/SSB. Priority bank, delay/hold and selectable search increments. Permanent memory. DC or AC with adaptors. Mtng Brkt & Antenna included. Size: 2 1/4H x 5 5/8W x 6 1/2D. Wt. 1lb. Fax fact #305



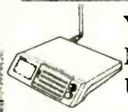
AR3000
$1195.00
400 Channels
100KHz to 2036MHz

Patented computer control, top rated receiver in its class, offers AM, NFM Wide FM, LSB, USB, CW modes. RS232 control. 4 priority channels. Delay & hold & Freescan. AC/DC pwr cord and whip ant. Size: 3 1/7H x 5 2/5W x 7 7/8D. Wt 2lbs., 10oz. Fax fact document #105

NEW AOR AR1500
$499.00.
Full Coverage with SSB and 1000 Channels.

500KHz to 1300MHz. Ten scan banks, ten search banks. Search lock and store. BFO. 2 Antennas. AM/NFM/WFM. Selectable increments . Tons of features, small size: 5 7/8 x 1 1/2 x 2. Wt 14 oz. Fax fact document # 250

Scanner with Shortwave



Yupiteru 8-1300MHz Mobile or Hand Held Units. $399.00, each.

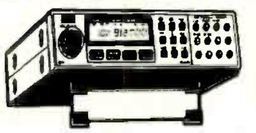
Top rated receivers from Japan now available in the USA. Tune down to 100KHz. Sensitivity guaranteed from 8MHz up. 200 scan channels. AM/NFM/WFM. No gaps, no cut-outs. Mobile is super slim line. AC/DC. Order MVT8000, includes antenna, mbl mnt. Order MVT7000 for the hand held. Complete with Ni-Cads, Charger, antenna & earphone. Fax fact document #275

Continuous Coverage

Bearcat 2500XLTA hand held	**$369.00**
Bearcat 8500XLTC mobile	**$389.00**
Bearcat 890XLTB mobile	**$279.00**

29-1300MHz, 500 ch. in 8500, 400 in 2500. 890 has 200 ch.& 29-956MHz. All cell locked. Spring delivery. Fax Fact#420

Mobile Scanners

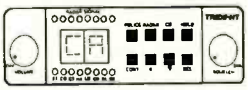


Bearcat 760XLTM
$229.95
100 Channel 800 MHz

Five banks of 20 channels each. Covers 29-54, 118-174, 406-512 and 806-954MHz (with cell lock). Features scan, search, delay, priority, CTCSS option, lockout, service search, & keylock. Includes AC/DC cords, mounting bracket, BNC antenna. Size: 4 3/8 x 6 15/16 x 1 5/8. Weight: 4.5lbs. Fax fact document #550

Bearcat 560XLTZ
$99.95
16 Channel 10 Band

Compact, digital programmable unit covers 29-54, 136-174, and 406-512MHz. Features scan, WX search, delay, priority, memory backup, lockout, review,& auto delay. Includes AC/DC cords, mounting bracket, and antenna. Size: 7 3/8 x 2 1/2 x 15/8. Wt: 2.5lbs. Fax fact #560



Trident TR-33WL
$399.00
Scan/CB. X,K,Ka,Wide & Laser

Scans police pre-programmed by state channel *plus* full radar and laser alerts in one small unit. Weather, CB receive & mobile relay. Size: 5 5/8 x 4 7/8 x 1 3/4. Wt: 1.5lbs. Fax fact #580

Hand Held Scanners

AOR 900 $249.95
100 Channel 800 MHz

Five scan banks 5 search banks. Covers 27-54, 108-174, 406-512 and 830-950 MHz (no cell lock). Features scan, search, delay, priority, permanent memory, lockout, backlite, & keylock. Includes AC/DC adaptor, belt clip, antennas, & Nicad. Size: 5 3/4H x 2W x 1 1/2D. Wt: 12oz.. Fax fact document #650

Bearcat 200XLTN
$229.95 200 Channels 800 MHz

Ten scan banks plus search. Covers 29-54, 118-174, 406-512 and 806 956MHz (with cell lock). Features scan, search, delay, 10 priorities, mem backup, lockout, WX search, & keylock. Includes NiCad & Chrgr. Size: 1 3/8 x 2 11/16 x 7 1/2. Wt. 32 oz. Fax Facts # 450

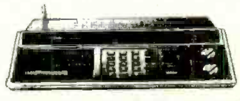
Bearcat 100XLTN 100Ch H/L/U	**$159.95**
Bearcat 70XLTP 20Ch H/L/U	**$139.95**
Bearcat 55XLTR 10 Ch H/L/U	**$ 99.95**

Coverage of above hand helds is: 29-54, 136-174, 406-512 except 100 which also adds 118-136 Air Band. Fax facts #475

Table Top Scanners

Bearcat 855XLTE 50Ch w/800	**$159.95**
Bearcat 142XLM 10Ch H/L/U	**$ 84.95**
Bearcat 147XLJ 16 Ch H/L/U	**$ 89.95**
Bearcat 172XM 20Ch H/L/U/Air	**$124.95**
Bearcat 210 16Ch H/L/U/Air	**$129.95**

Coverage of above units is: 29-54, 136-174, 406-512, plus Air in 172 and 210 and air plus 800MHz in the 855. Fax facts #675



Bearcat 800XLX
$219.95

12 bands and 40 channels with 800MHz and nothing cut out. AC or DC. Fax facts #690

Accessories & Etc.

Mag Mount Mobile Ant MA100	**$ 19.95**
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Downconverter 800 to 400 DC89	**$ 89.00**
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LIMITED QUANTITIES

CABLE CONVERTERS

Blow Out!!

Jerrold 400 Refurbished

60 Channel Remote w/fine tune

6 Month Warranty New Transmitter

400 MHZ 60 Channel **$59.95** each

$55.00 each - 5 lot • $50.00 each - 10 lot

$45.00 each - 20 lot • $40.00 each - 50 lot

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HC Protek TEST INSTRUMENTS

20 MHz Afford-A-Scope

- ☐ Dual channel, 6" CRT.
- ☐ Sensitivity 5 mV/div to 20V/div.
- ☐ Vertical modes: CH1, CH2, dual, add, subtract.
- ☐ Time Base 20 steps from 0.2 μsec. plus X5 mag, X-Y, video sync.
- ☐ Two-year warranty.

P-3502 **$389.00**

Regulated DC Power Supply

- ☐ Output 0 – 30V, CV; 0 to 3A, CC.
- ☐ Two separate LED Displays (Green for voltage, Red for current).
- ☐ Short circuit overload protected with indicator LED.

3003 **$249.00**

True RMS Expanded Function DMM

- ☐ 3-3/4 digit, 4000 count, with bar graph.
- ☐ Auto ranging, with optical data output of V-Ω-A-Hz-CAP.
- ☐ Has relative set, min/max, memory data & range hold, plus unique adapter mode.
- ☐ Supplied with protective holster/stand, deluxe safety probes.

D-937 **$139.00**

3-3/4 Digit "High Capability DMM"

- ☐ Extra Large LCD, 4000 count with Bar Graph.
- ☐ Fully auto ranging for AC/DC volts, resistance, temp, capacitance and frequency, plus range and data hold, relative, min/max and auto power off.
- ☐ Supplied with protective holster, safety probes, "K" temp. probe.

D-981 **$125.00**

"Super-Value" VOM

- ☐ 20 KΩ/V Sensitivity.
- ☐ Measures AC/DC volts, DC current to 10A, resistance, dB and battery test.
- ☐ Color coded meter scales, with anti-parallax miror.
- ☐ Overload protected by Silicon Double Diode and 2A/250V fuse.

A-403 **$19.00**

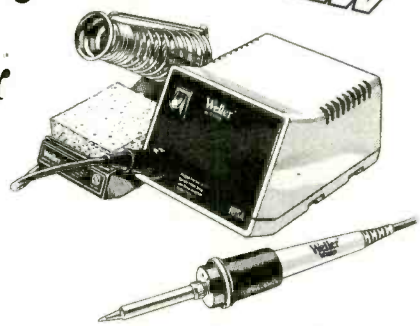
Controlled-Output Soldering Stations

NEW

Weller

WTCPT

$149.00



- ☐ Transformer powered soldering station complete w/lightweight, low voltage, temp. controlled soldering iron
- ☐ Special "closed loop" method of controlling maximum tip temperature...to protect temperature sensitive components
- ☐ Power unit housing features impact resistant plastic for durability
- ☐ Quick disconnect plug for soldering iron and lighted on/off switch
- ☐ Station housing and iron are grounded with separate conductor that terminates @ third pin of power cord

Transistors-Diodes-ICs Rectifiers-SCRs-TRIACs

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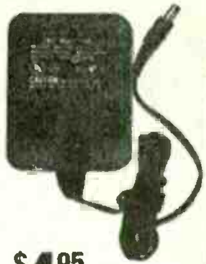
CIRCLE 280 ON FREE INFORMATION CARD

MECI

Mendelson Electronics Inc.

340 E. First Street Dayton, Ohio 45402
1-800-344-4465 FAX 1-800-344-MECI

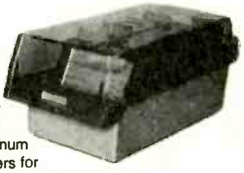
12VDC 1 Amp Adaptor



Heavy duty DC adaptor. 120VAC. 60 Hz input. 12VDC, 1 amp output. 6 ft. cord with 2.1mm DC coaxial plug (tip negative) UL listed.

No. 600-0225F $5.49 ea $4.95 (5+)

Diskette/CD Storage Case



Convenient carrying handle with snap lock. Translucent hinged dust cover for maximum protection. Sectioned dividers for easy access. Cushioned feet to protect surfaces.

Part No.	Size	Price
220-0124F	(40) 5.25" disks or (10) CD's	$2.95
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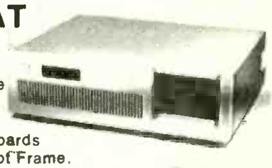
220-0123F	(100) 5.25" disks or (25) CD's	$3.99

3 1/2" Floppy Disk Drive

Matsushita JU-253
Includes two 3.5" Face Plates (Gray & Beige).
Comes with separate 5 1/4" Mounting Kit

No. 220-3418F $49 ea.

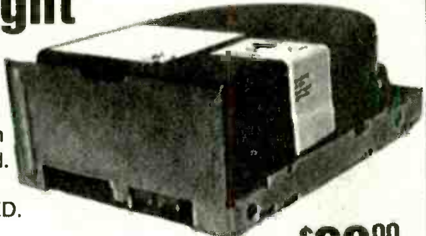
IBM PC/AT Case



Genuine IBM Case
Full Size AT Case
Accepts Mini or Full Size Motherboards
Slide-off Top 8 Slot Frame.
Made in U.S.A.

No. 220-2759F $49 ea.

44MB 5¼ Full Height Hard Drive



MFG. BY IBM MODEL 0665-53. New, pulled from unused equipment. Slightly scratched on top does not effect usage. Tested & formatted. Format removed. 7 HD, 733 CYL, 17 SECT. TYPE 14 ON ALL AT'S. No face plates or LED.

No. 220-3423F........ $69.00

DOS® and Windows®

Dos includes GWBASIC

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229-3911F	DOS 4.01	OEM 3.5" Disk	$14.95
229-3912F	Windows 3.0	OEM 3.5" Disk	$18.95

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An ideal getting started guide for beginners. Complete with Exploring The IBM Personal Computer Software. Learn the basics:
keyboard commands, printer functions, disk storage, dos, basic programming and Funwriter a basic word processing package.
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UHF 445-470MHz
5dB Gain.
Complete with 14 ft. of cable and PL-259

No. 110-0027F(3/4" Hole)
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High carbon steel fish tape in easy to grip deluxe non-conductive case with handle winder. Case is made of high impact ABS plastic with four viewing ports. Pistol grip trigger lock holds fish tape firmly in place when pushing wire and also wipes excess lubricant from tape.

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Single Channel Monitor Kit

This unit was originally a fixed frequency monitor on 157.295 MHz. With simple tools and minor modifications, you can monitor a VHF frequency (138-174 MHz) of your choice. Installation and optional squelch circuit data sheets included. Requires crystal (not included).

No. 660-0043F $12.95 ea.

Mini 120V Vacuum Cleaner

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Size: 4" Dia. x 12" (L)

No. 650-0205F $12.95 ea.

AT 200 Watt Supply

Factory Reburbished. Fits full size AT case only.120/220V Inpu

No. 500-0041F $39 ea.

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Taps most common holes in electrical boxes and fixtures; 6-32, 8-32 and 10-24. Tap is made of top grade steel, and can be replaced.

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Input: 110/230VAC.
Output: +5V @ 2A, +12V @ 1.5A. Power connections for disk drive and fan. Great external power supply.
7" x 5-7/8" x 3-1/4".

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Universal carrying case for long flat obejects like tennis rackets or musical instruments.
Fits objects up to 3-5/8'(H) x 11"(W) x 26"(L).

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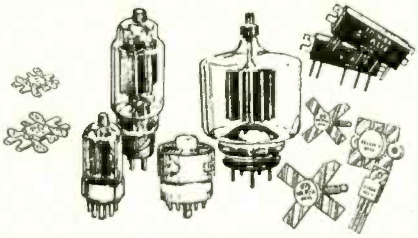
VISA DISCOVER

CIRCLE 251 ON FREE INFORMATION CARD

RF POWER TRANSISTORS – TUBES



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811A	$12.95	3CX400A7	$329.75	MRF485	$14.95
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4CX250B	89.95	4CX1000A	389.95	2SC2097	26.95
4CX250R	119.95	MRF247	26.95	2SC2166	1.75
8560AS	149.95	MRF422	37.95	2SC2290	15.95
8875	329.95	MRF429	44.95	2SC2312C	5.60
3-500Z	94.95	MRF454	14.50	2SC2509	10.85
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Price & availability subject to change without notice • Quantity Pricing Available

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GROUND SERVICE: 3-7 working days (max.) depending on destination in contig. U.S. $4.50 minimum. Add $.50 per pound above 2 pounds.

3-DAY SELECT GROUND SERVICE: UPS ORANGE, $5.50 minimum. Add $.75 per pound above 2 lbs.

2-DAY AIR SERVICE: UPS BLUE. $7.00 minimum. Add $1.00 per pound above 2 pounds. Federal Express also available at same charge.

NEXT DAY DELIVERY: UPS RED, $15.50 minimum. Ask for shipping charges above 1 lb. Saturday delivery available for additional $10.00

CANADA: $5.50 minimum shipping/handling charge up to 1 lb. for postal. UPS available, call for charges.

PAYMENT METHOD:
PREPAID with check or money order. VISA/MASTERCARD accepted.
C.O.D.: Add $4.50 UPS charge. Cash, Cashiers Check, Money Order, or Pre-approved Company Check only. No C.O.D. to Alaska/Hawaii/Puerto Rico/Canada.
FOREIGN: Bank check drawn on U.S. Bank, or VISA / M.C.
WIRE TRANSFER: Contact us for account information.

OPEN ACCOUNT: Net 30 to firms whose credit has been pre-approved.

CALIFORNIA: Residents add appropriate sales tax.

FOREIGN: Insurance/Registration is often available. Advise if desired. SMALL PACKET: Ideal Air shipment for small orders of parts. $10.00 up to 8 oz.; 4 lb. max. 8"x8"x8" box. AIR PARCEL POST is available on larger items.

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MAIN ORDER LINE	**619-744-0700**	INFO./TECHNICAL
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RF PARTS
435 SOUTH PACIFIC ST.
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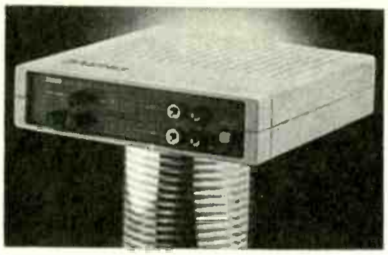
CIRCLE 268 ON FREE INFORMATION CARD



CIRCUIT DEBUGGER

DCD-200A

New Inovative Instrument for
- Open / Short Test
- Impedance Wave Check (R.C.L.)
- CMOS, TTL, ASIC, CUSTOM IC, In/Out Wave Check
- DIODE, TR, SCR, TRIAC, DIAC: Wave Check.
- Electric/Electronic Parts Check

* Use on Un-Powered Boards !
* Repair without Circuit Diagram !
* You can find out a defect point by comparing wave forms only ! * Simple to use !

* If you already have Oscilloscope, this Circuit Debugger is the next one you want to have

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ELECTRONICS 123
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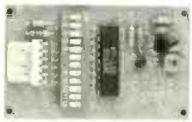
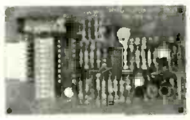
RF Trans. & Recv. Set

The RC-99 *RF Transmitter & Receiver Set*
(300MHz, 12 bit address or 8 address & 4 data.)





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Selectable pulse count, Area coverage: 90° wide angle, up to 40 feet, Very reliable, 9-16VDC, 17mA.

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CIRCLE 254 ON FREE INFORMATION CARD

VACUUM TUBE DEALER PRICE LIST Mar. '93

SOVTEK®, RUSSIA

				USED BY:
5881/6L6WGC	$7.25 each	10 at $6.50 each	25 at $5.95 each	Fender, Soldano, VTL
5AR4/GZ34	7.50	6.90	6.25	Matchless
5U4G	5.25	4.75	4.25	Mesa Boogie Dual Rectifier
5Y3	3.95	3.50	3.00	
6922 (military 6DJ8)	6.75	5.90	5.20	Counterpoint, Convergent
6L6GC	3.80	3.25	2.95	
6V6GT	4.25	3.50	3.20	SLM
12AX7WA/7025	4.35	3.75	3.40	Hartke, Bedrock, SLM
12AX7WB/7025	5.60	4.90	4.50	
EL84/6BQ5	3.50	2.90	2.60	Peavey, Hughes & Kettner
EL84M/6BQ5WA	6.50	5.90	4.90	

SINO, CHINA

2A3	$13.50 each	10 at $12.50 each	25 at $11.50 each	100 CALL FOR SPOT QUOTE
6L6GC "Straight"	4.50	3.90	3.60	" " " " "
6L6GC "Coke"	4.90	4.30	4.00	" " " " "
12AX7a	3.85	3.25	3.10	" " " " "
12AT7	3.90	3.55	3.40	" " " " "
12AU7	4.10	3.75	3.60	" " " " "
6550	10.50	9.90	9.50	" " " " "
KT88	13.50	12.50	11.50	" " " " "

EI, YUGOSLAVIA

12AT7/ECC81	3.90	3.60	3.25	" " " " "
12AX7/ECC83	3.75	3.40	3.15	" " " " "

SIEMENS, GERMANY

12AT7/ECC81	$4.50	10 at $3.90	25 at $3.75	100 CALL FOR SPOT QUOTE
EL34	9.25	8.50	7.95	" " " " "

TESLA, CZECHOSLOVAKIA

EL34	$7.60 each	10 at $7.00 each	25 at $6.50 each	100 CALL FOR SPOT QUOTE
E83CC/12AX7a	5.90	5.35	4.95	" " " " "

GE, USA

5U4GB	$12.50 each	10 at $11.60 each	7025/12AX7a	$13.90 each	10 at $12.25 each
6550a	25.50	23.00	7868	17.50	16.90
6CA7/EL34	14.90	13.50	8417	17.50	16.90
6L6GC	13.90	12.90	12AT7	7.80	6.30
6LF6	20.00	18.75	12BH7a	9.95	8.75

SOLID STATE RECTIFIER

Built into tube socket. Direct plug-in replacement for all 5Y3, 5U4 and 5AR4 types. $6.25 each 10 at $5.90

ODD BALL TUBES

2K25	$28.00 each	6AQ8	$5.85 each	6CA4	$4.50 each	6SJ7	$2.90 each	12DW7	$9.90 each
5749	2.90	6AS7	4.25	6CG7	6.90	6SK7	2.90	12FQ8	8.00
(6BA6W industrial)		6AU6	2.25	6CX8	5.15	6SL7	2.90	811	11.50
5879	8.90	6AX5	4.90	6DR7	5.15	6SN7	2.50	813	15.00
5C22	60.00	6BA6	1.95	6EA8	5.50	6SQ7	3.50	7027a	26.00
5R4	4.90	6BE6	3.25	6EU7	11.80	6U8/6KD8	5.00	7199	17.80
5V4GT	2.90	6BH6	3.90	6FH8	12.50	6U10	5.50	7591A	28.00
6189W	4.15	6BK11	13.75	6GW8	6.90	6X4	4.50	OA2	3.75
(12AU7W industrial)		6BL8	4.20	6J5	5.00	6X5	3.90	OA3	2.25
6267/EF86	3.60	6BM8	5.00	6J7	5.50	6X8	3.50	OB2	2.25
6973	14.90	6C33C-B	34.00	6K6	3.50	12AV7	2.50	OC3	3.75
6AL5	2.40	(Triode + ceramic socket)		6K11	6.90	12AY7	7.25		
6AN8	5.50	6C4	3.90	6SC7	6.90	12AZ7	4.50		
6AQ5A	4.90	6C10	6.90	6SG7	3.50	12BY7	7.25		

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***MATCHING** AVAILABLE ON MOST OCTAL POWER TUBES 75¢ extra per tube.*
***"PLATINUM" MATCHING** ALSO AVAILABLE WITH 24 HOUR*
TEST AND BURN-IN, ENSURING PREMIUM MATCH. PAIRS OR QUADS $2.00 extra per tube.

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74xx	
7400	.32
7401	.32
7402	.32
7403	.32
7404	.40
7405	.34
7406	.45
7407	.40
7408	.35
7409	.40
7410	.32
7411	.34
7412	.32
7413	.40
7414	.40
7416	.40
7417	.40
7420	.40
7422	.54
7423	.54
7425	.40
7426	.40
7427	.40
7428	.56
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7439	.89
7440	.40
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7443	1.24
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7445	.79
7446	1.24
7447	.95
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7451	.32
7453	.32
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7460	.32
7470	1.09
7472	1.34
7473	.69
7474	.49
7475	.49
7476	.64
7480	.79
7482	2.29
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7485	.55
7486	.45
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7493	.54
7495	.49
7496	.69
7497	3.00
74100	4.95
74107	.45
74109	.39
74110	.60
74116	1.69
74120	1.29
74121	.54
74122	.99
74123	.59
74125	.55
74126	.55
74128	.73
74132	.55
74136	.55
74141	1.55
74142	2.59
74143	5.95
74144	6.95
74145	.99
74147	2.29
74148	1.19
74150	1.39
74151	.49
74153	.49
74154	1.59
74155	.59
74156	.59
74157	.55
74159	1.89
74160	.89
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74163	.79
74164	.79
74165	.79
74166	.89
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74170	1.49
74172	5.95
74173	.89
74174	.59
74175	.59
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74177	.69
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74181	2.09
74182	1.00
74184	3.49
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74193	.89
74194	1.24
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74221	.59
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74298	.79
74351	2.59
74365	.69
74366	.69
74367	.49
74368	.55
74376	1.69
74390	1.39
74393	1.09
74425	1.69
74426	.99
74490	4.95

74LSxx	
74LS00	.30
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74LS02	.30
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74LS75	.38
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74LS114	.45
74LS122	.57
74LS123	.49
74LS124	2.69
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74LS163	.55
74LS164	.59
74LS165	.69
74LS166	.65
74LS168	.99
74LS169	.99
74LS170	.69
74LS173	.45
74LS174	.49
74LS175	.45
74LS181	1.99
74LS189	4.95
74LS190	.59
74LS191	.59
74LS192	.69
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74LS196	.59
74LS197	.59
74LS221	.69
74LS224	12.95
74LS240	.59
74LS241	.65
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74LS243	.69
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74LS245	.79
74LS247	.79
74LS248	.79
74LS249	1.29
74LS251	.59
74LS253	.59
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74LS257	.49
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74LS279	.45
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74LS283	.65
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74LS293	.65
74LS295	1.09
74LS298	.79
74LS299	1.59
74LS322	1.59
74LS323	1.59
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74LS352	1.09
74LS353	.99
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74LS364	1.09
74LS365	.45
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74LS368	.45
74LS373	.75
74LS374	.75
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74LS447	1.19
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74LS465	1.09
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74LS540	.99
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74LS573	1.39
74LS574	1.29
74LS590	4.95
74LS595	5.95
74LS612	1.99
74LS620	2.99
74LS623	1.49
74LS624	2.19
74LS629	2.69
74LS640	1.09
74LS641	1.50
74LS643	1.28
74LS645	1.09
74LS646	2.39
74LS668	1.39
74LS669	.99
74LS670	.89
74LS674	14.95
74LS682	2.19
74LS683	2.19
74LS684	1.69
74LS685	8.00
74LS688	2.19
74LS689	3.50
74LS783	25.00

74Sxx	
74S00	.35
74S02	.35
74S04	.35
74S05	.35
74S10	.25
74S11	.39
74S20	.35
74S30	.35
74S32	.35
74S37	.25
74S38	.35
74S40	.35
74S51	.40
74S64	.35
74S65	.50
74S74	.35
74S85	.59
74S86	.25
74S112	.55
74S113	.35
74S114	.59
74S124	1.29
74S132	.35
74S133	.30
74S140	.55
74S151	.35
74S153	.35
74S157	.55
74S158	1.00
74S161	1.00
74S163	.50
74S174	.45
74S175	.35
74S189	1.89
74S195	.55
74S240	.69
74S241	.69
74S253	.89
74S257	.34
74S258	.45
74S260	.69
74S280	.45
74S283	1.00
74S287	1.79
74S373	.55
74S412	3.00

74HCxx	
74HC00	.30
74HC02	.30
74HC04	.34
74HC08	.30
74HC10	.30
74HC11	.34
74HC14	.35
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74HC32	.35
74HC51	.30
74HC74	.35
74HC75	.35
74HC85	.89
74HC86	.40
74HC93	1.39
74HC107	.45
74HC109	.45
74HC112	.45
74HC125	.45
74HC133	.49
74HC138	.49
74HC139	.49
74HC148	.89
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74HC161	.59
74HC163	.59
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74HC165	.69
74HC166	.79
74HC174	.59
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74HC193	.79
74HC194	.79
74HC195	.79
74HC237	.79
74HC238	.89
74HC240	.69
74HC241	.69
74HC242	.69
74HC243	.69
74HC244	.69
74HC245	.69
74HC251	.59
74HC257	.59
74HC258	.69
74HC259	.69
74HC273	.89
74HC280	.92
74HC299	1.39
74HC367	.69
74HC368	.69
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74HC374	.69
74HC390	.69
74HC393	.69
74HC541	.89
74HC573	1.39
74HC595	1.29
74HC652	1.79
74HC688	1.09
74HC4017	.99
74HC4020	.89
74HC4024	.99
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74HC4050	.69
74HC4051	1.29
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74HC4538	.99

74HCTxx	
74HCT00	.30
74HCT02	.30
74HCT04	.30
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74HCT85	.34
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74HCT125	.59
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74HCT193	.79
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74HCT273	.79
74HCT280	.69
74HCT299	1.09
74HCT367	.69
74HCT368	.69
74HCT373	.69
74HCT374	.69
74HCT377	.99
74HCT393	.79
74HCT423	.69
74HCT534	1.09
74HCT541	.69
74HCT573	.89
74HCT574	.89
74HCT597	.79
74HCT640	.99
74HCT670	1.09
'HCT4017	.79
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'HCT4040	.79
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4000	
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4006	.59
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4008	.79
4009	.79
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4011	.30
4012	.30
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4014	.69
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4052	.69
4053	.69
4056	.69
4060	.69
4063	1.09
4066	.35
4067	2.09
4068	.49
4069	.30
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4086	.79
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4098	.79
4099	.89
40106	.70
40107	.70
40174	.89
4501	.65
4502	.99
4503	.49
4507	1.09
4508	1.09
4510	.79
4511	.79
4512	.79
4514	1.19
4515	1.09
4516	.79
4518	.79
4519	.69
4520	.79
4521	1.09
4522	.99
4526	.89
4527	.99
4528	.89
4529	.99
4530	.89
4531	.99
4532	.89
4538	.99
4539	1.09
4541	.89
4543	.99
4552	1.35
4553	2.49
4555	.79
4556	.79
4558	1.69
4560	1.69
4561	2.00
4566	2.00
4569	2.69
4572	.90
4581	1.69
4582	1.69
4584	.69
4585	.79
4702	9.95
4724	1.19
14174	.60
14175	.60
14409	12.95
14410	6.95
14411	7.95
14412	6.95
14419	2.19
14433	5.95
14451	1.50
14490	4.95
14497	6.95

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TL072	.69
TL074	.99
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TL082	.55
TL083	1.09
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XR215	1.50
MAX232	4.95
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LM307	.49
LM308	.79
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LM309K	1.50
LM310	1.69
LM311	.49
LM312H	5.50
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LM317T	.79
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LM319	1.19
LM322	1.19
LM323K	3.39
LM324	.40
LM329	.79
LM331	5.95
LM334	1.19
LM335	1.39
LM336	1.29
LM337K	2.95
LM337T	.99
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LM339	.49
LF347	.75
LM350K	3.99
LM350T	2.99
LM350H	9.95
LF351	.55
LF353	.65
LF355	.99
LF356	.89
LF357	.95
LM358	.59
LM359	2.19
LM376	1.39
LM380	1.09
LM381	3.95
LM382	2.49
LM383	2.95
LM384	2.09
LM385Z12	1.69
LM386	1.19
LM387	1.89
LM389	1.29
LM390	1.59
LM392	.99
LM393	.45
LM395K	9.95
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LF411	.75
LF412	1.19
TL489	1.59
TL494	1.89
TL496	1.59
TL497	2.09
NE531T	1.99
LM555	.38
LM556	.59
LM558	.79
NE564	1.69
LM565	1.59
LM566	1.39
LM567	.69
NE570	2.99
NE571	2.09
NE590	2.69
NE592	.50
NE602	1.95
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MAX691	8.95
LM709	.69
LM710	.79
LM711	.89
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LM723H	1.29
LM733	.69
LM741	.38
LM741HC	1.09
LM747	.69
LM748	.69
LM1014	2.69
LM1303	1.69
LM1310	1.69
MC1330	1.69
MC1349	2.09
MC1350	1.09
MC1358	.99
MC1372	2.69
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MC1558	2.59
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LM1877	3.95
LM1889	3.95
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ULN2003	.79
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XR2211	2.69
XR2240	1.69
XR2242	1.50
XR2567	2.50
LM2877	2.19
LM2878	5.95
LM2900	2.19
LM2901	.69
LM2907	1.69
LM2917	2.19
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CA3037	1.50
CA3039	1.99
CA3046	.99
CA3059	2.39
CA3060	2.95
CA3065	1.70
CA3080	1.09
CA3081	.79
CA3082	1.09
CA3083	1.09
CA3086	.99
CA3089	1.59
CA3096	1.09
CA3130	.99
CA3140	.89
CA3146	1.09
CA3160	.99
CA3161	1.99
CA3162	6.00
CA3183	.99
CA3401	1.50
MC3302	.75
MC3340	1.69
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MC3360	1.50
MC3373	1.09
MC3401	.90
MC3403	.70
MC3470	1.29
MC3480	9.95
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MC3487	1.09
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LM3905	1.39
LM3909	1.69
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LM3916	2.49
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7107	5.95
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7208	20.00
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75107	.79
75108	.89
75110	.89
75138	1.69
75150	1.29
75154	1.29
75160	3.75
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75189	.50
75365	.89
75450	.99
75451	.49
75452	.59
75453	.59
75454	.59
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PN2907	.20
2N3055	.85
2N3393	.35
2N3417	.40
2N3567	.55
2N3568	.25
MPS3638	.25
PN3643	.25
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2N3703	.25
2N3704	.25
2N3730	.50
2N3772	1.99
2N3866	1.20
2N3903	.30
2N3904	.20
2N3905	.20
2N3906	.20
2N4123	.30
2N4124	.30
2N4126	.30
2N4220	1.00
2N4236	1.59
2N4240	1.00
2N4385	.50
2N4401	.30
2N4402	.30
2N4403	.30
2N4424	.25
2N4857	1.10
2N4919	.30
2N4992	.25
2N5086	.30
2N5109	1.50
2N5222	.35
2N5306	.50
2N5308	.50
2N5401	.35
2N5484	.35
2N5550	.35
2N5819	.50
2N5840	6.00
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2N6045	1.85
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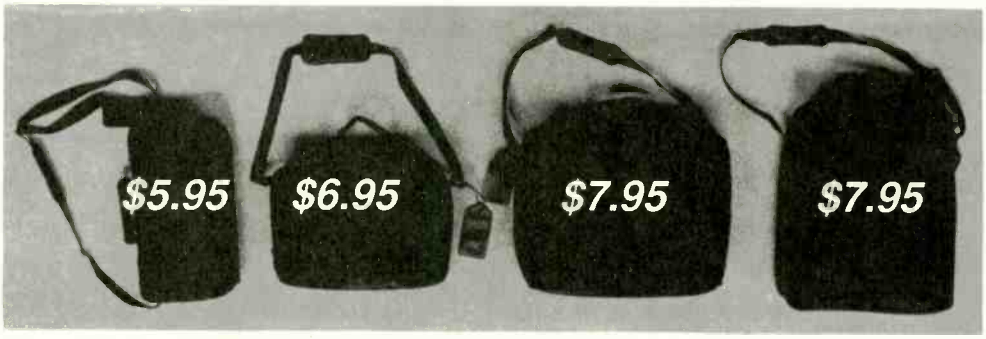

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- Sensitive, picks up sounds at the level of a whisper.
- Up to 1 mile range.

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- Tunes 88-108 MHz.
- No batteries required, powered by phone line.
- Up to 3/4 mile range.
- Attach to phone line anywhere in house, even inside phone.

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- 16 levels of voice masking.
- Button for normal operation.
- Complete anonymity on all calls

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STOP THOSE ANNOYING PHONE CALLS! Sound older and tougher when you want to. Not a kit, fully assembled. Single line phone operation only.

TRANSITION 2000 .... $89.95

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Use with any modular phone.
- Connects between handset and phone.
- 16 levels of voice masking.

TRANSITION 2001 VOICE CHANGING Accessory

STOP THOSE ANNOYING PHONE CALLS! Sound older and tougher when you want to. Use with single or multi-line phones. Not a kit, full assembled.

TRANSITION 2001 .... $59.95

- Transmits both sides of phone conversation.
- Adjustable from 88-108MHz.
- Works with any FM broadcast receiver.
- Up to 1 mile range.
- Turns off when phone is not in use to extend battery life.

XTT100 LONG RANGE PHONE TRANSMITTER

Similar to our very popular XSP500, the XTT100 is battery powered for maximum range. It plugs into any phone jack and transmits all calls on that line.

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- Super sensitive, hear every sound in a house!
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- Use with any FM broadcast receiver.
- Up to 1 mile range.
- Powered by 9V battery.

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- Transmits a continuous beeping tone.
- Adjustable from 88-108 MHz.
- Up to 1 mile range.
- Works with any FM broadcast receiver.
- Operates at battery voltages of 3 to 18 volts.

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Measuring .7 by 2.4 inches, the XTR100 is ideal for use in locating lost model rockets, bicycles, automobiles, games of hide-and-seek, and contests.

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- Uses sensitive microwave transistor amplifier.
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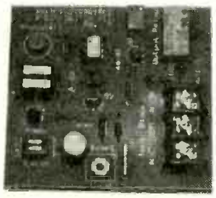
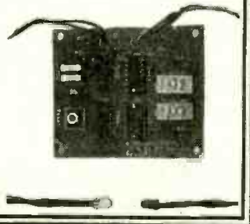
Detects Light or Dark. Can be used to control security & indoor lights, alarms, motors, etc. Sensitivity adjustment, latching / reset function and Normally open & closed output relay. 0.6 Amps @ 120v switching capability. Terminal Block
Dimensions: 2.850 x 3.20 inches
Kit # 93-P01:........................$ 19.95



INFRARED 0 - 99 COUNTER

When the infrared transmitter beam is interrupted the LED display counts up from 0 to 99 and recycles. Great for counting objects, laps or anything you can think of. Includes a reset button and a push-button for manual counting.
Dimensions: 2.70 x 3.10 inches
Kit # 93-P02:........................$ 16.95



DC POWER SUPPLY

Fuse Protected, 3 individual fixed outputs, terminal block and output voltage LEDs.
Input: 12 - 18v AC or DC
Output: 5V DC @ 0.5 amps
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Transformer sold separately....$ 5.00
Dimensions: 2.670 x 4.150 inches
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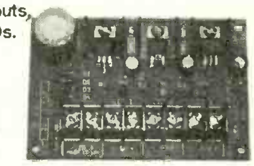

7-CH. CONTROLLER / EXPERIMENT WITH EPROMS

This EPROM light chaser consists of 7 channels. Includes speed control, reset & music input. EP1 (Nite Rider) included. Extra Programs ..$ 5.95 ea.
EP2 - Worm Chaser EP4 - Centipede
EP3 - Mirror Image EP5 - Disco Chase
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Dimensions: 2.765 x 3.975 inches
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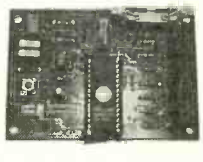

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For use with the above kit. Easy ribbon connector interface. Fuse protection. Optoisolated Triacs switch up to 1 amp of current @ 120 Vac per channel. Great for controlling incandescent lights, motors or any AC equipment. Ideal for disco lights. Easy to connect terminal block. Dim.: 3.80 x 3.935 inches
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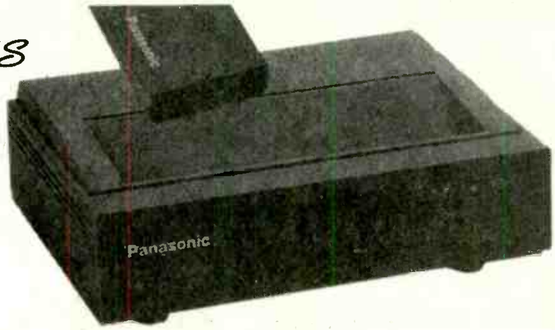

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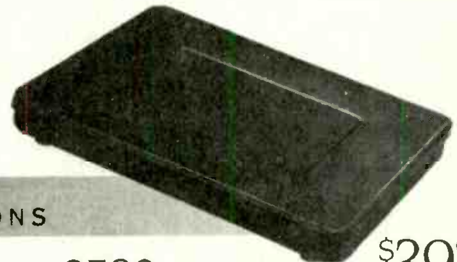

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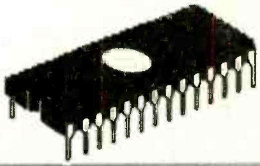
ZENITH $16.99



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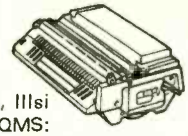

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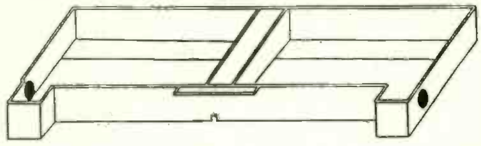

VT-103 $9.95

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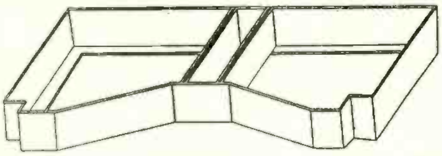

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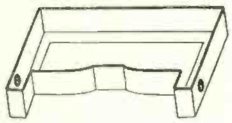

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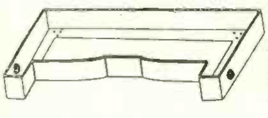

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NOTICE !!
THE ORIGINAL VHS VU-THRU TOOL WILL WORK IN ALL VCR'S, NEW UNITS OR OLDER UNITS-FRONT LOAD,–TOP LOAD,–SIDE LOAD, AND CAMCORDERS. INCLUDING THE DISCONTINUED "G" CHASSIS VCR'S.
(see page 9 of our up-dated ILLUSTRATED & COPYRIGHTED instruction manual)

INSTRUCTION MANUAL

HOW TO:
* Clean Video Heads pg 3
* Check tape end sensors pg 5
* Renew drive wheels pg 4
* Adjust loading posts pg 7
* Renew pinch roller pg 6
* Clean erase & audio heads pg 7
* Check Spindle sensors pg 8
* Adjust tape guides pg 9
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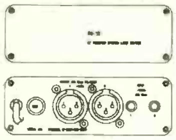

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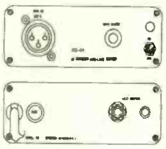

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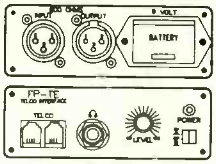

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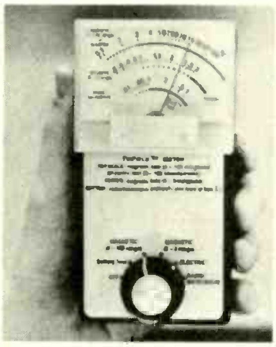

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Kit: $165.00
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120 W MOSFET POWER AMPLIFIER (MONO)
TA-477 ▲▲

T.H.D.: Less than 0.007% • Power Output: 120 watts into 8 ohms RMS • Frequency Response: 8 Hz - 20 KHz. + 0-0.4 dB • Sensitivity IV • Power Requirements: ±55 VDC @ 3 amps. May use Mark V Model 003 Transformer • Suggested Capacitor 10,000uf80V-100V Model 019 • Suggested rack mount cabinet: Model LG-1925

Kit: $68.00
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TA-800MKII ▲▲

Power Output: 120 watts RMS per channel into 4 ohms load. 72 watts RMS per channel into 8 ohms load • Frequency Response: 10 Hz - 20 KHz. • Total Harmonic Distortion: Less than 0.01% • Tone Control: Bass: ±12 dB. Mid: ±8 dB. Treble: ±8 dB • Sensitivity: Phono Input, 3 mv into 47K. Line, 0.3 v into 47K. Signal to noise ratio 86 dB • Power Requirements: 40V DC @ 6 amps. May use Mark V Model 001 or 008 Transformer • Suggested rack mount cabinet: Model LG-1924 or 1925

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Power Output: 80 watts per channel into 8 ohms • Total Harmonic Distortion: Less than 0.05% at rated power. • Intermodulation Distortion: Less than 0.05% at rated power • Frequency Response: DC to 200 KHz. -0 db,-3 db. @ 1 watt • Power Requirements: 30 VAC x 2 @ 6 amps. May use Mark V Model 001 or 008 Transformer • Suggested Capacitor 8,200uf50V Model 017 • Suggested rack mount cabinet: Model LG-1924

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SM-333 ▲▲★

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Kit: $73.00
Assembled & Tested: $85.00

60W + 60W STEREO POWER AMP. (WITH MIC. & GUITAR INPUT)
SM-302 ▲▲★

Frequency response: 20Hz to 20 KHz • Total Harmonic Distortion: <0.1% • Power output 60W per channel into 4 ohm load RMS • 33W per channel into 8 ohm load RMS • Input Sensitivity: Mic/Guitar 10 mv • Hi 380 mv • Lo 640 mv • Signal to noise ratio: Better than 70 db • Power Consumption: 100W. (Case & Transformer are included)

Kit: $73.00
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#007	53V x 2 8A	$45.00
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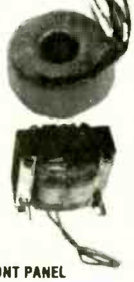

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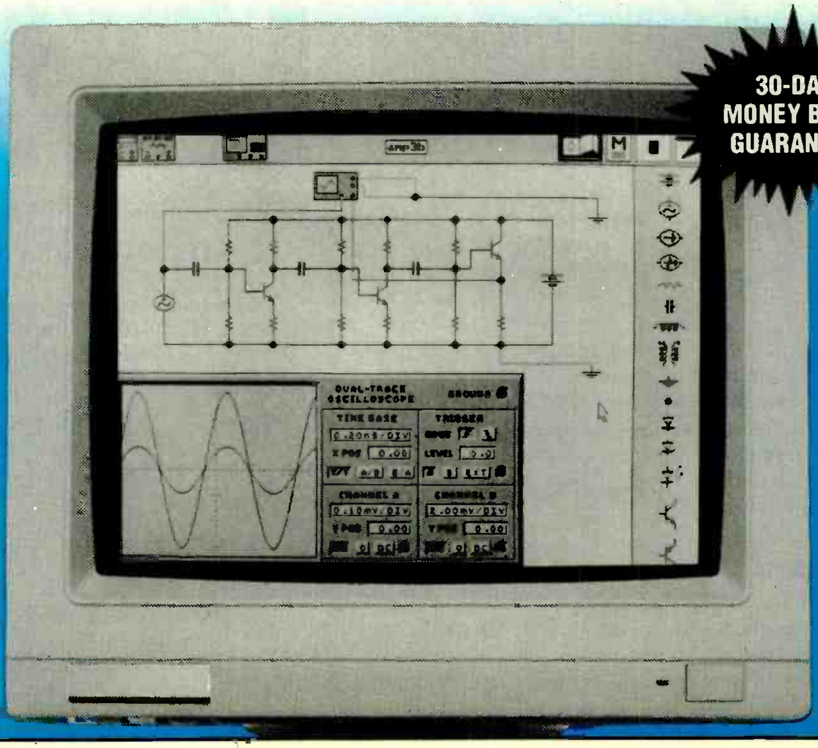

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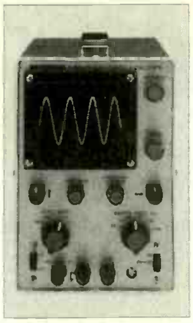

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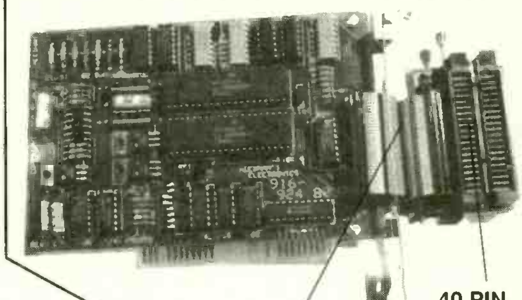

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- **Flash** 28F256–28F020, (29C256–29C010 (EMP-20 only))
- **Micros** 8741A, 42A, 42AH, 48, 49, 48H, 49H, 55, 87C51, 87C51FX, 87C751,752
- **GAL, PLD** from NS, Lattice, AMD-**16V8, 20V8, 22V10** (EMP-20 only)

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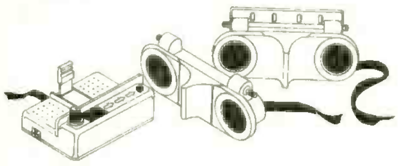
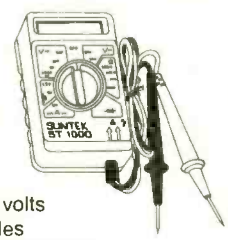


The ED-100 was designed for use as an auto/RV/truck back-up alarm. It consists of two computer controlled 40 kHz ultrasonic modules that attach to the back of a vehicle and warn the driver when the rear of the vehicle is within 14 feet of another object. A digital display that clips onto the rear-view mirror continually monitors the distance to the object. As the vehicle gets closer to the object, an audible signal beeps inside the car at increasingly closer intervals. There is also a visual indicator. The ultrasonic modules measure 5.81" long X 1.9" wide X 2.05 " and have swivel mounting brackets. Operate on 12 or 24 Vdc. Includes instructions for installation. The units are all new, in original display cartons and, as far as we know, in working condition. The company that originally marketed this device is no longer in business, and no manufacturer's guarantee is in effect. ***We offer these ultrasonic detectors on an experimental basis only, and in no way wish to promote their usefulness as an aid to driving a motor vehicle.***
This unit originally sold for over $100.00.

CAT# ED-100 $24.95 per set

LOW COST 3 1/2 DIGIT MULTIMETER



3 1/2 digit LCD multimeter. Tests DC and AC volts, DC current, resistance, diode test, battery test for 1.5 volts and 9 volts. Includes instructions. Ideal for students, hobbyists and use around the house.

CAT# ST-1000 $19.95

TRANSISTORS SPECIAL PURCHASE LARGE QUANTITY

NPN, TO-92 transistors. Two types available:

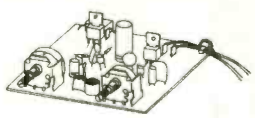
SAMSUNG # KSR1009 (R1009902).
Same as 2N3706, 2N3708 or 2N3711.
Crosses to ECG 85/289A or NTE 85/199.

CAT # TRX-1 12 for $ 1.00
100 for $ 5.00 (5¢ each)
1000 for $ 30.00 (3¢ each)

NATIONAL House numbered part #
136207C0058 Same as MPSH11.
Crosses to ECG or NTE 229.

CAT # TRX-2 12 for $ 1.00
100 for $ 5.00 (5¢ each)
1500 for $ 45.00 (3¢ each)

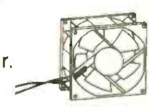
TWO CHANNEL COLOR ORGAN



Create your own light shows. Electret mike on control board responds to music or other sounds causing lights to brighten and dim depending on frequency and volume. 120 Vac input and output. Provisions for two light strings, up to 200 watts per channel. Separate sensitivity controls for each channel. 0.25" qc terminals for output. Lights not included. 4.25" X 3.85". Hook-up diagram included.

CAT# CORG-1 $6.50 each

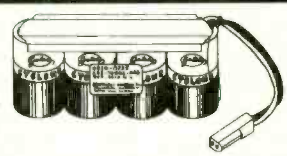
12 Vdc COOLING FAN



Elina Fan # MDA 120925LB
12 Vdc,110 ma.
Black thermoplastic housing and 5 blade impeller.
3.63" square X 1" thick.
14" pigtail leads.

CAT# CF-128 $ 7.50 each

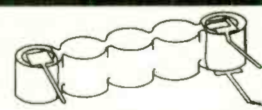
RECHARGEABLE BATTER PACK (USED)



8 volts @ 2.5 AH. Four-pack of Gates "Cyclon" 2 volt 2.5 amp-hour sealed lead cells. Each cell measures 1.33" diameter X 2.36" long. Pack measures 5.3" long X 1.35" X 2.57". Has 4.5" long pigtail leads with 2 conductor connector. Pack can be disassembled and reconfigured in packs of higher voltage or current.

CAT# LB-825U $5.50 each

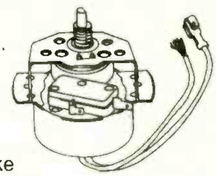
RECHARGEABLE BATTERY PACK WITH 5 1/3AA BATTERIES



Gates nickel-cadmium rechargeable battery pack with 5 1/3AA cells in series to make 6 volts. The end battery in the pack has its own positive and negative leads so that 1.2 volts can be accessed separately if desired. Pack can be disassembled and put together in other configurations. 2.5" X 0.6" X 0.5".

CAT# NCB-135 $2.50 each

10 MINUTE TIMER



Eaton Controls Div. # 366-101-30. 115 vac Electro-mechanical shut-off timer. Switch rated at 5 amps. Turn knob to make connection and start timer motor; after 10 minutes knob returns to starting position and breaks connection. Can be wired to run 115vac through switch, or switch can be used for other voltage. 3/8" threaded bushing for through panel mount. Also has mounting bracket for added stability. Overall size: 2.3" x 2" x 1.5" thick behind the panel depth. Includes black pointer knob.

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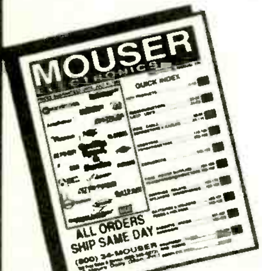

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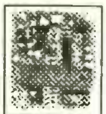

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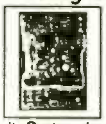

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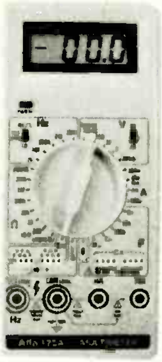

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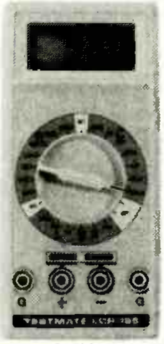

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Basic accuracy:R:1%, C:2%, L:3%
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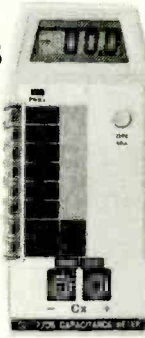

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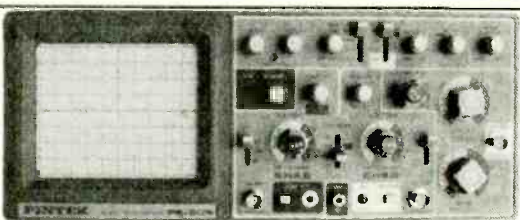

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8 bit vertical resolution (25 Lerel/div)
Expanded Timebase 10ms/div - 0.5 s/div
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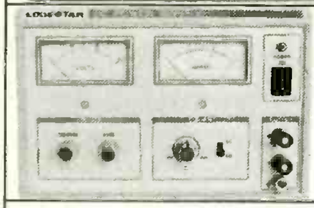

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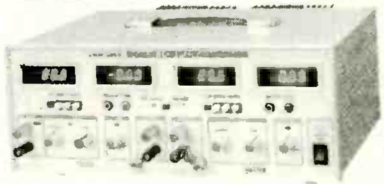

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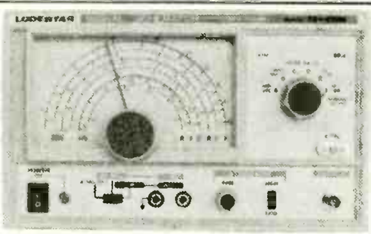

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Sensitivity <50mV

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Output: 0-8Vrms sinewave
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Synchronization: ±3% of oscillation frequency per Vrms
Output distortion:
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Output impedance: 600 ohm

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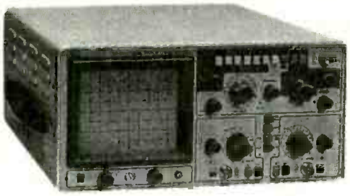

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OS-3304/3324, 25 MHz
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- Uncalibration LED.
- High Sensitivity 1 mV/div to 20V/div X-Y modes, Z Axis (intensity modulation)
- Rise time 14n Sec. or less.
- Full TV Trigger for TV-V & TV-H
- Acceleration Potential 2kV

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- DC to 40 MHz. Dual Channel
- Delayed Sweep 100nS to 1 Sec.
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- Uncalibration LED.
- High Sensitivity 1 mV/div to 20V/div X-Y modes, Z Axis (intensity modulation)
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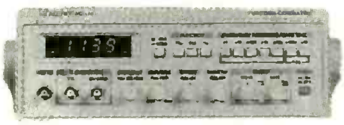
2MHz Sweep / Function Generator w/Built-in Frequency Counter



- 4 Digit LED Display
- 0.2 Hz ~ 2.0 MHz
- Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, TTL
- Linear or Logarithmic Sweep
- Variable DC Offset Control
- 10 MHz Frequency Counter

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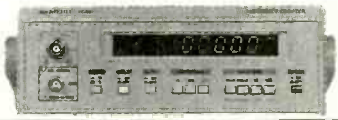
High Resolution Frequency Counter



- 1.0 Hz ~ 1.0 GHz
- 8 Digit LED Display
- Auto & Manual Range
- Measured Value Hold
- 4 Selectable Gate Times
- Below 20mV Input Sensitivity
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- 10:1 Input Switchable Attenuator

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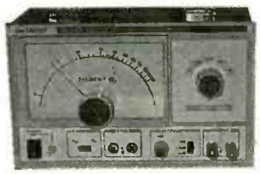
RF Signal Generator, SG-310 100KHz - 150MHz

- 100KHz ~ 150MHz, 6 Ranges.
- Accuracy : ± 5%
- RF Output: 100 m Vrms (Up to 35MHz Unloaded)
- Modulation
  Int. 1KHz (AM) 30%
  Ext. 50Hz ~ 20KHz
- Audio Output: 1KHz Min 2 Vrms

Reg. $199. **$119.00**

Audio Generator, AG-350 10Hz ~ 1MHz



- 10Hz ~ 1MHz, 5 Ranges.
- Accuracy : 5% ± 2
- Output Inpedance : 600Ω
- Sine Wave Output
  - Range : 10Hz ~ 1MHz
  - Output Voltage : 8 Vrms
- Square Wave Output
  - Range : 10HZ ~ 100KHz
  - Output Voltage : 15Vp-p

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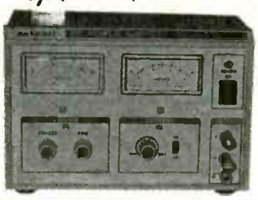
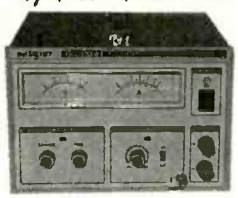
DC Power Supply, PS-500 0-30VDC, 0-3A



- 0 ~ 30VDC Continuously Variable
  - Regulation : ≦0.01% + 3mV
  - Ripple Voltage : p-p ≦ 2m Vrms; ≦ 1mV
- 0.1A ~ 3A Constant Current
  - Regulation : ≦0.2% + 3mA
  - Ripple Current : ≦ 3m Arms
- Short Circuit Overload Protection w/Indicating Lamp

Reg. $399. **$289.00**

DC Power Supply, PS-540 0-16VDC, 0-10A



- 0 ~ 16VDC Continuously Variable
  - Regulation : ≦0.01% + 3mV
  - Ripple Voltage : p-p ≦ 2m Vrms; ≦ 1mV
- 0.1A ~ 10A Constant Current
  - Regulation : ≦0.2% + 3mA
  - Ripple Current : ≦ 3m Arms
- Short Circuit Overload Protection w/Indicating Lamp

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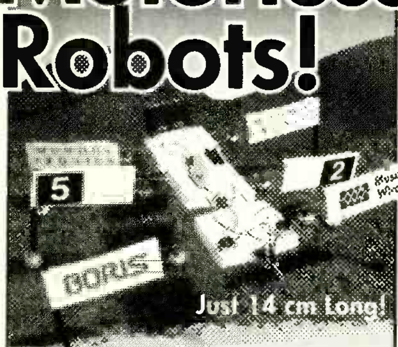

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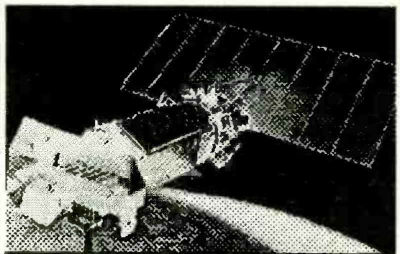

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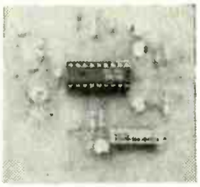

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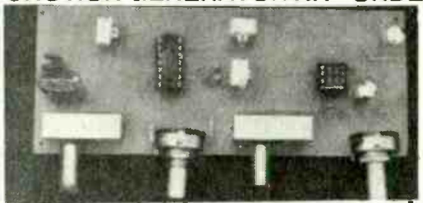

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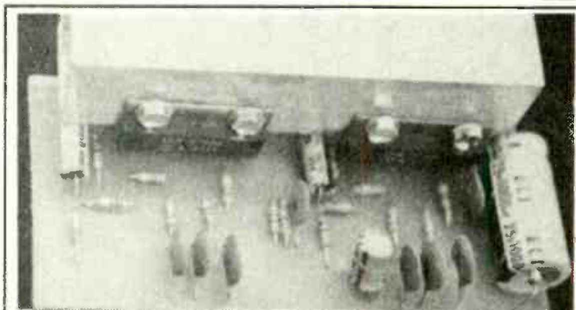

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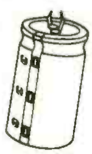

I.C. SOCKETS

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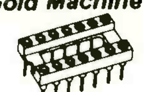

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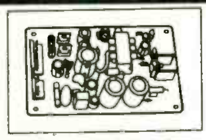

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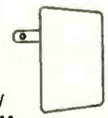

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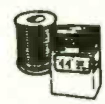

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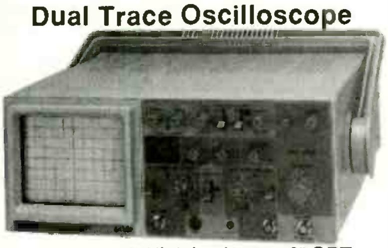

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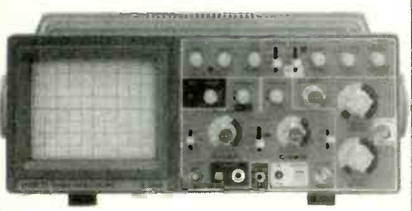

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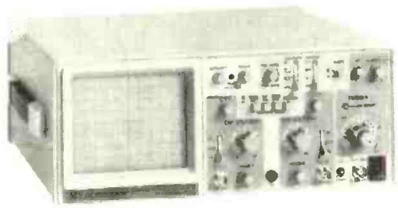
- Plotter Output
- 8 Bit Vert. Resolution
- 2048 Pts Hor. Resolution
- Much More

B+K 2120



20MHz $395 2 Channel
Model 2125 $539.95 Delayed Sweep

40MHz DUAL-TRACE
Model 1541B

749.95

- 1mV/div sensitivity
- Video sync separators
- Z axis input
- Single sweep
- V mode-displays two signals unrelated in frequency

60MHz DUAL-TRACE
Model 2160

949.95

- 1mV/div sensitivity
- Sweep to 5 ns/div
- Dual time base
- Signal delay line
- V mode-displays two signals unrelated in frequency
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100MHz THREE-TRACE
Model 2190

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- 20MHz analog bandwidth
- 10MS/s sampling rate
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- 20MHz equivalent time sampling
- Pre-trigger capture

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- Resolution bandwidth of 10kHz
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SPECIAL BUY HITACHI V-212

20MHz
2 Channel
$409

Hitachi Popular Series

V-525 - 50MHz, Cursors	$975
V-523 - 50MHz, Delayed Sweep	$949
V-522 - 50MHz, DC Offset	$849
V-422 - 40MHz, DC Offset	$749
V-222 - 20MHz, DC Offset	$625

Hitachi Compact Series Scopes

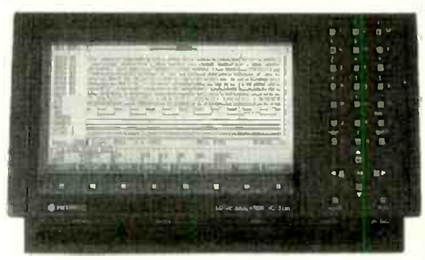
V-660 - 60MHz, Dual Trace	$1,095
V-665A - 60MHz,DT, w/cursor	$1,325
V-1060 - 100MHz, Dual Trace	$1,375
V-1065A - 100MHz, DT, w/cursor	$1,649
V-1085 - 100MHz, QT, w/cursor	$1,995
V-1100A - 100MHz, Quad Trace	$2,195
V-1150 - 150MHz, Quad Trace	$2,695

Hitachi RSO Series

RSO's feature; roll mode, averaging, save memory, smoothing, interpolation, pretriggering, cursor measurements.

VC-6023 - 20MHz, 20MS/s	$1,650
VC-6024 - 50MHz, 20MS/s	$1,950
VC-6025A - 50MHz, 20MS/s	$2,350
VC-6045A - 100MHz, 40MS/s	Call
VC-6145 - 100MHz, 100MS/s	Call

Logic Analysers



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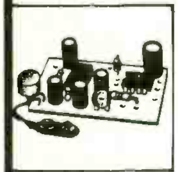


SUPER SNOOPER BIG EAR

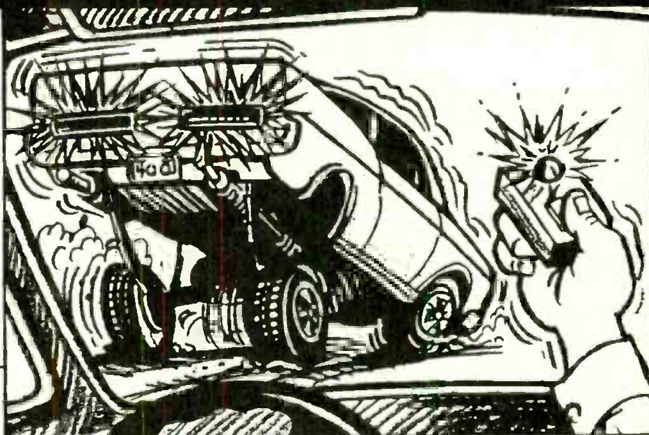
Listen through walls, hear conversations across the room. Add a parabolic reflector & hear blocks away. The BIG EAR can be hidden about anywhere. Makes an ultra- sensitive intercom, Can be used as a 1.5W AMP. We supply a mini- electret mike in the kit. 1"x1.75" 6 to 12vDC

AA-1 **$10.95**

PHONE TRANSMITTER

Small but mighty, it fits anywhere. Phone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz TO 130MHz FM. You can also use it as a speaker phone. Size .5"x1"

TEL-B1 **$12.95**



THE ZAPPER

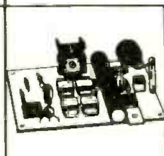
activates any radar detector within 3/4 of a mile. Check the brake lights of that sports car that just went by 90 miles an hour. Back off those 18 wheelers trying to eat your back bumper. Put the fun back in driving. THE ZAPPER is a 10GHz amateur transmitter the size of a cigarette pack, operates on a 9v battery, when the button is pushed, brake lights and radar detector light the skies. Complete with the rules of the new ROAD WARRIOR GAME... TROLLING FOR TAILGATES, America's fastest growing highway participatory sport.

Built **$49.95**
Kit **$39.95**

PHONE RECORDING SWITCH

This phone line powered switch is small enough to be installed any where. Every time the phone is picked up the recorder will record both sides of the conversation automatically. Use it in your office to record all phone calls so you don't loose important information. 1"x.6"

TEL-SW1 **$12.95**



STROBE LIGHT

Do you need an attention getter, warning light, or flashing light for model airplanes, then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a variable flash rate. Size 3.5"x1.8" operates on 6 or 12v DC only.

ST-1 **$9.95**

DIGITAL THERMOMETER

The DT-3 kit will turn your digital volt meter into an accurate digital thermometer with .1 degree resolution. Measures temperature from -40F to 250F degrees. It has a remote sensor .25" SQ. and can be mounted many feet away from the meter. Size 1.5x1.2" 9vDC

DT-3 **$8.95**

CAPACITANCE METER

This kit will turn your digital volt meter into a capacitance meter. Turn that junk box of unmarked capacitors into a fortune of usable parts. Measures capacitors from <2.2pF to 2.2uF. 1.75"x2" 9vDC

CA-1 **$12.95**

VOLTAGE MONITOR

This kit has 7 multi-colored leds to monitor your 12, 8, or 5v DC systems. Build it to work in 1v, 1/2v, or 1/4v steps. Great for nicad packs, autos, boats, mobile homes, or battery chargers. P.C.B. 1.3"X2.7"

VM-1 **$7.95**

BLINKEY LIGHT

This kit is perfect for decorating hats, name badges, & model trains. Add a box, set it on the dash of your car, use it as an auto burglar alarm. Comes with 2 alternate flashing leds. Size .5"x.5" 9 to 12vDC

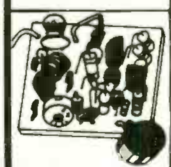
RB-2 **$3.95**

TV NOTCH FILTERS

Our TV filters eliminate unwanted TV channels or interference that alters both sound & video with a beep-beep-beep. Works on cable channels 2 thru 22. and the 'SNOOPER & BULLET.

Note: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

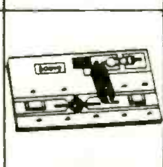
DF-222 Kit **$14.95**



WIRELESS FM MICROPHONE

Small but mighty, this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-1 kit is a buffered wireless mike that operates from 80-MHz to 120MHz FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. .8"x1" 6 to 12vDC

WM-1 **$14.95**



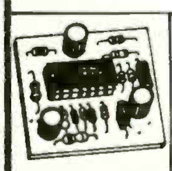
WIDE BAND PREAMP

Ideal for preamp for scanners, hand held radios, frequency counters. Amplifies low level (weak) signals. If the signal is extremely low 2 amps can be used in series. 1MHz TO 2.5MHz @ 2.8dB nf 1dB compression = +0 dBm gain: 1MGHz-20dB to 2.5GHz-6dB Requires 12vDC @ 16Ma

WBA-6 **$19.95**

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.

KIT BOOK **$14.95**
$5.00 off if you buy any kit



VOICE ACTIVATED SWITCH

This VOX circuit can be used to operate a tape recorder, ham radio, CB radio, or turn on an alarm. The VOX-1 kit has 100MA of output. That operates a relay, light, motor, or ? What could you do with a sound activated switch? Size 1.5"x1.3" 7.5 TO 18vDC

VOX-1 **$6.95**

INDUCTANCE METER

This is the kit every one has been asking for. Turn your digital volt ohm meter into an inductance meter. It will read inductors 3uH to 7MH. Size 1.5"x1.6" 9vDC

IA-1 **$14.95**
CABINET **$ 8.95**

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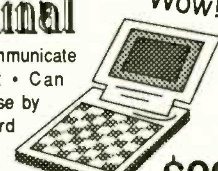
20 x 2 $12.00	24 x 2 $12.00
32 x 4 $20.00	40 x 2, 2 for $25.00
40 x 4 $25.00	4 x 2 $5.00

5V power required • Built in C-MOS LCD driver & controller • Easy "Microprocessor" interface • 98 ASCII character generator • *Certain models are backlit, call for more info.*

Portable Micro Terminal

Wow!



• Flip up LCD display (9-16 VDC) • Can communicate with any computer having RS 232 port • Can communicate with another Microterminal • Use by itself as electronic notebook • Onboard microprocessor, data RAM (32K) and Video RAM (64K) • Complex built in diagnostics and set up capabilities. • Original intention for POS applications. • display size 40x16 (256 x 128 pixels.) Dim: 6.3" W, 11"L, 2"H. (With LCD up height is 7.1")

$99.00

or 2 for $149.00

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Flat Faceplate • 640 x 200 Dot Resolution • CGA & Hercules Compatible • 12 VDC Operation • 15.75 KHz Horiz. Freq. • 60 Hz Vert. Sync. Freq. • Open Frame Construction • Standard Interface Connector • Degaussing Coil Included • *Mfg.: Samtron*

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Includes: • 20 character dot matrix display with full alpha-numeric capability • keypanel with full alpha-numeric entry • separate 7.5 VDC/0.5 Amp power supply • standard telephone interface extension cord • lithium battery and flat-cone speaker.

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286 - 12 Computer. Ideal for the handyman, great for the testbench.

Includes: 286-12 motherboard (Intel Chip) • built in IDE, floppy and VGA controller • 1 Mb RAM on board (expandable to 5 Mb) • Phoenix Bios • 1 serial, 1 parallel, 1 mouse port • keyboard • DOS 4.01 • real time clock • (2) 16 bit slots, (1) 8 bit slot • (Note: Does not include power supply or upper part of the case. The motherboard and case are not standard IBM footprint size. Call for more details.)

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Horizontal or vertical mounting.
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Links 3270 mainframe systems to IBM PC

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.39 dot pitch. Model #:9CM053. EGA card available.

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Graphic & Alphanumeric Liquid Crystal Display

480 Dot x 128 Dot, (80 x 16 line)
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Driver board available: $75.00

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Assembly intended for a laser printer. Includes laser diode, polygon motor (6 sided) and misc. optics and lenses.

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Laser diode with collimator......$25.00
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73 WATT SWITCHING $19.00 or 2 @ $30.00, (2) 4 pin power connectors attached • 115/230 Volt, Dim: 8.5" L x 4.5" W x 2" H • Output: +5V @ 2-9.75 A, +12V @ 0-1.5 A, -5V @ 0-0.4 A, -12V @ 0-0.5 A

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NEC N9630-P 9600 bps External Modem $129.00

Hayes compatible • Full duplex asynchronous or synchronous operation • Dial up (voice) or lease line operation • Follows the V.32 standard • Automatic fallback to 4800 bps • Built in error correction (can be enabled or disabled) • Seven (7) mode of operation LED indicators • Seven (7) interface LED indicators • Two (2) signal quality LEDs • Eight (8) Character message display

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We cannot bill for classified ads. Payment in full must accompany your order. We do permit repeat ad or multiple ads in the same issue, but in all cases, full payment must accompany your order.

WHAT WE DO

The first two words of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is $1.25 per word. Minimum charge is $18.75 per ad per insertion (15 words). Any words that you want set in bold or caps are 20¢ each extra. Bold caps are 40¢ each extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged as all-caps words. State abbreviations must be Post Office 2-letter abbreviations. A phone number is one word.

CONTENT

All classified advertising in the **Electronic Shopper** is limited to electronics items only. All ads are subject to the publisher's approval. We reserve the right to reject or edit all ads.

DEADLINES

Ads received by our closing date will run in the next issue. For example, ads received by April 1 will appear in the July, 1993 issue that is on sale in June 3. Shopper ads will appear Jan., Mar., May etc. 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.

AD RATES: $1,25 per word, Minimum $18.75.

Send your ads with payment to:
Electronic SHOPPER, 500-B Bi-County Blvd. Farmingdale, NY 11735

CATEGORIES

100 — Antique Electronics	270 — Computer Equipment Wanted	450 — Ham Gear Wanted	630 — Repairs-Services
130 — Audio-Video-Lasers	300 — Computer Hardware	480 — Miscellaneous Electronics For Sale	660 — Satellite Equipment
160 — Business Opportunities	330 — Computer Software	510 — Miscellaneous Electronics Wanted	690 — Security
190 — Cable TV	360 — Education	540 — Music & Accessories	710 — Telephone
210 — CB-Scanners	390 — FAX	570 — Plans-Kits-Schematics	720 — Test Equipment
240 — Components	420 — Ham Gear For Sale	600 — Publications	

CLASSIFIED AD COPY ORDER FORM

Ad No. 1—Place this ad in Category # ______

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5 - $18.75	6 - $18.75	7 - $18.75	8 - $18.75
9 - $18.75	10 - $18.75	11 - $18.75	12 - $18.75
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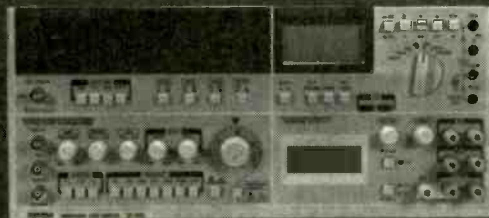

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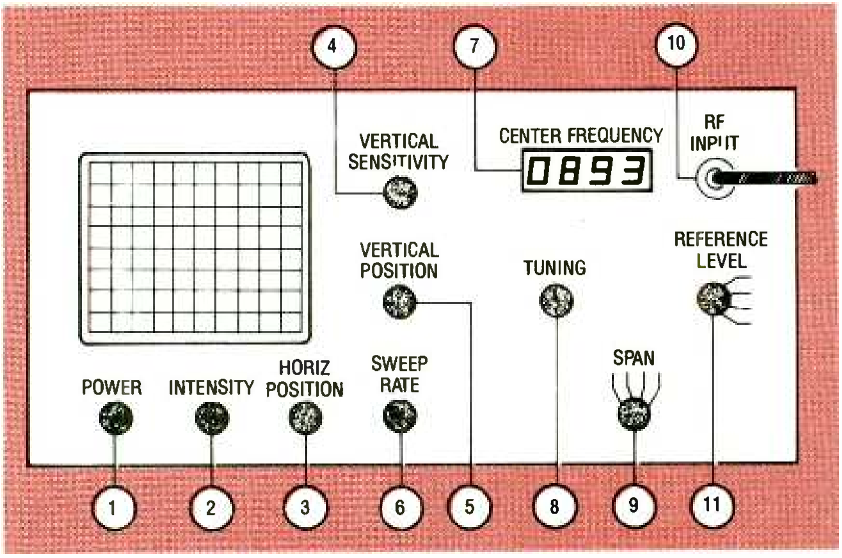
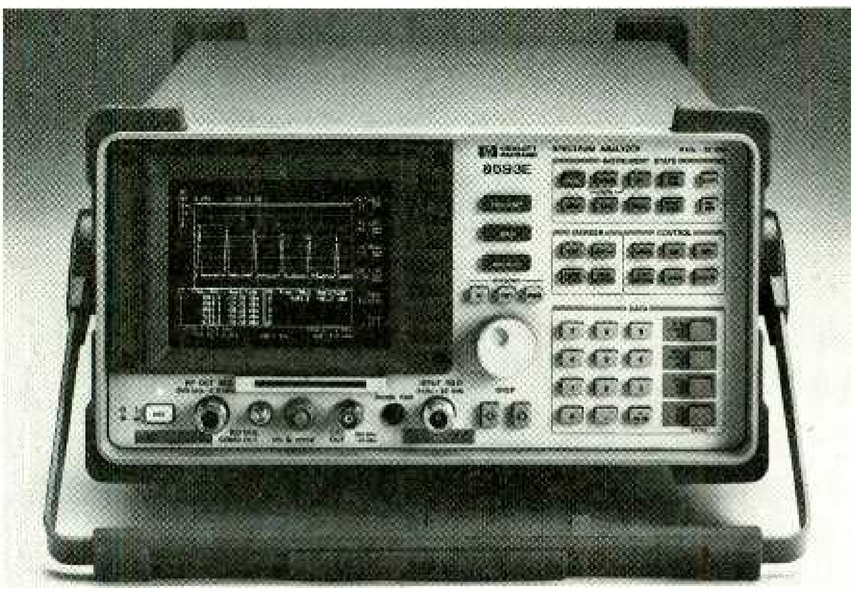


FIG. 8—SPECTRUM ANALYZER FRONT PANEL: The controls of a basic model.
1. POWER switch turns power on and off.
2. INTENSITY controls brightness of the display.
3. HORIZONTAL POSITION shifts the display on the screen.
4. VERTICAL SENSITIVITY selects an amplitude sensitivity.
5. VERTICAL POSITION moves the CRT display vertically.
6. SWEEP RATE controls the sweep speed across the CRT
7. CENTER FREQUENCY is a readout of center frequency.
8. TUNING centers the frequency on the CRT display.
9. SPAN controls the spectrum display width.
10. RF INPUT accepts the signal to be observed.
11. REFERENCE LEVEL sets waveform to the graticule top.
More advanced models have additional function knobs, switches, and pushbuttons.



PORTABLE SPECTRUM ANALYZER from Hewlett-Packard covers the RF and microwave frequency range from 9 kHz to 22 GHz. It offers frequency-synthesized accuracy of 7.6 kHz at 1GHz. Second- and third-order dynamic ranges are 77 dB and 90 dB, respectively. Memory cards can quickly transform the unit into an application-specific instrument.

ponent in the wave contributes a pair of side frequencies to the spectrum. These side frequencies are located at equal distances on each side of the carrier, and they are spaced away from the carrier by the modulating frequency of the wave under study.

In frequency modulation, a single modulating tone will produce a carrier with an infinite number of side bands. Nevertheless, the spectrum will be symmetrical about the center frequency, as shown in Fig. 5.

Pulse modulation is a special case of amplitude modulation in which the carrier is on during selected intervals (pulses), and is off between these pulses. It is done to increase the ratio of peak to average power in the modulated wave as in pulsed radar or to encode a signal as in pulse code modulation (PCM).

Without going into the mathematical derivations, it is sufficient here to point out that the spectral display of a pulse-modulated carrier is that of a large magnitude *lobe* centered on the carrier's center frequency with side lobes of diminishing amplitude spaced equidistantly on either side of the center frequency, as shown in Fig. 6.

Graphic records

Figure 7 show a photograph of a 45.75 MHz, video-modulated, intermediate-frequency signal from a tuner, taken from an oscilloscope display. It can be seen that the modulation makes it impossible to freeze the display on this time-domain oscilloscope picture. Peak-to-peak voltage is the only measurement that can be accurately made.

Figure 7 also shows a spectrum analyzer presentation of the same waveform. It is now possible to recognize (reading from left to right) the audio subcarrier, the modulated 3.58 MHz chroma subcarrier, and the modulated video carrier with its sidebands. Because this is an IF output, the audio subcarrier is lower in frequency than the video signal.

From that waveform it is possible to measure the video carrier level, the audio carrier level below video, the frequency of the video carrier, and the frequency span from the video to the audio carriers. This is particularly important because an off-frequency audio subcarrier causes an annoying distortion on the TV screen called "beats."

With tedious adjustments and care, it might be possible to measure modulation depth, audio deviation, and signal-to-noise ratio. However, none of these can be measured with a conventional oscilloscope.

Basic control functions

Figure 8 shows the front face of a spectrum analyzer with a minimum number of controls. The input connector is usually placed on the front panel. The power switch typically has a lamp nearby to indicate if the power is on or off.

The controls includes knobs for setting waveform intensity, horizontal position, vertical sensitivity, vertical position, and sweep rate. A tuning knob sets the center frequency, which is displayed on a liquid crystal display panel. SCAN WIDTHS or SPAN (MHz/div) sets the scan width and REFERENCE LEVEL (dBm) sets reference level. Some instruments have a knob for setting for BANDWIDTH (BW—normal or wide).

The vertical axis is calibrated in amplitude. Most analyzers offer a choice of linear scale calibrated in volts or power, or a logarithmic scale calibrated in decibels. The log scale offers a much wider usable range. The top line of the graticule is normally assigned as the reference level, and scaling per division permits the assignment of values to other graticule locations. This permits the measurement of both the absolute signal value or the amplitude difference between any two signals.

The cost of spectrum analyzers has been declining over the past decade while their perfomance, efficiency and reliability has been improved. The availability of higher levels of integrated circuitry has permitted lower power consumption.

The battery-portable 2610 spectrum analyzer from B+K Precision, shown on the first page of this article, covers the frequency range of 1 MHz to 1 GHz. It offers a fixed 1 MHz bandwidth, regardless of scan width. This, B+K says, simplifies the observation of video, television, and cable television signals. This B+&K instrument is considered to be a general purpose analyzer.

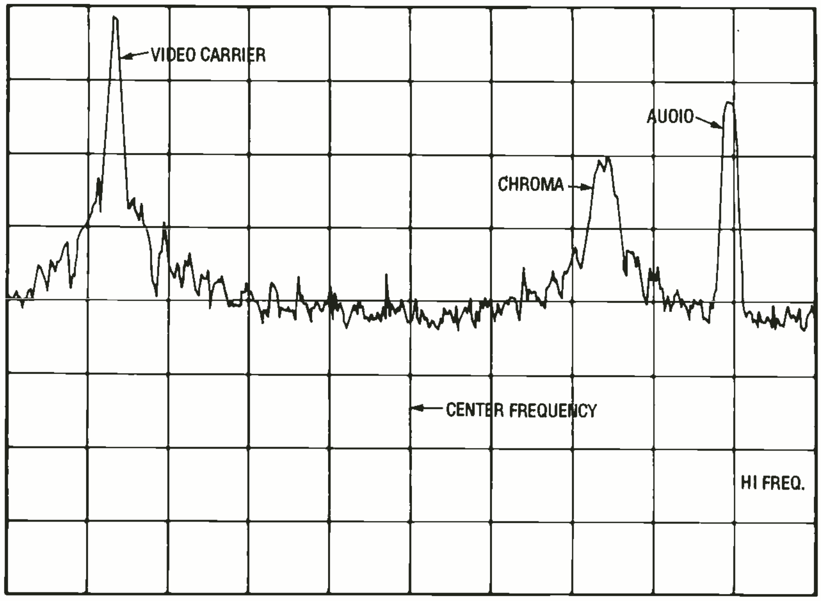


FIG. 9—THE STANDARD VIDEO CARRIER WAVEFORM (V) shown with its chroma (C), and audio (A) subcarriers at higher frequencies. Table 1 gives the basic settings.

TABLE 1
INITIAL SETTING ON SPECTRUM ANALYZER

Control	Abbrev.	Value	Units
1. Reference level	REF	9.3	dBmV
2. Attentuation		10.0	dB
3. Decibels/division		10.0	db/div.
4. Tune center freq.	CENTER	63.96	MHz
5. Residual bandwidth	RES BW	30.0	kHz
6. Visual bandwidth	VBW	30.0	kHz
7. Span	SPAN	6.0	MHz
8. Sweep rate	SWP	600	msec

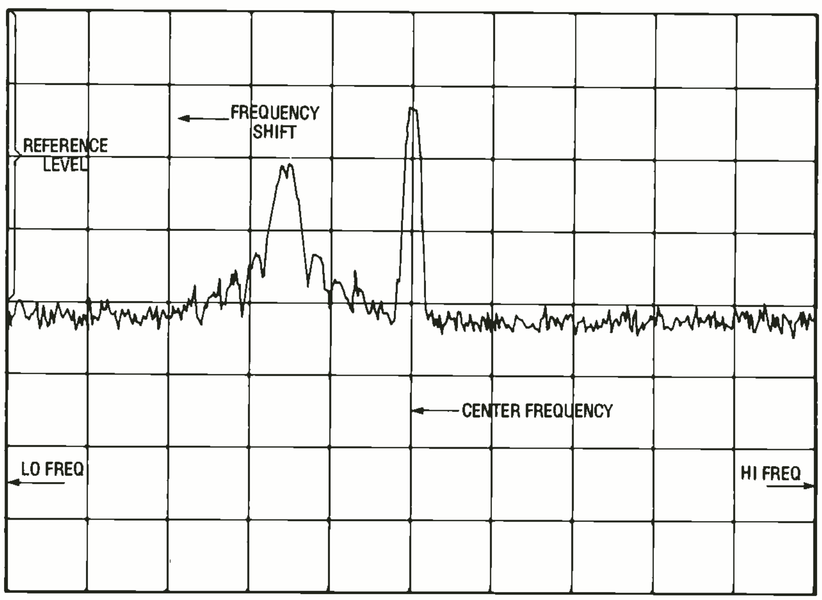


FIG. 10—RETUNING THE CENTER FREQUENCY from 63.96 to 66.33 MHz shifts the trace toward the higher frequency. All other settings remain the same.

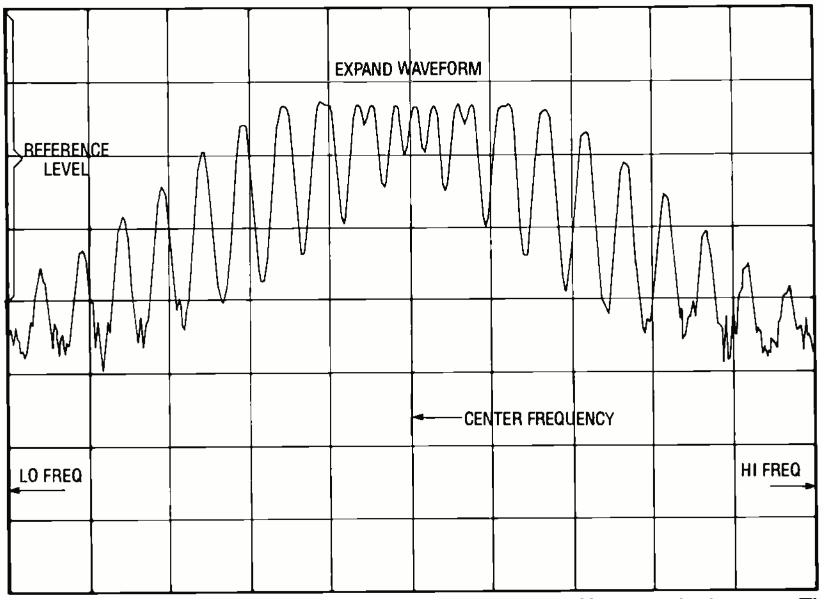


FIG. 11—DECREASING THE SPAN FROM 6.0 MHz to 200.0 kHz expands the trace. The center frequency has shifted from 66.33 to 66.31 MHz, and the sweep has decreased from 600 to 20 milliseconds. All other settings remain the same.

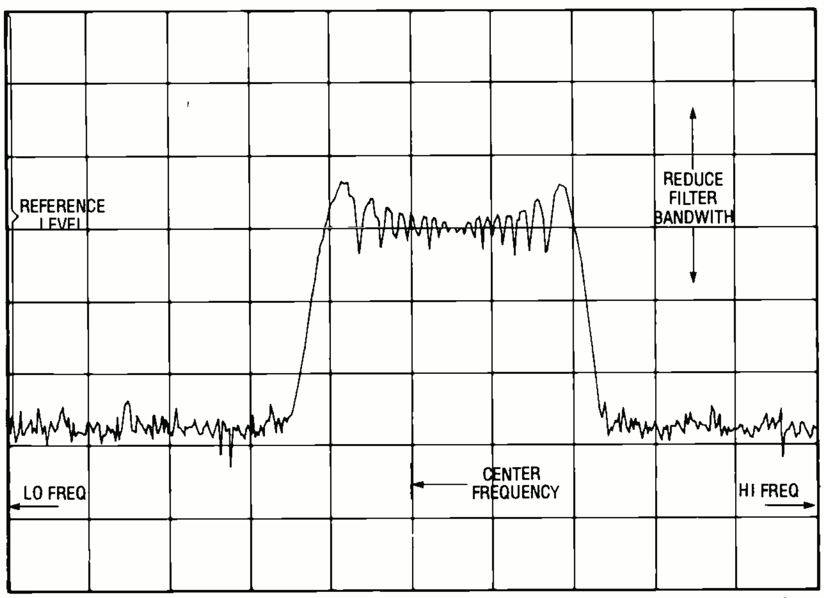


FIG. 12—DECREASING THE RESOLUTION BANDWIDTH from 30 kHz to 1 kHz shows the true amplitude of the sidebands. The sweep has increased from 20 milliseconds to 18 seconds. All other settings remain the same.

The high end of the market is represented by the 8593E from Hewlett-Packard. It is a spectrum analyzer that can make frequency measurements at 22 GHz. One of a family of HP spectrum analyzers, it is designed so that relatively unskilled operators can make routine specialized precision measurements on the factory floor just by pushing a few front-panel buttons.

Some of the high-end models include microprocessors which permit the display of alphanumeric legends on the CRT screen to verify settings. It also permits the selection of amplitude units on either log or linear scale.

Some models have movable cursors that can be located at any point on the displayed trace so that the frequency or amplitude values at that point will be displayed. Digital storage of the displayed waveform eliminates display flicker at the sweep rate. Pushbuttons have replaced control knobs on some models, and battery-portable analyzers are also becoming popular.

Advanced spectrum analyzers have provision for "personality cards," which, when inserted, dedicate the instrument to specific applications and minimize the number of settings and adjustments that must be made. This feature permits relatively unskilled operators to carry out precise production-line or laboratory measurements.

Control settings

The two basic settings that must be made when operating an oscilloscope are vertical volts per division and horizontal time (seconds) per division. Of course, other setting such as trigger level, horizontal and vertical position, and certain other enhancements will give the clearest possible waveform.

By contrast, when operating a spectrum analyzer, there are more required settings. These include the vertical reference level, horizontal center frequency, horizontal sweep time, and resolution bandwidth.

Some analyzers offer a choice of vertical reference level units. These include decibels referred to a milliwatt (dBm), to a nanovolt (dBnV), to a microvolt (dBμV), and to volts and watts. A choice can also be made between a 50-ohm and a 75-ohm input impedance.

Figure 9 is a rendering of an actual spectrum analyzer waveform of a radio-frequency video carrier reproduced with an X-Y plotter. Notice that because it is a radio-frequency signal and not an intermediate-frequency video signal, the carriers are in their normal positions—the audio has a higher frequency than the video signal. Table 1 gives the initial settings.

Referring back to the spectrum analyzer front-panel diagram, Fig. 8, the following information can be gained:

- *Reference level*—The reference level is given at the top of the graticule. All other voltage or power levels are below that maximum level. The REFERENCE LEVEL knob adjusts the input attenuator and IF gain so that the top graticule corresponds to the

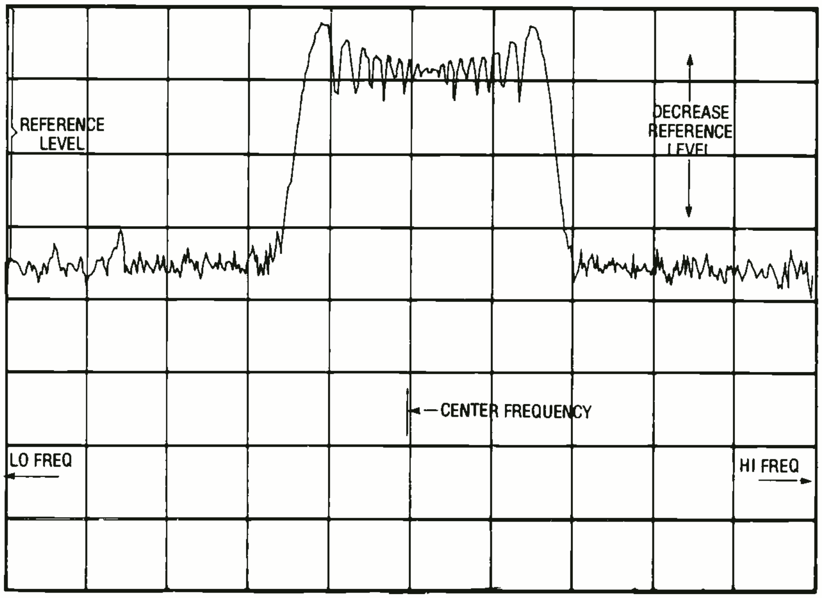


FIG. 13—DECREASING THE REFERENCE LEVEL from 9.3 dBmV to -12 dBmV elevates the waveform. All other settings remain the same.

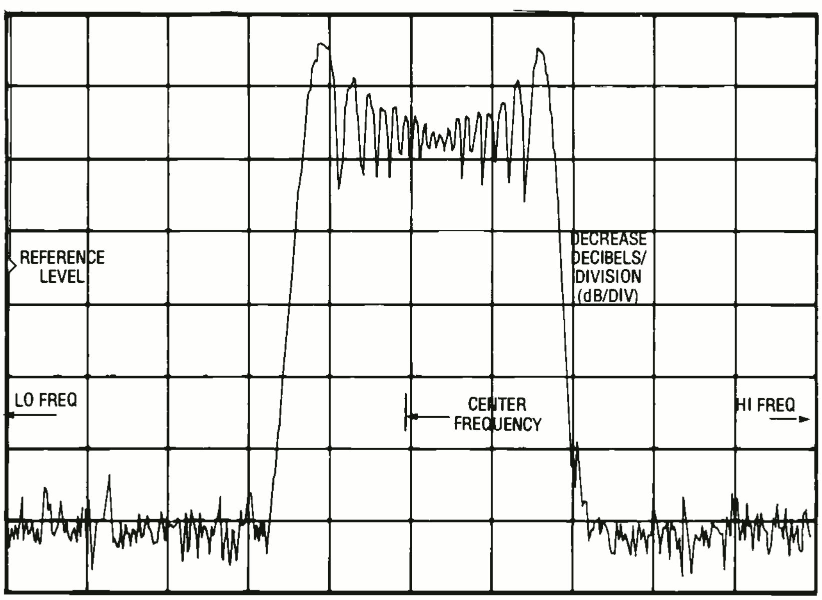


FIG. 14—DECREASING THE DECIBELS/DIVISION value from 10 to 5 dB/div amplifies the waveform. All other settings remain the same.

indicated signal level. Calibrations might be in dBm or dBmV.

• *Vertical sensitivity* or *scale*—selects the amplitude sensitivity of the graticule. Typical selections are 10 dB/div or 2 dB/div.

• *Tuning*—sets the mean or center frequency of the display. Some models display this value separately on a liquid-crystal display.

• *Span*—controls the width of the spectrum being displayed, and automatically selects a filter for optimum resolution. It is the difference between the low and high frequencies.

• *Low frequency*—A value that can be determined by subtracting half the value of the span from the center frequency.

• *High frequency*—A value that can be determined by adding half the value of the span to the center frequency.

• *Resolution bandwidth*: RES BW—A setting that is unrelated to signal amplification, but it affects the resolution of the waveform presentation.

• *Sweep rate*: SWP—controls the speed of the sweep across the CRT, typically measured in milliseconds. For most measurements the spectrum analyzer automatically selects the proper sweeptime.

With the instrument set up with the desired input signal, the first step is to center the audio subcarrier for a later setting of amplification and resolution. The easiest way to do this is to retune the center frequency upward to shift the display to the left as shown in Fig. 10.

If you want more information on the subcarrier, decrease the frequency span of the horizontal sweep without shifting the center frequency. (This can also be done by increasing the low frequency and decreasing the high frequency the same amount in the same direction.) The result is that the carrier expands as shown in Fig. 11.

The horizontal frequency per division has been decreased from 600 kHz/div to 20 kHz/div. The results of this adjustment are a decrease in SPAN from 6.0 MHz to 200.0 kHz, and a decrease of SWEEP from 600 to 20 milliseconds. Sweep time SWP is proportional to SPAN if the resolution bandwidth remains constant.

The spectrum analyzer should have as much selectivity or resolution as possible. This means that the bandpass filter should have as narrow a passband as practical. This calls for an engineering tradeoff: increased resolution increases sweeptime (SWP) because sweeptime is inversely proportional to the square of the resolution bandwidth.

Decreasing resolution bandwidth by half increases sweeptime by a factor of four. There is a practical limit because sweeptime would become excessive, measurable in tens of seconds rather than milliseconds. Fortunately, it is rare that there is ever a need for resolution so high that those unusual sweeptimes would be encountered. The rule is to keep sweeptime as fast as possible.

In the example given here, there is a need for increased res-

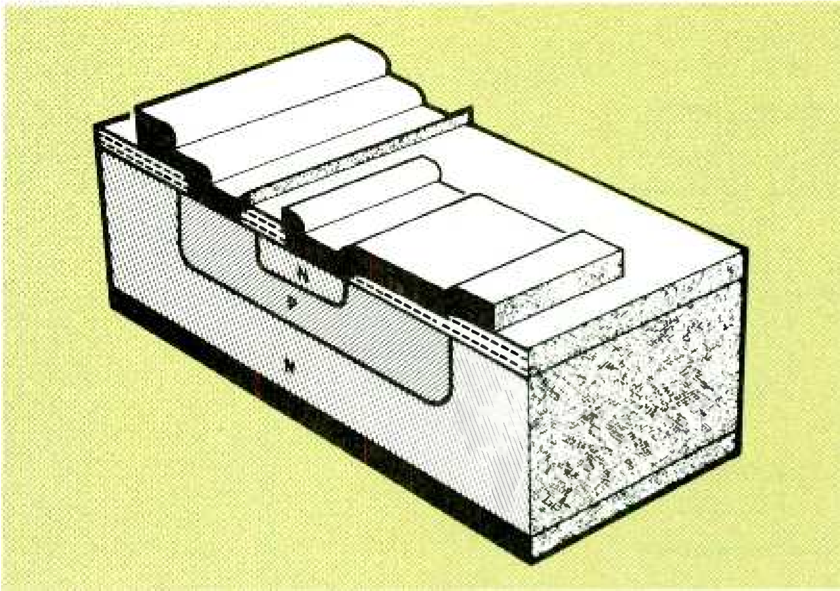
Continued on page 86

RAY MARSTON

THE BIPOLAR JUNCTION TRANSISTOR (BJT) triggered the revolution in modern solid-state electronics in the 1960's. Although the discrete small-signal BJT has since yielded to the integrated circuit in economic importance, it lives on in the form of discrete linear and switching power transistors as well as radio-frequency transistors into the microwave region.

The principles behind the operation of the BJT are important to the understanding of many of today's most popular linear and digital integrated circuits. Moreover, the transistors in the digital logic transistor families—TTL, Shottky TTL, and emitter-coupled logic (ECL) are BJT's.

This article focuses small-signal BJT's and practical circuits that can be made with them. They function either as a linear amplifiers or digital switches.



BIPOLAR TRANSISTORS

The bipolar junction transistor is the cornerstone of modern solid-state electronics. Learn (or review) the basics of this important active device.

The term bipolar junction transistor (BJT) distinguishes it from the junction field-effect transistor or JFET.

BJT basics

A BJT is a three-terminal (*base*, *emitter*, and *collector*) device. There are two types: NPN and PNP. Today both are typically made by the double-diffusion process that involves the deposition of two additional layers of doped silicon on a doped silicon wafer.

Figure 1-*a* shows the cross section of an NPN BJT. Its base and emitter terminals are metal depositions on top of the silicon wafer, and its collector is the metalized lower surface of the wafer. Figure 2-*a* shows the cross section of a PNP BJT. It is similar to the NPN BJT, except that the N- and P-type materials have changed places.

Figures 1-*b* and 2-*b* are the schematic symbols for the NPN and PNP transistors, respectively. Notice that they are the same except for the direction of the arrowhead within the symbol at the emitter terminal. This difference will be explained shortly.

The term *bipolar* means that the BJT's operation depends on the movement of two different carriers: *electrons* and *holes*. In NPN BJT's the electron is the *majority carrier* and the hole is the *minority* carrier. This situation is reversed in the PNP BJT.

By contrast, all field-effect transistors (JFET's and MOSFET's) depend upon the movement of only one carrier, either electrons or holes, depending on whether they are N-channel or P-channel devices, so they are technically *unipolar* devices. (For more information on this, see **Electronics Now**, April and May 1993.)

The voltage on the collector of the NPN BJT must be positive with respect to its emitter if current I_C is to flow. That current will increase with a positive bias on the base. Figure 3-*a* shows how a small input current applied at the base (I_B) of the NPN BJT can control I_C. The arrowhead indicates the direction of conventional current flow—collector to emitter. Note that it is in the same direction as the arrowhead in the symbol for the NPN transistor. (Electrons flow in the direction opposing the arrowhead.)

Similarly, the PNP transistor

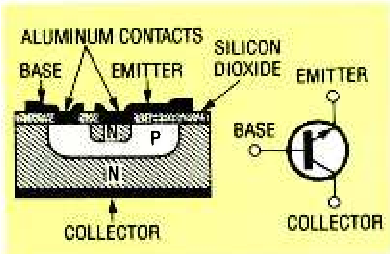


FIG. 1.—NPN BIPOLAR JUNCTION transistor section view (*a*), and graphic symbol (*b*).

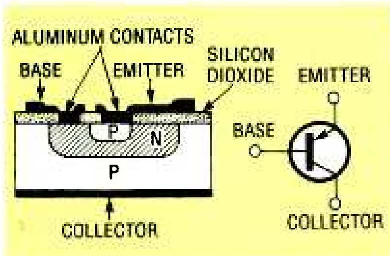


FIG. 2—PNP BIPOLAR JUNCTION transistor section view (*a*), and graphic symbol (*a*).

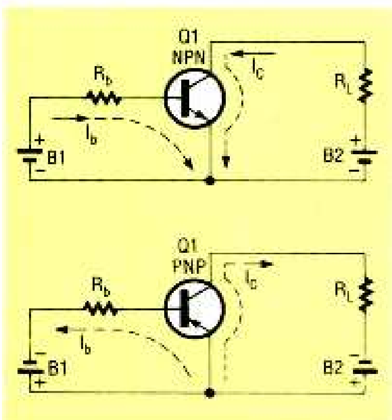


FIG. 3—CURRENT FLOW IN transistors: NPN (*a*), and PNP (*a*).

requires a negative collector supply with respect to its emitter to operate, and a negative base bias to increase conduction. Fig. 3-*b* shows conventional current flow in the PNP BJT from the emitter to the collector, as shown in the symbol for the NPN transistor, but opposite to that shown in Fig. 3-*a*.

Most of the common commodity NPN and PNP BJT's available from electronics distributors and retail stores have been standardized and are made by many different suppliers around the world. Table 1 lists the basic characteristics of two typical general-purpose, small-signal BJT's that are included in the projects discussed in this article: the 2N3904 NPN-type and the 2N3906 PNP-type. Both are packaged in small, three-pin plastic cylindrical TO-92 packages with flat faces.

Brief definitions for the parameters listed in Table 1 are:

- *Power dissipation* is the maximum *mean* power that the BJT can dissipate without an external heatsink, at normal room temperature, 25 °C.
- f_T is the *gain-bandwidth product*, the frequency at which the common-emitter forward current gain is unity.
- V_{CBO} is collector-base voltage (emitter open), the maximum voltage that can be impressed across collector and base when the emitter is open.
- V_{CEO} is the collector-emitter voltage (base open), the maximum voltage that can be impressed across collector and emitter when the base is open.
- $I_{C(max)}$ is the maximum *mean* current that should be allowed to flow through the collector terminal of the BJT.
- h_{FE} is the DC forward-current gain, the ratio of DC collector current to DC base current for a transistor in a common-emitter configuration

The gain-bandwidth product, the frequency at which common emitter forward current gain is unity, applies in the following way: If a transistor in a voltage-feedback circuit has a voltage gain of ×100, its bandwidth will be one hundredth of gain-bandwidth value. However if the voltage gain is reduced to ×10, the bandwidth will increase to that value divided by 10.

Transistor characteristics

A knowledge of the *static* and *dynamic* characteristics of BJT's will be useful in obtaining the optimum performance from the device. *Static* characteristics are values obtained when the device is in a test circuit and operated under DC conditions with the measurements made by an ohmmeter.

Figure 4-*a* shows the static equivalent circuit of an NPN BJT, and Fig. 4-*b* shows the static equivalent of a PNP BJT.

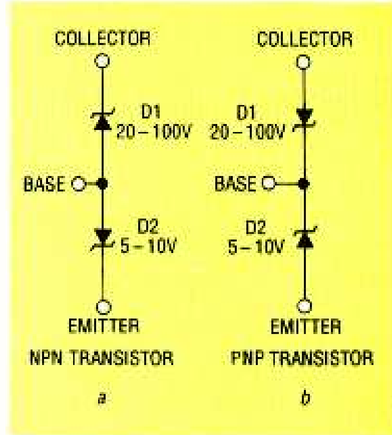


FIG. 4—STATIC EQUIVALENT CIRCUITS for a NPN BJT (*a*), and a PNP BJT (*b*).

Each device can be considered as equivalent to a pair of reverse-biased zener diodes in series between the collector and emitter terminals, with the base terminal connected to the common point between to the two zeners.

Examination of Figs. 1-*a* and 2-*a* shows that each BJT is really two diodes: the emitter and base form one PN diode with an emitter-base junction, and the base and collector form a second PN diode with a base-collector junction. When these diodes are properly biased, they reach an avalanche or zener breakdown point.

In most small-signal BJT's, the base-to-emitter junction has a typical zener value of 5 to 10 volts, while the base-to-collector junction has a typical zener value of 20 to 100 volts. Thus, if the base-to-emitter junction of the BJT is forward biased, it exhibits the characteristics of an ordinary diode. However, when reverse biased it exhibits the characteristics of a zener diode. The forward-biased junction in a silicon BJT blocks virtually all current until the bias voltage rises to about 600 millivolts.

Beyond that value the current will increase rapidly. When forward biased by a fixed current, the forward voltage of the junction has a temperature coefficient of about −2 millivolts per degree C. When the transistor is configured as an emitter open-circuited, the base-to-collector junction exhibits similar characteristics to those just described—except for a greater zener value.

If the transistor is configured with its base open-circuited, the collector-to-emitter path acts like a zener diode in series with an ordinary diode.

Dynamic characteristics

The dynamic characteristics of a BJT can be better understood by examining the typical common-emitter *collector characteristics* for a small-signal silicon NPN transistor shown in Fig. 5. Direct current collector current I_C is plotted on the *Y* axis, and DC collector-emitter voltage V_{CE} is plotted along the *X* axis.

A family of curves for different values of DC base current I_B is drawn on Fig. 5. Base current is plotted because the BJT is a *current-operated* device. As mentioned earlier, the base-emitter junction is forward biased for normal transistor operation. Base current flows and is a necessary variable for establishing the BJT's operating point.

Observe the following specific points on Fig. 5:

- When base current (I_B) is zero, the transistor conducts barely measurable collector *leakage* current.
- When the collector to-emitter voltage exceeds a few hundred millivolts, the collector current value is almost directly proportional to the base current value. It is only slightly affected by the actual collector voltage value. Thus, the transistor can perform as a constant-current generator by feeding a fixed bias current into the base.

The transistor can also perform as a linear amplifier by superimposing the input signal on a nominal input bias current. (This will be discussed in more detail later.)

Circuit applications

Even a simple small-signal BJT has many applications related to its ability to amplify or switch. Some of the most important and practical circuit designs are described here. With few exceptions, all of the circuits are based on the 2N3904 NPN transistor. (With certain minor component value changes, other NPN transistors can be substituted.) The circuits can also be made with a PNP transistor such as the 2N3906, if the polarities are altered.

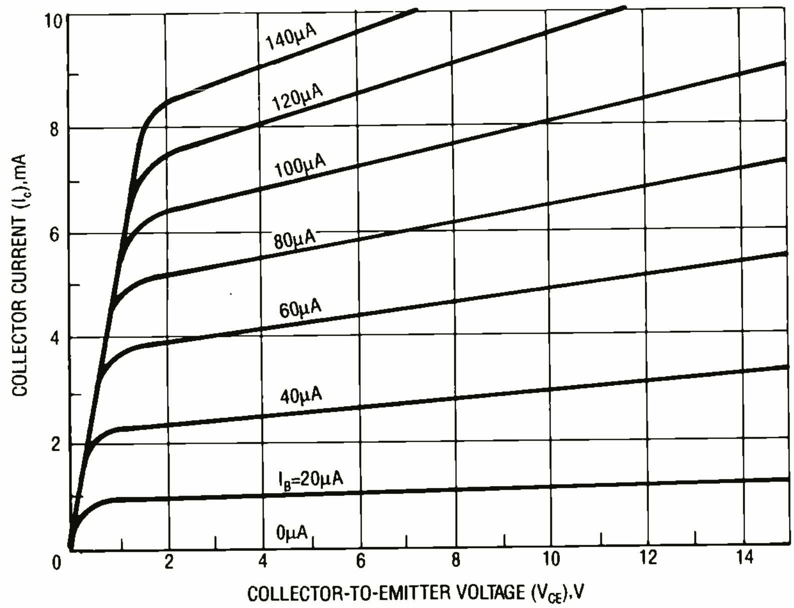


FIG. 5—TYPICAL COLLECTOR CHARACTERISTICS for an NPN bipolar transistor in a common-emitter configuration.

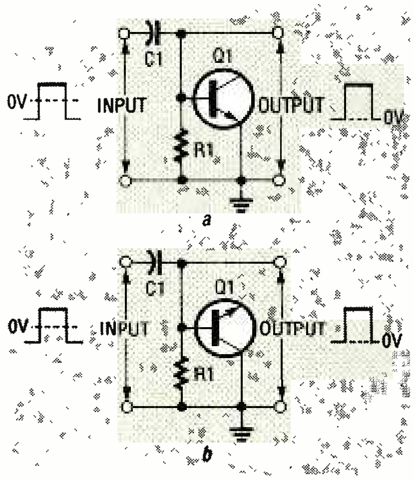


FIG. 6—A CLAMPING DIODE CIRCUIT with an NPN transistor acting as a diode.

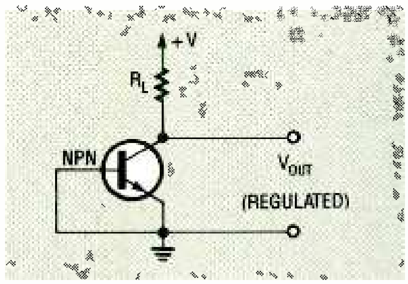


FIG. 7—A TRANSISTOR FUNCTIONING as a zener diode.

Diodes and switches.

It was explained earlier that both the base-emitter and base-collector junctions of a silicon BJT can be considered equivalent to a zener diode. As a result, either of these junctions can perform as a fast-acting rectifier diode or zener diode, depending on the bias polarity.

Figure 6 shows two alternative ways to make an NPN BJT perform as a diode in a *clamping* circuit that converts an AC-coupled rectangular input waveform into a DC square wave. The input AC waveform is symmetrical above and below the zero-voltage reference. However, the output signal retains the input's form and amplitude, but it is clamped to the zero-voltage reference.

If you build this circuit, use the base-collector terminals as the diode as in Fig. 6-*b* because they provide a larger zener voltage value than the circuit shown in Fig. 6-*a*.

Figure 7 shows how an NPN BJT can function as a zener diode in a circuit that converts an unregulated supply voltage into a fixed-value regulated output voltage. Typical values range from 5 to 10 volts, depending on

TABLE 1
RATINGS FOR THE 2N3904 NPN AND 2N3906 PNP TRANSISTORS

Variable	2N3904	2N3906
Material	silicon	silicon
Polarity	NPN	PNP
Power dissipation*	625 mW	350mW
Gain-bandwidth product, f_T	300 MHz	250 MHz
V_{CBO}	60 V	40 V
V_{CEO}	40 V	40 V
I_{Cmax}	200 mA	200 mA
h_{FE}	100 – 300	60
Case style	TO-92	TO-92

* 25°C (free air)

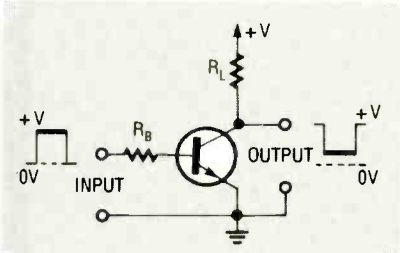


FIG. 8—A TRANSISTOR SWITCH or digital inverter.

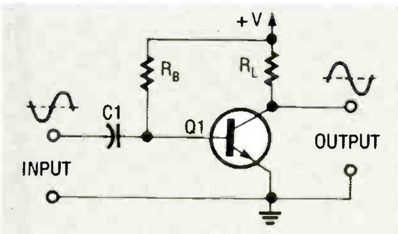


FIG. 9—A COMMON-EMITTER LINEAR amplifier.

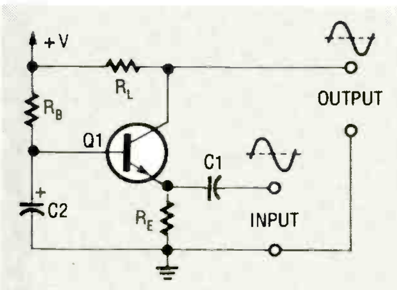


FIG. 10—A COMMON-BASE LINEAR amplifier circuit.

the characteristics of the selected transistor. The base-emitter junction is the only one suitable for this application.

Figure 8 shows a BJT functioning as a simple electronic switch or digital inverter. Here the base is driven through resistor R_B by a digital input step voltage that has a positive value. The load resistor R_L can be a simple resistor, a tungsten lamp filament, or a relay coil. Connect the load between the collector and the positive supply.

When the input voltage is zero, the transistor switch is cut off. Thus no current flows through the load, and the full supply voltage is available between the collector and emitter terminals. When the input voltage is high, the transistor switch is driven fully *on*. Maximum current flows in the load, and only a few hundred millivolts is developed between the collector and emitter terminals. Thus the output voltage signal is the inverted form of the input signal.

Linear amplifiers.

A BJT can function as a linear current or voltage amplifier if a suitable bias current is fed into its base, and the input signal is applied between a suitable pair of terminals. A transistor amplifier can be configured for any of three operating modes: *common-emitter* (Fig. 9), *common-base* (Fig. 10), and *common-collector* (Fig. 11). Each of these modes offers a unique set of characteristics.

In the common-emitter circuit of Fig. 9, load resistor R_L is connected between the collector and the positive supply, and a bias current is fed into the base through R_B. The value of R_B was selected so that the collector takes on a quiescent value of

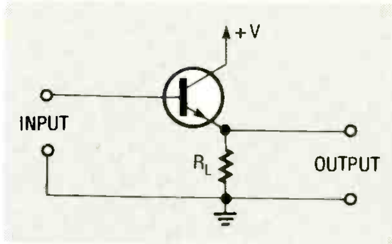


FIG. 11— A DC COMMON-COLLECTOR linear amplifier or voltage follower.

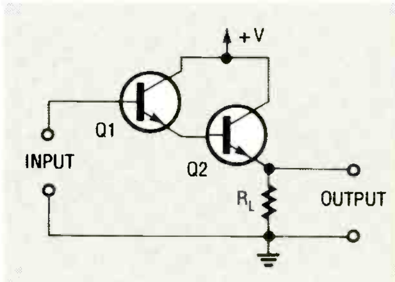


FIG. 12—DARLINGTON DC EMITTER-follower.

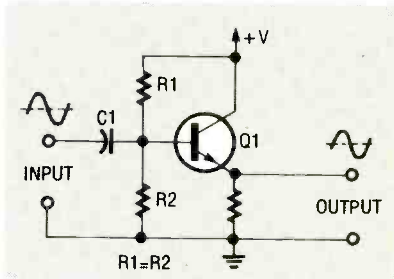


FIG. 13—AN AC COMMON-COLLECTOR amplifier.

about half the supply voltage (to provide maximum undistorted output signal swings).

The input signal in the form of a sine wave is applied between the base and the emitter through C1. The circuit inverts the phase of the input signal, which appears as an output between the collector and emitter. This circuit is characterized by a medium-value input impedance and a high overall voltage gain.

The input impedance of this amplifier is between 500 and 2000 ohms, and the load impedance equals R_L. Voltage gain is the change in collector voltage divided by the change in base voltage (from 100 to about 1000). Current gain is the change in collector current divided by the change in base current or h_{FE}

In the common-base linear

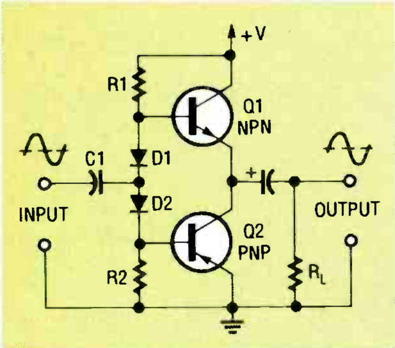


FIG. 14—COMPLEMENTARY OR bilateral AC emitter- follower circuit.

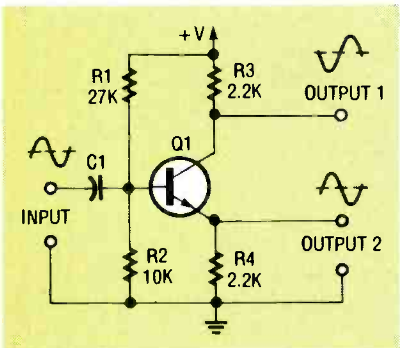


FIG. 15—PHASE-SPLITTER circuit.

amplifier circuit of Fig. 10, the base is biased through R_B and AC-decoupled (or AC-grounded) through C_B. The input signal is applied between the emitter and base through C1, and the amplified but non-inverted output signal is taken from between the collector and base. This amplifier offers very low input impedance, and output impedance equal to the resistor R_L. Voltage gain is from 100 to 1000, but current gain is near-unity.

In the common-collector linear amplifier circuit of Fig. 11, the collector is connected directly to the positive voltage supply, placing it effectively at ground impedance level. The input signal is applied directly between the base and ground (collector), and the non-inverted output signal is taken between the emitter and ground (collector).

The input impedance of this amplifier is very high; it is equal to the product of h_{FE} and the load resistance R_L. However, output impedance is very low. The circuit's overall voltage gain is near-unity, and its output

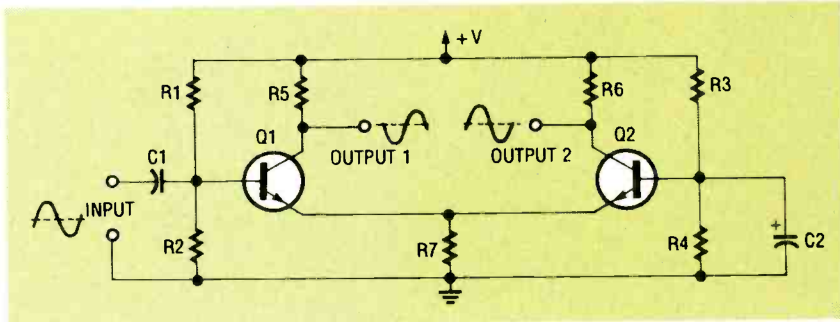


FIG. 16—LONG-TAILED PAIR PHASE-splitter.

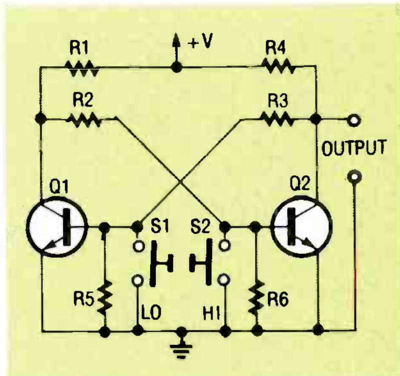


FIG. 17—FLIP-FLOP OR BISTABLE multivibrator with pushbutton triggering.

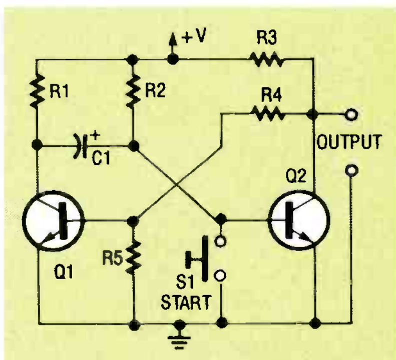


FIG. 18—MONOSTABLE multivibrator with pushbutton triggering.

voltage is about 600 millivolts less than the input voltage. As a result, this circuit is known as a *DC-voltage follower* or an *emitter-follower*.

A circuit with very high input impedance can be obtained by replacing the single transistor of the amplifier of Fig. 11 with a pair of transistors connected in a *Darlington* configuration, as shown in Fig. 12. Here, the emitter current of the input transistor feeds directly into the base of the output transistor with an overall h_{FE} value equal to the product of the values for the individual BJT's.

For example, if each BJT has an h_{FE} of 100, the pair acts like a single transistor with an h_{FE} of 10,000. Darlington BJT's with two transistors on a single chip (considered to be a discrete device) are readily available for power amplification.

The voltage-follower circuit of Fig. 11 can be modified for an alternating current input by biasing the transistor base with a value equal to half the supply voltage and feeding the input signal to the base. Figure 14 shows how this particular circuit is structured.

The emitter-follower circuits of Figs. 12 to 14 can *source* or feed relatively high currents into an external load through the emitter of the transistor. However, those circuits cannot *sink* or absorb high currents that are fed to the emitter from an external voltage source because the emitter is reverse-biased under this condition. As a result, these circuits have only a *unilateral* output capability.

In many applications (such as audio amplifier output stages), a bilateral output characteristic is essential. A bilateral amplifier has equal sink and source output capabilities. This is obtained with the *complementary* emitter-follower circuit of Fig. 14. The series-connected NPN-PNP transistor pair is biased to give a modest quiescent current through the network consisting or resistors R1 and R2 and diodes D1 and D2. Transistor Q1 can provide large source currents, and Q2 can absorb large sink currents.

Phase-splitters

Transistor linear amplifiers can be used in active filters or oscillators by connecting suitable feedback networks between their inputs and outputs. Phase splitting is another useful linear amplifier application. It provides a pair of output signals from a single input signal; one is in phase with the input phase, and the other is inverted or 180° out of phase. Figures 16 and 17 show these alternative circuits.

In the circuit shown in Fig. 15, the BJT is connected as a common-emitter amplifier with nearly 100% negative feedback applied through emitter resistor R4. It has the same value as collector resistor R3. This configuration provides a unity-gain inverted waveform at output 1 and a unity-gain non-inverted waveform at output 2.

The phase-splitter circuit shown in Fig. 16 is known as a *long-tailed pair* because the two BJT's share common-emitter feedback resistor R7. An increasing waveform applied at the base of transistor Q1 causes the voltage to increase across resistor R7, reducing the bias voltage on transistor Q2. This results in the generation of an inverted waveform at the collector of Q1 (at output 1), and an in-phase waveform at the collector of Q2, (at output 2).

Multivibrators.

Figures 17 to 20 show BJT's in the four different kinds of multivibrator circuit: *bistable, astable, monostable, and Schmitt trigger.*

The bistable multivibrator is a simple electronic circuit that has two stable states. It is more often known as the *flip-flop*, but is also called a *binary multivibrator*, or an *Eccles-Jordan circuit*. The circuit is switched from one state to the other by a pulse or other external signal. It maintains its state indefinitely unless another input signal is received.

Figure 17 is a simple, manually-triggered, cross-coupled bistable multivibrator. The base bias of each transistor is obtained from the collector of the other transistor. Thus one transistor automatically turns OFF when the other turns ON, and

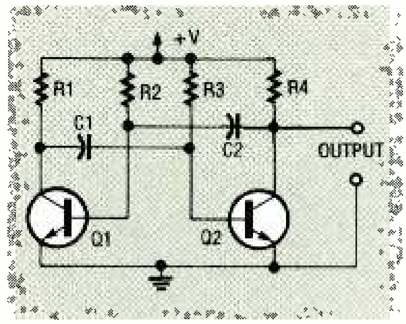


FIG. 19—ASTABLE MULTIVIBRATOR or free-running square-wave oscillator.

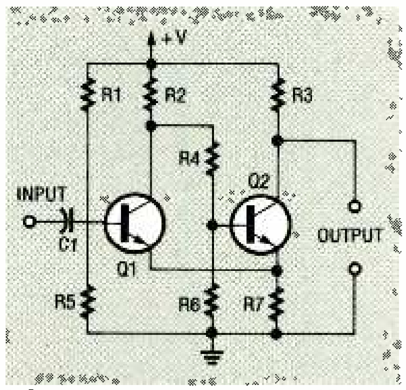


FIG. 20—SCHMITT TRIGGER OR sine-to-square wave generator.

this cycle can be continued indefinitely as long as it is powered.

The output of the multivibrator in Fig. 17 can be driven low by turning off transistor Q2 with switch S2. The circuit remains "locked" or stable in this state until transistor Q1 is turned off with switch S1. At that time, the output is locked into its high state, and the process is repeated. It can be seen that this action makes it a simple digital memory circuit that holds its state until manually or electronically switched.

Figure 18 is the schematic for a *monostable multivibrator* or *one-shot* pulse generator. It has only one stable state. The output of this circuit, a manually triggered version, is normally low, but it switches high for a period determined by the values of capacitor C1 and resistor R2 if transistor Q1 is turned off with switch S1. It then returns to its original state.

The pulse-duration time of the monostable multivibrator can be determined from the equation:

$T = 0.69\ RC$

Where: T is in microseconds, R is in ohms, and C is in microfarads

Monostable multivibrators are used as pulse generators and sweep generators for cathode-ray tubes.

Figure 19 is the schematic for an *astable multivibrator* or free-running, square-wave oscillator. The transistors are in a common-emitter configuration so that the output of one is fed directly to the input of the other. Two resistance-capacitor networks, R3 and C1, and R2 and C2, determine the oscillation frequency.

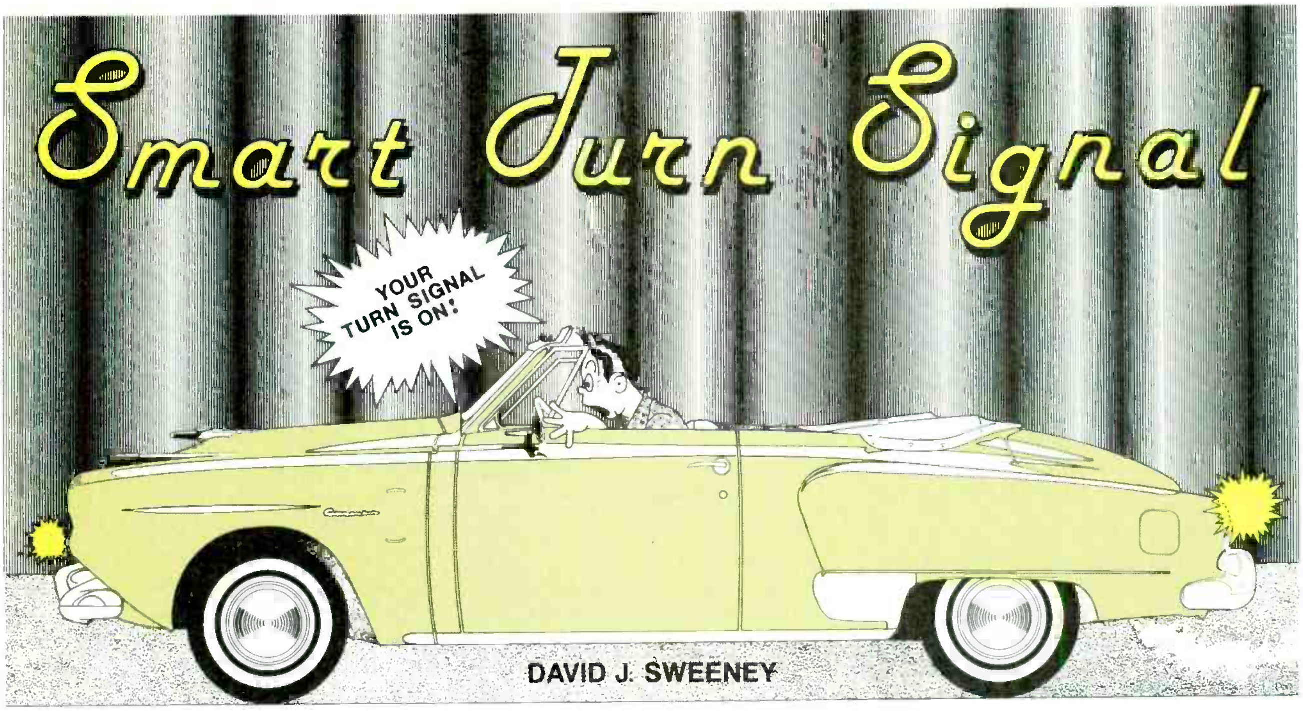
The output of each transistor is 180° out of phase with the input. An oscillating pulse might begin at the base of Q1. It is inverted at the collector of Q1 and is sent to the base of Q2. It is again inverted at the collector of Q2 and therefore returns to the base of Q1 in its original phase. This produces positive feedback, resulting in sustained oscillation.

The astable multivibrator is frequently used as an audio oscillator, but is not usually used in radio-frequency circuits because its output is rich in harmonics.

Figure 20 is a schematic for a *Schmitt trigger*, a form of bistable multivibrator circuit. It produces rectangular waves, regardless of the input waveform. The circuit is widely used to convert sine waves to square waves where there is a requirement for a train of pulses with constant amplitude.

The Schmitt trigger circuit remains off until the rising input waveform crosses the preset threshold trigger-voltage level set by the values of resistors R1 and R2. When transistor Q1 is switched ON, transistor Q2 is switched OFF and, the Schmitt trigger's output voltage rises abruptly.

When the input signal falls back below its drop-out level, Q1 switches OFF and Q2 switches ON. The output voltage of the Schmitt trigger drops to zero almost instantly. This cycle of events will then be repeated indefinitely, as long as the input signal is applied. Ω



Avoid potential road hazards, as well as potential embarrassment, with the Smart Turn Signal.

EVERYONE WHO DRIVES A CAR OCcasionally forgets to shut off the turn signal. That sends the wrong message to other vehicles and could cause an accident. At the very least, other drivers will assume that there's an idiot at the wheel of a car whose turn signal continues flashing long after the turn has been made. An electronic turn-signal alert, able to remind the driver that his turn signal is continuing to flash, could prevent an accident or at least save the driver some embarrassment.

We have a circuit that is sure to be welcomed by drivers worldwide. It sounds a warning signal whenever a blinker has been left on for more than 15 seconds. If, however, a blinker is left on while the driver is waiting to make a turn, that warning signal would become more annoying than helpful. In that case the Smart Turn Signal remains silent. Also, when the warning signal sounds, it starts off softly, and then gets louder, in the event that road noise prevents the driver from hearing the alarm.

The Smart Turn Signal, or STS, is easy to install in any car because it connects only to the contacts on a typical automotive flasher and to the brake-pedal switch—one need not interfere with the car's wiring.

A typical flasher

Figure 1 shows a representative schematic for a typical automotive flasher. When you operate the turn signal, the heating element and 50-ohm resistance wire are connected in series with the turn-signal lamps. With a 50-ohms resistor in series, the lamps will not light. As current passes through the heater element it warms up, heating the bimetallic contacts which then close (the clicks you normally hear from a flasher), bypassing the resistance wire and heater. That's when the turn signal lamps are lit. The bypassed heater element then cools, allowing the bimetallic contacts to open, reconnecting the heater and resistor wire in series with the bulbs. The process repeats as long as the flasher remains connected in the circuit through the driver's turn-signal control switch. To add delayed, dynamically varying sound to the turn signals, you can add the Smart Turn Signal circuit to a standard flasher circuit.

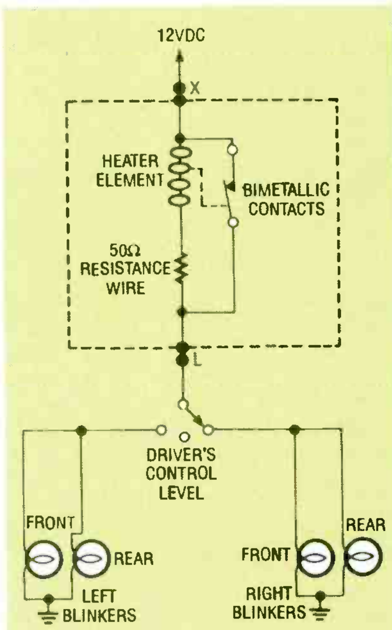


FIG. 1—A TYPICAL AUTOMOTIVE flasher. Initially the heating element and a 50-ohm resistance wire are in series with the turn signal lamps so they do not light. When the heater element warms up, the bimetallic contacts close and bypass the resistance wire and heater, allowing the lamps to light. The bypassed heater element then cools, allowing the bimetallic contacts to open.

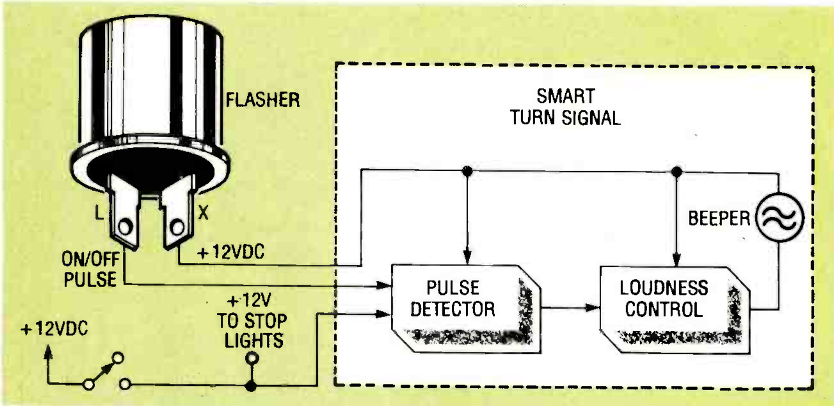


FIG. 2—Flasher terminal L connects to the load and X connects to the 12-volt supply. When the driver engages the turn signal, the L terminal voltage varies with the blinking lights. The STS senses the changing voltage and, after 15 seconds, it applies power to a buzzer through a current-limiting device to control loudness.

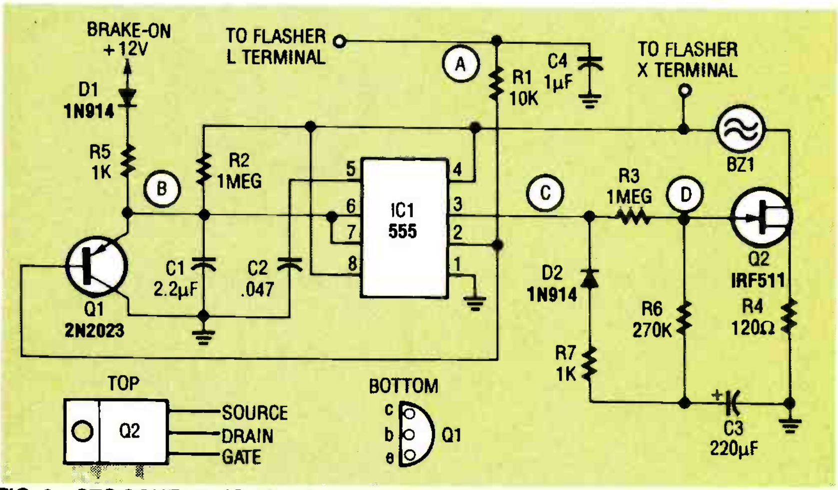


FIG. 3—STS SCHEMATIC. The Q2 gate voltage increases with the charge on C3. After 15 seconds of charging, the buzzer will warble. As the charging continues, the sound will grow louder.

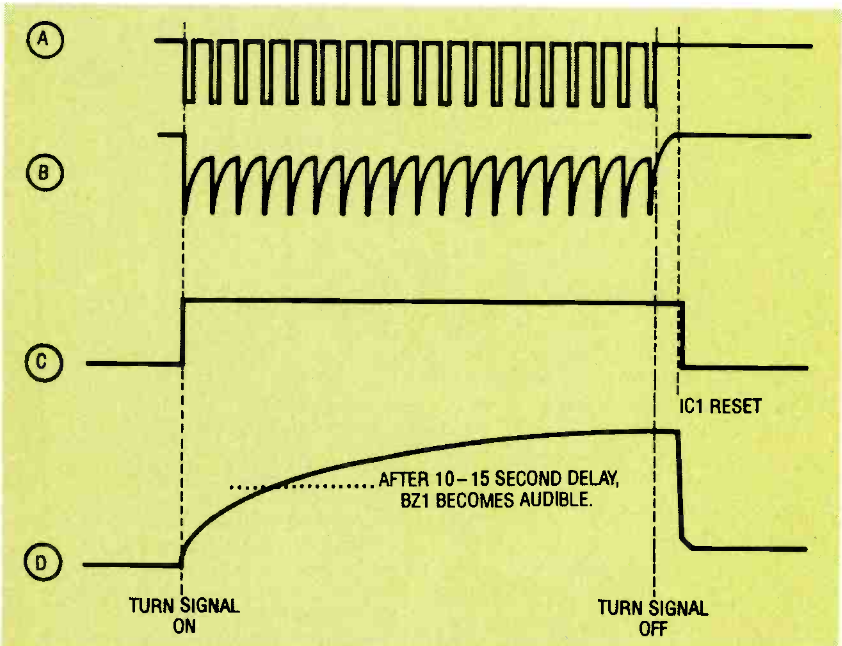


FIG. 4—CIRCUIT WAVEFORMS. Point A shows the signal from the flasher. The voltage at point D will increase as long as the pin-3 output of IC1 (point C) remains high. The C1-R2 time constant (point B) determines how long the output will be high.

Figure 2 shows how the STS and flasher work together. Flasher connections are usually labeled L and X, where L connects to the load and X connects to the vehicle's 12-volt supply. The L connection remains at 12 volts until the driver engages the turn signal. The voltage then varies with the blinking lights. The STS senses that changing voltage, unless the brake is applied, and applies power to a buzzer through a current-limiting device to control loudness. The buzzer's loudness varies with current.

Circuit operation

Figure 3 is the schematic diagram for the STS. In order for the buzzer (BZ1) to sound, Q2 must be turned on. As the voltage at point D (Q2's gate) increases, the current through BZ1 increases, with a resulting increase in loudness. The Q2 gate voltage increases with the charge on C3. To charge C3, pin 3 of IC1, a 555 timer, switches from low to high when the first pulse from the turn signal is applied to pin 2 of IC1. With the values shown for R3 and R6, the initial voltage at Q2's gate will be nearly sufficient to sound the buzzer. After C3 charges for 15 seconds, the voltage will be high enough for the buzzer to warble and, as the charging continues, the sound will grow louder.

Figure 4 shows some of the waveforms at various points in the circuit. Notice that the voltage at point D continues to increase as long as the pin-3 output of IC1 remains high. When the output goes low, C3 rapidly discharges through D2. The 555 timer (IC1) operates as a one-shot multivibrator, where a negative going input to pin 2 causes pin 3 to go high, until C1 charges through R2. The C1-R2 time constant determines how long the output would be high, and is set to about 2 seconds with the values shown. To keep the 555 output high, transistor Q1 operates as a missing-pulse detector (see **Electronics Now**, November, 1992). While the first negative pulse from the flasher sets pin 3 of IC1 high, later pulses turn on Q1, which shorts

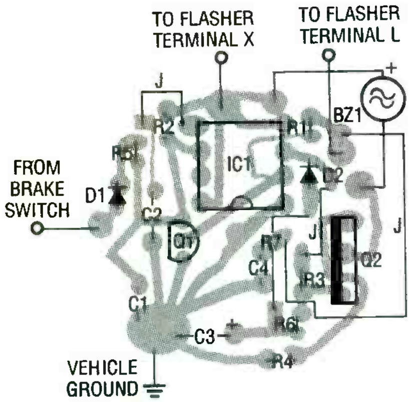
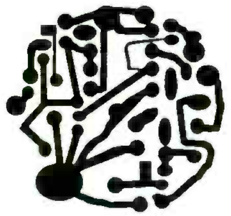


FIG. 5—PARTS-PLACEMENT DIAGRAM. You must make your own circuit board if you want to use one, as they are not for sale. Otherwise use perforated construction board.



1⅛ INCH

STS FOIL PATTERN.

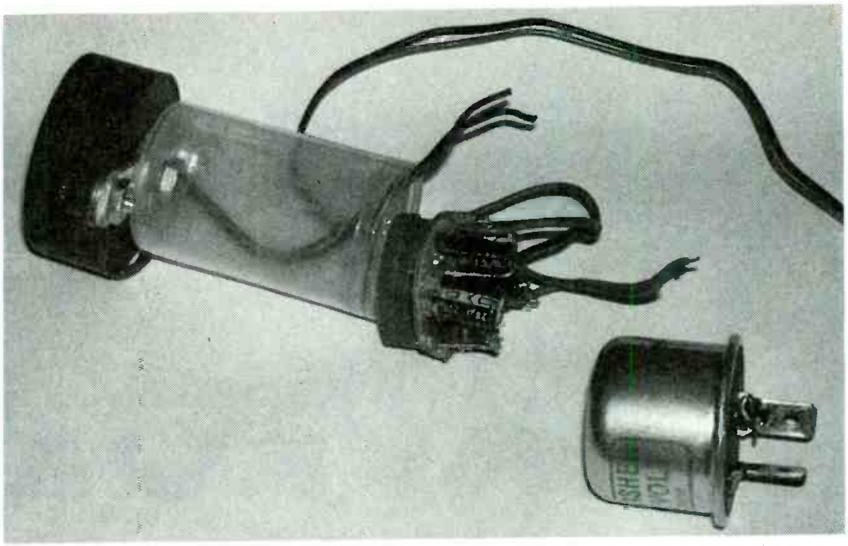


FIG. 6—YOU CAN PACKAGE THE UNIT in a 35 mm film canister which takes advantage of the size and shape of standard turn-signal flashers, as well as the STS PC board.

C1 and restarts the charging cycle. As long as the turn signal operates, the pulses continue to keep C1 discharged and pin 3 high.

When the driver's foot is on the brake pedal, 12 volts is applied to the anode of D1. Capacitor C1 then quickly charges through R5, resetting IC1 after every turn-signal pulse, and the buzzer does not sound.

Packaging

The STS circuit can be assembled on one small PC board. We've provided the foil pattern in case you want to make your own. See the parts-placement diagram in Fig. 5. All parts are mounted vertically on the board. Also note that a few jumpers, marked "J," must also be installed on the component side of the circuit board; use insulated wire for the jumpers to avoid any possible shorting on the small board.

Because this project will be operating in your motor vehicle, extreme care should be taken to produce a reliable, quality device. A failure could result in annoying beeping or in a short circuit to the turn-signal flasher. To package the unit, use a solid, weather-tight case, such as the 35 mm film canister shown in Fig. 6. The cylindrical packaging takes advantage of the size and shape of standard turn-signal flashers, which fit snugly in plastic 35 mm canisters. The STS PC board is also circular, and sized to fit inside a film canister. The buzzer is mounted on the base of the film can.

FIG. 7—THE STS FLASHER plugs into the original flasher socket.

PARTS LIST

All resistors are ¼-watt, 5%.
R1—10,000 ohms
R2, R3—1 megohm
R4—120 ohms
R5, R7—1000 ohms
R6—270,000 ohms

Capacitors
C1—2.2 µF, electrolytic
C2—0.047 µF
C3—220 µF, electrolytic
C4—1 µF, electrolytic

Semiconductors
IC1—555 timer
D1, D2—1N914 diode
Q1—2N2023 PNP transistor
Q2—IRF511 FET

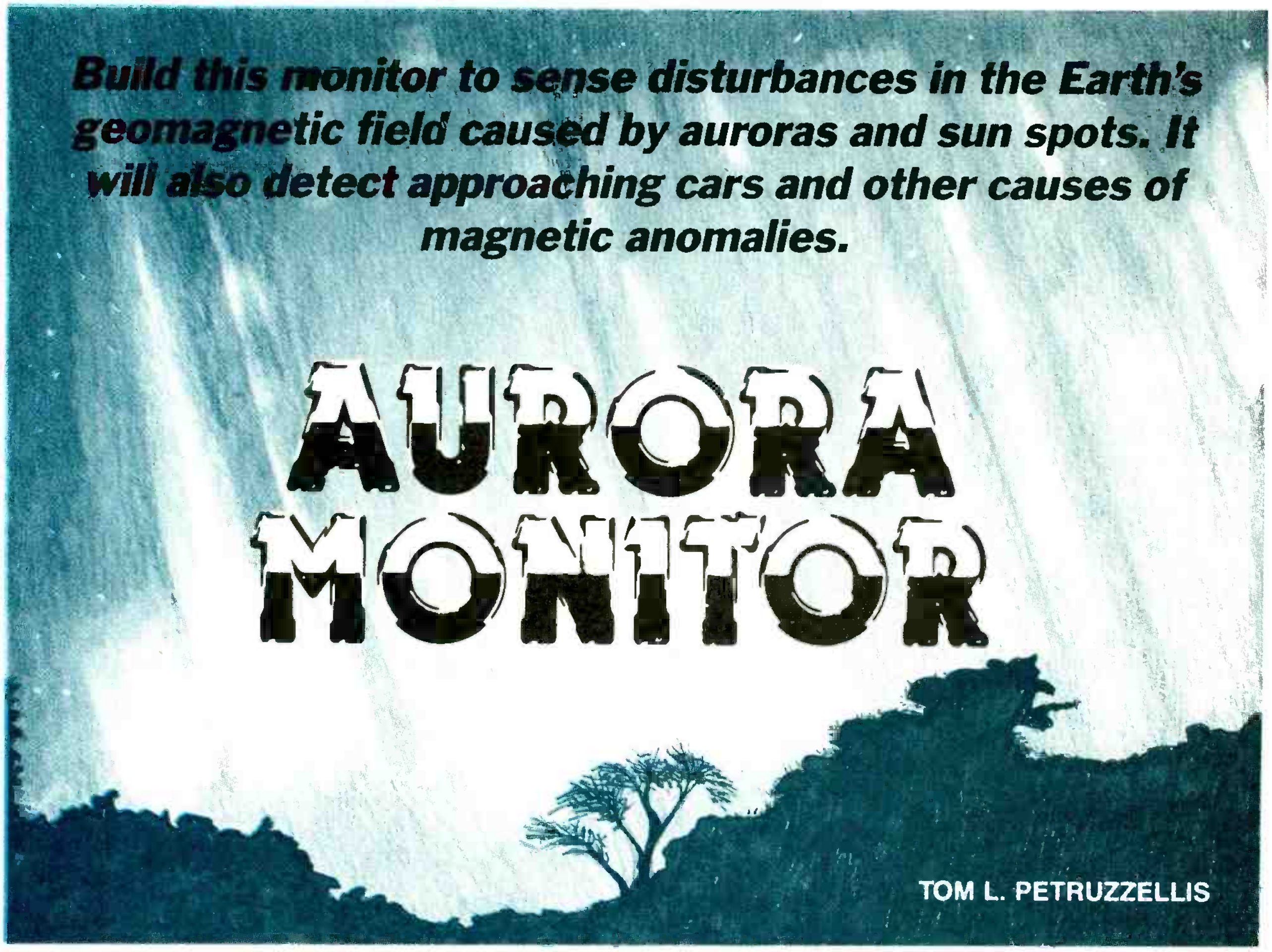
Other components
BZ1—Piezoelectric buzzer (Radio Shack RS273-066 or equivalent)

Miscellaneous: PC board, turn-signal flasher, 35 mm film canister or other suitable case, wire, solder.

Drill the holes in the film can for the wires. Make all connections to the flasher directly to the prongs, as close to the body of the flasher as possible. A separate ground wire will be necessary. If your car has a three-prong flasher, one prong will provide a ground connection.

It should take only a few minutes to install the STS flasher in your car. It plugs into the original flasher socket as shown in Fig. 7. If the STS fails to work when installed, switch the wires connected to the flasher prongs.

If, when you go to install the smart turn signal in your car, you find that it's too tight under your dashboard to fit the entire unit as one assembly, simply run leads to the flasher terminals and mount the rest of the unit wherever you find room. Just make sure the circuit is well protected and mounted where it won't interfere with anything else. Ω



Build this monitor to sense disturbances in the Earth's geomagnetic field caused by auroras and sun spots. It will also detect approaching cars and other causes of magnetic anomalies.

AURORA MONITOR

TOM L. PETRUZZELLIS

THE AURORA BOREALIS IS ONE OF nature's most spectacular nighttime displays. Shimmering curtains of green, white, and even red light dance in the northern skies. Visible effects of charged particles from the sun raining down on the Earth's ionosphere, northern lights or auroras, are visible in the northern night sky during high sunspot activity. The Aurora Australis, the southern hemisphere's counterpart of the Aurora Borealis, can be seen at night by looking toward the south pole.

These displays of undulating light are formed when flares from the sun's surface (sunspots) launch showers of high-energy ionized particles and X-rays into space. Mostly electrons, the showers stream out from the sun and are attracted by the Earth's magnetosphere, an invisible magnetic field around the Earth.

Shaped like an pumpkin, the magnetosphere terminates at both magnetic poles but is many miles thick above the equator. Dimples at both poles form "sinks" that funnel the particles toward the poles where they ionize the gas in the ionosphere. Those collisions induce the gases to emit their characteristic light wavelengths—as in neon signs and fluorescent lamps.

The charged particle bombardment of the magnetosphere initially compresses it, temporarily increasing the strength of the Earth's geomagnetic field. The aurora monitor described here is sensitive enough to detect changes in the field caused by those "magnetic storms." Thus it can indirectly sense sunspots and predict the presence of auroras in the night sky.

The monitor also senses changes or anomalies in the magnetic field caused by large metal objects such as cars or trucks moving near the monitor. This permits it to act as an intrusion detection monitor able to detect the approach of vehicles at night in restricted areas. The monitor can also detect the presence of permanent magnets (such as those in speakers), and stray fields from AC-power lines.

Early warning of auroras will both permit you to observe them in the night sky or use them for boosting the range of your amateur radio transmissions. Auroras and their accompanying magnetic storms generally block or scramble the lower radio frequencies, but the higher frequencies can overcome this interference. Radio amateurs aim their antennas north during those storms, thus taking advantage of the phenomena to reach other hams on the opposite side of the Earth that could not be contacted during periods of low sunspot activity.

In addition to scrambling low-frequency radio communications, the magnetic storms

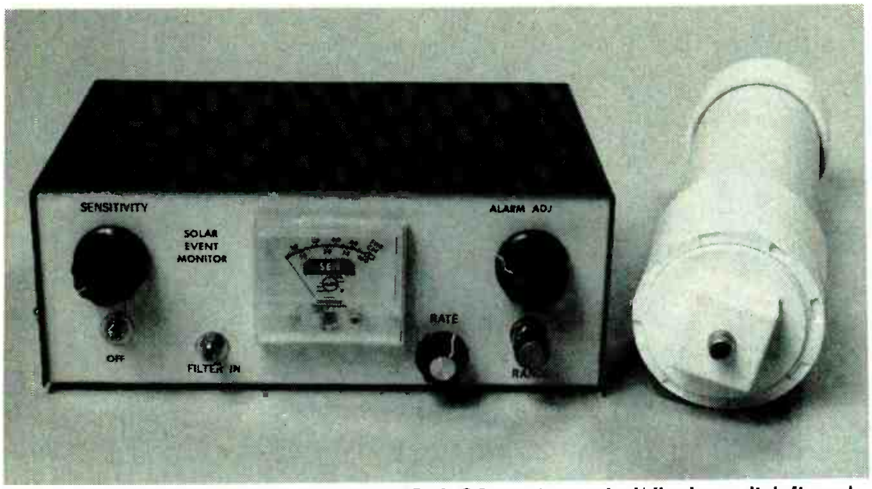


FIG. 1—THE TWO PARTS OF AURORA MONITOR are the control/display unit, left, and the sensor head, right.

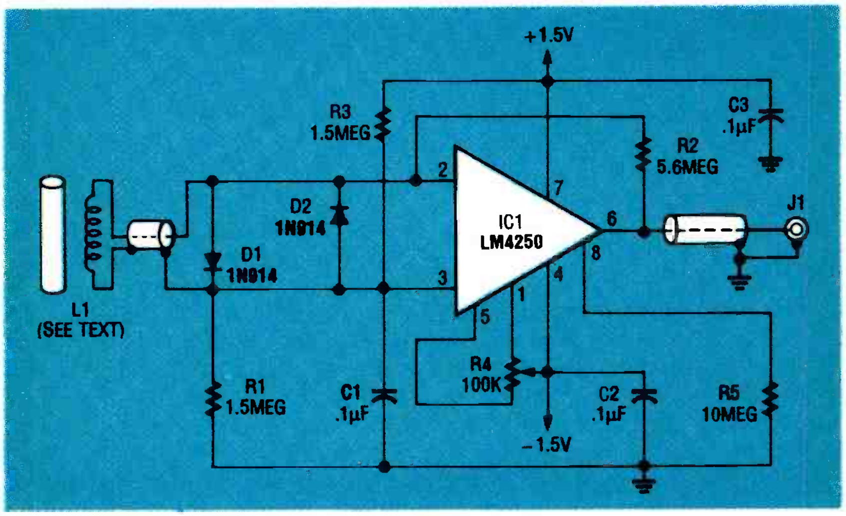


FIG. 2—SCHEMATIC FOR THE SENSOR HEAD circuit.

caused by auroras can induce large currents in power transmission lines. Those currents can cause overload, plunging large regions of the country into darkness. Auroras and related magnetic storms are quite common during the decreasing parts of the 11-year sunspot cycle such as the period we are now in.

Detecting magnetic activity.

Figure 1 shows the author's prototype Aurora Monitor. It is sensitive to a pulse of one ampere at distance of one meter, which corresponds to one milligauss. (The Earth's magnetic field is about 0.5 gauss.)

The Aurora Monitor has two components—the sensing head and the control/display unit which are connected by a coaxial cable. The sensing head contains a sensing coil, a DC nano amplifier capable of current amplification of 500, and a separate power pack, all enclosed the tubular case shown on the right side of Fig. 1.

The control/display unit contains an active filter, additional amplification circuitry, a moving-coil ammeter, and an audio oscillator with speaker. Figure 1 shows the front-panel controls and indicators of the monitor: moving-coil ammeter, SENSITIVITY, RATE, and ALARM ADJUST potentiometers as well as power (OFF), filter-in and RANGE switches.

How the sensor head works

Refer to the sensor circuit schematic, Fig. 2. Gain is provided by IC1, a National Semiconductor LM4250 programmable operational amplifier. It is protected from overvoltage and transients by diode D1 and D2, and its overall gain is set by resistors R1 and R2. The output of IC1 is driven to zero or balanced by network R3 and R4. Its output should remain at zero as long as no changes occur in the ambient magnetic field.

Bypass capacitors C2 and C3 are placed across the positive and negative power supply. Power for the sensing amplifier is obtained from two C cells. The circuit draws very little current, so it can be left on at all times—the reason why it has no power switch.

Control/display operation

Refer to Fig. 3 for the schematic of the control/display circuit. It provides an additional gain of 200 over that of the sensor circuit. The control/display circuit includes an adjustable low-pass notch filter, IC2, a Linear Technology LTC1062. By adjusting the clock frequency of the filter with resistor R11 and the capacitors C4, C5, and C6, the filter cancels interference frequencies and noise in the 2-Hz to 10-kHz band. The notch filter can also screen out 60-Hz noise. Switch S2 inserts or removes the filter.

IC3, an LM201A general purpose op-amp, filters out the clock noise generated within the filter chip. The output of IC3 is fed into the non-inverting input of IC4-a, half of a dual 747 general purpose op-amp. The overall gain of IC4-a is adjusted by resistor R16. Trimmer potentiometer R15 adjusts the offset or balance. PULSE SHAPE potentiometer R17 and capacitor C5 form an optional pulse-shaping network for coupling the Aurora Monitor to a chart recorder or an analog-to-digital conversion board of a personal computer.

The output of IC4-a is coupled to a voltage follower at IC4-b. The output of IC4-b is divided into two channels. One channel is fed through 5000-ohm SENSITIVITY potentiometer R18, which adjusts the output level of the signal fed to the 100-microampere panel meter M1. Movement of the meter's needle

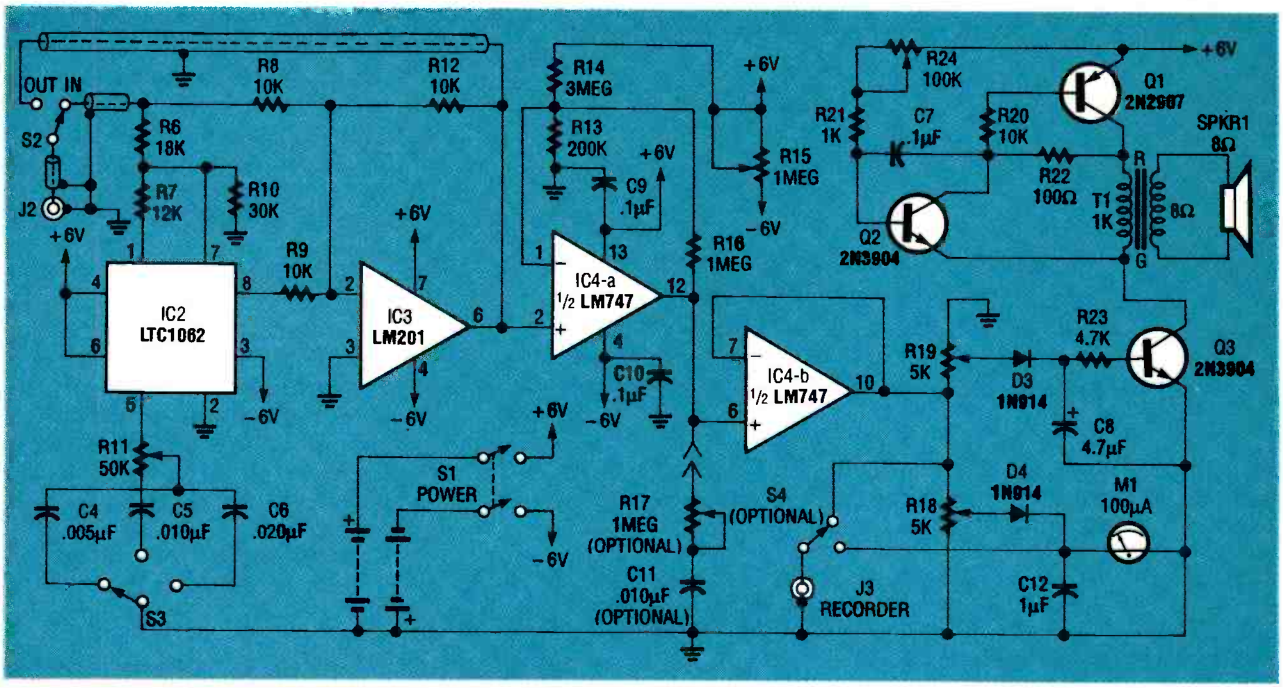


FIG. 3—SCHEMATIC FOR THE DISPLAY-ALARM circuit.

shows changes in the local magnetic field. Potentiometer R18 also adjusts the output signal that can be fed to a chart recorder for data logging.

The other channel is fed through ALARM ADJUST 5000-ohm potentiometer, R19, which sets the threshold or setpoint for the reflex oscillator circuit that follows it. The oscillator consists of transistors Q1, Q2, and Q3 and associated components. Speaker SPKR1 gives an audible indication of changes in the local magnetic field. The network of diode D3 and aluminum electrolytic capacitor C8 performs additional filtering for the input signal to the reflex oscillator section.

Transistor Q1 controls the audible alarm by clamping the negative voltage returning through the ground path. When a magnetic event occurs, the speaker emits an audible alarm, and the meter gives a visual indication of a changing magnetic field. The adjustment of ALARM ADJUST potentiometer R24 can remove distortion from the sound of the speaker.

The author's prototype control/display unit is powered by eight AA cells: four cells provide positive voltage and four cells provide negative voltage. As an alternative, the monitor can be powered by rechargeable nickel-cadmium cells.

Construction

Finished sensor and control/display PC boards can be purchased from the source given in the Parts List. However, the circuit boards can be fabricated and drilled with the foil patterns included here. The outline dimensions of the author's prototype sensor board are 2 1/16 × by 2 9/16 so the smaller dimension can fit inside the pipe section used as the sensor head housing.

The outside dimensions of the control/display board in the prototype are 2 7/8 × 5 inches to fit inside the instrument case selected. Unless the completed board is purchased, holes must be drilled in the board for mounting transformer T1 and mounting the board in the instrument case.

The circuitry can also be built on standard punch board for point-to-point wiring. The outside dimensions of the circuit boards can be modified for packaging in the instrument and sensor head cases of your choice.

Sensor circuitry

Refer to sensor parts-placement diagram Fig. 4. It is recommended that all integrated circuits for this project be mounted in sockets. Position the socket for IC1 and all resistors, capacitors and diodes on the sensor board, paying attention to the polarity of the diodes. Solder all board-mounted components in position and trim excess leads. Set the sensor board aside and assemble and solder all board-mounted components to the control/display board.

Control/display circuitry

Refer to control/display placement diagram Fig. 5. Position the three sockets for IC's 2, 3 and 4, the three transistors Q1, Q2 and Q3 and all resistors, capacitors, diodes and board-mounted potentiometers as shown, making sure that the polarities of the diodes and the electrolytic capacitor are observed. Solder all leads and trim them close to the PC board.

Verify the locations of the 1000-ohm and 8-ohm windings of transformer T1 and orient it as shown in Fig. 5. Insert the tabs of the transformer through the drilled holes and bend them to clamp the transformer to the board. Before soldering any transformer winding leads, check the windings with an ohmmeter. The reading across the 1000-ohm winding should measure in hundreds of ohms while that across the 8-ohm winding should be only a few ohms.

Solder all transformer windings to the correct board pads and cut a length of bare copper wire and solder it across both mounting tabs on the foil side of the board. Now complete the sensor-head assembly.

Winding the detection coil

The coil L1 in the sensor head detects changes in the local magnetic field. Wind approximately 1500 turns of 28 AWG magnet wire over a soft iron core ½-inch in diameter and 12 inches long. (The iron core concentrates the flux lines by offering a lower reluctance path than air.) Coil impedance should measure from 20,000 to 30,000 ohms.

Wind the fine insulated magnet wire carefully on the iron core to avoid kinks and breakage. Tape the ends of the winding temporarily to the core and carefully solder hook-up wire at each end to form permanent terminals. The terminals can be secured to the core with with room-termperature vulcanizing (RTV) adhesive to relieve any strains that might develop in the fine magnet wire.

Sensor-head housing

In the author's prototype, the sensing circuit board, coil, and battery pack are housed in a case made from standard 2$^1/_{16}$-inch inside diameter PVC water pipe cut to a length that will accommodate all of those elements as shown in Figs. 6 and 7.

The covers of the sensing head housing are PCV caps that press fit over the 2⅜-inch outside diameter of the pipe. The upper cap is a simple cup, but the lower cap is a sleeve with a threaded insert at its end. Drill a hole in the square base of the threaded insert for jack J1 and fasten it with a ring nut. Then close the cover on the empty pipe and drill two pilot holes 180° apart in the sleeve for self-tapping screws to clamp the cap in position after the sensor head is assembled.

Cut about a 6-inch length of RG-174/U coaxial cable, strip both ends and solder the inner conductor of one end to the jack terminal and its shield to the jack lug. Solder the inner con-

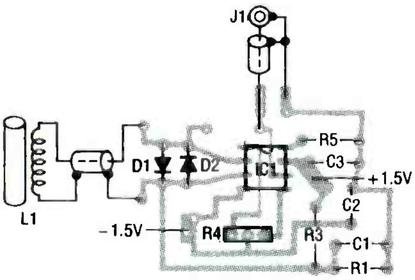


FIG. 4—PARTS ASSEMBLY DIAGRAM for the sensor head. Note that the coil L1 is a separate assembly wired to the circuit board. Refer to Fig. 7 for the mechanical assembly.

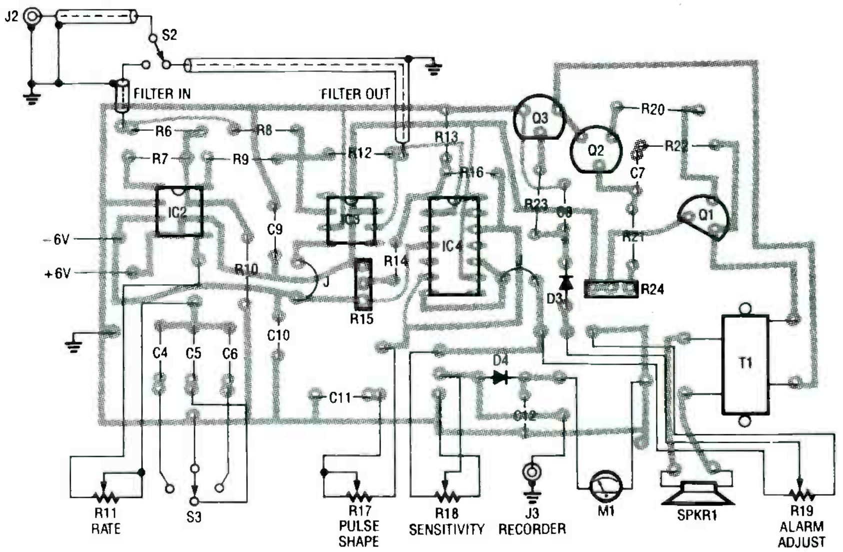
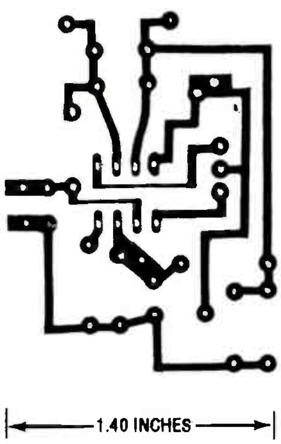
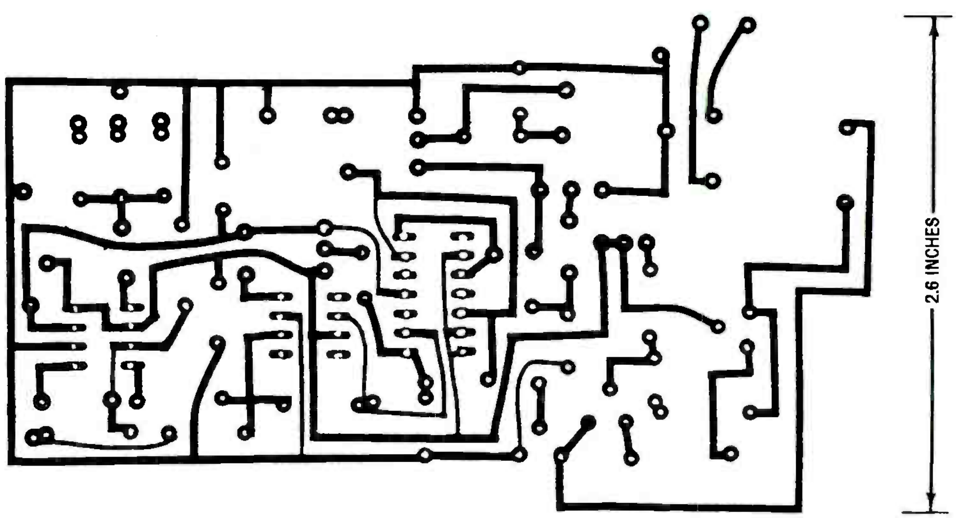


FIG. 5—PARTS ASSEMBLY DIAGRAM for the display-alarm unit. Note the panel-mounted potentiometers, switches, meter and speaker.



FOIL SIDE OF SENSOR CIRCUIT board



FOIL SIDE OF CONTROL-DISPLAY board

PARTS LIST

All resistors are 1/4-watt, 5%, unless otherwise specified
R1, R3—1,500,000 ohms
R2—5,600,000 ohms
R4, R24—100,000 ohms, PCB trimmer potentiometer, carbon, Digi-Key CEG-15 or eqivalent
R5—10,000,000 ohms
R6—18,000 ohms
R7—12,000 ohms
R8, R9—10,000 ohms
R10—30,000 ohms
R11—50,000 ohms, panel-mount potentiometer, Radio Shack No. 271-1716 or equivalent
R12, R20—10,000 ohms
R13—200,000 ohms
R14—3,000,000 ohms
R15—1,000,000 ohms, PCB trimmer potentiometer, Digi-Key CDG-16 or equivalent
R16—1,000,000 ohms
R17—1,000,000 ohms, panel-mount potentiometer, carbon, Radio Shack No. 271-1714 or equivalent
R18, R19—panel-mount potentiometer 5,000 ohms, Radio Shack 271-1714 or equivalent
R21—1,000 ohms
R22—100 ohms, 1/2W, 5%
R23—4,700 ohms
Capacitors
C1, C2, C3, C7, C9, C10—0.1μF, 35-volt
C4—0.005μF, 25-volt
C5, C11—0.010μF, 25-volt
C6—0.020μF ,25-volt
C5—0.010μF, 25-volt
C8—4.7μF, aluminum electrolytic, 25-volt
C12—1μF, 35-volt
Semiconductors
Q1—2N2907, PNP transistor
Q2, Q3—2N3904, NPN transistor
IC1—LM4250 (National Semiconductor), programmable op-amp
IC2—LTC1062 (Linear Technology) active filter
IC3—LM201A (National Semiconductor) op-amp
IC4—LM747 (National Semiconductor) dual op-amp
D1 to D4—1N914 diodes
Other Components
S1—DPDT toggle power switch, panel-mounted. Digi-Key No. or equivalent ON-OFF
S2, S4—SPST toggle switches, panel mounted, Radio Shack No. 275-326 or equivalent
S3—three-position rotary switch, break before make, panel-mounted
M1—100-microampere moving-coil meter, GC (Rockford, IL) No. 20-1111 or equivalent
SPKR1—8-ohm speaker, 2-inch diameter, Radio Shack No. 40-245 or equivalent
T1—1000-ohm to 8-ohm transformer, Radio Shack No. 273-1380 or equivalent
L1—sensing coil (See text)
PL1 and PL2—plug, RCA-type, Radio Shack No. 274-339 or equivalent
J1, J2, and J3—jack, RCA-type, Radio Shack No. 274-346 or equivalent
Miscellaneous: PC boards for sensor and control-display, sockets for IC's (three 8-pin and one 14-pin DIP), Instrument case with removable cover (Radio Shack No. 270-274 or equivlent), PVC pipe with 2 1/16-inch I.D.(see text), two PVC end caps for 2½-inch O.D. pipe (one plain, the other with a threaded end plug), two quad AA-cell holders, one dual C-cell holder, two C and eight AA alkaline cells, knobs for potentiometers and switches, RG-174/U coaxial cable (see text), spool of No. 28 AWG magnet wire, iron rod ½-inch O.D. × 12 inches long, non-magnetic stainless steel self-tapping screws, hook-up wire, bare copper wire, solder, nuts, bolts, lockwashers, PVC adhesive, RTV adhesive, miscellaneous hardware.
Note: The following monitor parts are available from Tom L. Petruzzellis, 340 Torrance Ave., Vestal NY 13850:
- PC board only—$12.95
- Kit of parts less cell holders, alkaline cells, cases, speaker—$59.95

Check, and money order accepted. Please add $3.50 shipping and handling. New York State residents must add sales tax of county of residence.

ductor and shield of the other end to the sensor circuit board as shown in the parts placement diagram Fig. 4.

Attach the coil to the sensor circuit board with about a 6-inch length of RG-174/U coaxial cable as shown. Connect the inner conductor to one terminal and the shield to the other as shown in Fig. 4, and solder both in position. The prototype includes a twin C-cell holder that, with cells in position, has a maximum width dimension of less than 2 inches permitting it to slide easily into the sensor head pipe section.

Cut three lengths of hook-up wire to extend the lengths of the positive, negative and ground leads of the battery pack. Solder one end of those wires to the holder leads and the other ends to the sensor circuit board as shown in Fig. 4.

Bond the upper cap to the PVC pipe section with PVC cement. Then position IC1 in its socket, making certain that pin 1 is located correctly as shown in Fig. 4. Finally, insert the C cells in the holder.

Wrap a layer of polyurethane foam around coil L1 to center it within the pipe section and insert both in the pipe section with the cover at the end. Then assemble the completed circuit board and battery pack to make sure that all of these parts will fit in the pipe section. Set the assembly aside until you are ready to perform the checkout steps.

Control/display unit

The control/display assembly is housed in a standard 7 ×5 ×3-inch aluminum electronics instrument case with a removable cover. Drill the holes in the front panel of the case for power ON switch S1, FILTER IN switch S2, RANGE switch S3 and (if used) optional recorder switch S4. Also drill the holes for SENSITIVITY, ALARM ADJ., and RATE potentiometers (R18, R19, and R11 respectively). Cut out the hole for mounting meter M1. Note: If you want to use the monitor strictly as a security monitoring system the meter can be omitted.

Drill the holes in the back panel for jacks J2 and J3, and PULSE SHAPE potentiometer R17.

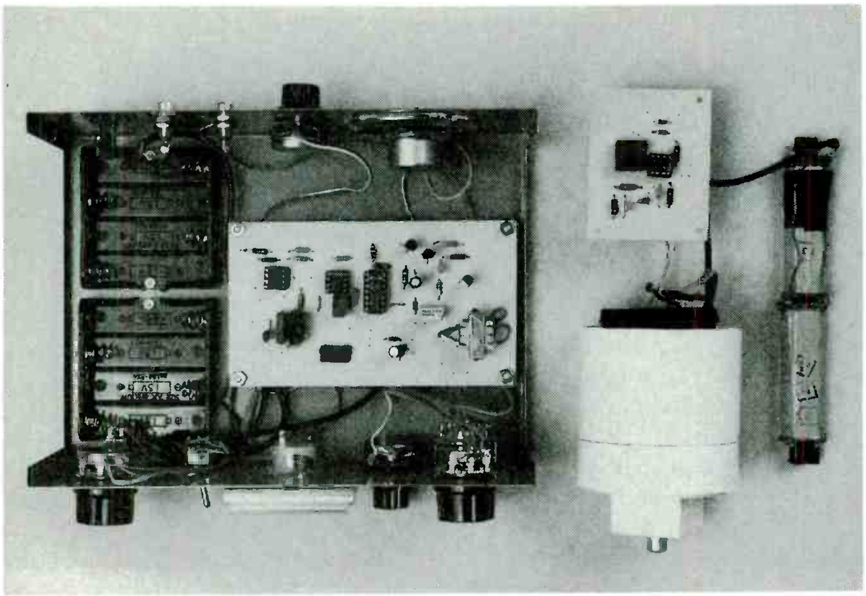


FIG. 6—AURORA MONITOR WITH HOUSING COVERS REMOVED showing internal arrangement of circuit boards and panel mounted components. Control-display unit is at left and sensor head is at right. Sensing coil L2 is at extreme right.

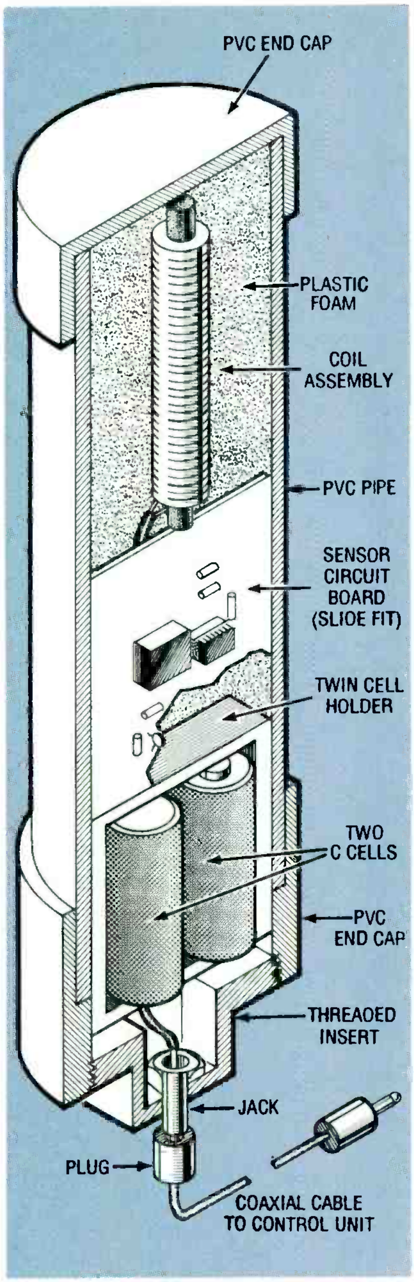


FIG. 7—MECHANICAL ASSEMBLY of sensor head. The coil is wrapped in polyurethane foam and inserted into the case followed by the circuit board and the C-cell holder. The lower cap is fastened to the pipe with non-magnetic self-tapping screws.

Drill a series of holes in a circular pattern for the speaker SPKR1. Drill holes in the bottom of the case for mounting the control/display circuit board and two quad AA cell holders.

Assemble the panel-mounted switches, jacks, potentiometers, meter and speaker to the front and back panels of the case as shown in Fig. 6. (You might prefer to bond the face of the speaker to the inside of the back panel with RTV adhesive rather than bolts and nuts.)

Determine the length of speaker wires needed to permit assembly of the circuit board in the instrument case, cut the wires to length and solder them to the board. Cut and solder all leads from panel-mounted components to the circuit board as shown in Fig. 5, allowing sufficient lengths to permit unimpeded circuit board assembly, yet not allowing too much slack.

Cut about a 6-inch length of RG-174/U coaxial cable to connect INPUT jack J2 and the FILTER IN switch S2 and two other lengths about 6 inches long to connect S2 to the FILTER-IN and FILTER-OUT pads on the control/display board as shown in Fig. 5. Strip all cable ends and solder and trim all connections.

Assemble the control/display board to the base of the case with screws and ½-inch insulating standoffs, lockwashers and nuts. Bolt the two quad AA cell holders to the base of the case as shown in Fig. 6. Position the IC's in their sockets on the control-display board, making sure that all pin 1's are in their correct positions. Insert the eight AA cells in the spring-loaded holders, observing the correct polarity.

Cut a length of RG-174/U coaxial cable cable to the length that will suit your installation (up to 20 feet). Strip the wire ends and attach phono plugs PL1 and PL2 to cable ends and solder or crimp them in position.

Test and checkout

Test the sensing circuit first. Connect a general purpose oscilloscope or multimeter to the output of IC1. Position a permanent magnet near coil L1 and the oscillscope display should show a pronounced pulse. If a multimeter is used, its readout should jump.

Next, move L1 away from the magnet and the reading on the multimeter should fall to zero. If the reading does not go to zero, adjust trimmer potentiometer R4 in the sensor circuit. When

Continued on page 89

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HARDWARE HACKER

Single-station FM traps, FM DX reception update, free GPS receiver boards, and nonlinear graphic transforms.

DON LANCASTER

The GPS logjam seems to be finally breaking up. We have already seen where *Trimble Navigation* offers a Global Positioning Satellite receiver for $390 in single quantities. Better yet, *Sony* has dumped their *PYXIS* Backpacker's GPS receiver to the "yuppy surplus" resellers. *Damark* stocks these at $599. But our helpline lore says they are still overpriced, even at one-third the original list.

Best of all, *Plessey* has announced a GP1010 receiver front end IC at $21, along with their companion GP1020 six-channel correlator. Plessey offers pretested GPS receiver boards. Free *if* you can show them any credible plan for engineering a GPS product.

We have a mixed bag of goodies for this month...

Nonlinear graphics

I have long been fascinated by the mapping of images onto distorted surfaces. That's useful for doing *Star Wars* lettering, drawing on a sphere, putting words on a blowing flag, or logos on a rootbeer cup.

I've found PostScript to be ideal for this sort of thing. Let's do a quick summary and then find out where to go for the full set of plans.

There are two key tools needed for fancy graphic mappings. These are the *linear graphics transform* and the exotic *non-linear graphics transform*. Several examples of what you can do with the transforms appear in Fig. 1.

We have already found out about transforms in previous *Hardware Hacker* columns. A transform is just a way of taking one group of numbers and playing tricks with it to create a new group of numbers. The new group will somehow end up "better," or at least more what you have in mind.

In a two-dimensional transform, a pair of *x* and *y* values is changed into a new pair of *x* prime and *y* prime values that are "elsewhere." The relationship of the "elsewheres" determines the mapping you end up with.

Fancy matrix math techniques are usually used for graphics transforms. Plain old ninth-grade algebra can be used just as well. The linear graphics transform is simply:

$$x \text{ prime} = Ax + By + C$$
$$y \text{ prime} = Dx + Ey + F$$

You could view A as the *horizontal scale*, B as the amount of *lean*, C as the *horizontal offset*, D as the amount of *climb*, E as the *vertical scale*, and F as the *vertical offset*.

To move a figure around on your page, you change C and F. This is called *translation*. To make a figure larger or smaller, you change the size of A and E. This is known as *scaling*. Usually, you'll scale A and E by the same amount. Otherwise you'll get an *anamorphic* scaling that gives you a compression or an extension.

Make A negative, and you'll get a special case of scaling that prints backward. Make E negative and it prints upside down—or do both.

Rotating a figure gets tricky. You use some sines and cosines on A, B, D, and E. You might use fancier combinations to do fancier mappings. For instance, the *isometric* mapping shown in Fig. 1 can be done with a linear transformation.

The *sequence* of the transforms is critical. Scaling and then translating is vastly different than translating and then scaling. If you know what you are doing, you can use one single transform to translate, rotate, and scale all at once.

You can do a surprising amount of stuff with a plain old linear mapping. A square can be changed into another square of any chosen size, orientation, and position, or into any rectangle, line, or point.

But note you can *not* use a linear transform to convert your square into the *trapezoid* needed for perspective lettering. Or to draw on a sphere. Or to scribble. Nonlinear techniques are required for any of those tricks. Since the linear transform is well known and fast to implement, you usually do a nonlinear transform by *modifying* a linear one.

In a linear transform, the values A through F are *constants* that stay the *same* over the entire mapping. To do a nonlinear transform, you can define A through F as *variables* which might need to be recalculated for each point of the mapping. And that can take a very long time.

An alternative is to use some *sparse data set* that makes use of graphic *primitives*. That lets you nonlinearly transform *only the ends* of a line segment or only the control points of a curve. A linear transform is then performed on everything between. The process is ridiculously faster and produces more compact results.

Four examples of graphical primitives are custom *moveto*, *lineto*, *curveto*, and *closepath* procedures. They are used respectively for positioning, straight lines, curved line segments, and path completion operators.

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Don Lancaster
Synergetics
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For fast **PSRT** access, modem (800) 638-8369, then an HHH. Then XTX99005,SCRIPT.

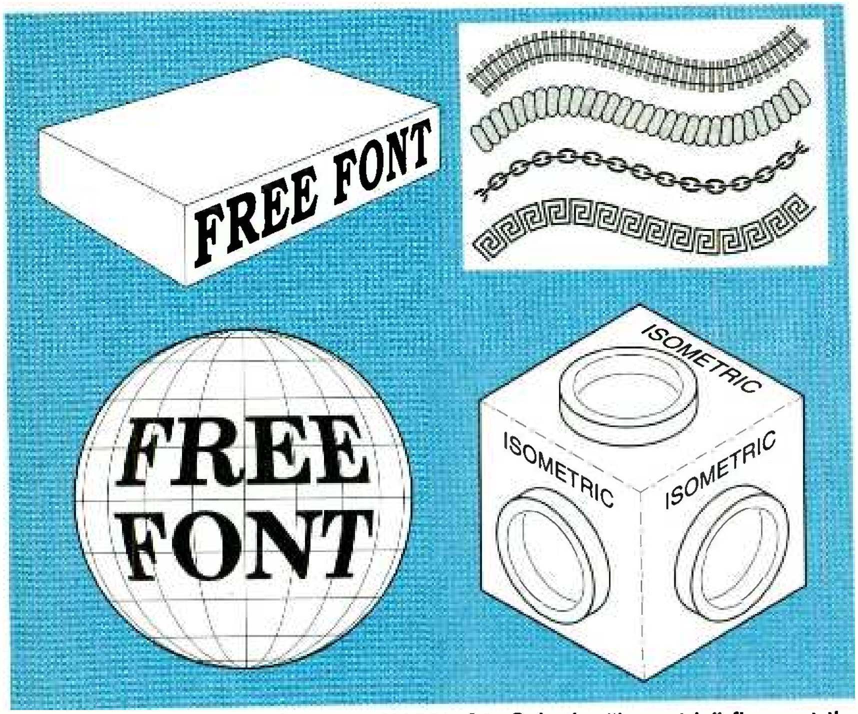


FIG. 1—TYPICAL FANCY GRAPHIC MAPPINGS. Only the "isometric" figure at the lower right can be done with a stock linear graphics transform. The others require use of nonlinear transform techniques.

Nonlinear mapping with primitives should appear "perfect" as long as each straight line ends up as a straight line on the final image. But if you try to map onto a sphere or do anything else where any straight lines become curves, you'll get into severe *corner cutting* problems. For instance, you might end up running *through* your sphere instead of along its surface.

The workaround here is to change any longer straight lines into shorter segments of "unbent" curves. This can give you reasonable results with sparse data.

Another nonlinear mapping trick is shown in Fig. 2. Very often, computer art ends up looking like it was done on a computer—too exact and precise. Nonlinear techniques can be used to let you scribble, making the results as ratty as you want. To achieve this effect, some random numbers are introduced into the nonlinear mapping.

I've posted a complete tutorial and lots of plans for nonlinear transforms up to my *GEnie* PSRT as file #719 NONLINGR.PS. Rumor has it that this one might also show up in the December 1993 issue of *PC Techniques*. Or, I'll be happy to throw in a free copy with any *Synergetics* order.

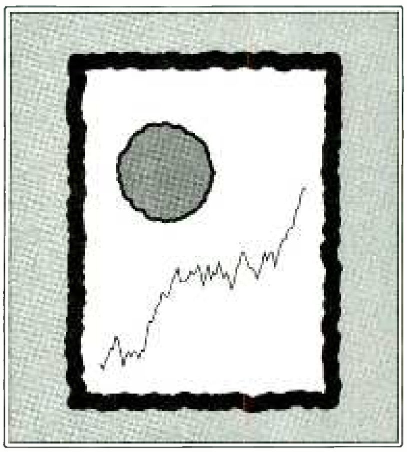


FIG. 2—THIS NONLINEAR "scribble" transform can make computer art less exact and precise.

FM DX update

We looked into the reception of distant FM stations a number of times in the past. I thought I'd give you a rundown of what I'm using now, along with several newer schemes for further improvement.

Figure 3 shows my present setup. I've now got this humongous *Winegard* #CA-6065 antenna up on the roof with a fixed two-mast mount pointing due west. While this slightly cuts signal strength from Phoenix stations and really hurts Tucson, it is cheap and rugged. And we do get occasional high winds here. The antenna height is around 24 feet above ground.

The antenna signal goes to a *Radio Shack* #15-1117 coaxial inline amplifier. This can make the antenna load more uniform and gives 10 decibels of gain to compensate for the line losses and signal distribution. On the other hand, because the amp probably adds cross-modulation and distortion, the results would likely be about the same without it.

The amplified signal is then routed to a coaxial two-set splitter. One output drives a high-quality receiver in the living room. The other runs through what used to be the cable system to source an el-cheapo FM receiver in my computer room.

The key test here is good old 93.3 KDKB in Mesa, 145 miles away. This comes banging into the good receiver with full stereo and total quieting. On the cheap receiver, it is very hard to tune, slightly noisy, and mono only. The problem is a 50,000-watt random-noise source at 94.1 that is only a mile and a half away,

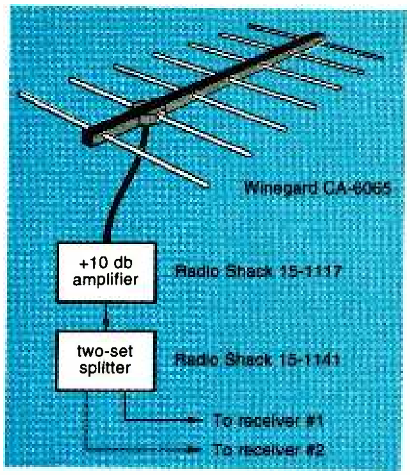


FIG. 3—FM DX SETUP gives a 145 mile range with a 24 foot antenna height.

and that the shielding on cheap receivers is often purposely left off so that local stations can be received without an antenna. MKJZZ , the Phoenix NPR station, comes banging in at 91.5 on both sets so strong that you can arc weld with it—at 158 miles range.

How can you improve on a scene where a strong local station overloads a weak and desired one? First and foremost, the quality of better-grade FM receiver front ends has improved greatly in recent years. Key advances are FET transistors having low cross modulation and excellent overload specifications. And four-quadrant linear multipliers are replacing those flaky old mixers. Getting a newer receiver might help a lot. A mid- to high-end car radio can be a good choice, because of its better shielding. Naturally, coaxial cable should always be used instead of twin lead.

Note that any old random hacker junk inserted between your correctly matched antenna and any properly designed receiver is much more likely to hurt you than help. But there are some things you can try that might help. Some of these are shown in Fig. 4.

I was very surprised that you can't buy simple, inexpensive, one-station FM traps. These aren't even available in *Anixter* or other cable-TV suppliers. After making several calculations and talking to some crystal-filter folks, I found out why.

The problem is that exotic high-Q components that also have extreme temperature stability are needed. Ordinary capacitors and coils simply won't hack it. Instead, you have to go to exotic crystals, helical resonators, or transmission-line components. On passive filters, you have insertion and mismatch losses that could kill any desired but weaker signal. Add gain, and you might pick up cross modulation and overload problems that get you right back to square one.

One solution is to perform *spatial* filtering, instead of *frequency* filtering. Any directional antenna will have one or more deep *nulls* which, when pointed directly at any station, could attenuate it by 30 decibels or more.

Instead of pointing your antenna directly at the desired station, you'll carefully *misalign* it to *throw a null at the interference*. Even though your desired station might now come in a tad weaker, the unwanted one will become strongly attenuated.

A second scheme, phase cancellation, is sometimes used in radar systems. The main antenna is pointed at the desired station, while a smaller antenna is pointed *at the interference*. After very carefully adjusting the amplitude and phase of the second input signal to give you equal amplitude and 180 degree phase, you then combine the two signals through a two-set coupler.

Phase is adjusted by changing the lengths of the cables involved. Amplitude is adjusted with variable resistors or other attenuators. The goal is to get the residual interfering signal small enough that it doesn't cause cross modulation when it hits the receiver.

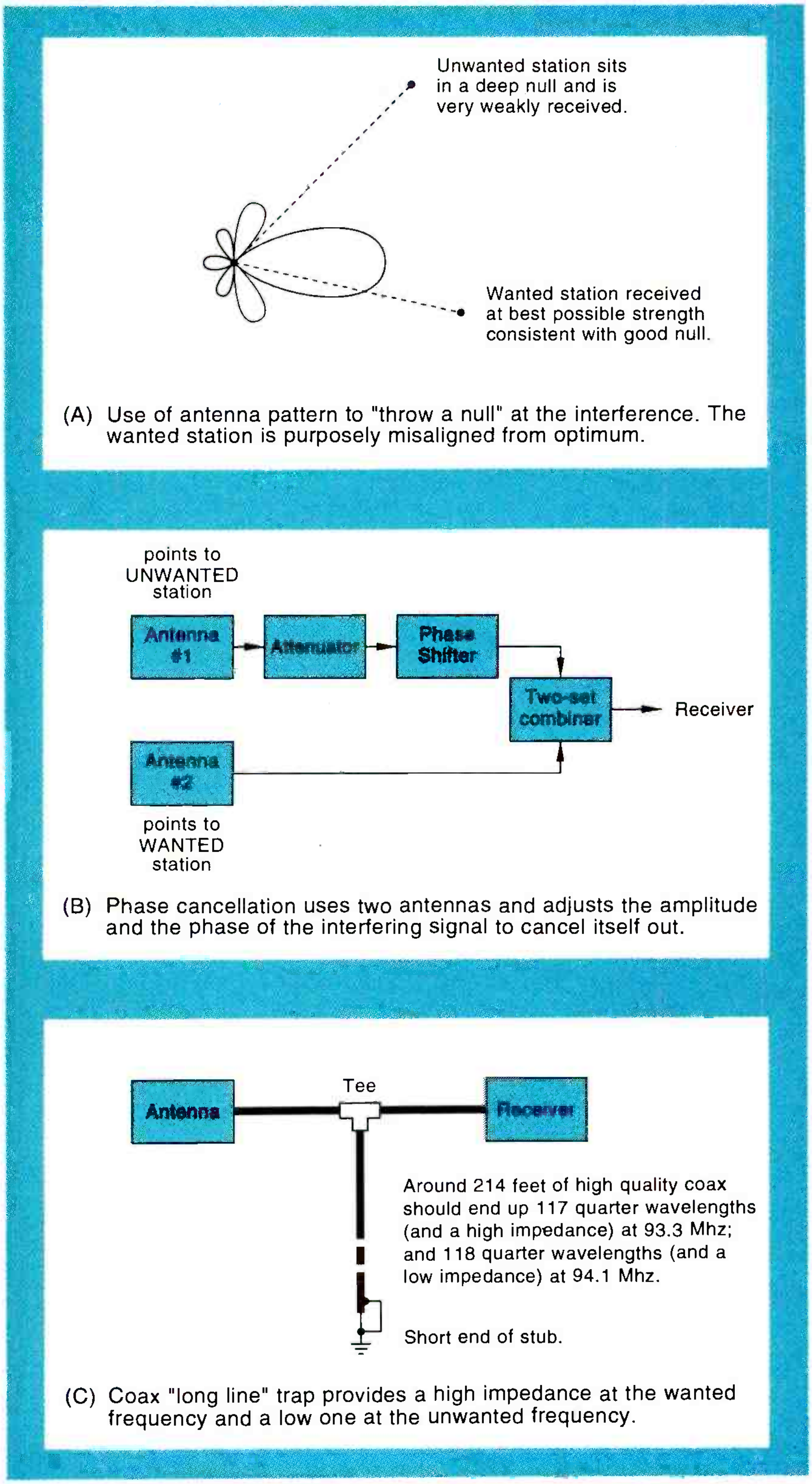
A *long line canceller* is a third possible interference-reduction hack. A shorted transmission line looks like an open at *odd* quarter wavelengths, and appears as a short at *even* quarter wavelengths. In theory, the shorts and opens repeat for longer cable lengths.

Let n be any old number. Now, $2n$ has to be some *even* number—every time. And $2n + 1$, *by definition, has to be an odd* number.

Let's do a quick calculation to find the *minimum* length of cable needed to get an odd number (and an open) at 93.3 and an even number (and a short) at 94.1 MHz...

$$93.3\,(2n+1) = 94.1\,(2n)$$

That solves as $2n = 118$.



(A) Use of antenna pattern to "throw a null" at the interference. The wanted station is purposely misaligned from optimum.

(B) Phase cancellation uses two antennas and adjusts the amplitude and the phase of the interfering signal to cancel itself out.

(C) Coax "long line" trap provides a high impedance at the wanted frequency and a low one at the unwanted frequency.

FIG. 4—SINGLE-STATION FM TRAPS are hard to design because of the extreme Q values needed. Here are three creative alternatives.

The wavelength at 94.1 MHz is 3.19 meters. A quarter wavelength will be 0.80 meters. And 118 of those will be 94 meters total. Assume a 0.7 velocity factor, and the result is roughly 214 feet.

So, take 214 feet of coaxial cable, and then solidly short the end and wrap it up inside a well-shielded and grounded paint can. Add a T connector to your main antenna line. After carefully adjusting for an exact length, what theoretically should happen is a dead short at 94.1 and an open at 93.3. For reception at other frequencies, you disconnect the coaxial cable. Or change its length suitably.

If the wanted station is *higher* than the unwanted one, you should use 2n and 2n – 1 instead.

Sadly, the length of the cable will severely attenuate the depth of those shorts and opens. And you probably won't get nearly the Q you need, even when using premium coaxial cable. It might be worth trying, though. Or perhaps something similar done with stripline on a PC board could get decent Q with acceptable size.

In general, transmission-line components can be cheap and useful substitutes for high-Q parts. But the math gets tricky and special test gear might be needed.

Tellyawhat. Let's work up a new group hacker project and contest out of this. For the usual *Incredible Secret Money Machine II* book prizes plus a possible all-expense paid (FOB Thatcher, AZ) *tinaja quest* for two, either (A) send me the measured FM band reactance plot of a long piece of shorted premium coaxial cable, or else (B) show me a single-station FM trap that works. Cheap and hacker-friendly, of course. And easily retuned. As usual, be sure to send all your entries directly to *Synergetics*, rather than to **Electronics Now** editorial. Let's hear from you.

"Free energy" resources

I got a surprisingly high number of "free energy" enthusiasts calling and writing over our recent coverage of heat-engine basics. I was bemused by those of you using biblical quotes to disprove the thermodynamic laws.

There was one minor error in the column. Rankine's name was spelled wrong. Sorry about that.

To me, looking for any free energy is senseless. First, because the odds of finding any are pitifully low. Second, because others will see you as being a few chips shy of a full board. Last, unlimited free energy is *not* in the least bit desirable in any way, shape, or form. Free energy would hasten the isoentropic heat

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death of the planet. That would be the most heinous crime against humanity imaginable.

Nearly all free-energy experiments involve bad or missing lab work, blatant misinterpretation of the data, ignored hidden factors that mask what is really coming down, or plain old outright cons. Quoting Carl Sagan, "Extraordinary claims all require extraordinary evidence." It is not enough to claim something is happening. Instead, you must have absolute proof of your claim which is incontrovertible and overwhelming.

Proof far above experimental noise levels. And well within the statistical bounds. And free of hidden factors. And easily and openly duplicated by anyone, anywhere, anytime. That's what the scientific method *always* calls for.

Now, I am very much in favor of encouraging individuals to check out oddball, unpopular, or controver-

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sial technical areas on their own. That's what hardware hacking is all about. But the odds of any success should end up far higher if you stay within the guidelines dictated by the laws of physics and electronics.

It turns out there is a rather lively "free energy" industry. These include specialty booksellers, associations, conferences, and individual authors who publish books, papers, projects, and kits. Just for kicks, I thought we would gather all of these together as this month's resource sidebar.

Why? Well, first because they are there. Second, because even the free catalogs can be wondrously bizarre reading. And, finally, because many of these publications are textbook perfect examples of how *not* to do research, how *not* to do technical writing, and how *not* to desktop publish.

Let's do a quick rundown of some of the major players: Start with *High Energy Enterprises*, which offers a wide selection of publications on topics ranging from free energy to perpetual motion to Tesla to intergalactic happy faces on Mars. They also run conferences. A recent spinoff is the *National Association for New Science*, which offers similar services and publishes the *New Science News*. A Canadian group is the *Planetary Association for Clean Energy*.

Two unique outfits are *Borderland Research*, which focuses on paranormal and free-energy theories. It also publishes the *Journal of Borderland Research*. Is it ever! And *Lor'd* is concerned with alternate medical electronic therapies.

For the "more miles per gallon" miracle carburetors, you can try *H&A Industries*.

Checking the classifieds in *Whole Earth Review* reveals *Super Science* which covers *Orgone Energy Blankets* and *Rife Resonators*. And there's also *Amazing Archives* on antigravity and on "300 suppressed technologies."

Nikola Tesla seems to be the center of much "free energy" research. The key problem is that Tesla was both a brilliant inventor *and* a superb con artist. Four additional resources that focus on Tesla are the *Tesla Society* (who publish *Extraordinary Science*), the *Tesla Bookstore*, the *Tesla Coil Builder's Association*, and *Resonance Research*. The latter custom builds museum-quality exhibits.

An outfit known as A.D.A.S. stocks papers including *The Final Secret of Free Energy* by T. Bearden. The key circuit Beardon describes as one that is needed for extracting the "zero-point scalar energy from the fabric of space" has long been available as the LTC1073 by *Linear Technology*. I find it somewhat strange that the Linear Technology engineers haven't noticed their oscilloscopes melting or all their test benches vaporizing when testing these chips.

There are several outfits offering technical kits and plans based on the "Don Britton" model of one person offering a bunch of self-designed low-budget projects. The engineering on these designs ranges from impeccable down to missing completely. Two firms here include *Consumertronics* and *Information Unlimited.*

Of course, *Lindsay Publications* is a unique source for any obscure technical books. It stocks several fascinating perpetual-motion titles.

Finally, there's the *Skeptical Enquirer*, which is written mostly by high-profile and "name brand" scientists who attempt to debunk pseudo-tech, junk science, and claims of the paranormal. Sadly, a lot of their debunkings are handled with such manic religious fervor that they become what they are attacking. But it is still great to read.

New tech lit

Through *Industrial Arts Supply*, a combined catalog on industrial arts and technical education products is available. Included are injection molding machines, heat formers, and casting products. This one is a "must have."

The *SAW Scene* is a new and free newsletter on surface-wave acoustical devices from *Sawtek*.

From *Alpha Supply*, a fat catalog of tools and findings for jewelers and rock hounds is available. Plenty of obscure tools here with great hacker possibilities.

Those hard-to-find 72-pin Super Nintendo game-cartridge connectors are offered by *Parts Express*.

Another useful source of VCR and camcorder stuff is *Premium Parts*.

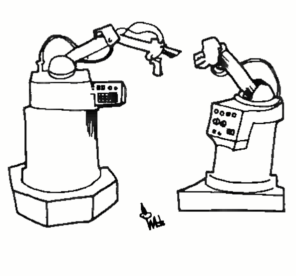
Texas Instruments has some free samples of their new *Power Arrays* low-cost, high-power drivers. Its triple TIPC2301 looks quite handy for converting any car alternator into a power stepper motor.

A new incandescent lamp or LED dimmer that makes use of pulse-width modulation is available as the BTS 629 from *Siemens. Cavers are sure to scoop this up for helmet lights.*

One source of lower-cost digital voice technology is Eltech. Remote controls, security devices, and related hi-tech goodies are offered by *Home Automation Laboratories.* A pair of reasonably priced sources for sheet-rubber products include *Biltrite* and *Hygenic Manufacturing*.

For the fundamentals of starting up your own technical or craft business, you might check into my *Incredible Secret Money Machine II*, available per my *Synergetics* ad.

A reminder that I have arranged for a new and faster *GEnie* signup for my PSRT RoundTable. Refer to the *Need Help?* box for details. Genie has just sharply reduced their rates and now is a really great buy. Ω



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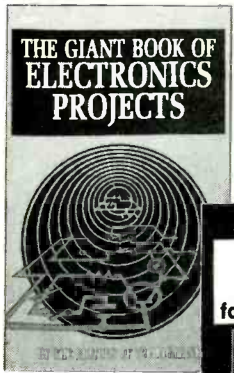

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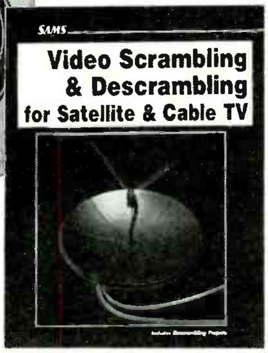

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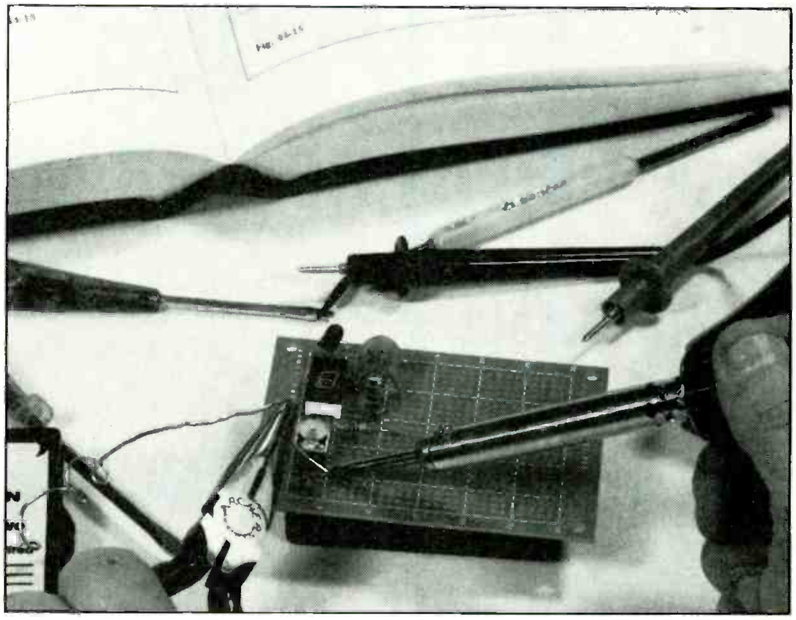

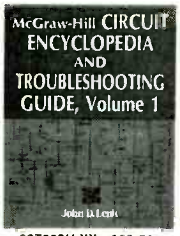

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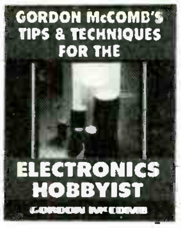

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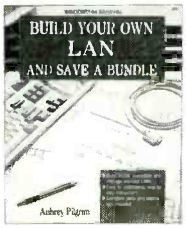

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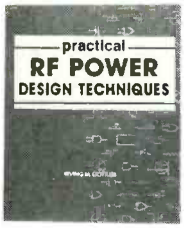

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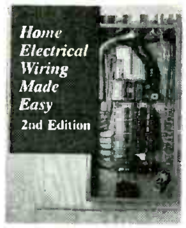

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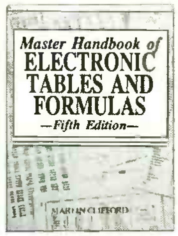

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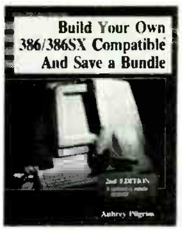

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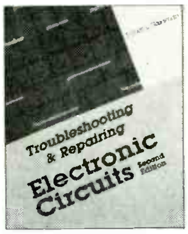

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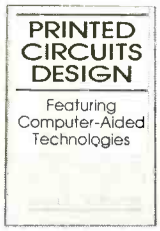

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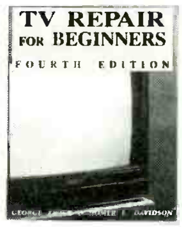

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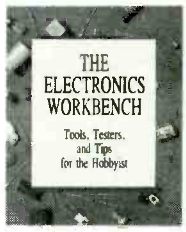

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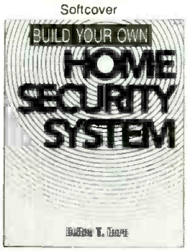

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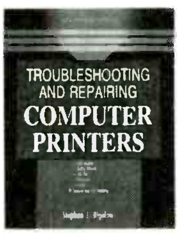

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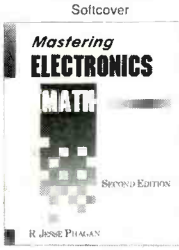

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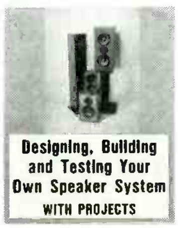

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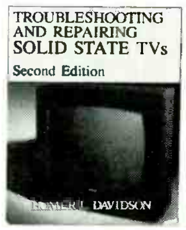

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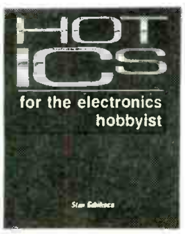

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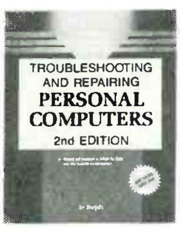

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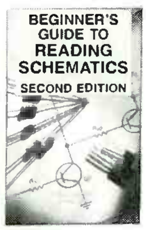

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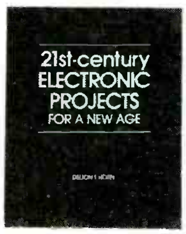

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DRAWING BOARD

Let's get to work eliminating those software document checks.

ROBERT GROSSBLATT

Writing about copy protection creates a bit of a problem. I'm a firm believer that the best way to learn anything is to look at real-world examples, but experimenting with software isn't the same as hardware. Reproducing scope traces of scrambled video is not the same as reprinting sections of code, especially when copyright restrictions are taken into consideration.

Even though document checks (when software asks you to check a certain page in the manual, or *document*, for the answer to a random question) are one of the latest wrinkles to show up in the arena of copy protection, the principles behind finding and eliminating them are basically the same as those used for any other protection scheme. Let's go through the basic steps you have to follow when you sit down to eliminate copy protection from your favorite piece of software. We'll assume you have a legitimate copy of the program (the original disks and manuals) and the DOS DEBUG utility. You'll find a copy of DEBUG included with DOS, and DOS can provide on-line help with DEBUG if you're not familiar with it.

The very first thing you should do is to become completely familiar with how the program loads. Find out what happens when you incorrectly answer the document check and what happens immediately after you answer correctly. What you're trying to do here is get a handle on the structure of the code. This is an important step because tracing through the actual code is a lot of work; the more you know about the program before going into DEBUG, the easier the job is going to be.

Once you know the loading sequence of the program and have written it down on paper (very important), you must get into the code itself. Most programmers write software in a logical way and the code that calls up the introductory parts of the program (the ones leading up to the document check) are likely to be in separate routines. The reason to snoop through the code is to locate the CALL instructions in the main body of the program that execute those routines. The CALL instructions are the only signposts you can rely on to tell you where you are in the code. It's easy to get lost when you're plowing through a disassembly listing, so you should think of a CALL instruction as a friend—try a sample DEBUG session and you'll see what I mean!

There's nothing stopping you from using DEBUG's search command to look for CALL instructions but, unfortunately, a typical one is nothing more than that shown in the seventh line of Listing 1. You can see that there isn't a lot of code to search for. You'd be surprised at how many times a "9A" can be used. A much smarter way to find the CALL's is to use a resident debugger and let the program from which you want to eliminate copy protection do the work for you.

Software such as Codeview, Periscope, and others will let you run a piece of software and then break out of it with a "hot" key so you can examine the code at the breakout point. The two programs I mentioned are commercial packages, but there are similar shareware and public programs available as well. These include such old favorites as XRAY, MEMVIEW (both posted on the *Electronics Now BBS*), and others. In general, the commercial packages are more powerful and mature. But the job you want done is fairly simple so, at least in the beginning, the shareware and public-domain programs are going to be more than adequate.

No matter which debugger you use, there are several things you have to do before you start your preliminary examination of the program you want to crack. The environment in which you work has to be clean. That means no memory-resident programs other than the debugger—TSR's can really muck things up in this kind of work. Another reason for keeping things simple is that you want the program to load in the same place every time. That's particularly true when you're working with DEBUG, but it could be a problem with other debuggers as well.

Once everything is set up, run the copy-protected program and use the debugger to break out of it when something you recognize begins to

LISTING 1

```
2BC0:1873 55            PUSH BP
2BC0:1874 8BEC          MOV BP,SP
2BC0:1876 83EC2A        SUB SP,+2A
2BC0:1879 C746DE2385    MOV WORD PTR [BP-22],8523
2BC0:187E B80A0B        MOV AX,0B0A
2BC0:1901 50            PUSH AX
2BC0:1902 9AB3194F55    CALL 554F:19B3
2BC0:1907 59            POP CX
2BC0:1908 48            DEC AX
```

happen on the screen. As an example, let's say you've drawn up the following list for a program you're working on:

1—The screen blanks
2—The company logo appears
3—The screen is cleared
4—The title screen appears
5—The music starts
6—Any keypress stops the music and clears the screen
7—The document-check screen appears
8—Bad code displays a message and exits to DOS
9—Good code clears the screen and starts the game

The big question is where to break out of the program and run the debugger. There's no hard and fast rule to follow. Software is a series of loops and calls that execute one after another in a sequence that's determined, in part, by the commands issued from the keyboard. What might seem like a simple routine—playing music, for example—is usually a lot of nested calls and loops. When you come across a CALL instruction, even though it might be a part of some routine that you're not interested in, the CALL to the routine you're looking for might be buried several layers underneath the first CALL you found.

Since we're not talking about any specific software, a good rule to follow is break out of the program at the first recognizable point you can. Blanking the screen is nothing in particular because it can be done before or after the video mode changes. The appearance of the company logo is definitely recognizable, and although it's probably a general routine that is pasted to the front of every piece of software published by the company, it's handy to know where it is.

Let's assume that as soon as the company logo appears, you break into the debugger and get to the line of code that called for the logo display. The first thing you see might look something like Listing 2, along with a bunch of other stuff.

Believe it or not, the only code you're interested in is the first line in Listing 2. When I activated Periscope (the debugger), it ran one of its routines and left me sitting in a disassembler immediately following the end of that routine. By executing the IRET (return from subroutine) instruction, Periscope's debugger will put me into the code at the point where I pressed the hot key.

LISTING 2

```
3A22:2256 CF        IRET
3A22:2257 59        POP CX
3A22:2258 48        DEC AX
```

What you see when you get there will depend completely on what the program was doing when you pressed the key. Chances are that all you'll see is the same kind of assembler drivel you would find by aimlessly wandering through the code in DEBUG. The difference is that this drivel shows up somewhere after the company logo appeared. Write down the address.

Since you want to find where the company logo routine is called, and you know that the current address is somewhere in the middle of the logo routine, page forward and look for the IRET that marks the end of the routine. After scrolling through pages of code (or using a search function in your debugger), you'll eventually come across an IRET. Write down the address. How you proceed at this point depends on whether or not your debugger has a single-step function. You want to execute the IRET only to get back to the original CALL (the one we're looking for) so you want the debugger to do the IRET and then drop you back into command mode.

If you can single-step, set the increment to one and execute the IRET. The address where you wind up will be one past the CALL we just paged through. If you can't single-step, you can find the same address by using your debugger to examine the processor's stack. The address you're looking for will be the last one on the stack. Once you get it, just use the JUMP instruction in your debugger to get back there.

Write down the address of both the IRET instruction you just found as well as the address of the CALL you just located. Once you've done that, set a breakpoint just past the CALL, and then use the debugger to execute the CALL instruction. If you've done a good job, you'll see the company logo on your screen. If something else happens, you'll know you haven't found the right CALL address. That means you'll just have to go back to the address of the IRET instruction and search further on for the correct IRET.

If you were successful, write down both the address of the CALL and the hex equivalent for the instruction. This is your first roadmap in the code. Whenever you see the company logo appear on screen, you know exactly where that happens in the program.

The next step is to find the addresses of the CALL's for each of the steps you listed in the loading sequence of the program. It's a bit of a mindless activity, but as you trace through the code following the CALL to the logo routine, you'll have to test each of the CALL instructions you come across by using your debugger to execute them. Don't forget to write down the CALL address, and set a breakpoint just after it before executing the code. That's because executing unknown code in this manner can crash the computer. You want to be able to get back to where you left off if that happens to you.

It might take some time, but sooner or later you'll execute a CALL and the title screen will appear on your monitor! That's always a thrilling moment, no matter how many times you do this stuff. Even though you're far from your ultimate goal of getting rid of the document check, you're definitely on the right track.

By following the process I've described, you'll sooner or later arrive at the CALL that takes you into the document check. When you finally get there, the boring part of the job is just about over and the intellectual part is about to begin. That's what we'll talk about next time. In the meantime, pick a piece of software to experiment with, and collect the software tools you'll need. Remember that XRAY.ZIP and MEMVIEW.ZIP are posted on the *Electronics Now BBS* (516-293-2283). Ω

ULTRASONIC RADAR

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to the resolution of the drive motor selected). Pressing the "F" key reduces the points in the scan (to a minimum of 12, depending on motor resolution).

You can modify RADAR.DAT text file with any text editor or word processor. Each parameter is followed by a comment about its function. The first parameter allows you to select a monochrome display, which is useful if you want to make a hard copy by pressing the print-screen key. (You also must set up the graphics print driver in DOS.)

The speed-of-sound value you determined is set next. The next few parameters specify the stepper motor used; the drive type, steps per revolution for your motor at that drive type, and the motor speed in milliseconds-per-step. The last parameters adjust for the characteristics of the rangefinder and radar display. You can leave these values at their defaults. Be sure to save any changes that you make to RADAR.DAT as a text or ASCII file.

The QuickBASIC source code for the radar program can be downloaded from the *Electronics Now BBS*. However, it is also available on disk, along with the DISTANCE program, in both source and executable form from the source given in this article. Versions for the Macintosh computer are also available.

The relative difficulties of converting the radar program to run on other types of computers will depend on how closely the version of BASIC on that machine resembles Microsoft's QuickBASIC. You can contact Fascinating Electronics (see supplier list) to determine if anyone has already performed the conversion for your type of computer. If so, the program will probably be available to you at little cost. If not, you might want to consider making your translation available to other hobbyists through Fascinating Electronics. Ω

SPECTRUM ANALYZER

continued from page 56

olution, but the resolution bandwidth was reduced from 30 to 1 kHz. Figure 12 illustrates how this narrow bandwidth presents the true deviation of the audio sidebands. The viewing bandwidth has decreased from 30 kHz to 1 kHz. The sweep has increased from 20 milliseconds to 18 seconds. All other settings remain the same.

In the original presentation shown in Fig. 9, the reference level was adjusted so that the video carrier would fit in the vertical span of the display. Because the audio carrier is lower, it should be shifted upwards. This is done by decreasing the reference level from 9.3 dBmV to −12 dBmV, elevating the audio carrier position, as shown in Fig. 13.

In the previous step, only the reference level was moved, but there was no change in the dB value per vertical division. If you want to expand vertical resolution, the value of graticule divisions can be changed, as shown in Fig. 14. The roughly horizontal noise base or floor is pushed below the lowest division.

This last step calls for a control available only in digital spectrum analyzers that have digital marker labels. These have been set at the extremes of the audio subcarriers. If this feature is not available, the operator must count divisions and multiply that value by the value of frequency per division.

The last control to be discussed is the *span* or *video bandwidth* control. It is a low-pass, post-envelope detector that smooths the displayed waveform by averaging random noise. The normal detection mode for a spectrum analyzer is peak, so the displayed noise level drops from a peak to an average value in the smoothing process. This improves the visibility of signals close to the noise floor. However, as with resolution bandwidth, only the setting necessary to make the measurements you need should be used. Ω

IRON-ON PC PATTERNS

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put on clear safety goggles and wear rubber gloves. Check to be sure there are no pin holes in the gloves for acid to enter. Also make sure that the workplace is well ventilated.

Position the board vertically in the acid so that the etching process occurs uniformly on both sides. The byproducts of the etching process will gravitate to the bottom of the etching tank. The board can be mounted in a carrier, or it can be suspended from nylon monofilament fishing line passed through two drilled holes attached to a bar across the top of the tank.

If you elect to etch with ferric chloride, you will get the best results by heating the solution to about 120°F and circulating the solution with the bubbler. Both will reduce the time required to etch away the unwanted copper cladding. It takes about seven minutes to etch an eight-inch square board if the acid is fresh and heated to a temperature of about 100°F. However, actual etching time will depend on a number of variables: acid concentration, temperature, the degree of agitation, and the surface area to be removed.

Caution: Be sure that the ferric chloride temperature does not reach 180°F or the toner will dissolve from the board.

Turn off the heater when the etchant temperature has reached at least 100°F. (You might want to remove the heater to get it out of the way when you are etching the board. It will not cool significantly in the time taken to etch a board.

Remove the board from the etchant periodically, and examine it carefully to see if the etching is progressing uniformly. Look for any contaminated areas that might be blocking the etching action. When etching is complete, rinse the board thoroughly under running tap water to remove all traces of acid. *Caution*: ferric chloride attacks most metals and stains porcelain, so use a lot of water in the rinsing process.

Board cleaning

Remove the toner resist manually by scrubbing it with the same combination of household cleanser and fine steel wool that were used to clean the bare copper initially.

Drilling the holes

Use a rigid drill press for drilling the holes in the PC board. The holes must be accurately positioned and drilled vertically with respect to the PC board. If there is play in the motion of the drill press, the hole might be offset, and there is a risk of breaking a fine drill bit.

A piece of perforated prototyping circuit board with holes drilled 0.10 inch-on-centers works well as a drill jig. Circle the holes in the perforated board that are to be used as a drill guide with a colored marking pen so they can located quickly in a logical sequence while drilling.

Clamp the perforated board jig to the circuit board with double-sided adhesive tape to keep the two pieces from shifting with respect to each other. When drilling the board through the jig, hold the combination so that the drill bit can self-center in the pilot hole. Be sure to press down firmly on the work when the drill bit is withdrawn to prevent it from being caught and breaking off.

Periodically check to be sure that all drilled holes are centered in the pads on both sides. You might have to offset the drill jig slightly to average out any alignment error on both sides.

Minor hole runout in a series of aligned holes (such as required for mounting SIP's and DIP's) can be tolerated; the error build-up should not be enough to hinder device pin insertion.

Through-hole conduction

Complete all vias first. These are conductors inserted through the board and soldered to pads on both sides. Insert a length of bare copper wire with the same diameter as the drill bit in the via hole, and solder it to the pads on both sides of the board. Then trim the wire close to the board surface on both sides with a wire cutter.

Because these boards don't have plated-through holes, low-profile sockets with hollow machined pins are needed if you want to solder component pins to traces on both top and bottom surfaces of the board. Alternatively, you can use individual machined socket pins.

The machined pins call for slightly larger drilled holes, but they can be soldered to the board in the same way as the vias. Try to avoid getting any solder inside the hollow pins while soldering them to both top and bottom pads. Ω

References *Electronic Prototype Construction*, by Stephen D. Kasten, 1983, Howard W. Sams & Co.
Printed Circuits Handbook by Clyde F. Coombs, Jr., 1988 McGraw-Hill, Inc.

AUDIO UPDATE

continued from page 16

wise knowledgeable engineers who believe that expensive, strangely constructed speaker cables can make an enormous improvement in the sound of one's system. However, it's safe to say that the usual reasons advanced for the special sonic properties of the esoteric cables are technically "off the wall." Every objective test that I have heard of, including those rigorous tests described in the *Journal of the Audio Engineering Society*, has failed to reveal any virtue in the esoteric cables that is not found in standard (and far cheaper) 12- or 14-gauge single-conductor stranded wire available in electrical-supply stores.

Among the speaker accessories available in high-end hi-fi salons are special "spiked" stands and separate pointed feet meant to be installed under speaker cabinets. Spikes are said to provide improved coupling to the floor or other surface on which the speaker is installed. As is usual in such cases, there has been no test data put forward, nor any effort made to scientifically justify the perceived benefits of such spiking. However, it seems to me that going out of your way to couple the vibrations of a speaker cabinet to a shelf or the piece of furniture on which it is installed will simply force those supporting structures into vibration. I don't know whether this will have any audible effect, but if it does, it surely will not be a desirable one.

If the mounting surface is the floor, then the effect of spiking, if any, will depend on the floor structure. Coupling speakers to a rigid poured-concrete floor might help "clamp" the speaker panel resting on the spikes and, therefore, to some degree, inhibit vibration in the other panels of the cabinet. (When the speaker cabinet panels are inadequately braced and damped, this might be helpful.) But since most home floors are not poured concrete, how well you like the sound of your spiked speakers might depend on how well you like the sound of your vibrating floorboards. Ω

AURORA MONITOR

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the sensing head is adjusted and working correctly, close the lower cap and fasten it with two non-magnetic stainless steel self-tapping screws to complete the assembly. Connect one end of the plug-terminated coaxial cable to the sensor head jack 1 and the other end to the control/display unit jack J2.

Turn on the power toggle switch of the control/display unit and turn SENSITIVITY potentiometer R18 full clockwise. *The meter should remain at zero.* Rotate ALARM ADJUST potentiometer R19 clockwise until the alarm just begins to sound. Then turn it back slightly so that no sound is heard to obtain the maximum sensitivity setting. Next, turn potentiometer R19 full clockwise.

There should be no sound from the speaker.

Position a small magnet or piece of metal next to coil L1, in the sensor head and the unit should now be activated: the speaker should emit sound, and the meter should read full scale. If everything checks out, you can now start observing magnetic field disturbances or anomalies.

Operating the monitor

In a quiet magnetic environment it might be necessary to adjust potentiometer R4 in the sensor head to the threshold of the meter movement. This fine adjustment eliminates any small dead zones in sensitivity. Test the instrument's ability to detect the Earth's magnetic field by rotating the sensing head with short, quick, snapping motions in a counter-clockwise direction.

The meter movement should jump off scale.

As rotation is continued, a direction will be found where the meter will have its lowest response. This nulling point is the north-south direction. Any objects containing permanent magnets such as speakers or meters that are brought into close proximity to the Aurora Monitor's sensing head coil L1 will affect the accuracy of the instrument's readings.

The Aurora Monitor can be connected to a chart recorder or it can pass signals to a personal computer with an analog-to-digital converter board. The recorder or PC can collect data for the study of magnetic fields, magnetic storms, and sunspot activity over long periods of time for futher analysis. A set of high-impedance (greater than 1 kilohm) headphones can be plugged into jack J3 if you wish to "hear" the changes in magnetic fields.

If you want a permanent installation, mount the sensing head assembly so that it is directed away from any large metal obstructions, oriented on a north-south axis, and pointed slightly upwards. It's aos a good idea to fasten it to a heavy wooden post to prevent wind-induced vibrations. **R-E**

SCREEN PRINTING

continued from page 41

image area, and tape cardboard registration guides along the edges to position the rest of the printing run. Scrap pieces of blank circuit board material, strips of plastic, or any other rigid material can be used as register guides as long as they are no thicker than the blank you are printing on.

Gather all your support materials near you before you begin printing so that you will not have to interrupt the printing once you begin. Stopping the printing action for even a short length of time will allow the ink to begin drying in the screen image and necessitate a complete clean-up. Materials needed at hand include newsprint for proofs, tape to stop leaks should they occur, paper towels, and paint thinner (mineral spirits) to clean spills and mistakes.

Pour the resist ink above the image area and, holding the squeegee with both hands at about a 45 degree angle with respect to the table surface, pull firmly and smoothly toward you, as shown in Fig. 7. After printing, lift the screen to remove the board and insert a new one. It's best to do a few practice pulls on paper until you get the hang of it and begin to get good impressions. Then place some double-sided tape on the work table where the boards will be placed to hold them in place so they won't stick to the back of the screen when it's lifted. In commercial applications, a vacuum table holds the boards in place; a similar unit can be built to work from your home vacuum cleaner, should you decide to get into volume production. A set of plans for building a vacuum table is also included in the booklet or starter kit, as well as instructions for more complicated techniques such as printing double-sided PC boards and multi-color printing in close registration.

Set the printed boards aside to dry (about 30 minutes), inspect and correct any mistakes, and then etch and drill as you would with any other circuit board process. After etching, the resist can easily be removed with any slightly aggressive solvent or by lightly sanding.

Scrape out the excess ink from the screen and put it back into the can to reuse it another day. Wash the screen well with mineral spirits in a well-ventilated area, and set it aside to dry. At this point you can save it to reprint the same design or strip it clean with ordinary household bleach to use with an entirely new circuit design.

You can use this same process to print component layout guides on the opposite side of your circuit board, instrument panels, or even signs and book covers. Signplex, in Bessemer, Alabama, offers a kit of materials that allows a beginner to experiment with this process and produce high-quality circuit boards. It contains sufficient material to do 6 to 12 different designs, depending on the board sizes. Ω

COMPUTER CONNECTIONS

New and interesting products.

JEFF HOLTZMAN

We've been dealing with some pretty weighty issues over the past few months; this time, let's relax and take a look at of the some great new products.

Color printing from a desktop computer used to mean a pretty simple tradeoff: low-cost, low-quality or high-cost, high-quality. Low-cost units typically use dot-matrix or ink-jet technologies; high-quality units use thermal-transfer or dye-sublimation. Dye-sublimation units (e.g., Tektronix' Phaser series) provide high quality, but cost over $10,000. Thermal-transfer units provide lower quality, but cost significantly less—typically around $3000. And ink-jets are available for well under $1000.

Into this three-tiered structure comes Fargo Electronics and its Primera printer, a thermal-transfer unit with a list price less than $1000. The Primera effectively brings $3000 quality to the $1000 level.

The Primera's print quality easily exceeds that of better ink-jet units (e.g., HP's DeskJet series). Resolution is comparable to that of a fax machine, about 200 dpi. This means that text and very fine curves are noticeably more jagged than those from a 300-dpi laser printer. However, when printing continuous-tone images (e.g., scanned photographs), quality is comparable to that of a color newspaper (e.g., USA Today). You won't see Primera prints in *Architectural Digest*, but if you're used to black-and-white printouts, you will definitely sit up and take notice.

The Primera is a Windows-only printer. It does not understand PCL (HP LaserJet), PostScript, Epson, or IBM control codes, but it does have an ASCII text mode. It's basically designed to accept lines of raster data, as generated by a special Windows print driver. This, in effect, makes your PC the print controller, a scheme that has several advantages: cost and ease of software updates. Of course, it also slows down your computer. Running this type of printer driver in a pre-emptively, multitasked environment (e.g., OS/2) would give much better performance. However, no OS/2 driver is currently available.

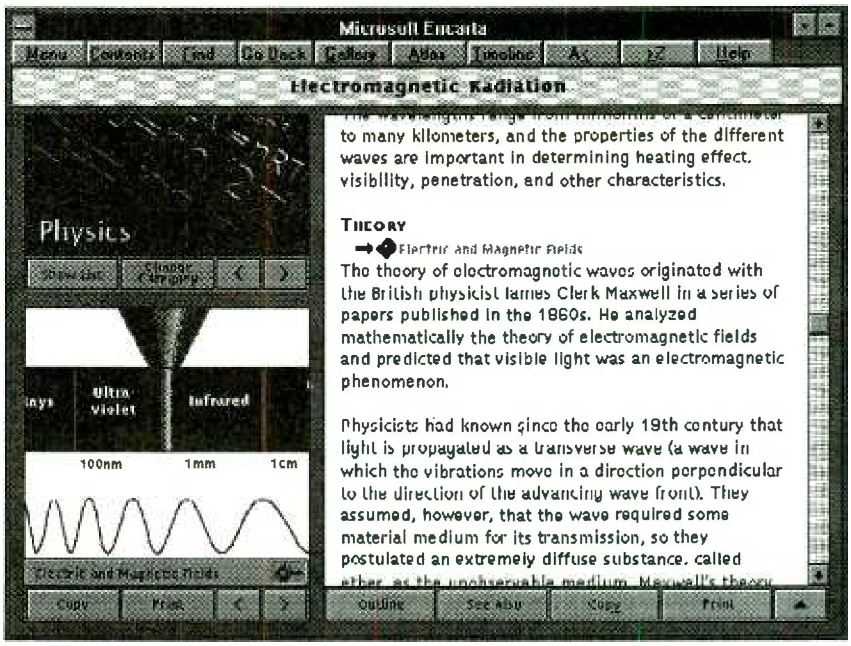

FIG. 1—MICROSOFT CONTINUES TO PENETRATE the consumer market with its best product to date, Encarta, a mesmerizing multimedia encyclopedia. It's easy to spend hours browsing through Encarta.

Typical black and white laser output costs about $0.03–0.05 per page; Primera output costs about $0.40 per page for paper and $1.09 per page for transparencies. Its paper rate is comparable to ink-jets, but the transparency rate is much cheaper.

The Primera can use three different ribbons. The first provides plain black and white printing, the second provides three-colors (cyan, magenta, yellow, or CMY), and the third, four-color (CMYK, where the K is black). The four-color ribbon is useful if you print a lot of (or need accurate) black; the three-color units obtain near-black by mixing cyan, magenta, and yellow. What you end up with is a grayish greenish brown. The printer comes with a three-color ribbon good for about 30 pages. The Primera also includes 25 pages of specially coated paper, and five transparency films. I got much better results using the coated paper than typical office-bond laser paper.

I had some trouble with early versions of the Windows printer driver; fortunately, the company posts updates on CompuServe. (However, they're not easy to find. Look in Library 1 of WINAPD.) As for print quality, I had the best luck with vector drawings created in packages like Micrografx Designer. Bitmap images had a tendency to be somewhat fuzzy. An upgrade, due to be released shortly, is claimed to provide dye-sub quality, particularly with scanned photographs. I'll keep you updated.

Each page must pass through the printer several times (once for each color); pages typically print in about 150 seconds. The Primera is quite a bit noisier than an ink-jet, because as the ribbon rotates, it makes a sound like crinkling cellophane. I definitely preferred moving the unit as far from my work machine as possible. In fact, I created a separate network print server on the other side of the room to drive it.

The Primera weighs about 15 pounds, and is equipped with an external power supply. There are two front-panel controls (power and on-line), and an internal DIP switch allows you to choose a character set for international usage.

Perhaps you've never heard of Fargo Electronics, the company is a big name in bar-code printers; Primera represents the company's first foray into the consumer marketplace. From the looks of things, it's going to be successful.

Who would buy a Primera?Its quality is not good enough for boardroom meetings or publication-quality graphics. However, its color saturation (richness) is definitely better than that from under-$1000 ink-jets. The Primera should suffice for departmental use, home use (in lieu of a low-cost laser printer), very small businesses, and lecture room overhead presentations.

If you're looking for an inexpensive color printer, the Primera offers your best bet to date.

Encarta

Encarta is a new Windows-based multimedia encyclopedia from Microsoft (see Fig. 1). There are three important characteristics for any electronic reference work: quantity of information, quality of information, and ease of use. On all three counts, Encarta is unquestionably the best CD-based work on the market. It includes fairly detailed text, many photographs, sound bytes (e.g., samples of national anthems and ethnic music), animations, and maps.

You can get at the information stored in Encarta in several ways. Contents provides a simple alphabetical list of all articles in the database. The Category Browser allows you to choose a category and a subcategory; subsequently, Encarta provides a list of relevant topics in a separate window. When you click on the title of the article listed in the secondary window, Encarta displays the article in the primary window. You can also search by keyword, including Boolean (e.g., transistor and Shockley, for which Encarta finds five articles). Encarta also includes a horizontally scrollable timeline of history, and a world atlas that allows you to click on an area of interest and get information about it. Unfortunately, the articles associated with the timeline are separate from the main encyclopedia entries, as if the timeline were a totally independent product.

The Encarta screen consists of three main panels, moving clockwise from the upper right: article, gallery, and category. The article contains the text of the current article. Most articles contain *hyperlinks* to other articles, as in any standard Windows Help file. By clicking on a highlighted word or phrase, you make the referenced article the current article.

The gallery panel contains a miniature display of any image(s) associated with the current topic; the image can be enlarged and copied to the clipboard. Article text can also be copied freely to the clipboard. Last, the category panel allows you to change articles and topics. Encarta also has a button bar for performing common actions quickly.

Encarta is no Encyclopedia Brittanica, but it has the deepest content of any currently available title. Also, there are things about the user interface that I don't like. In spite of those deficiencies, it's easy to spend hours browsing through Encarta. Its Boolean search capability should be extremely useful for research purposes. If you've been looking for an excuse (other than games) to upgrade to a multimedia PC, Encarta is it.

P. S. In case you're wondering what *Encarta* means, don't ask Encarta; the word does not appear in the product.

Trak 101

Key Tronic Corporation is famous for its keyboards. After years of promoting a narrow product line, the company has recently introduced several innovative new items, including fully programmable keyboards, one with a built-in calculator, and one with a built-in trackball.

I've always enjoyed working with trackballs, but keyboards I'd seen in the past with built-in trackballs universally suffered from poor quality. Not so with the Trak 101, a full-size 101-key layout with the classic Key Tronic feel. What is unique is a small (about 1.25-inch) trackball mounted just to the right of the Enter key, in place of the inverted-T cursor keys.

A separate cable connects the trackball to a COM port. The ball emulates a Microsoft mouse, and it worked just fine with Windows as soon as I installed it. The keyboard also includes several convenience features: the ability to switch the Control and Caps Lock keys, the ability to produce a comma or a period, regardless of whether Shift is pressed with the corresponding key, and several others. Key Tronic also includes a software driver for DOS applications that need an external mouse driver.

It took a little while to stop reaching for the mouse, but when I did, I found that I really liked having the trackball so close to the keyboard. Now I can "touch-mouse" (touch-track?)—move my hand from the keyboard to the trackball and back again without looking. In addition, you can't lose the trackball under a mound of papers, and you don't have to keep enough clear desk space to operate a mouse (or an external trackball).

News bits

IBM released version 2.1 of OS/2, and Microsoft released Windows NT. IBM is finally mounting some effective advertising, such as full-page ads in several trade journals carrying the phrase Nice Try, with the *N* and the *T* in a huge typeface. Microsoft seems to be lying fairly low for the time being.

As discussed here last time, in early spring the Unix vendors (HP, IBM, SCO, Sun, Univel, and Unix Systems Laboratories) formed a new open-systems consortium, the Common Open Software Environment (COSE). In retaliation, Microsoft announced a licensing deal with

Insignia Solutions, a company that builds and sells an Intel x86 emulator called Soft PC that run on numerous RISC chips and the Macintosh. Soft PC works but is slow, because both the CPU and DOS are emulated in software. The deal gives Insignia complete Windows 3.1 source code, which should lead to increased efficiency and compatibility for Unix users who also want to run Windows applications on the same box.

SunSelect, a division of Sun Microsystems, announced its solution to that problem: the Windows Binary Application Interface, or Wabi. Wabi will allow binary Windows apps compiled for the x86 architecture to run on supported RISC boxes, without the presence of either DOS or Windows. Performance should be better than the Soft PC approach, because there is neither emulation of the CPU nor DOS. Instead, Windows API calls are translated directly into equivalent X Windows (i.e., Unix graphics) calls. SunSelect already claims to have most important Windows 3.1 applications running under Wabi.

SunSelect made another, even bolder move, one that if successful could wrest control of the Windows API right out of Microsoft's hands and into the public domain. In short, SunSelect has proposed the creation of a Public Windows Interface (PWI). The PWI idea has already achieved verbal support from numerous industry heavyweights, including IBM, Borland, HP, Sun, SCO, USL, and WordPerfect Corp. Could Bill be losing his grip? Ω

RESOURCES

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- Encarta ($395), Microsoft Corp., One Microsoft Way, Redmond, WA 98052-6399. (800) 426-9400, (206) 882-8080.
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- Trak 101 ($224), Key Tronic Corp., P.O. Box 14687, Spokane, WA 99214-0687. (800) 262-6006, (509) 928-8000.
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9R47458	74LS30	.25
9R47466	74LS32	.25
9R48004	74LS74	.29
9R48039	74LS76	.49
9R48098	74LS86	.25
9R46447	74LS112	.25
9R46480	74LS123	.39
9R46607	74LS138	.39
9R46957	74LS175	.35
9R47036	74LS193	.59
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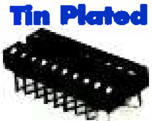

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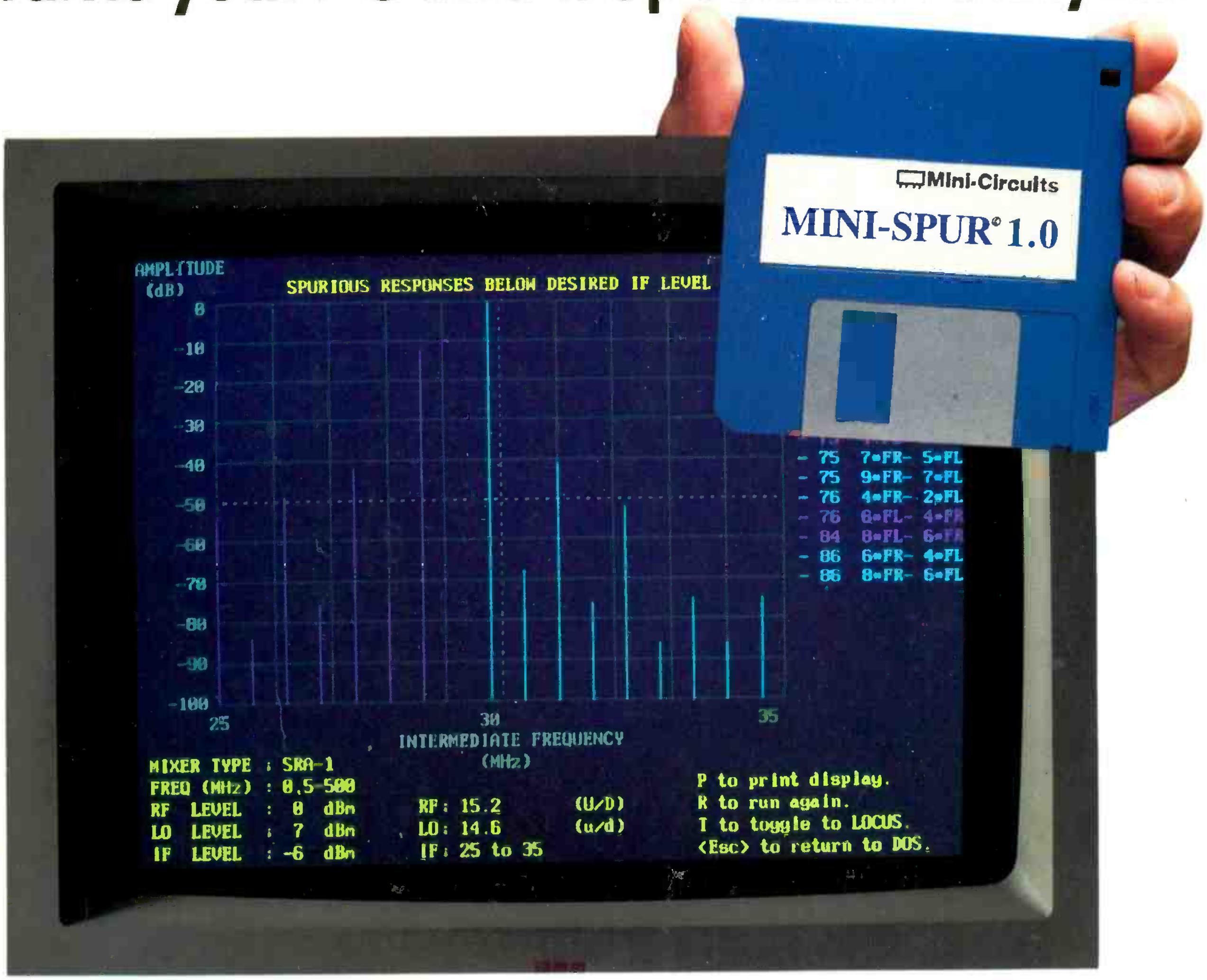

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