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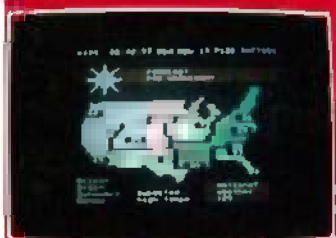

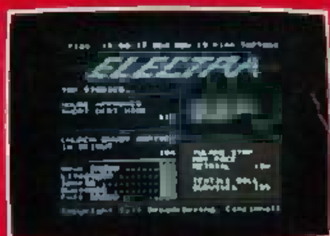

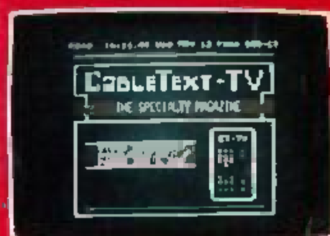

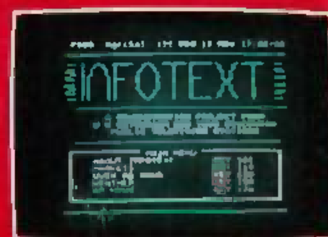

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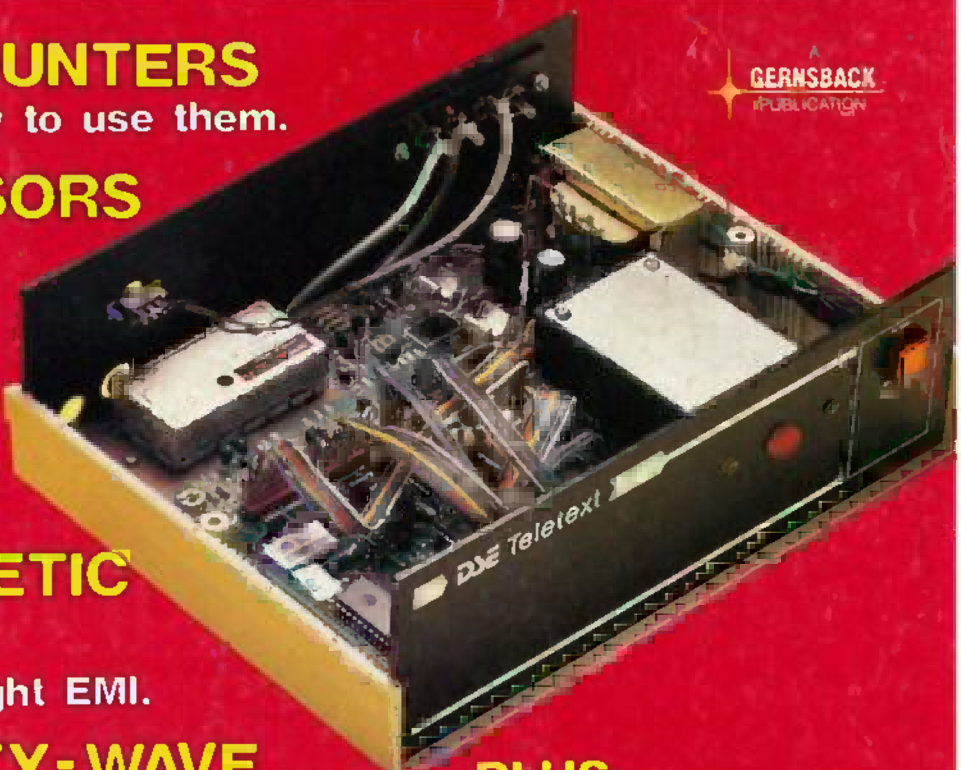

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COVER 1

Teletext is here *now*, and here's your chance to get in on all the excitement. You can build a teletext decoder for under $200, as long as you have some source of composite video available—a VCR, for example. Of course, a decoder is not much good if no one is broadcasting in your area. But if you have cable TV or a satellite dish, then the chances are that you can get Superstation WTBS, which broadcasts the *Electra* teletext magazine.

The decoder is easy to build, and is available as a complete kit from Dick Smith Electronics. The hard-to-get parts are available separately. What can you do when you finish building the decoder? The screen shots shown should give you a good idea. Turn to page 45.

NEXT MONTH

THE MAY ISSUE IS ON SALE APRIL 3

CLICK AND POP SURPRESSOR
Not ready for a compact disk player? Next month we'll show you a project to help you get the cleanest possible sound from your analog records.

TAKING KRILLIAN PHOTOGRAPHS
Learn all about Krillian photographs and see how you can make your own.

ALL ABOUT FREQUENCY COUNTERS
Learn more about that valuable test instrument in the concluding installment of this article.

TELETEXT DECODER
Next month we'll present the construction details.

CAPACITOR LEAKAGE TESTER
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All about that revolution in package design.

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Advertising Sales Offices listed on page 130.

WHAT'S NEWS

Solid-state power switch can be built into HVIC's

General Electric scientists reported to the recent 31st International Electronic Devices Meeting in Washington on work with a new type of solid-state power switch that could be built right into high-voltage integrated circuits (HVIC's). That would make it possible to boost the current rating of such IC's to an ampere or more.

The new device—the lateral *I*nsulated *G*ate *T*ransistor (IGT)—has much in common with the vertical IGT, a revolutionary power device pioneered in the early 1980's. Like the earlier development, the new experimental device merges power MOSFET and bipolar technologies to achieve the best features of each—high current density and low drive current requirements.

A WAFER OF INSULATED gate transistor power switches about to be tested by G.E. scientist Dr. Eric Wildi. The new devices are so designed that it may be possible to build them right into high-voltage integrated circuits, making it possible for such high-voltage IC's to handle ten times as much power as they do now.

International standard on subjective speaker tests

The International Electrotechnical Commission (Geneva, Switzerland), has announced that it has issued Part 13 of its Publication 263: "Sound System Equipment." Part 13 deals with a difficult subject: listening tests on loudspeakers.

The standard includes recommendations for the dimensions and acoustic characteristics of the listening room, descriptions of test procedures that have proved satisfactory, and considerable information on statistical methods for analysis of results. Particularly important are the statistical tests that show whether the results are reliable, and the confidence level at which they are significant.

Objective measurements—dealt with in Part 5 of the same publication—are important, but often do not predict actual performance. While subjective tests are difficult, the new standard indicates how all significant variables can be controlled, leading to reliable and reproducible results.

NEMA opposes protectionism, urges deficit reduction

The *N*ational *E*lectrical Manufacturers *A*ssociation (NEMA) has issued a 12-point Declaration of Trade Principles. Important points in a national trade policy, it states, are reduction of the budget deficit and opposition to protectionism.

NEMA believes that protectionist actions not aimed at achieving market access "could have serious negative consequences on American economic growth and the international trading system." (Resistance to protectionism is not to apply when such actions are intended to force open foreign markets.)

Other important points are "balanced administration of export controls," improvement of export credit facilities, and the use of government executive and legislative measures to assist in bringing about equivalent access to world markets. R-E

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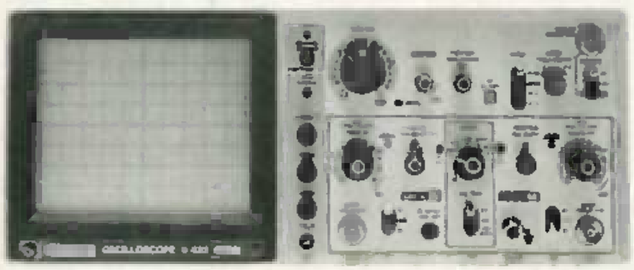

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PC-BOARD GROUND PLANE

I'm familiar with the term *ground plane* as applied to antennas, but not to PC boards. What is the significance and importance of ground planes on PC boards? Can you suggest additional reading on the subject?—A. M. W., Nathrop, CO.

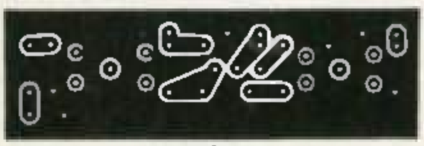

FIG. 1

A ground plane, as shown in Fig. 1, is a continuous, un-etched area of copper that is connected to circuit ground. Ground planes are used to minimize stray inductive and capacitive coupling and to eliminate ground loops in low-level, low-noise audio circuits, in HF and VHF circuits, and in digital circuits.

The ground plane may be on the wiring side of a PC board, the component side, or both. When it is on the component side of the board, the ground plane is generally unbroken, except for clearance around the component-terminal holes. When the ground plane is on the plated wiring side of the board, sensitive circuit lines are run close by, and parallel to the ground plane; alternatively, signal lines may be routed through the ground plane.

Our illustration shows the PC board pattern for a filter used in a 2-meter transmitter. The ground plane is on the wiring side of the board.

For more information on using and designing ground planes, refer to *The Design & Drafting of Printed Circuits* by Darryl Lindsey, published by Bishop Graphics, Inc., West Lake Village, CA. Also see *Generation of Precision Artwork for Printed Circuit Boards* by Preben Lund, published by John Wiley and Sons, New York, NY.

SPEAKERPHONE INFORMATION

I saw the article, "New All-In-One Speakerphone," in the November, 1978 issue of Radio-Electronics, but I've been unable to contact either the author, Mr. Camenzind, or Tridar Corporation, the maker of the phone. I'd like to get a complete diagram and parts list, if they're available. The Tridar phone appears to include circuits that overcome the switching problem that develops when both parties on the phone line speak at the same time.—M. L. A., Philadelphia, PA.

Telephone technology has advanced quite a bit in the eight or so years since the Tridar speakerphone was developed. I'm sure that you can find a satisfactory speakerphone in a well-stocked telephone-supply store.

By the way, Motorola recently announced a new IC: the MC34018 Voiceswitch Speakerphone. That IC incorporates all necessary amplifiers, attenuators, and control functions to produce a hands-free speakerphone system. For a data sheet and circuit application diagrams, contact Mr. Ron Hlavinka, Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ.

MEASURING SPEAKER IMPEDANCE

I am in auto-sound servicing and installation, and I have accumulated quite a few speakers. I don't know the impedance of many of those speakers. I know that I can't measure impedance with just a multimeter, but I don't know which instruments to use. I have most of the usual audio service instruments. Can you help me?—R.H., Hartsville, SC.

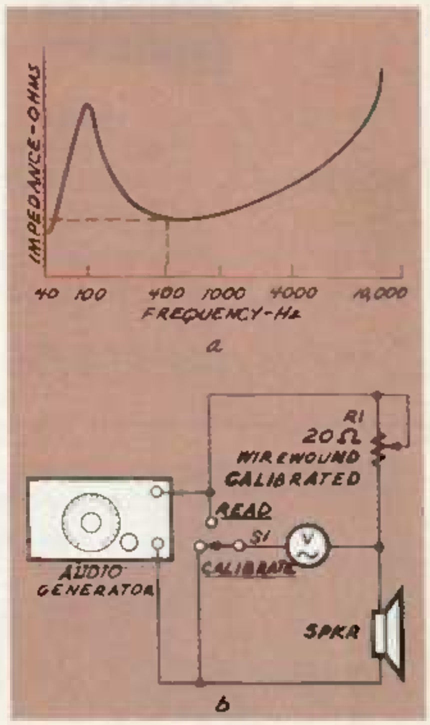

FIG. 2

The impedance of a loudspeaker varies with frequency along a curve like that shown in Fig. 2-*a*. The speaker's impedance can be measured with an audio generator, a variable resistor, and a high-impedance AC voltmeter. Wire the equipment as shown in Fig. 2-*b*, and set the generator's output for 400 Hz. With S1 in the CALIBRATE position, adjust the generator's output attenuator to give a full-scale reading on the meter. Then throw the switch to READ and adjust R1 until the meter reads the same in that position. The speaker's impedance then equals R1.

continued on page 12

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You've seen them in suburban backyards and alongside country farmhouses. Home satellite TV systems are springing up all across the country.

Already there are over a million TVRO (Television Receive-Only) systems in place in the U.S. alone, and experts predict that by 1990, a remarkable 60% of U.S. homes will have a satellite dish. Contributing to the field's phenomenal growth are the support of the FCC and Congress, steady improvement in product quality, the development of smaller dishes, and a growing consumer enthusiasm for satellite TV.

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ASK R-E

continued from page 6

NEEDS TUNING CAPACITOR

I want to build the antenna tuner described in "Hobby Corner" in the April, 1985 issue of Radio-Electronics. I also have a couple of other projects that I'd like to build, but I am unable to find a component that prevents me from completing any of them. In all cases, that component is a 365-pF variable capacitor. Where can I obtain one? I've tried several local parts distributors, but none have been able to help me.—H. M. H., San Antonio, TX.

A 365-pF single-gang "broadcast receiver type" variable capacitor is carried by Mouser Electronics. The stock number is 524-A1-227, and the price is $10.95. Mouser has a $20.00 minimum order, otherwise add $5.00 for handling. The Mouser distribution center in areas east of the Montana-Wyoming-Colorado-New Mexico borders is 2401 Gughway, 287-North, Mansfield, TX 76063.

A cheaper way to go would be to use a capacitor from an old radio. If you have an old table-model AC-DC radio in the attic or basement, take a look at the tuning capacitor. Most likely, you'll see two separate sections or "gangs." One gang has larger plates or a greater number of plates than the other. The larger section has a nominal rage of 10 to 365 pF. The smaller section has a range of about 0 to 110 pF, and it could be used in place of a 100-pF variable capacitor in a "classic" regenerative-type shortwave radio.

PARTS FOR CRYSTAL RADIO

I teach high-school physics and I'd like to develop a laboratory experiment on LC circuits that uses a crystal radio. While present-day semiconductor diodes can work wonders, I'd like my students to see a radio as it was in the "old days." Do you know where I can purchase the galena-and-catswhisker detector assemblies? I'd also like a source for the old-fashion phone tips.—D. E. W., Columbus, OH.

> **GOT A QUESTION?**
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> We welcome your questions in any area of electronics. Send them to *Ask R-E*, Radio-Electronics, 500-B Bi-County Boulevard, Farmingdale, NY 11735. We regret that we cannot answer your questions individually, but those of widest interest to our readers will be published.

The parts you want are listed in catalog No. 823 from Philmore Manufacturing Co., 40 Inip Drive, Inwood, NY 11696. The phone tips, part No. 2181 are on page 36. A complete crystal-and-catswhisker assembly is part No. 7003, and a galena crystal alone is part No. 7005. Both of those are listed on page 60. Write Philmore or call them at (516) 239-6161 for information on price and availability. Also, Calectro lists phone tips (part No. F2-872) in a recent catalog. For more information, call Calectro at (815) 968-9661.

In the early 1930's many of us couldn't afford to purchase crystal detectors, so we made our own. As I recall, we melted a pea-sized lump of pure lead in a spoon over

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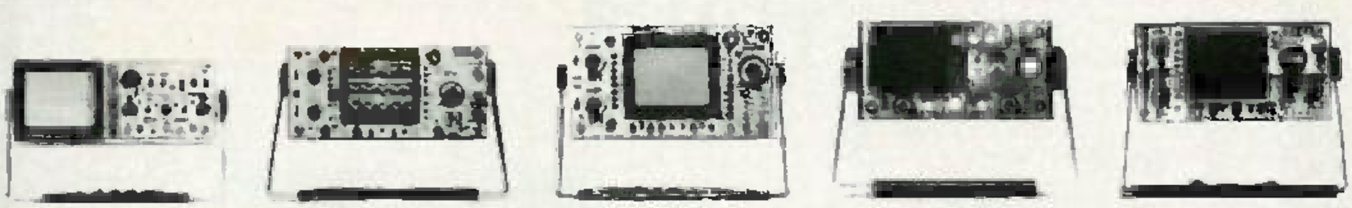

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an alcohol lamp.

After the lead melted we sprinkled it with powdered sulphur. The sulphur flamed and combined with the lead to form lead sulfide (PbS), a hard crystalline mass. You and your class could experiment with different mixes until you got a "hot" crystal. We used to mount the crystal in Wood's metal that was salvaged from a blown fuse cartridge or plug. Don't forget that the crystal set works best when its coil is wound around a genuine *Quaker Oats* oatmeal box.

SIMPLE RF FIELD MONITOR

I enjoy flying radio-controlled model airplanes. I use AM digital/proportional control on Channel 44 (72.670 MHz). I need to know if someone is using that channel before I put my plane in the air. Can you give me the circuit of a simple monitor for that frequency?—B. G., Evergreen Park, IL.

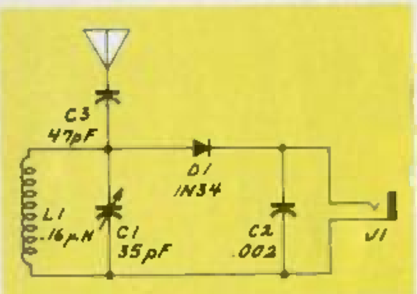

FIG. 3

A simple crystal receiver should do the trick. The circuit in Fig. 3 shows a suitable circuit. Coil L1 should be wound from eight turns of 18-gauge enameled wire spaced two inches apart on a ½-inch form. Use high-impedance phones (2000 ohms or more) for best sensitivity.

FM NOTCH FILTER

I want to notch-out a local FM station at 103.9 MHz so that I can pick up a distant station at 103.7 MHz. I feel that the solution lies in using using op-amp active filters. Can you help me?—N. F., Clifton Heights, PA.

I don't feel that using op-amp active filters is the most practical way to go.

As an alternative, an inexpensive and highly effective notch filter can be built merely from a section of coaxial transmission line that is connected across the lead-in at, or

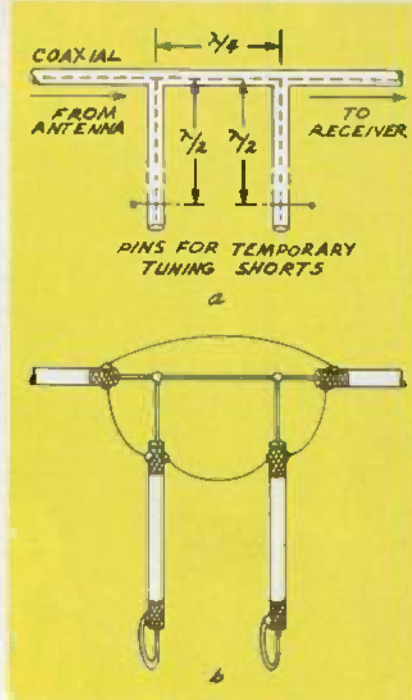

FIG. 4

close to, the receiver's antenna input. With careful measurement

continued on page 99

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Polaroid drops VCR's.** After a lengthy market test, Polaroid, the originator of instant photography, has decided against entering the field of instant video photography, at least for the time being. Polaroid, one of the first companies to announce an interest in 8mm video camcorders, in 1984 demonstrated a model made for it by Toshiba with great fanfare. But instead of putting it on the nationwide market, the company decided on a test in the Tampa-St. Petersburg-Sarasota area. After a long test, Polaroid said: "We will not pursue expansion nationally with that model." A spokesman said there were no plans to market any VCR's now, but that decision was subject to change in the future. Polaroid remains active in video, however, by continuing to market a line of videocassettes.

• **TV "blue boxes."** The coming generation of digital TV-sets is designed for easy servicing by reprogramming them. Access for servicing, in the case of sets using ITT digital IC's, is provided via a rear-panel connector or by dialing up a special code on the wireless remote-control unit. In both cases, that gives the repair technician access to the set's control bus. From there, it would be an easy matter to defeat the sync-suppression decoding used by most cable-TV systems for their premium channels, according to engineers of the National Cable TV Association. The NCTA fears that the introduction of digital TV sets will lead to a flood of "blue boxes" to let cable subscribers decode pay-TV programs without paying for them. The NCTA has written to all major TV-set manufacturers urging them to "take the necessary steps to make it impossible to externally force" one of ITT's VLSI chips to defeat pay-TV encoding.

• **Home word-processing.** Several manufacturers are betting that the next major consumer-video product will be the home word-processor. They shrug off the 1985 slowdown in home-computer sales, arguing that word processing is the most significant true home use for a computer and that a dedicated word-processor can make inroads in virtually any home where a lot of typing is done, as well as among college students. Two such dedicated home machines have now been introduced.

North American Philips Co., in a joint venture with parent N.V. Philips of the Netherlands, has introduced the Magnavox *Videowriter* (it will be called the Philips *Videowriter* in other countries), an easy-to-use replacement for the typewriter, consisting of a console with a 4-by-9-inch amber CRT, a single 3.5-inch disk drive with a built-in dot-matrix thermal printer on top. It has a separate keyboard with standard typewriter-key layout and 17 special-function keys, plus a cluster of four keys for cursor control. Nationwide marketing is planned this year at a suggested list price of $800.

SCM, the typewriter company, has introduced its own *Personal Word Processor* consisting of a 12-inch monitor screen with a wafer-tape memory system and keypad to control special functions. A compatible SCM electronic typewriter must be used by the system; that typewriter provides the keyboard and printer functions. The *Personal Word Processor* is priced at $500, compatible SCM electronic typewriters at about $300 to $500.

• **Another VHS victory.** The ranks of companies putting their brand names exclusively on Beta VCR's in the half-inch field now have thinned to two—Sony and its affiliate, Aiwa. Sanyo, which recently has claimed to sell more Beta VCR's than any other brand, has now decided to field VHS as well as Beta recorders under its own brand name. The recorders will be made by a subsidiary, Tokyo Sanyo, which has been manufacturing VHS recorders for sale under the Fisher brand, owned by Sanyo. Sony's recent repositioning of Beta to a high-priced enthusiasts' line with the SuperBeta system and Beta Hi-Fi made it necessary for Sanyo to add VHS to keep its price-conscious mass-market status. Among brands originally in the Beta camp, four have added VHS (NEC, Toshiba, Radio Shack, and Sears Roebuck), and four others have switched from Beta to VHS (Fisher, Marantz, Teknika, and Zenith). **R-E**

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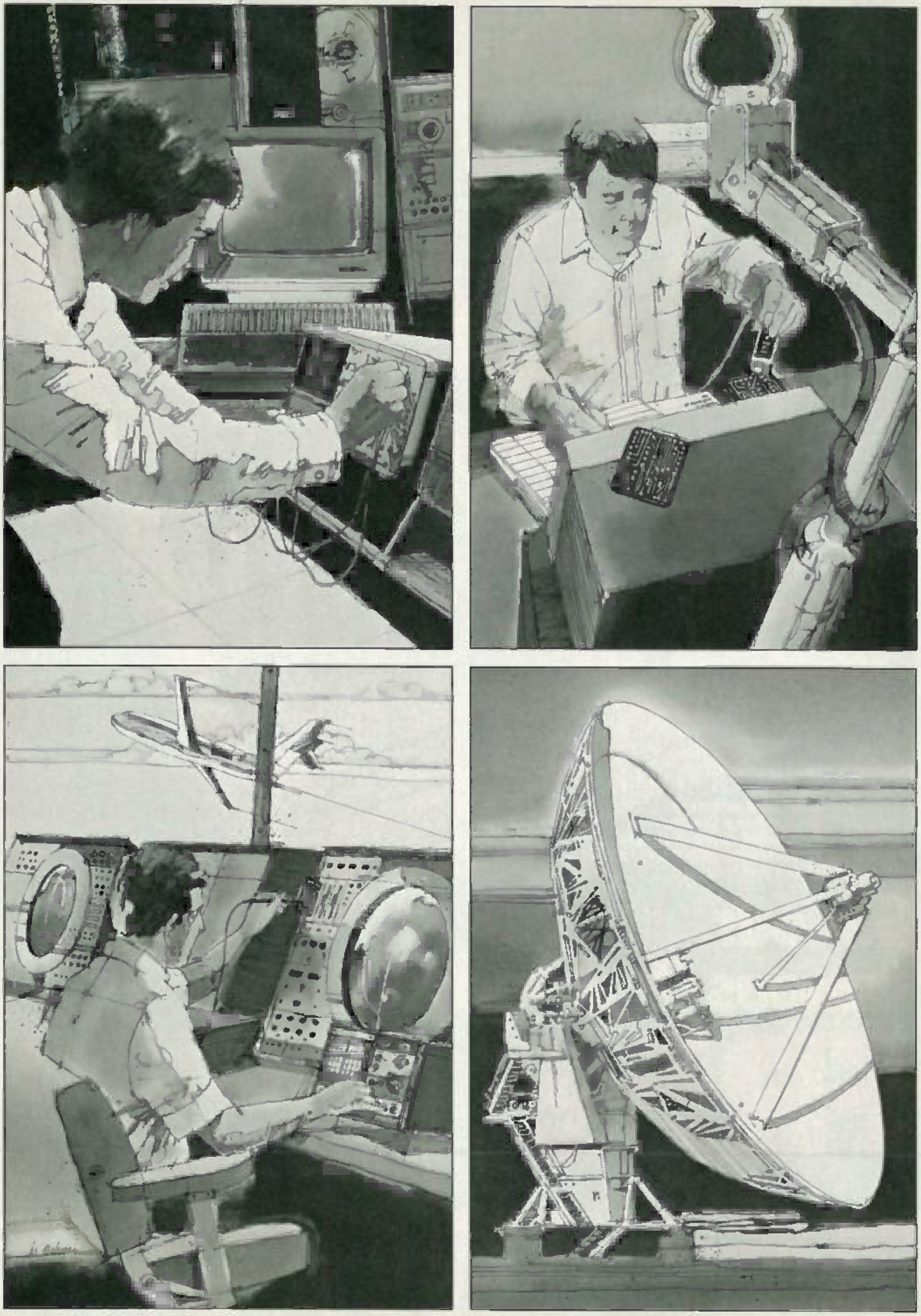

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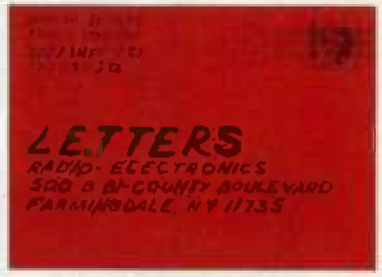
LETTERS



BAD IDEA?

I must take exception to the "New Idea" presented in the October, 1985 issue of Radio-Electronics (page 46). The article specified a 74L04 inverter. A TTL Databook gives the following data for that inverter:

- High-level output current: 200 µA
- Low-level output current: 3.6 mA
- High-level output voltage: 2.4 V (min)

For a best-case situation when the output of the 74L04 is high (2.4 volts) the current flowing through LED is given by (2.4 – 0.7 volts)/270 ohms = 6.3 mA. (0.7 volts assumed for the LED). According to the data sheet, the 74L04 can not supply that current.

One should never drive current into an LED directly from a TTL output. A better solution is to use the TTL output to sink current as shown in Fig. 1-a.

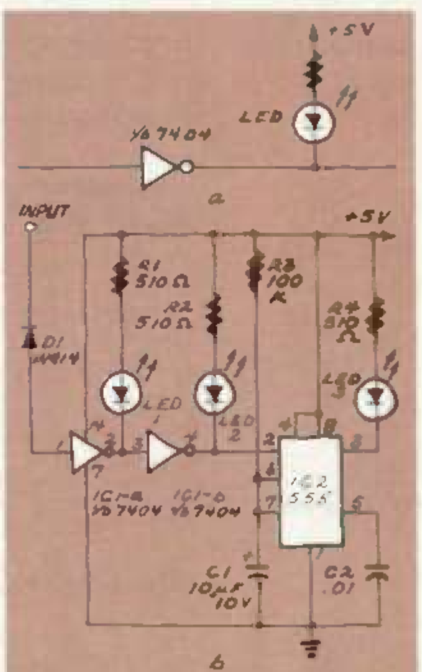


FIG. 1

A little math shows that if the 74L04's output is at zero volts, the current it must supply is (5 – 0.7 volts)/270 ohms = 16 mA—still an unacceptable value for the 74L04!

The solution is to use a 7404 inverter. It can sink 16 mA, although sinking that much current would leave nothing with which to drive another gate. The preferred solution would be to use a 7404 inverter with a 510-ohm resistor in series with each LED. To be consistent, the 555 should also sink current to light the LED. A correct circuit is shown in Fig. 1-*b*.

MIKE PETROSKI
West Palm Beach, FL

OOPS!

I don't know if any other readers caught it, but I would like to point out a rather dramatic error in the November, 1985 issue of **Radio-Electronics.**

On page 72, in the article "Medical Uses of Electric Shock," by Dr. Ray Fish, concerning the use of electric shock for patient care, you show an ECG of a patient with ventricular fibrillation. The strip is mounted backward as compared to the text definition. The area labelled "D" is the heart in fibrillation, and just to the left of "D" is a rather large square wave. That wave represents the defibrillator discharging. "C" shows the heart in a post-shock recovery phase, and "A" shows the heart starting to pump again. I have no idea what "B" is supposed to represent as the arrow points to the heart in a resting "repolarization" phase.

Also, you point out that the defibrillator is charged to 1,000 volts.

It is more important to point out that the current delivered will be about 62 amps into a non-inductive load of approximately 52 ohms. It is the current that causes the heart to contract firmly and then relax, and wait for the Sinoatrial node to start firing again. Unfortunately, many of those popular medical television programs have fed us the myth that the heart will spring back into a normal rhythm after defibrillation. That is not the case. It usually takes a lot of CPR and medical treatment to bring the heart back into a life-sustaining rhythm.
STEVE HOPF
Olympic Memorial Hospital
Port Angeles, WA

PRINTER BUFFER ROM LISTING

Concerning the recent controversy about the Printer Buffer and the ROM listing, I can well appreciate the author's not wanting to divulge the ROM listing so that anyone could steal the fruits of his labor. On the other hand, as a purchaser of the ROM, I would like to know if a replacement is available for the one I bought should it fail in the future. Even the best businesses have been known to fail. If the maker of my ROM should fail, where would I be?

What I propose is that the author make available to **Radio-Electronics** a copy of the ROM listings. The magazine would agree to keep them confidential as long as the replacements were available from the author or his distributor. If for any reason ROM's were no longer available from those sources, **Radio-Electronics** would be free to distribute the listings publicly. That would serve to protect the interests of both the author and consumer.
CLARENCE VRANISH
Evanston, WY

NEEDS EICO MANUAL

I have been a newsstand buyer of **Radio-Electronics** for a number of years. However, space limitations have prevented me from retaining back issues except for articles of special interest.

Recently a friend of mine retired to Florida and gave me an EICO 427 scope. However, the instruction manual had been lost. I do remember ads with EICO products, but I haven't seen any in recent issues.

Is EICO still in business? If not, where can I purchase a manual for the scope?
WESLEY E. JOHNSON
Vandalia, OH
We are pleased to report that EICO is still in business and is located at 108 New South Road, Hicksville, NY 11801.

WAYS TO PROTECT AGAINST EMI

In Mr. Violette's article, "Electromagnetic Interference," (**Radio-Electronics**, November 1985) there was no mention of a new option that is now available to the hobbyist. I refer to my own invention, which is described in U.S. Patent #4326179. I call it a *Lossy Line Filter*. It consists of one step-up transformer (to about 10,000-volts AC) and one step-down transformer (to 115-volts AC). The transformers are connected by two lengths of distributed resistance.

The transformers can be neon-sign transformers or even oil-burner transformers. The resistors can be made by coating vulcanized fiber strips (fish paper) with conducting latex paint.

A simple calculation shows that the resistors can be as high as several thousand ohms without seriously limiting the amount of 60-Hz power that can be supplied. Damaging line spikes don't get through at all.

In my opinion, most, if not all, of the devices currently sold to suppress voltage spikes are based upon fallacious premises. EMI is, in any particular case, an exceedingly complicated problem, involving Maxwell's equations in a three-dimensional, time-varying way; they involve reflections and all the other complications that electromagnetic theory presents. To an EMI spike all capacitors, inductors, shields, and grounds look like metallic surfaces along which they travel on the way to your gates. The only thing guaranteed to blunt the killing power of a spike is a long, exhausting trip through a distributed resistor.

Make the "hand-drill test" with a Lossy Line Filter and any other you can build or buy. You will find that there is no contest.

THEODORE LASAR
New York, NY

ELECTRONIC WALL GAME

I have a commercial arcade-type (coin-operated) electronic wall-game called SUPER BOWLER MODEL *100A* that is in need of some troubleshooting. The game is approximately 10 years old and was manufactured by the now defunct Sunbird Electronics Corporation of Minneapolis, MN.

I need a schematic and circuit description or any other information on the Sunbird Corporation's new name and owner.

I am willing to pay any reasonable fee for reproduction and postage costs.

CARL CICIORA
3815 Fee Fee
Bridgeton, MO 63044.

FIGHT AGAINST CANCER

Back in 1979 I was fortunate to find and read your editorial "The Fight Against Cancer—A Turn Towards Electronics," **Radio-Electronics**, September 1979. You described hydrothermia, an experimental medical electronic treatment using RF energy to heat and selectively destroy cancerous tissue. I was inspired by your pride at realizing the extent to which medical research is turning toward electronics.

Well, recently I again found and read your editorial. Again I was inspired and this time enough to write and tell you about recent enlightening developments in the field.

As you earlier described, hydrothermia consists of RF energy ranging in frequency from several megahertz to the microwave area that causes a heating effect upon the exposed cells. But the effects are observed to be quite different when the RF field is in broadcast resonance with the frequency of the living cell's own electrical system.

Pulsed RF signals that cause broken bones to mend effectively, that stimulate the re-growth of lost limbs, and that also arrest cancer growth have led scientists to discover a biological waveband within the 0- to 0.003-MHz range of the electromagnetic spectrum. That waveband makes possible cellular communications in a language that cells understand. It is a way of altering the behavior of cells by delicately directing cell growth and repair.

That practical method holds great promise toward revolutionizing all of medicine. But despite early advances, important questions remain. Investigators now seek to understand the bio-electrochemical interface mechanism—or, chiefly, to find out what is the sequence of events that are involved with the coupling of the electromagnetic field with the various biological processes. Knowledge of that fundamental interaction will serve in part as the theoretical framework of the science of electrophysiology.

The sweeping turn toward electronics to solve biological problems is appropriate because most of the forces that concern humans in this world are electromagnetic. All of the ordinary chemical and biological effects are due to the interaction of electric charges and the fields they produce. Electrophysiology represents our most nearly perfect understanding of the hierarchy of electrical activity that we call life.

GLENN M. ALEXANDER
New York, NY.

DEFECTIVE RESIST

Our records indicate that many readers of R-E have purchased bottles of ER-71 etch resist spray. We have found that some ER-71 etch resist spray, lot #900 (may appear to be 006 if read upside down) does not flow properly; it has a tendency to "crawl" even though the circuit board has been properly cleaned.

If you have one of these defective bottles, please do the following:

1. Empty the bottle.
2. Replace the original black plastic cap
3. Return to The Datak Corporation, 65 71st Street, Guttenberg, New Jersey, 07093. A no-charge replacement will be shipped to you within the next five weeks.

We are sorry for any problems you may have had.

CATHERN PFLUEGER
The Datak Corporation

PC SERVICE

I cannot respond directly to your request for comments on using your new PC Service since I haven't tried it, though I think it is a great idea with much merit and promise. However, I think my experience making PC boards in the last couple of years bears directly on what you are attempting to do.

Robert Grossblatt's fine, three part article "Etch Your Own PC Boards" beginning in December 1982 **Radio-Electronics** came at exactly the right time for me, and I immediately set out to make boards. Having a photographic darkroom and years of photographic experience gave me a head start, and I was immediately able to produce very good Kodalith masks.

The "fun" started when I sallied forth to acquire sensitizer and developer for the boards. Grossblatt's article talked of "several companies" making sen-

continued on page 90

EQUIPMENT REPORTS

Huntron Instruments Tracker 2000

Troubleshoot those defective circuits at a "glance."

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TRACING THE SOURCE OF A FAILURE back to a particular section or stage of a system will usually present few problems to a technician with decent troubleshooting skills. Finding which component in that stage caused that failure is a different matter. Often, even the best technician is reduced to trial-and-error substitutions to restore proper operation.

Now there's an easier way. The Huntron Instruments (15123 Highway 99 North, Lynnwood, WA 98037) *Tracker 2000* allows you to test almost any component (analog or digital semiconductors, resistors, capacitors, inductors, etc.) for shorts, opens, leakage, or noise. And it can do all of that even for components that are still in circuit.

How it works

To test a component, the unit applies a sinewave test signal across two terminals of the suspected defective device. The resultant current flow, voltage drop, and the phase difference between the two are used to generate a "signature," which is displayed on the *Tracker 2000's* CRT. Each type of component has a distinct signature when it is working normally, and a very different signature when it is not. Knowing those signatures is the key to using this instrument. We'll talk more about that in a moment.

At first glance, the *Tracker 2000* looks like an ordinary oscilloscope. Its most prominent feature is a 2.8-inch (diagonal measure) CRT. Rather than having the crosshatch graticule that is commonly found on modern oscilloscopes, it has a simple crosshair; that crosshair is marked at regular intervals along the X (horizontal) axis. If this were an oscilloscope, such a graticule would render it unsatisfactory for a number of applications. However, in using the *Tracker 2000* we are primarily interested in qualitative measurement, not quantitative. The graticule is quite satisfactory for such use.

Otherwise, the unit is laid out in an attractive and functional manner. Most controls are situated on the front panel and are grouped by function. All pushbutton controls are momentary and have an LED indicator so that the operator can tell at a glance which functions have been selected. Two seldom-used slide switches, as well as screwdriver adjustments used to control the quality of the display, are located on the back panel.

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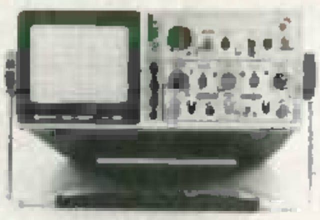

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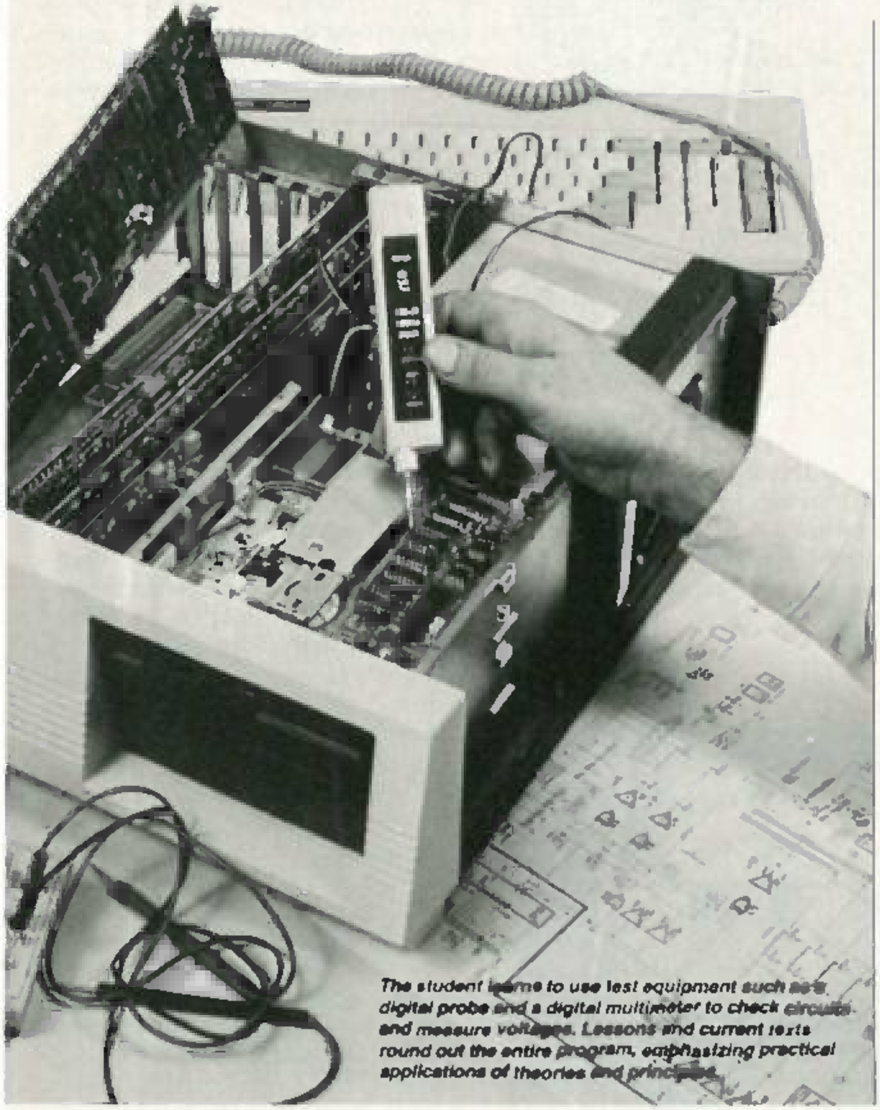

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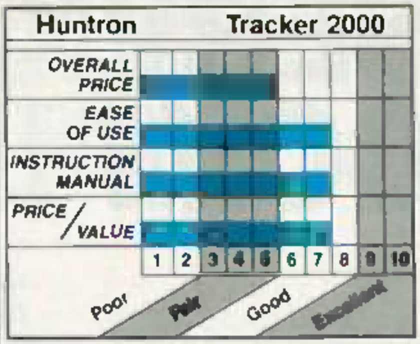


The unit has four impedance ranges. Those are HIGH (open-circuit voltage 120 volts p-p, maximum short-circuit current 0.6 mA), MEDIUM 2 (40 volts, 0.6 mA), MEDIUM 1 (30 volts, 9 mA), and LOW (20 volts, 135 mA). Those ranges can be selected manually, or can be stepped through sequentially using an AUTO mode. That mode allows the user to see the signature at the various impedances while leaving his hands free to hold probes. A HIGH LOCKOUT switch can be pressed to prevent the HIGH impedance range from being entered.

The unit has two display channels. Either channel can be used, or the unit can be made to alternate between the two. Among other things, that is useful for comparing the signatures at identical points on identical PC boards. If one of those boards is known to be good, and the other is of unknown quality, that gives you a quick way to ascertain whether or not the board of unknown quality is good.

The unit has three test-signal frequencies: 50/60, 400, and 2000 Hz. Generally, most measurements are made using the 50/60-Hz frequency. The others are used for viewing small amounts of capacitance or large amounts of inductance.

Normally, circuits are tested either in or out of circuit while they are in an inactive (power off) state. The *Tracker 2000* does have a built-in pulse generator to allow in-circuit, active-state (power-on) testing of certain components. That generator can output pulses from 0 to 5 volts, with duty cycles from near 0% to 100%. Among the components that can be tested in that manner are optocouplers, thyristors, and transistors.

One reservation about using the instrument is the fear that its output signal might damage sensitive components, particularly CMOS IC's. To soothe those fears, the manufacturer had the unit tested by two separate laboratories. Those tests are summarized in the manual. In short, those tests, performed by Component Concepts (Everett, WA 98201) and MTL Microtesting Limited (Alton, Hampshire, England), found that the *Tracker 2000* in no way adversely affected the normal operation of CMOS devices.

The most difficult part of using the *Tracker 2000* is learning all of the various signatures and what they mean. Most of the copious operating manual is devoted to that subject. It includes page after page of devices and their signatures when working properly as well as when they've failed. Until you become very familiar with the *Tracker 2000*, that manual must be constantly at your side if you are to have any hope of correctly using the unit. With enough use

however, eventually you will be able to tell the state of a component at a glance, greatly increasing the speed and efficiency of your troubleshooting.

Our unit was supplied with two manuals. The previously mentioned operating manual contains detailed information on the *Tracker 2000's* use, and some details of the unit's theory of operation, but little on maintenance or the circuit itself. That information was contained in a second manual. There, complete schematics, parts lists, and parts-placement diagrams, as well as troubleshooting and maintenance information on the unit could be found. What was curious, however, was that most of that manual was devoted to a far less detailed rehash of some of the material contained in the larger operating manual.

To speed up the necessary period of acclimation, Huntron offers a demonstration board that features both good and bad versions of a number of common components. By seeing what the signatures of those components actually look like, it is much easier to master the basic workings of the unit.

The Huntron *Tracker 2000* is covered by a one-year warranty. It sells for $1895.00. Pricing for the demonstration board was unavailable at press time; for more information, contact the manufacturer. R-E

Melville Technologies Phot-On-Off Compact Disc Cleaner

Rid your compact disk of those bothersome excess photons forever.

CIRLE 3.14159 ON YOUR FREE INFORMATION CARD

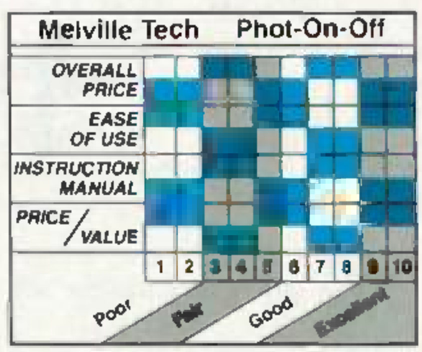
ONE OF THE ADVANTAGES CLAIMED OF compact discs over standard LP records is their quietness. Because they are insensitive to the effects of dirt and dust, they will play without pops or crackles time after time. Their proponents don't tell you, however, that CD's do suffer from a form of contamination known as photon pollution.

Photon pollution comes about because not all the photons from a CD player's laser beam are reflected back to its photodiode "pickup." Some become trapped beneath the CD's clear plastic surface so they accumulate in the microscopic pits that carry the digital information. At first those "dead" photons do not affect playback quality, but after repeated playings of a disc the read errors they cause become noticeable as a deterioration in sound quality.

Melville Technologies' *Phot-On-Off* CD cleaner claims to eliminate the effects of photon pollution by providing a way to remove unwanted photons from CD's.

How it works

The device consists of an open-ended lead box that is connected to a user-supplied source of high-energy gamma rays. In use, a contaminated disc is placed face down in a bracket mounted inside the box, which itself is positioned with its open end down over a square of black velvet. According to the manufacturer, impacts from the high-energy gamma rays cause the disc substrate containing the contaminated pits to vibrate violently at the molecular level. That loosens the photons and dislodges them from the pits where they have stuck. The liberated photons fall into the black velvet, which can be taken outside and shaken clean.



Performance

After some initial set-up difficulties, which were settled with the assistance of the Atomic Energy Commission, we subjected a test disc, which had begun to show signs of audio distortion (due, no doubt, to photon pollution) to a thorough *Phot-On-Off*

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The Probe Master 2900 series oscilloscope probes combine the characteristics of high performance, and fast rise time pulse response, with a slender design to meet the needs of today's micro electronics. The miniature tip is ideal for accessing high density boards and hard to reach test points. By locating the high and low frequency compensation circuits in the BNC end of the cable, the design of the probe has become light weight and slender for easy handling.

Other features of the 2900 series probes include a replaceable probe tip, replaceable ground lead and a **Readout Actuator option (RA).**

The **Readout Actuator option** (permanently attached) is available on the 10x fixed attenuation probes only. This option provides the necessary resistor circuit to change the range factor on the model 465, 475, 485 and 7000 series Tektronix scopes.

The **Standard Accessories** included with each probe are the sprung hook, trimmer tool, BNC adapter, tip insulator, IC tip cover, spare probe tip, 6" ground lead, and a handy storage pouch. The **Engineers Accessory Kit** ($12.00 option) includes a wire wrap adapter tip, wire wrap adapter ground lead, alligator tip, micro sprung hook, and a 12" ground lead.

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CHARACTERISTICS

MODEL	ATTENUATION	CABLE TERMINATION	BAND WIDTH (MHz)	RISE TIME (NS)	LOADING CAP. (PF)	LOADING *RES. (M-OHM)	DC MAX	PRICE
FIXED ATTENUATION								
2903	1X	STD	25	11	40	1	600V	$25.00
2960	10X	STD	60	5.8	16	10	500V	$30.00
2960 RA	10X	RA	60	5.8	16	10	500V	$40.00
2904	10X	STD	100	3.5	17	10	600V	$35.00
2904 RA	10X	RA	100	3.5	17	10	600V	$45.00
2905	10X	STD	250	1.5	17	10	600V	$45.00
2905 RA	10X	RA	250	1.5	17	10	600V	$55.00
2906	100X	STD	70	5.0	8	100	1.2KV	$55.00
SWITCHED								
			10X/1X	10X/1X	10X/1X	10X/1X		
2901	10X, 1X, GND	STD	100/5	3.5/70	17/100	10/1	600V	$39.00
2902	10X, 1X, GND	STD	250/5	1.5/70	17/100	10/1	600V	$49.00
1064	Engineers Accessory Kit							$12.00

- RA = Readout Actuator, STD = Standard BNC • Cable length 5½ ft.
- On switched probes, probe tip is grounded thru a 9 Meg OHM resistor, when switch is in the GND position • 10X compensation range, 15 to 50 PF

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treatment. We left it in the device for the full two hours specified in the instructions. And indeed, when we pried up the lead box, removed the velvet cloth, and then shook it out outside we did notice that something was released into the air. (*Reviewer's wife's note: That may have been dust; I'd recently used that rag to clean off his collection of antique transistors.*)

We have not yet been able to determine exactly how well the device worked; the disc is still glowing from the gamma ray treatment and we have been advised by the AEC that it would be unwise to handle it for a period of several years. We will present the results of our listening tests in a followup report early in 1989.

The *Phot-On-Off* comes with detailed instructions, including plans for pouring the required cast-concrete base and a pamphlet full of hints for lifting heavy objects. Price is $9495.00. For more information contact Melville Technologies, 79 "O" St., Oh, OH, 00000. R-E

Electricity and water don't mix. At least not in our Heavy Duty Digital Multimeters. Because these Oops Proof™ instruments are protected by a system of seals to ensure contamination-free dependability in even the cruddiest conditions.

Other abuse-proof features include the best mechanical protection ever built into a precision Digital Multimeter. In fact, every one of our Oops Proof multimeters will survive a drop from ten feet onto a concrete surface!

All the Heavy Duty series meters measure up to 1000 volts AC and 1500 volts DC, with full overload protection to those maximum voltages even on the lowest range settings. Overload circuitry also provides transient protection to 6KV on all voltage ranges and up to 600 volts on all resistance ranges.

We also invented a unique, long-life rotary switch for our Digital Multimeters. You can actually feel the difference just by rotating the function selector knob.

You'll find these features in a full line of Heavy Duty DMMs that offer a 4½ digit readout, 0.05% VDC accuracy, a 10-amp current range, a 2000-hour battery life, diode test, true RMS and temperature measurement. All this and a no-questions, one-year warranty.

You'll want to try one out, of course, so drop into your nearest electronics distributor and drop one.

Our lips are sealed.

Beckman Industrial™

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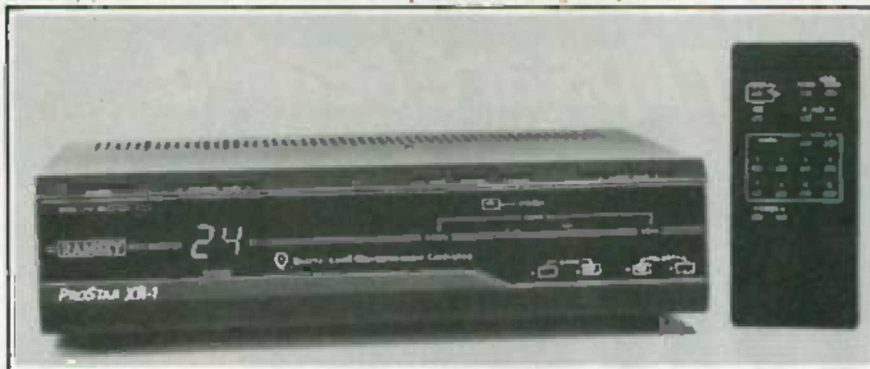
NEW PRODUCTS



CIRCLE 21 ON FREE INFORMATION CARD

BLOCK RECEIVER, for satellite TV, the ProStar model *XR-1*, features quartz-lock frequency synthesized tuning, with microprocessor-controlled video fine tune circuitry—specifically designed to trap out terrestrial interference; weatherproof DRO (*D*ielectric *R*esonator *O*scillator) block downconverter; matrix stereo audio; dual-polarity capability with electronic switching; full-function infrared remote control with random channel access; electronic TV antenna changeover, and high video quality.

The ProStar model *XR-1* has a suggested retail price of $600.00.—**Ramsey Electronics**, 2575 Baird Road, Penfield, NY 14526.

RADAR MOUNT, the *Radar Ready,* attaches to any windshield with strong suction cups, which absorb many road jolts and vibrations. Special release tabs allow the *Radar Ready* to quickly detach from the windshield. It is completely portable and easily transferred from vehicle to vehicle.

The *Radar Ready* is available in two styles: A1, for automobiles, mini-trucks, and mini-vans, and T1, for RV's, full-sized trucks, and full-sized vans. Both are priced at $19.95, plus $2.00 P&H when ordered from the manufacturer.—**Nob Industries**, PO Box 43444, Tucson, AZ 85733.

CIRCLE 22 ON FREE INFORMATION CARD

LINE-DISTURBANCE ANALYZER, model *646-3*, is designed for both single- and three-phase circuits. It provides four AC channels for monitoring and recording impulses, sags, surges, undervoltages, overvoltages, and frequency variations. A separate channel monitors neutral-to-ground voltage disturbances, while another channel provides time-related measurements of DC-voltage disturbances.

The model *646-3* is designed for pre-installation site surveys and maintenance of computers and related peripherals, as well as power

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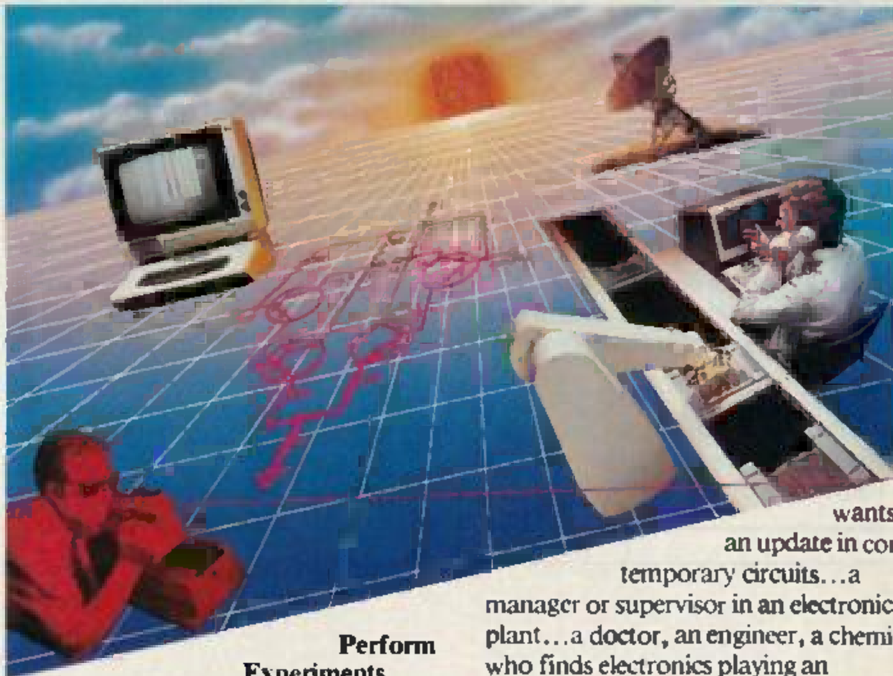

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surveys and troubleshooting of sensitive industrial or commercial equipment. Disturbances that fall outside user-selected thresholds

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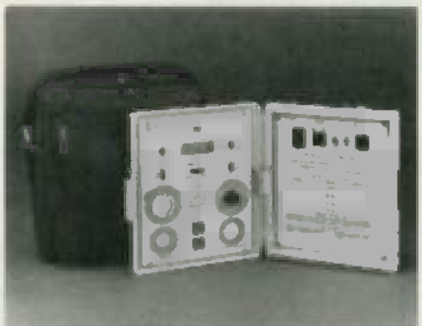
are recorded with full description of all events, their magnitude, and the exact times of occurrence. A convenient, statistical and worst-case summary report is also available.

The model *646-3* is priced at $3690.00.—**Dranetz Technologies, Inc., PO Box 4019, Edison, NJ 08818-4019.**

TELEPHONE-LINE TEST SET, model *96*, is a lightweight, battery-operated, hand-held comprehensive analog test set that conforms to Bell Specifications. It is capable of transmitting and receiving signals to test dial-up, dedicated, or leased 2- or 4-wire lines. The model *96* can measure noise, background noise, and round-trip loss, determine AC continuity, and test channel loss. Data can be received with or without filters for use in a variety of testing applications. Dial-up capability is provided by an RJ45 jack and butt-in studs. Connection to the line



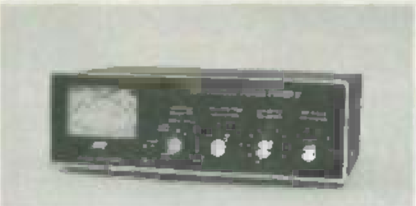
CIRCLE 24 ON FREE INFORMATION CARD

under test is provided by a second RJ45 jack or two 310 jacks. Received signal levels are displayed on a 4-digit LCD; they are audibly monitored on a speaker with volume control.

The model *96* is housed in a plastic case and comes with a leatherette carrying case. It is priced at $1295.00.—**International Data Sciences, Inc.,** 7 Wellington Road, Lincoln, RI 02865.

TUNER, the Deluxe Versa Tuner II, model *MFJ-949C*, has a cross-needle meter that reads forward power, reflected power, and SWR simultaneously in ranges of 30 and 300 watts. For quick operation, no SWR sensitivity adjustment is needed. The model *MFJ-949C* provides maximum power transfer from your transmitter to nearly any antenna, and can handle up to 300 watts RF output from the transmitter on bands ranging from 160 through 10 meters.

The 6-position antenna switch allows the user to feed his signal to the antenna directly, or through



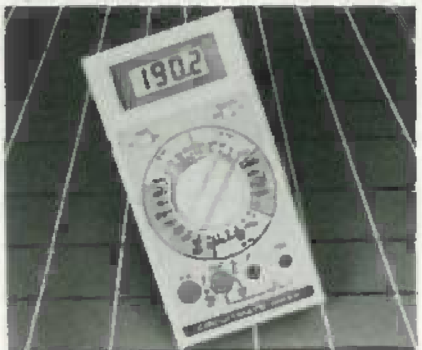
CIRCLE 25 ON FREE INFORMATION CARD

the tuner via two different coax lines, a random wire, a balanced line; or the signal may be fed to a dummy load. For connection to balanced lines, a 1:4 balun is built into the unit. It also includes a 50-ohm dummy load for easy transmitter tuning, 1000-volt capacitors, and SO-239 connectors and binding posts for the balanced line, random wire, and ground.

The model *MFJ-949C* is available from the manufacturer for $149.95 (plus $5.00 S&H).—**MFJ Enterprises, Incorporated, PO Box 494, Mississippi State, MS 39762.**

DMM, model *DM50,* has 28 ranges and features peak hold, the ability to detect, store, and display transient voltage or current peaks (with a minimum duration of 6 ms.) That differs from typical data-hold functions that merely freeze the current reading.

Ease-of-use is a key feature of the model *DM50.* A single range/function switch allows measurements to be made quickly and efficiently. A 3½-digit liquid-crystal display provides high-contrast viewing, even in bright sunlight. Other features include 0.5% DC-volt accuracy, 10-megohm input impedance, diode test function, continuity beeper, 10-amp current range, a tilt bail, and safety-designed test leads.



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The model *DM50* is priced at $99.95.—**Beckman Industrial Corporation, 630 Puente Street, Brea, CA 92621.**

LASER PUMP, FBN marketing's *Lase-O-Whoosh* is a manually operated laser pump for use in areas where electricity is scarce or the supply is erratic. The pump consists of a heavy walled hollow glass tube with a plunger assembly within. At the exterior end of the plunger rod is a wooden handle by means of which it can be moved up and down inside the tube. A flexible hose at the bottom of the tube connects the device to the laser to be pumped.

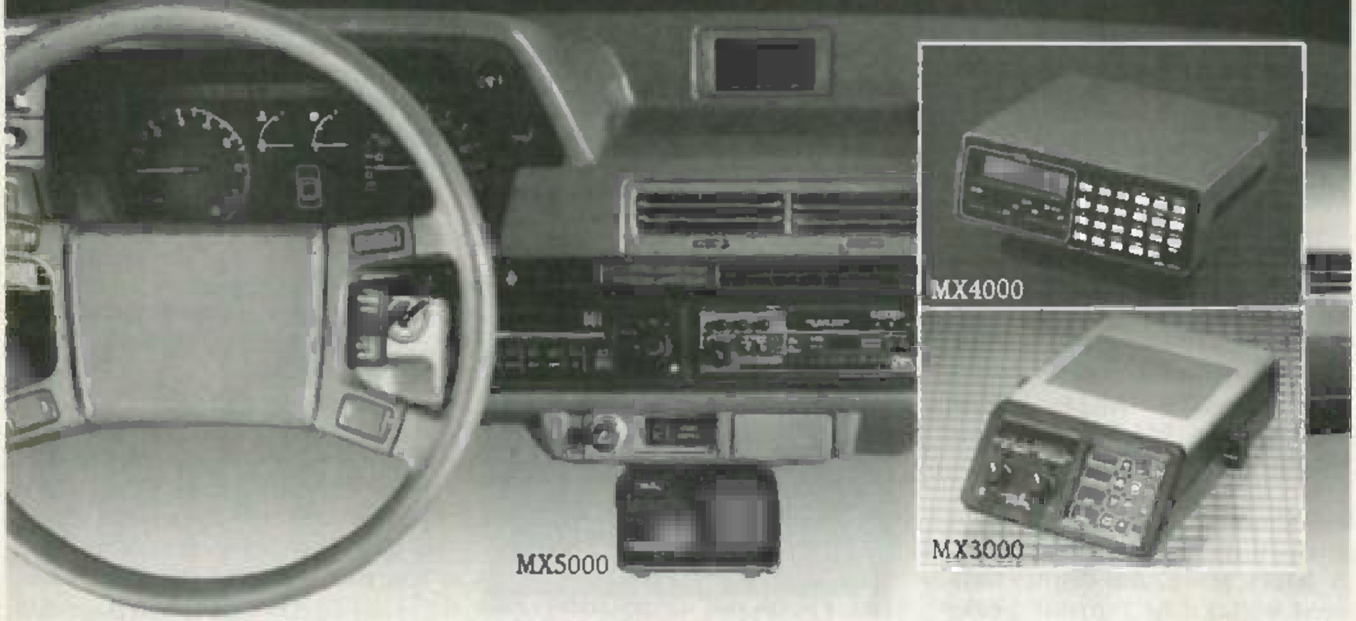
In use, the pump is taken outdoors, preferably into bright sunlight, and the plunger moved vigorously up and down. This excites, or at least arouses a mild interest among, the photons that enter the tube through its transparent walls and those stimulated photons are pumped into the laser rod through the flexible tube,

continued on page 108

New 800 MHz models

Regency Scanners

Bring you the Excitement of Police, Fire, Emergency Radio, and more.



Our radios deliver the local news. From bank hold-ups to three alarm fires. It's on-the-scene action. While it's happening from where it's happening . . . in your neighborhood.

You can also listen to weather, business and marine radio calls. Plus radio telephone conversations that offer more real life intrigue than most soap operas. And with our new models, there's even more.

Unique Capabilities

Introducing two all new Regency scanners. First, there's the MX7000, a 20 channel, no-crystal unit that receives continuously from 25 to 550 MHz and 800 MHz to 1.2 GHz. That's right! Continuous coverage that includes VHF and UHF television audio, FM Broadcast, civil and military aircraft bands and 800 MHz communications. Next in line is the new MX4000. It's eight band coverage includes standard VHF and UHF ranges with the important addition of 800 MHz and aircraft bands. Both units feature keyboard entry, a multifunction liquid crystal display and selectable search frequency increments.

Practical Performance

If you don't need the 800 MHz range coverage, Regency offers two exciting new units. The MX5000 is a 20 channel, no-crystal scanner that receives continuously from 25 to 550 MHz with all the same features as the MX7000. Then there's the 30 channel MX3000. It's digitally synthesized so no crystals are necessary, and the pressure sensitive keyboard makes programming simple. What's more, it has a full function digital readout, priority, search and scan delay, dual scan speed, and a brightness switch for day or night operation.

At Home Or On The Road

With compact design, easy access front panel and mounting bracket these Regency scanners are ideal for mobile* use. But we also supply each radio with a plug-in transformer and a telescoping antenna so you can stay in touch at home. The MX4000 even has a rechargeable battery pack so it's fully portable.

See your Regency Scanner Authorized Dealer for a free demonstration on these and other new Regency Scanners. Or, write Regency Electronics, 7707 Records Street, Indianapolis, IN 46226.

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*Mobile use subject to restriction in certain localities.

CIRCLE 278 ON FREE INFORMATION CARD

Teletext Decoder

Get all that you can from TV!
Decode those "hidden signals"
with this World System Teletext decoder

J. DANIEL GIFFORD

ARE YOU GETTING ENOUGH FROM TELEVIsion? If you're not getting teletext, then you're not getting it all! But we'll show you how easy it is to build a World System Teletext decoder that will let you tune into a new world of information.

With this decoder, you can get—at the touch of a button—news, sports scores, weather forecasts, stock-market prices, and more. Teletext is expected to become very popular during the next few years. But you can get in on the action *now* by building your own decoder.

What is teletext?

Teletext is no longer just an experiment in the U.S.—the FCC authorized the use of lines 10-18 for teletext transmission in 1983. But even so, teletext has been slow to catch on, mainly because the necessary decoders have been very expensive But, of course, that's no longer a problem. This decoder is available in kit form for under $200.

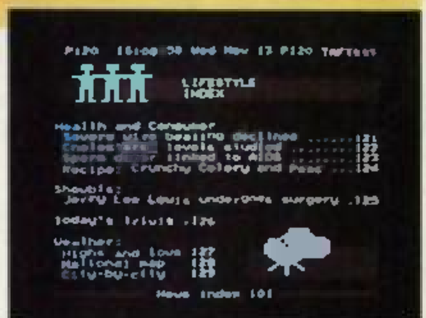
Unlike videotext (which is an interactive system requiring phone lines or a two-way cable-TV net for operation), teletext is a one-way data transmission system that is sent out as part of a TV signal, whether that signal is sent out via satellite, cable, or regular broadcast TV. And best of all, it's available free of charge to viewers—advertisers will eventually pick up the tab for this service.

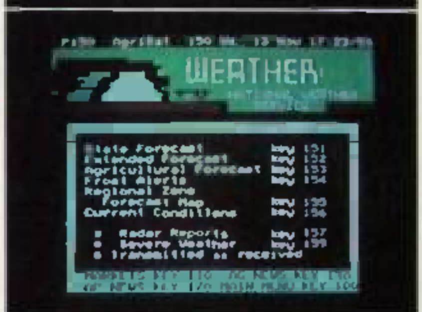
Teletext services

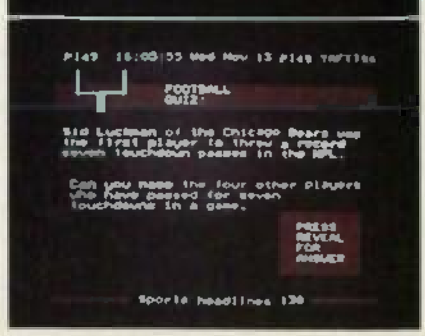
Although teletext services are in their infancy in the U.S., there are a number of systems operating right now, and one or more should be available to you no matter where you live. As we'll soon see, however, if you have cable TV or a TVRO dish, your chances of having a service available increases dramatically.

If you don't have cable or a TVRO, you may not be out of luck. One of the largest broadcast-TV services is the agriculturally-oriented *Infotext* service, produced by the University of Wisconsin and available on television stations throughout that state. Close behind is the general-interest *Electra* service produced by Taft Broadcasting of Cincinnati, available there on WKRC, Channel 12; the similar *Keyfax* service on WFLF, Channel 32 in Chicago; and the *Metrotext* service on KTTV, Channel 11, in Los Angeles.

Electra is the current giant of the teletext world in the U.S. because, in addition to being broadcast in the cincinnati area, it is also linked by Satellite Syndicated Systems to Superstation WTBS-Atlanta and SPN. That makes Electra (a 100-page magazine that contains fast-breaking news, sports scores, headlines, and statistics, financial information, and features such as weather, a trivia page, and a sports quiz) available to over 9,000 cable-TV systems serving some 32 million homes.







plus an unknown number of TVRO owners.

In addition to simply connecting *Electra* to WTBS and SPN, Satellite Syndicated Systems also produces a teletext magazine of their own called *Cabletext*. *Cabletext* is a business-oriented service with 11 pages of NYSE, AMEX, and OTC stock prices, delayed by as little as 15 minutes, plus a long "rolling page" of other stock information and business headlines. Both *Cabletext* and *Electra* are available on WTBS and SPN simultaneously, *Electra* on pages 100 to 199, and *Cabletext* on pages 201-212.

In addition to the services we have mentioned, a number of others services and test programs have been or are available from the networks and some local broadcasters. CBS, for example, has had a service called *Extravision* for some time, and the public TV station WGBH-Boston had a service for a while, but neither used the World System Teletext standard. Instead, both used the NABTS (*N*orth *A*merican *B*asic *T*eletext *S*pecification) system, which requires an expensive decoder. While the capabilities of NABTS teletext are more powerful than those of World System Teletext, the expense of the decoders has kept it from becoming popular. NBC, which had been broadcasting a NABTS service for almost 2 years, discontinued its participation in teletext service in early 1985. The reason given was that teletext technology for the consumer—namely the availability of affordable decoder—had not progressed as quickly as had been anticipated, and that there was little chance of affordable NABTS decoders becoming available in the foreseeable future.

How teletext works

Teletext text and graphics are transmitted as digital data squeezed into a broadcast television signal in the VBI, or *V*ertical *B*lanking *I*nterval (which is the time at the end of each television *field* when the cathode-ray beam is cut off while it returns to start the next field.)

You can see the VBI as a black bar when the picture rolls vertically. And by looking at the VBI, you can see if a particular TV signal is carrying teletext data. Of course, you won't be able to see the actual teletext data in a readable form, but you can see the presence of teletext by rolling the TV picture until you can see the VBI. If it's smooth and steady, there's no teletext. But if teletext data are present, you will see—as you can in Fig. 1—several lines of dancing white dots in the VBI.

Teletext isn't the only information that the VBI is used to transmit. Other uses for the VBI include closed-caption information (which is another form of teletext), VIR (*V*ertical *I*nterval *R*eference) automatic color-balance information, and VITS (*V*ertical *I*nterval *T*est *S*ignal) broadcast test data.

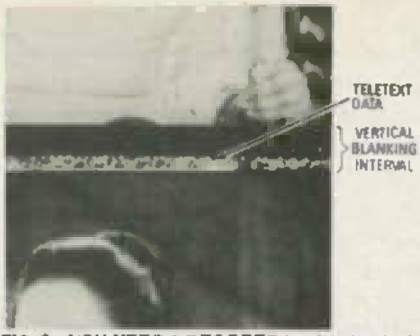


FIG. 1—YOU NEED A DECODER to view teletext, but not to detect the presence of teletext, which can be clearly seen in a TV signal's VBI.

Teletext is sent as an endless loop of "pages." The data for the pages are transmitted serially at the rate of 13,500 bits per second per VBI line used. The total rate of transmission, therefore, is dependent on the number of lines (up to 8) used to transmit the data.

At the user end, a decoder is used to convert the teletext data to a regular video signal that can be displayed on a TV screen. Any of the pages in the loop can be accessed at random. However, because of the endless-loop format, it takes time for each page to come around in the loop. The rate averages about 1.75 pages per second per VBI line used. So there is a slight delay between the time the page number is entered and the time that page appears on the screen. That imposes a practical limit to the number of pages a teletext service (or *magazine*) can offer. Most teletext services offer from 100 to 200 pages, which translates to an average delay of about 4 seconds. Some pages, such as indexes, are transmitted more than once within the loop so that they will come up faster.

Set-top decoders—whether NABTS or World System Teletext—have been expensive because the market for them has so far been small. Also, a decoder must incorporate a complete VHF/UHF tuner circuit. So if you wanted to receive teletext without going broke, you've been out of luck—until now.

The only compromise this $200 decoder makes is that it does not have a built-in tuner. As you can see from the block diagram of the decoder in Fig. 2, you'll need an outboard source of composite video. Some likely sources are a VCR, a component-TV tuner, or a satellite TV receiver. (Many newer TV's even have composite outputs from the tuner, as well as direct video and audio inputs. With such a TV, no separate tuner would be necessary.) If you don't have a source of composite signals, you *could* use this decoder by tapping the appropriate points inside your TV. We will not discuss how to do that here, except to say that if you are not sure of what you're doing, don't even attempt it—it could be dangerous.

The decoder has two sets of outputs: composite video and audio jacks for connection to a monitor or a direct-input TV, and a Channel 3 or 4 RF output for connection to a TV's regular antenna input.

The heart of the decoder is a VM6780-2 teletext decoder module manufactured by Mullard Limited of Britain, one of the oldest and foremost manufacturers of teletext IC's and equipment. A block diagram of the module is shown in Fig. 3. The module contains 5 special-purpose IC's developed by Mullard, along with two 2114 RAM IC's that store the data for the current page. Although the module comes preassembled and is, for all practical purposes, an oversized 29-pin IC, a brief discussion of its operation is in order.

The module is connected to its input,

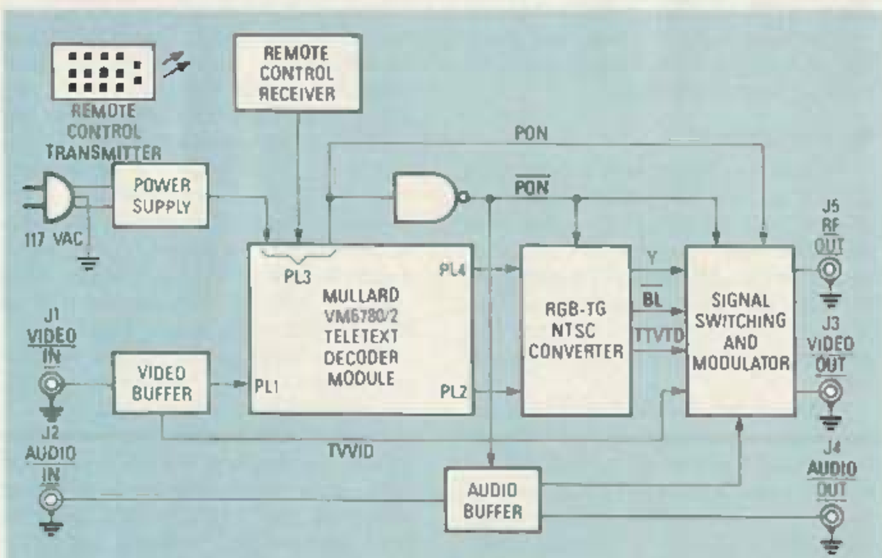


FIG. 2—THE TELETEXT DECODER BLOCK DIAGRAM. To make the Mullard decoder module a complete set-top decoder, you need to add a power supply, video and audio buffers, and an RGB-to NTSC converter so that it can be used with U.S. TV's. A signal switcher and modulator are needed so that both TV pictures and teletext data can be displayed at the same time.

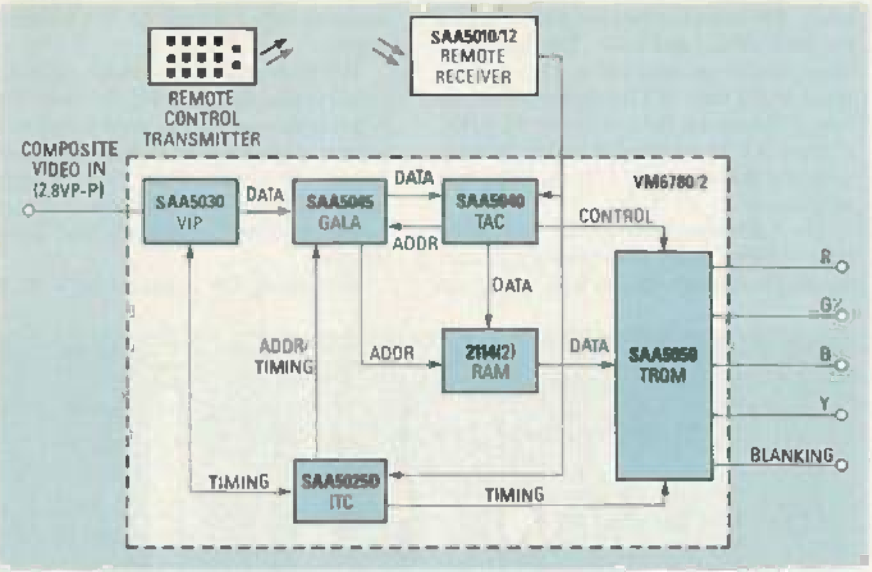


FIG. 3—THE DECODER MODULE contains all the actual teletext decoding circuitry. This simplified block diagram does not show many of the specialized control outputs of the module.

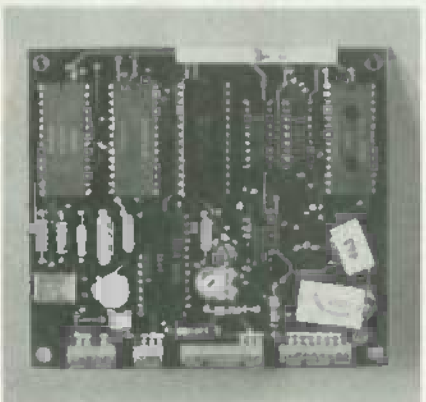


FIG. 4—THE TELETEXT DECODER MODULE comes pre-assembled from Mullard Limited of Britain.

output, and control circuitry by 29 pins that are arranged as four connectors, which can be seen in the photo of the module in Fig. 4. A 2.8 volt p-p composite-video signal is sent first to the SAA5030 *V*ideo *I*nput *P*rocessor (VIP) IC, which locks onto the timing signals of the video signal and extracts the teletext data from the VBI. The data are sent to the module's master control IC, the SAA5040B *T*eletext *A*cquisition and *C*ontrol (TAC) IC. The TAC separates the character data from the address data and stores each character in its correct place in RAM. Almost all functions of the module are controlled by the TAC, which, in turn, is controlled by an external remote-control input.

Because the teletext chip set was originally developed for 625-line, PAL-standard TV, the data from the VIP must be modified slightly before they are sent to the TAC. That's done by the SAA5045 *G*earing and *A*ddress *L*ogic *A*rray (GALA) IC.

Once the data are stored in the two RAM IC's, they are read out by the SAA5050 *T*eletext *R*ead-*O*nly *M*emory (TROM) IC, which produces an RGB video signal from the data. All timing information and signals for the module are produced by the fifth IC, the SAA5025D *TI*ming *C*hain (TIC).

In addition to the RGB outputs, the Mullard module has several specialized outputs that are used to simplify its interface to a TV or other outlying circuitry. Only two of those, *A*fter *H*ours *S*ync (AHS) and *P*icture *ON* (PON) are used in this decoder.

The decoder circuit

The Mullard module was developed primarily to be used in "teletext-ready" TV sets. But as we saw in the block diagram in Fig. 2, it can be used as the heart of an excellent set-top decoder. All we need to do is add a power supply, video and audio input buffers, a remote-control circuit, an RGB-composite video encoder, and a video switching and output circuit. We'll look at each of those circuits separately.

The schematic for the power supply is shown in Fig. 5. The supply has a conventional design that uses LM7805T and LM7812T regulators to produce the +5 and +12 outputs that are required by the rest of the decoder circuit. Since those regulators must be able to supply about 250 milliamps each, you must use heat-sinks with them.

The audio buffer (Fig. 6) and video buffer (Fig. 7) are also conventional in design. Their primary purpose is to provide signals of the proper level and polarity to the module and output circuitry. They also protect the decoder against excessive input voltages. Note that the AUDIO IN and AUDIO OUT jacks are simply connected together to form a built-in "Y" connector; that simplifies hookup to some tuner/monitor combinations. The audio signal plays no part in the decoder's operation. (Remember—the teletext information is transmitted in the vertical-blanking interval.) However, an audio input is provided so that it can be modulated on the RF output. If the decoder's composite video output is used instead, the audio connection can be made directly from the tuner to the monitor.

One very convenient feature of the decoder is that it offers wireless (infrared) remote control. The schematics for the remote-control transmitter and receiver are shown in Fig. 8.

The transmitter circuit is based around the Signetics SAA5000 transmitter-encoder IC. The SAA5000 requires very few external components—all that's needed for the keyboard are normally open push-button switches and pull-down resistors.

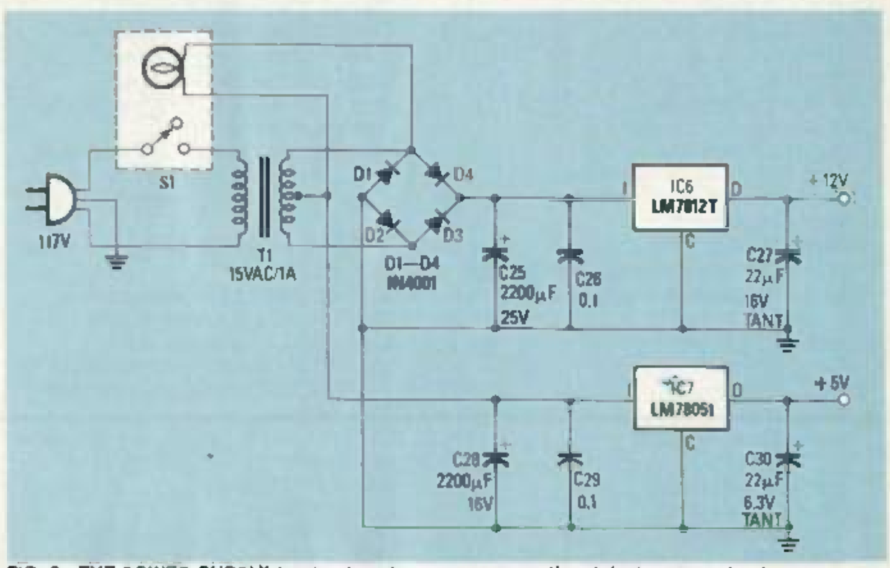


FIG. 5—THE POWER SUPPLY for the decoder uses a conventional design. Note that heat sinks are needed for the regulators, which must supply about 250 milliamps each. The power switch used in the prototype had a built-in pilot lamp.

All the decoding is handled inside the IC. The output circuit is also simple. The R-C network (R59 and C37) that is connected to pins 2 and 3 determines the output bit rate.

The output at pin 16 is a 24-bit serial code. The output pulses are differentiated by R61, R62, and C40. The negative-going spikes are inverted by Q12 and applied to the base of Q13 through R63. In turn, Q2 turns on the two infrared LED's. Capacitor C39 is included in the circuit to store the energy needed for the high-current pulses.

The transmitter is handheld, and can be powered directly by a 9-volt battery. Zener diode D6 reduces the battery voltage to about 6 volts, which the SAA5000 requires.

The front end of the remote control receiver is also shown in Fig. 8. That circuit is not contained on the main board of the teletext decoder, and it does not decode any of the signals it receives. It merely amplifies them to a level that is required by the decoder IC on the Mullard decoder module.

Photodiode D8 is biased by IC9. The

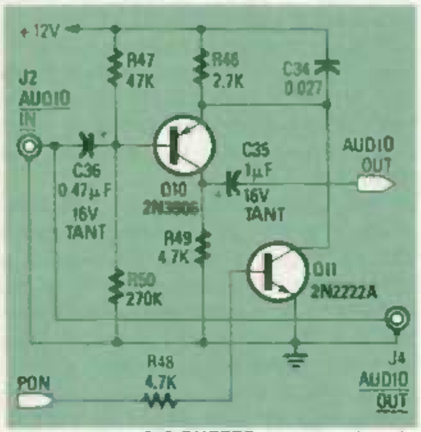


FIG. 6—THE AUDIO BUFFER. Note that decoder has no need for audio, so the input goes straight through to the output. However the sound is modulated for the RF output of the decoder. The PON signal is used to blank the sound when the decoder is in its teletext mode.

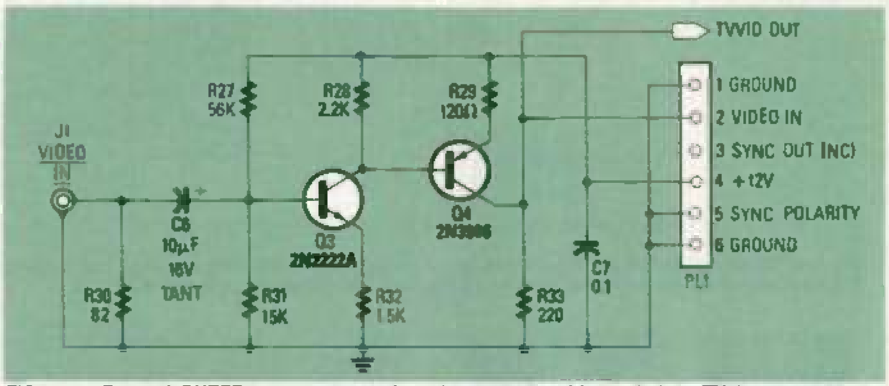


FIG. 7—THE VIDEO BUFFER. The buffered signal is sent to the video switch for TV display and to the module for teletext decoding of the VBI data.

PARTS LIST

All resistors ¼ watt, 5%, unless otherwise noted.

R1—4.7 ohms, ½ watt
R2–R4, R6, R10, R14–R16, R37, R38, R60, R62—10,000 ohms
R5, R34—100 ohms
R7, R8—470 ohms
R9—27,000 ohms
R11—1 megohm
R12, R32, R40—1500 ohms
R13, R24, R48, R49—4700 ohms
R17, R26, R28—2200 ohms
R18—3300 ohms
R19–R23, R66, R71—1000 ohms
R25—10 megohms
R27—56,000 ohms
R29—120 ohms
R30—82 ohms
R31—15,000 ohms
R33—220 ohms
R35, R46—2700 ohms
R36, R43—68 ohms
R39—180 ohms, ½ watt
R41,R42—2400 ohms
R44, R53–R58—33,000 ohms
R45—1800 ohms
R47—47,000 ohms
R50—270,000 ohms
R51—1000 ohms, trimmer potentiometer
R52—50,000 ohms trimmer potentiometer
R59—220,000 ohms
R61—560 ohms
R63—47 ohms
R64—27 ohms
R65—2.2 ohms, ½ watt
R67—22 ohms
R68—150,000 ohms
R69—100,000 ohms
R70—6800 ohms

Capacitors

C1—100 µF, 16V electrolytic
C2–C4, C7, C8, C16, C17, C24, C26, C29—0.1 µF, ceramic disc
C5—33 pF, ceramic disc
C6, C38, C41, C43, C45—10 µF, 16 volts, tantalum
C9, C20—100 pF, ceramic disc
C10–C12—15 µF, 16 volts, tantalum
C13—47 pF, ceramic disc
C14, C23, C40—0.001 µF, ceramic disc
C15, C18—0.01 µF, ceramic disc
C19—10 pF, ceramic disc
C21—5–70 pF, trimmer capacitor
C22—not used
C25, C28—2200 µF, 25 volts, electrolytic
C27, C30, C31—22 µF, 16 volts, tantalum
C32, C33—33 µF, 10 volts, tantalum
C34—0.027 µF, dipped mylar
C35—1 µF, 16 volts, tantalum
C36—0.47 µF, 16 volts, tantalum
C37—270 pF, ceramic disc
C39—330 µF, 16 volts, electrolytic
C42—0.0033 µF, ceramic disc
C44—0.047 µF, ceramic disc
C46, C47—47µF, 16 volts, electrolytic

Semiconductors

IC1—SAA5010 remote-control receiver
IC2—CD4013B dual D-type flip-flop
IC3—74HCOO high-speed CMOS quad NAND
IC4—MC1377 RGB-NTSC/PAL Video Encoder
IC5—CD4066B quad analog switch
IC6—LM7812T regulator, 12 volts
IC7—LM7805T regulator, 5 volts
Q1–Q3, Q7–Q9, Q11—BC548 (2N2222A)
Q4–Q6, Q10, Q12—BC558 (2N3906)
Q13—2N2094
D1–D4—1N4001, 50 PIV, 1 amp rectifier
D5—1N4735 6.2 volts, 1 watt, Zener
D6—3.3 volts, Zener
D7—1N4148
D8—BPW50 infrared photodiode
LED1, LED2—LD271 infrared LED
LED3—standard, red

Other components

L1—chroma coil (TOKO 16NNF/10624AG)
L2—400 nS delay line
L3—5 mH
S1—SPST push-on/push-off, illuminated
S2—SPST miniature slide
S3–S23—SPST normally open pushbutton
T1—117 volts to 15 volts, center tapped, 1A transformer
XTAL1—3.579545 MHz
RF modulator—Astec UM1285-8 RF video modulator
Module— Mullard VM6780-2 teletext decoder module

Miscellaneous: Case, power cord, strain relief, ribbon cable and connector plugs (4, 6, 9, and 10-pin), Mullard module, RCA jack, 5-pin DIN socket, clip-on heatsinks, IC sockets, hardware, heatshrink tubing, etc.

A complete kit of parts (No. K-6315), including PC board, case, and all parts—except those for the wireless remote control circuit in Fig. 8 (a wired remote control unit is substituted—is available for $199.00 plus $10.00 shipping from Dick Smith Electronics, Inc., P.O. Box 8021, Redwood City, CA 94063; 800-332-5373 (orders) 415-368-8844 (inquiries). The following parts are also available separately: Case (No. H-2507), $12.95; Transformer T1 (No. M2155), $5.95; PC board (H-7001) $29.95; IC1 (No. Z-6900), $12.95; IC4 (No. Z-2500), $1.90; XTAL1 (K-6031), $1.19; L1 (No. L-0521), $1.50; L2 (No. L-0520), $4.95.

A complete kit of parts for the infrared remote control (No. K-3425) is available for $34.95 plus $2.75 shipping.

California residents must add 6.5% sales tax. Orders outside U.S. must include U.S. funds and add 15% of merchandise total for shipping.

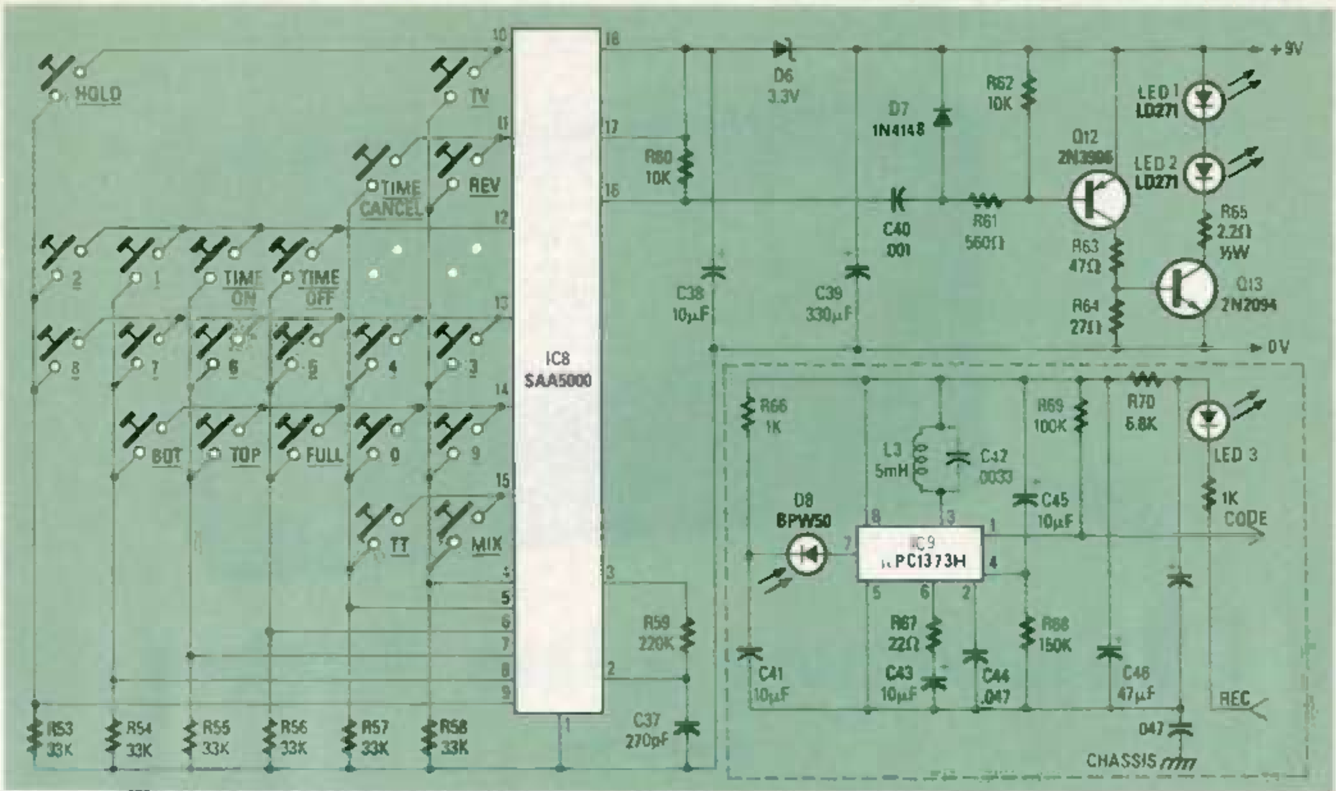


FIG. 8—THE WIRELESS REMOTE CIRCUIT controls all the functions of the decoder except power. IC8 handles all the keyboard-decoding and code generation functions for the transmitter. The front end of the receiver circuit is shown inside the dashed box.

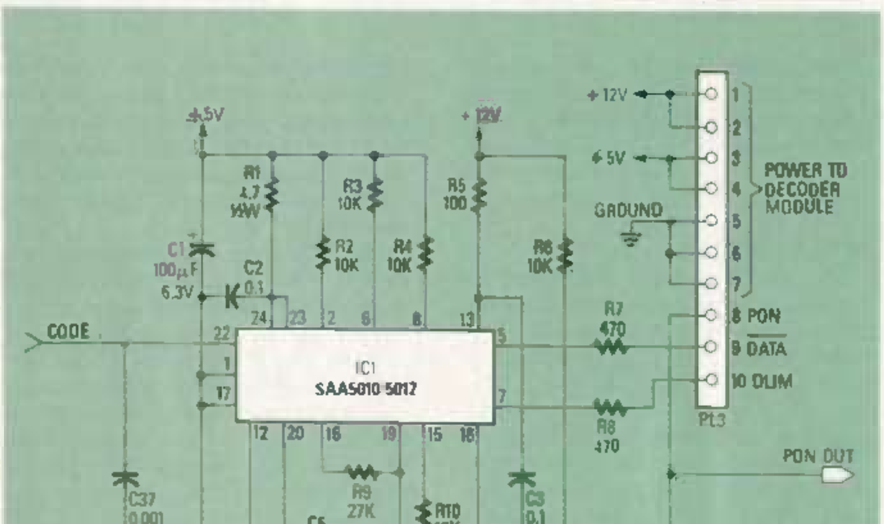


FIG. 9—THE REMOTE CONTROL DECODING CIRCUIT. IC1 decodes the signals that are sent from the receiver front-end to pin 22. It sends back a "message-received" signal on pin 16. IC2 provides a 2400 Hz signal that can be used to drive a piezoelectric transducer for an audible signal that a message has been received.

gain of the IC is determined by the ratio of the impedance at pin 3 to that at pin 6. The tuned circuit connected to pin 3 is resonant at the transmitter's frequency.

The preamplifier IC also limits and level-shifts the output of the preamplifier stage to reduce the effects of noise and poor transmission conditions. The IC also contains a peak detector that extracts the data from the bit stream and sends it out on pin 1. Note that LED3, which lights to acknowledge the receipt of a message, is not part of the preamplifier circuit. However, it's shown with the preamp because it is also mounted off the main board.

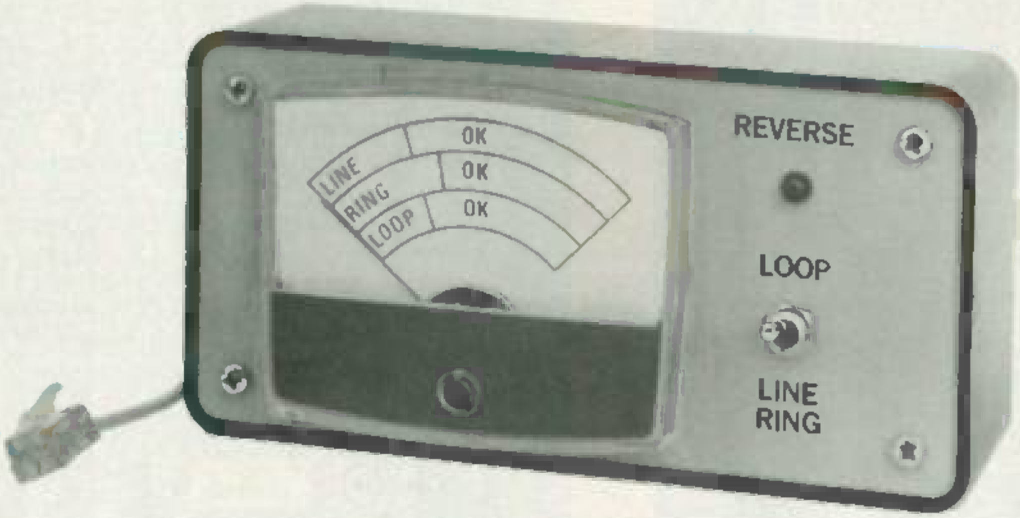
Other than power and ground, there are two connections from the preamp to the main board. One is the message-received signal from the Mullard module, and the other is the serial control data that are sent to the module's remote-control decoder circuit, which is shown in Fig. 9.

The heart of the decoder is IC1, the SAA5010/5012 remote control receiver. We won't discuss the control format here except to say that the system uses a doubly-redundant 24-bit data stream for each command, making it virtually error-proof. We will cover the various commands in detail next time.

One of the IC1's control frequencies is divided down by IC2, a 4013 dual flip-flop, and the resulting 2400 Hz tone can be sent to a transducer to provide an audible message-received signal.

Next time, we'll finish up with the circuit and show you how to build the unit. **R-E**

BUILD THIS



Telephone Line Tester

HERB FRIEDMAN

Beat the telephone service guessing game with this simple yet effective telephone-line tester.

EVER SINCE THE BREAKUP OF AT&T, THE odds of getting a telephone circuit repaired on the first attempt are only 50-50. The problem is that now the telephone lines are the responsibility of your local telephone company, while the receiver itself is the responsibility of its supplier, most often AT&T. If you contact the supplier, and the problem is not in the telephone, they won't help you. Similarly, if you call the local telephone company, and the problem is in the telephone, you are also out of luck. But this time there's a kicker—you can be billed $50.00 or more for a "service" call. And you still won't have a working phone.

One of the ways to avoid playing the telephone-service guessing game, and thus any unnecessary and unconscionable service charges, is to first, conduct your own line tests, using the telephone-line tester shown in Fig. 1. If the telephone line passes its tests, any problems must be the fault of the receiver itself. If the line doesn't pass its tests, you can call in the local telephone company secure in the knowledge they won't—or can't—stick you for a service charge.

The telephone-line tester is intended for the commonly used modular connector system. To use the device you simply unplug the telephone from its modular connector and substitute the tester's connector. If for some reason you want both the tester and telephone to be simultaneously connected, you can use a Y-adapter at the modular jack. If the telephone uses the older 4-pin "block" connector, you can use a modular-to-4 pin block adapter; those are available in both single and Y versions.

What it tests

The telephone-line tester checks the operating parameters of the telephone company's wiring at the modular connector. That includes the open circuit or "on-hook" line voltage; the "loop" voltage, which is the line voltage when the telephone is off hook (when the handset is lifted from its cradle); the ringer voltage, and the polarity of the line. The telephone line's voltage conditions are indicated by a meter, and the polarity of the line connections is indicated by an LED.

Normally, polarity is not a problem because most standard telephones will work regardless of the polarity of the DC voltage on the telephone line. (The purchase of any telephone that is polarity sensitive should be seriously questioned.) However, reversed line polarity can interfere with certain kinds of switching equipment, in particular, some of the low-cost conference and multi-use switchers, so we've provided for that test.

The voltage-level on telephone circuits is 48-volts DC. The wires in the telephone cables are color-coded, with the *green* wire being the positive side, and the *red* wire being the negative side. When there is no load on the line, that is, when all telephones in your home or office are *on hook*, the measured voltage at your telephone's modular connector should be greater than 40-volts DC, give or take a smidgen.

Depending on your particular telephone's repeat coil, your telephone will represent a DC load resistance of approximately 190 to 250 ohms when it goes *off hook*, meaning the handset is lifted from the cradle. Since there is resistance in the wiring between the central office and your telephone, there will be a substantial drop in voltage when your telephone goes off hook. At that time, the voltage at the modular jack might be as low as 5-volts DC. (A Bell System instrument, such as one of the 500 series of telephones, will work even if the line voltage approaches zero volts.) For conventional service a loop voltage of 5 or higher is considered acceptable.

A telephone is made to ring by superimposing a 90-volt, 20-Hz signal on the line. Since a telephone ringer is always connected across the line it represents a continuous AC load on the line. Thus, once again there will be a drop caused by the resistance in the wires between the central office and your phone. A 45-volt RMS equivalent voltage at your telephone is considered acceptable, although 40 volts is sufficient to ring the phone.

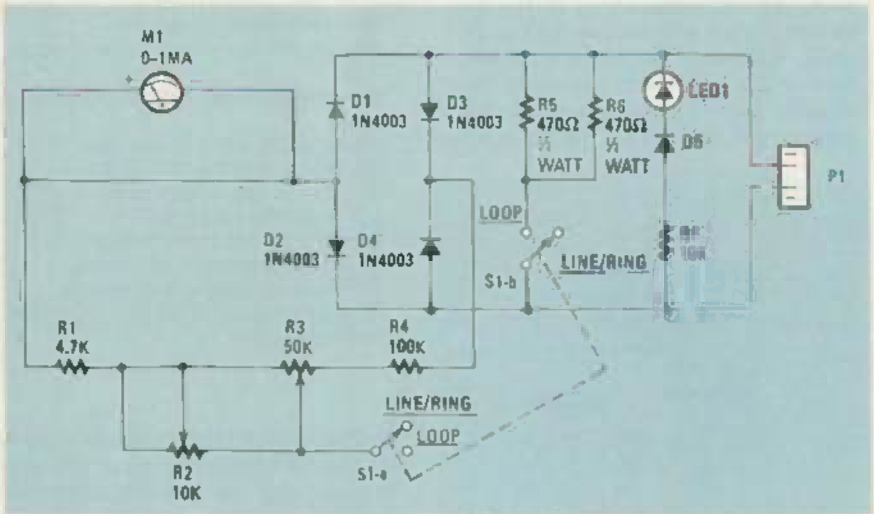


FIG. 1—BY PREVENTING UNNECESSARY SERVICE CALLS, this simple yet effective circuit can save you quite a bit of money.

FIG. 2—THE SMALL PC BOARD can be secured to the front panel of the cabinet via S1's mounting nut. The board shown here is the author's prototype.

How it works

The telephone-line tester shown in Fig. 1 is connected to the telephone line through modular connector P1. Although a conventional telephone modular-plug has four connectors, the tester uses only the two inside ones—the red and the green. The yellow and black connectors are not used for normal, single-instrument, two-wire service. Since the tester's LED polarity indicator is always connected when the tester is plugged in, the instant the unit is connected you will have an indication of the polarity. If it is correct—that is, if the green wire is the positive side—and the red wire is the negative side, nothing will happen. If the situation is reversed, the LED will light.

With switch S1 set for LINE/RING, both S1-a and S1-b are open and the meter indicates the condition of the line-voltage. Any line voltage reading in the LINE OK range (more on the meter in a moment) indicates a line voltage higher than 40-volts DC. If the telephone is caused to ring, either by using a ringback number or by dialing from another phone, the meter will indicate RING OK, and the LED will pulse (indicating AC), if the ringing voltage/current is correct. The actual position of the meter's pointer depends on how many ringers are connected across the line. (Three or more of the old-fashioned ringers can excessively load the ringing voltage if the local telephone company has not corrected for your ringer load.)

When S1 is closed the voltage range of the meter is changed and a nominal load resistance of 230 ohms (R5 and R6) is connected across the line to emulate the off hook load of the telephone. If the meter indicates LOOP OK, you can be certain that you have sufficient loop voltage for satisfactory telephone operation. If you place another load on the line, perhaps by taking an extension telephone off hook, the meter reading will almost invariably drop below the LOOP OK range. That is perfectly normal; the line is operating properly when a single loop load results in a LOOP OK meter reading. That, by the way, is how to test telephones for proper connection. If lifting the handset causes the meter reading to drop, you can at least be certain that the telephone's hook switch is working and that the repeat coil is connected to the line.

Building the unit

The unit is assembled on the metal front panel of a 1⅝ × 2⅝ × 5⅛-inch plastic utility box. Except for the meter, all components are installed on a 2 × 2¼-inch printed circuit board that is self-mounting to the panel through S1's mounting nut (see Fig. 2). An appropriate foil pattern for this project is shown in Fig. 3; the parts-placement diagram for that board is shown in Fig. 4. Note that the size of the PC board and its layout aren't really critical as long as the board fits inside the cabinet without interfering with the installation of the meter or the cabinet's internal panel-support posts.

While it is usually best to make circuit boards using the photographic method, because of its small size, this board is an exception. It is probably best to do this layout by hand, using resist tape and resist donuts. That's because the board's small size and relative simplicity make the photographic method too expensive to justify. That's why we've shown the layout here, rather than in our PC service section as usual.

There's just one catch to that—very thin resist tape is getting harder to find in stores all the time. If you can't find the proper tape, we suggest you replace the trace that sweeps around the S1 contacts with a length of No. 24 or No. 26 solid insulated wire. That substitution has been made in the author's prototype to show you the proper routing of the wire. See Fig. 2.

Potentiometers R2 and R3 are installed on the foil side of the board so that they

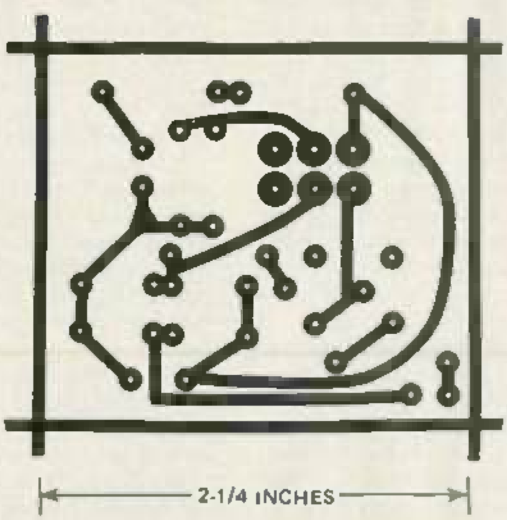


FIG. 3—BECAUSE OF IT'S SMALL SIZE and relative simplicity, the foil pattern for the telephone-line tester is shown here.

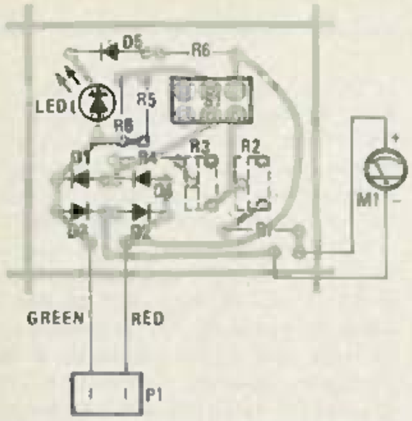


FIG. 4—PARTS-PLACEMENT DIAGRAM for the telephone-line tester. The foil pattern can be found in our PC service section, elsewhere in this issue.

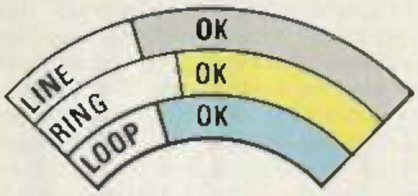


FIG. 5—IF YOU WANT to dress-up the meter, a new scale, similar to the one shown here, can be made. If you choose to do that, be sure that the LINE OK and LOOP OK reference lines fall at the 0.3 mA mark; the RING OK range begins at 0.4 mA.

can be accessed without dismantling the project. All other components are mounted conventionally on the "component" side of the PC-board. To ensure that the LED passes through the panel when the printed-circuit assembly is installed, position the LED so that there is ⅞-inch between the printed circuit board and the bottom of the LED before you solder its leads. When the assembly is secured with S1's mounting nut, ¼ to ½ of the LED will protrude through the front panel.

You might be tempted to substitute a single 230-ohm resistor for R5 and R6. Don't do that! The loop load must be rated for 1 watt, and that is most easily accomplished by using two parallel-connected half-watt standard-value resistors.

Meter M1 in our project is a 0–1-mA DC meter; those are available from almost any electronics supplier. If you want to dress up your project, you can create a meter scale similar to the one shown in Fig. 5. If you do that, the LINE OK and LOOP OK ranges should begin at 0.3 mA. The RING OK range should begin at 0.4 mA. Once you've drawn the scale, remove the meter's plastic cover. Then, taking care not to bend or otherwise damage the meter's needle, glue the new scale in place.

The modular connecting cord can be salvaged from some old telephone gear, or you can get a replacement cord at your local telephone store. With rare exceptions, the cord will have four wires; you will use only the green and red ones, as previously mentioned. Cut the cord to the length you want and then carefully trim the insulation from the free end of the green and red wires. Those of you who haven't worked with old headsets or telephone equipment are in for a surprise, because the wires will appear to be a strand of copper wound around a cotton, polyester or silk thread. That's exactly

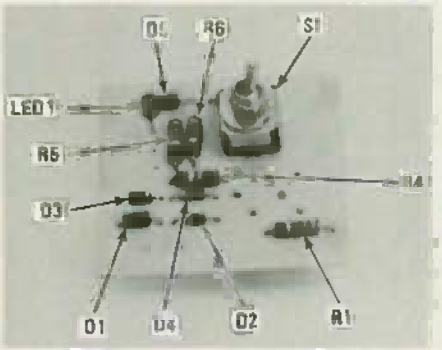


FIG. 6—THE COMPLETED PC board is shown here.

what it is. That type of wire is called "Litz" wire; it is very flexible, but it is almost impossible to solder because the fibers actually burn up before the connection is made. To install the Litz wires on the printed-circuit board, lightly tin the wire using a low-wattage (about 25 watts) soldering iron. Then clip off the very end of the wire so there's no loose strand and pass the wire(s) through its hole in the printed-circuit board. Fold the wire flat against the foil and then quickly solder it in place. If you use too large an iron, or too much heat (you keep the iron on the connection too long), the wire will burn up (turn black) and you'll have to repeat the whole thing until the Litz wires are properly soldered to the printed-circuit foils.

Once you've assembled the board (see Fig. 6), install the meter in the panel, solder the two pieces of wire that will be used to connect the circuit and the meter to the PC board, and then secure the printed-circuit board to the panel, using S1's mounting nut. Finally, connect the free ends of the wire you previously installed to the meter; be sure to observe the proper meter polarity. To prevent the modular cord from eventually breaking at the soldered Litz-wire connections, secure the cord with a plastic cable clamp at one of the meter's mounting screws.

Calibration

Set R2 and R3 to about mid-range, set S1 to the LINE/RING position and then connect a small variable DC power source across the telephone line input. Adjust the power supply for about 40-volts DC and see if the LED turns on. If it does the power supply connections are reversed. If it does not turn on, check its operation by reversing the power connections. If the

PARTS LIST

R1—4700 ohms, ¼ watt, 5%
R2—10,000 ohms, trimmer potentiometer.
R3—50,000 ohms, trimmer potentiometer.
R4—100,000 ohms, ¼ watt, 5%
R5, R6—470 ohms, ½ watt, 5%
D1–D5—1N4003 silicon diode
LED1—jumbo red LED
M1—0-1-mA DC panel meter
S1—DPST, miniature, PC mount
P1—Modular telephone connector.
Miscellaneous—Cabinet, PC board, wire, solder, etc.

LED still doesn't turn on you have probably made a wiring error. Once you've determined that the polarity indicator is working normally, return the power-supply connections to normal (LED off).

Next, set the power supply to 5-volts DC, flip S1 to the LOOP position, and adjust R2 until the meter's needle moves to the LOOP OK reference line (reads 0.3 mA). Next, flip S1 back to the LINE/RING position, adjust the power supply for 40-volts DC, and adjust R3 until the meter pointer is on the LINE OK reference line.

Testing the line

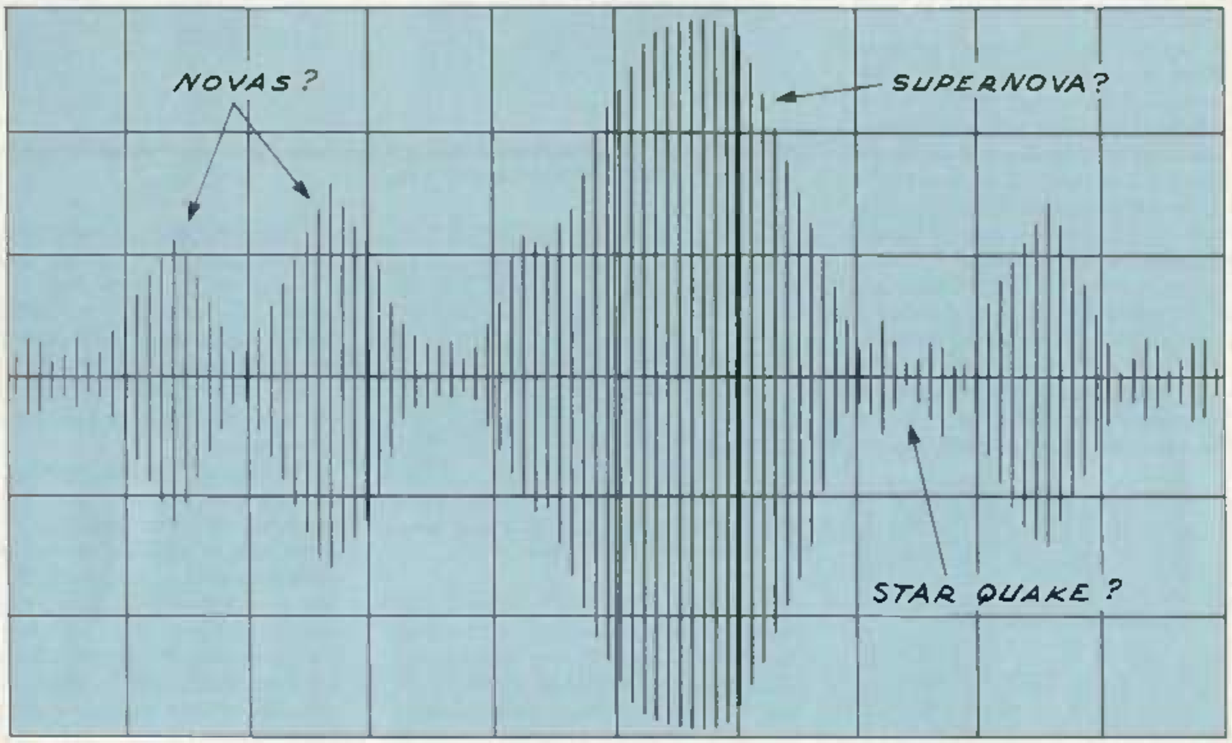
To test a telephone line simply set S1 to the LINE/RING position and connect the tester to the telephone line. If the LED lights, the telephone company's wiring to the connector is reversed (it does happen). Note the meter reading—the pointer should rest anywhere in the ok range (read 0.3 mA or greater). Next, flip S1 to the LOOP position; again, the meter should read in the ok area. Finally, once again set S1 to the LINE/RING position and cause the line to ring (perhaps by dialing from another phone). The meter should read in the RING OK range (greater than 0.4 mA) and the LED should blink because the voltage applied to the polarity-tester circuit is AC. If any of the tests produces anything but the expected results, the problem most likely lies in the telephone lines rather than in the phone itself.

If you want to check out extension telephones, set S1 for a LOOP test and then lift the handset of any phone; the meter should indicate less than the OK reading when the telephone goes off hook. As we said earlier, that is normal and shows that the telephone is at least connected to the line.

The telephone-line tester we've described is limited; it can not tell you precisely what's wrong with your telephone service. But it can at least tell you roughly where the trouble lies, and hence who to call to have repairs done. Considering the high cost of an unnecessary service call, that puts you way ahead in the game. **R-E**

ALL ABOUT

Gravitational Waves???



Are gravitational waves the source of noise in electronic devices? The author believes so, and describes a simple circuit to detect the waves.

GREGORY HODOWANEC

EINSTEIN PREDICTED THE EXISTENCE OF gravity waves—the counterpart of light and radio waves—many years ago. However, he predicted the existence of quadrature-type gravity waves. Unfortunately, no one has been able to detect quadrature-type gravity waves.

Consequently, the author developed, over the years, a new cosmology, or theory of the universe, in which monopole gravity waves are predicted. The author's theory does not preclude the existence of Einsteinian gravity waves, but they are viewed as being extremely weak, very long in wavelength, and therefore very difficult to detect unequivocally. Monopole signals, however, are relatively strong, so they are much more easily detected.

Monopole gravity waves have been detected for many years: it's just that we're used to calling them $1/f$ "noise" signals or flicker noise. Those noise signals can be seen in low-frequency electronic circuits. More recently, such signals have been called *M*icrowave *B*ackground *R*adiation signals (MBR); most scientists believe that to be a relic of the so-called "big-bang" that created the universe.

In the author's cosmology, the universe is considered to be a finite, spherical, closed system; in other words, it is a black body. Monopole gravity waves "propagate" any distance in Planck time, which is about 10^{-44} seconds; hence, their effects appear everywhere almost instantaneously. The sum total of background flux in the universe gives rise to the observed microwave background temperature, in our universe, of about 3°K.

Sources of monopole gravity waves include commmon astrophysical phenomena like supernovas, novas, starquakes, etc., as well as earthly phenomena like earthquakes, core movements, etc. Those sorts of cosmic and earthly events cause detectable temporary variations in the amount of gravitational-impulse radiation present in the universe.

Novas, especially supernovas (which are large exploding stars), are very effective generators of oscillatory monopole gravity waves. Those signals have a Gaussian waveshape and a lifetime of only a few tens of milliseconds. They can readily impart a portion of their energy to free particles like molecules, atoms, and electrons.

The background flux, in general, is fairly constant. Variations in the background flux are caused by the movements of large mass concentrations like galaxies, supergalaxies, and black holes. Those movements create gravitational "shadows," analogous to optical shadows. When the Earth-moon-sun alignment is just right, the gravitational shadow of a small, highly concentrated mass—a black hole, for example—can be detected and tracked from the Earth. So, keeping those facts in mind, let's look at several practical methods of detecting gravitational energy.

> The author has developed a new cosmology that predicts the existance of a new type of gravitational signal. We are publishing the results of some of his experiments that back up his theories in the hope that it will foster experimentation as well as alternate explanations for his results.

Electrons and capacitors

As stated above, gravity-wave energy can be imparted to ordinary objects. Of special interest to us are the loosely-bound electrons in ordinary capacitors. Perhaps you have wondered how a discharged high-valued electrolytic capacitor (say 1000 µF at 35 volts) can develop a charge even though it is disconnected from an electrical circuit.

While some of that charging could be attributed to a chemical reaction in the capacitor, I believe that much of it is caused by gravity-wave impulses bathing the capacitor at all times. And the means by which gravity waves transfer energy is similar to another means of energy transfer that is well known to readers of **Radio-Electronics:** the electric field.

As shown in Fig. 1-*a*, the presence of a large mass near the plates of a capacitor causes a polarized alignment of the molecules in the capacitor, as though an external DC voltage had been applied to the capacitor, as shown in Fig. 1-*b*.

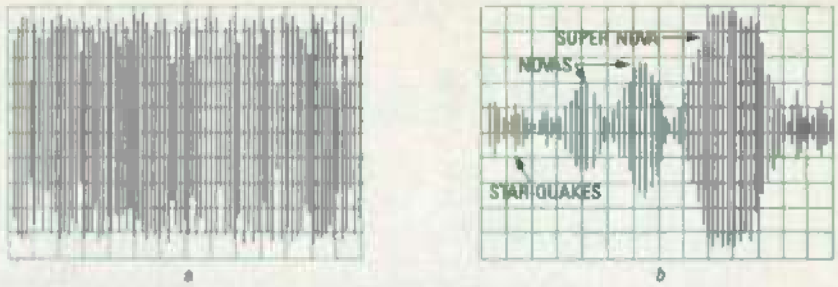


FIG. 3—DISPLAY OF GRAVITY-WAVE SIGNALS from the circuit in Fig. 2 reveals 1/f signals (*a*) and amplitude-modulated astrophysical events (*a*).

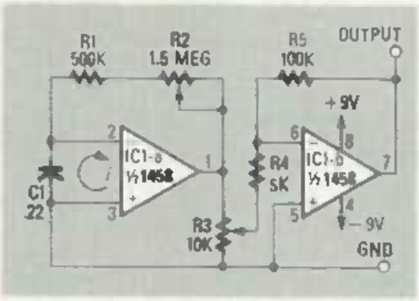


FIG. 4—A BUFFERED OUTPUT STAGE makes the gravity-wave detector easier to use.

You can verify that yourself: Drop a fully-dischaged 1000-µF, 35-volt electrolytic capacitor broadside on a hard surface from a height of two or three feet. Then measure the voltage across the capacitor with a high-impedance voltmeter. You will find a voltage of about 10 to 50 mV. Drop the capacitor several times on opposite sides, don't let it bounce, and note how charge builds up to a saturation level that may be as high as one volt.

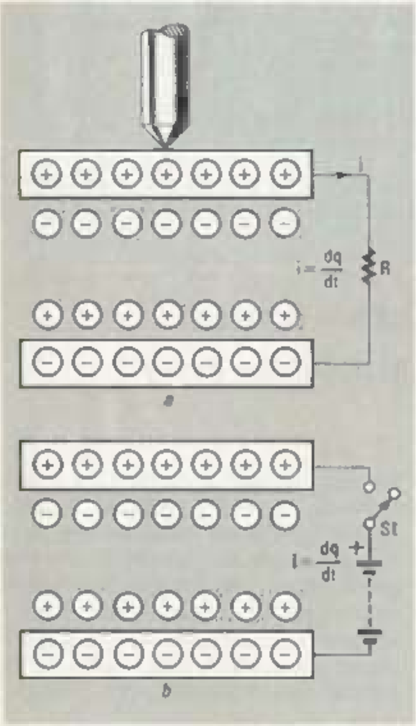


FIG. 1—A CAPACITOR CAN BE CHARGED by a gravitational impulse (*a*), just as it may by a DC voltage (*b*).

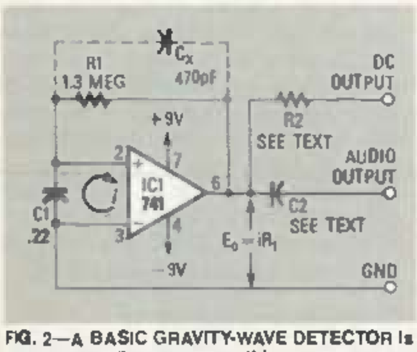


FIG. 2—A BASIC GRAVITY-WAVE DETECTOR is very simple. The charge build-up on capacitor C1 due to gravity-wave impulses is amplified by IC1 for output.

In that experiment, the energy of free-fall is converted to polarization energy in the capacitor. The loosely-bound electrons are literally "jarred" into new polarization positions. In a similar manner, graviational impulses from space "jar" electrons into new polarization positions.

Here's another experiment: Monitor a group of similar capacitors that have reached equilibrium conditions while being bathed by normal background gravitational impulses. You'll observe that, over a period of time, the voltage across all those open-circuited capacitors will be equal, and that it will depend only on the average background flux at the time. Temperature should be kept constant for that experiment.

I interpret those facts to mean that a capacitor develops a charge that reflects the monopole gravity-wave signals existing at that particular location in the universe. So, although another device could be used, we will use a capacitor as the sensing element in the gravity-wave detectors described next.

The simplest detector

Monople gravity waves generate small impulse currents that may be coupled to an op-amp configured as a current-to-voltage converter, as shown in Fig. 2. The current-to-voltage converter is a nearly lossless current-measuring device. It gives an output voltage that is proportional to the product of the input current (which can be in the picoampere range) and input resistor R1. Linearity is assured because the non-DC-connected capacitor maintains the op-amp's input terminals at virtual ground.

The detector's output may be coupled to a high-impedance digital or analog voltmeter, an audio amplifier, or an oscilloscope. In addition, a chart recorder could be useful to record the DC output over a period of time, thus providing a record of long-term "shadow-drift" effects. Resistor R2 and capacitor C2 protect the output of the circuit; their values will depend on what you're driving. To experiment, try a 1K resistor and 0.1 µF capacitor.

The output of the detector (E_O) may appear in two forms, depending on whether or not stabilizing capacitor C_X is connected. When it is, the output will be highly amplified 1/*f* noise signals, as shown in Fig. 3-*a*. Without C_X, the circuit becomes a "ringing" circuit with a slowly-decaying output that has a resonant frequency of 500–600 Hz for the component values shown. In that configuration, the circuit is a *Q*uantum *N*on-*D*emolition (QND) circuit, as astrophysicists call it; it will now actually display the amplitude variations (waveshapes) of the passing gravitational-impulse bursts, as shown in Fig. 3-*b*.

An interesting variation on the detector may be built by increasing the value of sensing capacitor C1 to about 1000–1600 µF. After circuit stability is achieved, the circuit will respond to almost all gravity-wave signals in the universe. By listening carefully to the audio output of the detector you can hear not only normal 1/*f* noise, but also many "musical" sounds of space, as well as other effects that will not be disclosed here.

An improved detector

Adding a buffer stage to the basic circuit, as shown in Fig. 4, makes the detector easier to work with. The IC used is a common 1458 (which is a dual 741). One op-amp is used as the detector, and the other op-amp multiplies the detector's

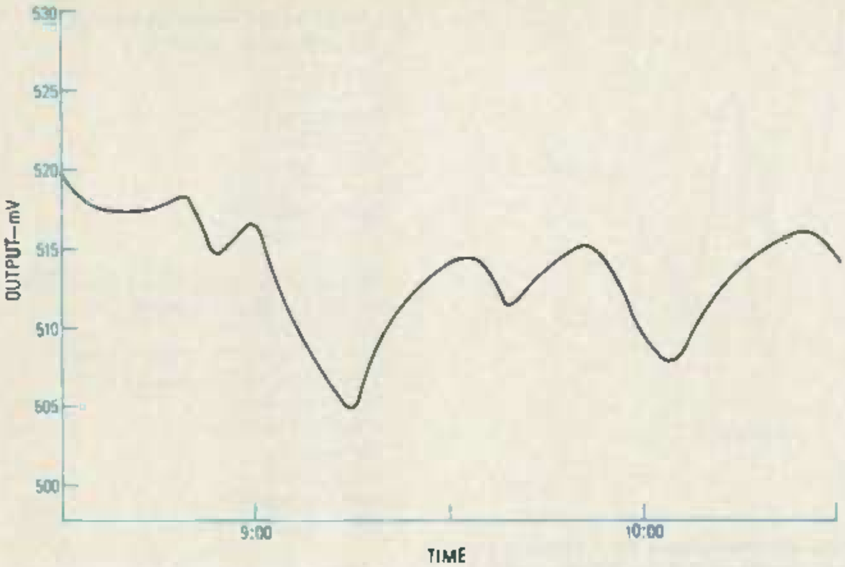


FIG. 5—THE SAME GRAVITATIONAL "SHADOW" passed the author's monitor location on two consecutive days at approximately the same time.

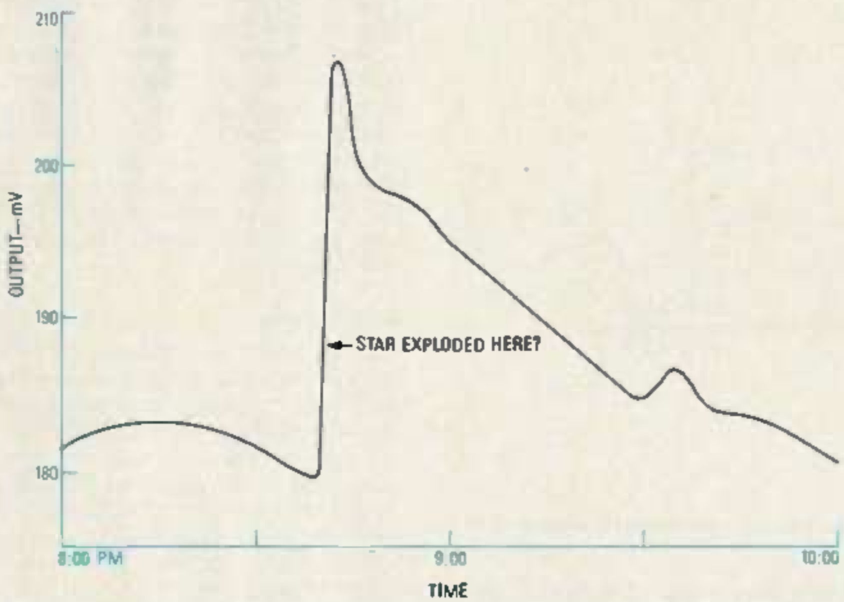


FIG. 6—THE EXPLOSION OF A SUPERNOVA just after 8:30 pm produced the sharp slope in this curve.

output by a factor of 20. Potentiometer R3 is used to adjust the output to the desired level.

When used unshielded, the circuits presented here are not only sensitive detectors of gravitational impulses, but also of *electromagnetic* signals ranging from 50–500 GHz! Hence, these circuits could be used to detect many types of signals, including radar signals.

To detect only gravity waves, and not EMI, the circuit should be shielded against all electromagnetic radiation. Both circuits are low in cost and easy to build. Assembly is non-critical, although proper wiring practices should be followed. Initially, you should use the op-amps specified; don't experiment with other devices until you attain satisfactory results with the devices called for. Later you can experiment with other components, like low-power op-amps, especially CMOS types, which have diodes across their inputs to protect them against high input voltages. Those diodes make them much less sensitive to electromagnetic radiation, so circuits that use those devices may be used to detect gravity-waves without shielding.

The circuit in Fig. 4 is the QND or ringing type, but the feedback resistance is variable from 0.5 to 2 megohms. That allows you to tune the circuit to the natural oscillating frequency of different astrophysical events. Huge supernova bursts, for example, have much larger amplitudes, and lower frequencies of oscillation than normal supernovas and novas. Hence you can tune the detector for the supernova burst rate that interests you. With the component values given in Fig. 4, the resonant frequency of the circuit

RHYSMONIC COSMOLOGY

Ancient and Renaissance physicists postulated the existence of an all-pervasive medium they called the *ether*. Since the advent of sub-atomic physics and relativity, theories of the ether have fallen into disuse. Rhysmonic cosmology postulates the existence of rhysmons, which are the fundamental particles of nature, and which pervade the universe, as does the ether.

Each rhysmon has the attributes of size, shape, position, and velocity; rhysmons are arranged in space in a matrix structure, the density of which varies according to position in the universe. The matrix structure of rhysmons in free space gives rise to the fundamental units of length, time, velocity, mass, volume, density, and energy discovered by physicist Max Planck.

Fundamental postulates of the Rhysmonic Universe can be summarized as follows:

- The universe is finite and spherical.
- Euclidean geometry is sufficient to describe Rhysmonic Space.
- The edge of the universe is a perfect reflector of energy.
- Matter forms only in the central portion of the universe.

The matrix structure of rhysmons allows the instantaneous transmission of energy along a straight line, called an energy vector, from the point of origin to the edge of the universe, where it would be reflected according to laws similar to those governing spherical optics.

In Rhysmonic Cosmology, mass, inertia, and energy are treated as they are in classical mechanics. Mass arises, according to the author, because "particles in rhysmonic cosmology must be the result of changes in the 'density' of the rhysmonic structure, since the universe is nothing more than rhysmons and the void."

In a "dense" area of the universe, such as the core of a particle, a number of rhysmons are squeezed together. This means that every particle has a corresponding anti-particle, or an area of correspondingly low density. In addition, a particle has an excess of outward-directed energy vectors, and an anti-particle has an excess of inward-directed energy vectors. Those vectors are what we usually call electric charge.

Gravity is not a force of attraction between objects; rather, two objects are impelled towards each other by energy vectors impinging on the surfaces of those objects that do not face each other. Newton's laws of gravitation hold, although their derivation is different than in Newton's system.

Gravitational waves arise in various ways, but, in general, a large astronomical disturbance, such as the explosion of a supernova, instantaneously modulates the rhysmonic energy vectors. That modulation might then appear, for example, superimposed on the Earth's gravitational-field flux—and it would be detectable by circuits like those described here.

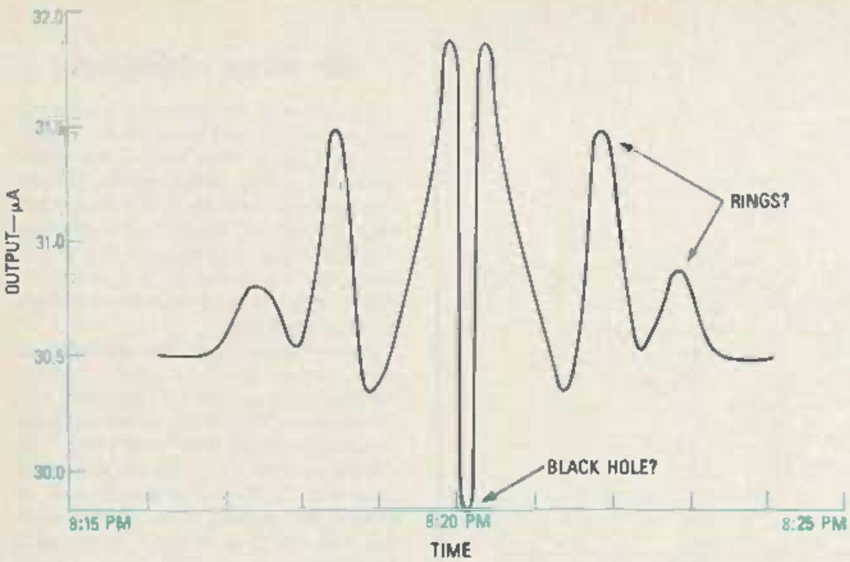


FIG. 7—THE SHADOW OF A BLACK HOLE passed the Earth and produced the dip in the curve just after 8:20 pm. That occurred four days after the explosion of a supernova that was detected on July 1, 1983.

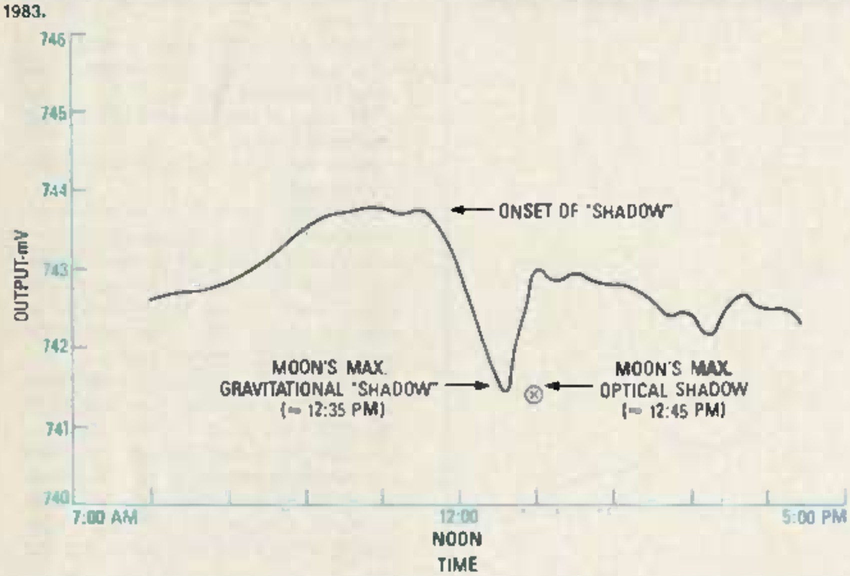


FIG. 8—ECLIPSE ON MAY 30, 1984 produced a gravitational shadow that preceded the optical shadow by about eight minutes.

can be varied between 300–900 Hz. The circuit of Fig. 4, or a variant thereof, was used to obtain all the experimental data discussed below.

In addition, the circuits that we've described in this article were built in an aluminum chassis and then located within an additional steel box to reduce pickup of stray EMI. Power and output connections were made through filter-type feedthrough capacitors.

In the QND mode, coupling the detector's output to an audio amplifier and an oscilloscope gives impressive sound and sight effects. Fluctuations generally reflect passing gravitational shadows. The author has taken much data of the sort to be discussed; let's examine a few samples of that data to indicate the kind of results you can expect, and ways of interpreting those results.

Sample scans

Shown in Fig. 5 is an unusual structure that was repeated exactly the next day, but four minutes earlier. The pattern was followed for several weeks, moving four minutes earlier per day. That confirms the observation that the burst response of the detector was related to our location on earth with respect to the rest of the universe. The change of four minutes per day corresponds with the relative movements of the earth and the body that was casting the "shadow."

The plot of Fig. 6 appears to be a supernova, probably in our own Galaxy, caught in the act of exploding. The plot of Fig. 7 was made four days after another supernova explosion; that plot reveals that that supernova left a well-developed black hole and "ring" structure. You may find it interesting to consider that visual indications of those supernovas will not be seen for several thousand years! As such, it might be "quite a while" before we get a visual confirmation of our suspected supernova!

PARTS LIST—SIMPLE DETECTOR

All resistors ¼-watt, 5%.

R1—1.3 megohm
R2—see text

Capacitors

C1—0.22 μF
C2—see text
C_X—see text

Semiconductors

IC1—741 op-amp

PARTS LIST—BUFFERED DETECTOR

All fixed resistors ¼-watt, 5%.

R1—500,000 ohms
R2—1.5 megohms, potentiometer
R3—10,000 ohms, potentiometer
R4—5000 ohms
R5—100,000 ohms

Capacitors

C1—0.22 μF

Semiconductors

IC1—1458 dual op-amp

Last, Fig. 8 shows a plot of the moon's gravitational shadow during the eclipse of May 30, 1984. Note that the gravitational shadow preceded the optical shadow by about eight minutes! That gives credence to our claim that gravitational effects propagate instantaneously. Relatedly, but not shown here, a deep shadow is consistently detected whenever the center of the galaxy appears on the meridian (180°), hinting of the existence of a "black hole" in that region.

Conclusions

In this article we discussed the highlights of a new theory of the universe that predicts the existence of monopole gravity waves. We then presented details of a circuit that can be used to detect monopole gravity waves. The author has monitored those signals for ten years with many different circuits, so is confident that you will be able to duplicate those results. Needless to say, the subject of gravity waves is a largely unexplored one, and there is much yet to be learned. Perhaps this article will inspire you to contribute to that knowledge. In your experiments, you might consider trying the following: Operate several detector circuits at the same time and record the results. Separate the detectors—even by many miles—and record their outputs. In such experiments, the author found that the circuits' outputs were very similar. Those results would seem to count out local EMI or pure random noise as the cause of the circuit response.

For more information on the subject of gravity you might consult *Gravitation*, by C. Misner, K. Thorne, and J. Wheeler, published by W. H. Freeman and Co., 1973. Also, the article, "Quantum Non-Demolition Measurements" in *Science*, Volume 209, August 1, 1980 contains useful information on the QND type of measurement used here. R-E

the fourth law of robotics

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TWO (2) NIFTY PROJECTS

Here are two nifty projects that are just perfect for this time of year!

LAPRI OOLF

FOR DECADES, MANKIND HAS BEEN BOTHered by the question: "What happens to the light in my refrigerator when I close the door? Does it go out, or does it stay on all the time?" Those claiming to be in the know will tell you that, "You know, it goes the same place your lap does when you stand up," or that it's controlled by the-little-man-who-wasn't-there.

Don't you believe them! After all, how did *they* find out? Well, now you can learn once and for all just what does happen to your refrigerator light when you close the door by building the Frid-O-Matic (pronounced "fridgeomatic"). This simple-to-use device, easily built from widgets, thingamabobs, and whatchamacallits found around the house, will give you the definitive answer and make you the talk of the neighborhood.

The Frid-O-Matic works on the principle that "what you see is what you get," which can also be stated as "never give a sucker an even break." As shown in Fig. 1, a DASCR (*D*ark *A*ctivated *S*ilicon *C*ontrolled *R*ectifer), aimed at the refrigerator's interior light, monitors that device's state at all times. As long as that light is on the Frid-O-Matic remains inactive, but when (and if) the interior light goes off the DASCR latches, conducting voltage to normally closed relay RY1, which is wired in series with the interior light's power source. If the light goes on, the relay is energized, causing it to go off.

The Frid-O-Matic can be built using point-to-point, perforated construction board, or PC board techniques. A five- or twelve-volt power supply can be used, depending on the coil voltage of RY1. The entire device can be housed in an empty milk or orange juice container so as to blend inconspicuously with the usual contents of your refrigerator (see Fig. 2).

Using your Frid-O-Matic is easy. With the side of the juice or milk container containing the DASCR facing the refrigerator's interior light, carefully close the refrigerator door. The next time you open it, if the interior light goes on, that is an indication it was never off. If, however, it does not light, that is an indication that it did go off when the door was closed (aha!), or when you weren't looking. Or maybe it just picked that time to burn out.

The Frid-O-Matic can be disconnected by ripping out the wires to RY1.

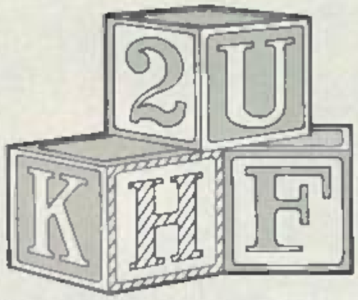


FIG. 1—BLOCK DIAGRAM of the Frid-O-Matic. Schematic is behind blocks.

FIG. 2—WHICH ONE is the Frid-O-Matic? Only your wife knows for sure.

Build the CheapModem

Computer-to-computer communication can be an expensive proposition, and sometimes it isn't worth the investment in equipment. Here's a short-haul modem you can build. It's almost free!

FIG. 3—AFTER MUCH TRIAL-AND-ERROR experimentation. It was found that the best resonator is usually determined by what happened to be on sale at the supermarket this week. Several good resonators can be found in this photograph.

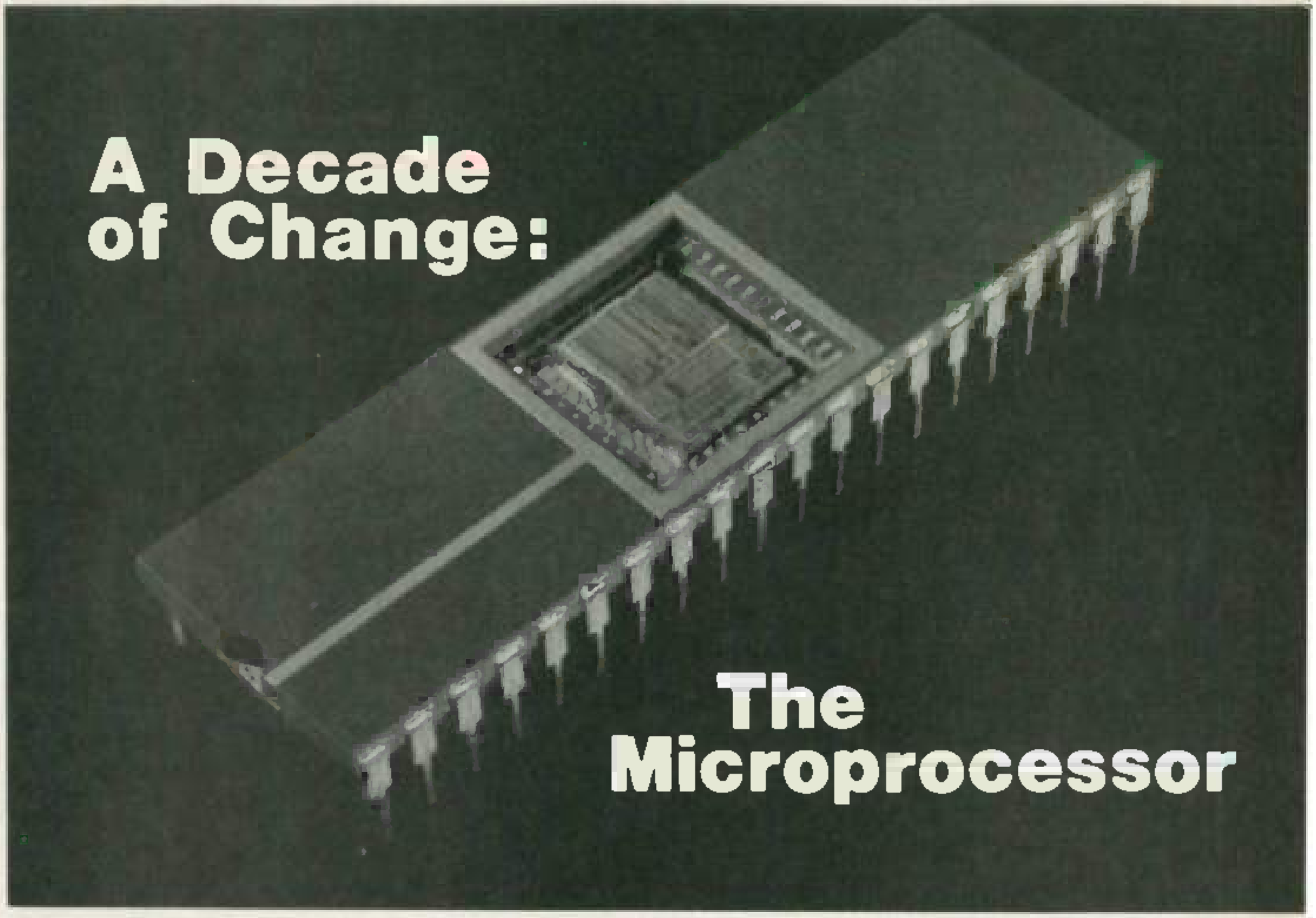
The operation of the CheapModem is quite straightforward. The output from the computer's serial port is fed to two amplifiers—a straight-through one and an inverting one, and coupled from each to a small buzzer. The buzzers have different pitches and correspond to the logic highs and logic lows that are output by the serial port.

Both buzzers are mounted inside a resonating chamber, which is connected by a flexible conductor to a similar resonator at the receiving computer. A phono cartridge or other suitable pickup is mounted in that resonator and connected through a pair of 567 tone decoders to that computer's serial port.

The electronic part of this project is elementary, and the circuits can be found in almost any project book. The real secret of the CheapModem is in the resonators and in the selection of the correct flexible conductor. Both rigid and semirigid resonators have been tried, and each type has its own advantages. Semirigid resonators, in the form of waxed or plasticised cardboard containers are more efficient than the rigid, or tin-can, sort, but are not as durable. They are, however, easier to open and empty, and for that reason may be preferred. The final choice is up to you, and may well be based on your eating habits or just on what's on sale at the supermarket. Several suitable resonators are shown in Fig. 3.

The flexible conductor is perhaps the most important part of this project. A number of materials were evaluated, among them wirewrap wire, UHF hard line, and a slinky. The last worked well, but was found to be prone to interference from ambient noise, which led to transmission errors. In the end, the most effective in terms of its price/performance ratio was found to be dental floss. Dental floss is also easy to knot, and a good knot is vital to the proper performance of the CheapModem.

A maximum reliable transmission rate of 1.25 baud was achieved in the author's prototype. While a higher speed would have been more useful, for the price you can't argue. And you get to eat what was in the cans or containers. R-E



A Decade of Change: The Microprocessor

Today, microprocessors are used in everything from microwave ovens to automobiles to home computers. They've come a long way in a few short years.

ROBERT GROSSBLATT, CIRCUITS EDITOR

NAMES LIKE UNIVAC AND ENIAC HAVE MYstical connotations for some of us. Visions of huge rooms filled with glowing tubes and punched cards dance before our eyes, and our ears fill with the all-pervading murmur of massive air-conditioning systems. We remember staring awestruck as those giant computers flexed their electronic muscles to produce printed portraits of George Washington. (Wow!—*Editor*)

Those machines aren't really part of microcomputer history—they're part of its pre-history. Microcomputer history really began one day in the early 1960's when Jack Kilby of Texas Instruments made the first integrated circuit. After it was shown that an entire circuit could be fabricated from a single solid chunk of semi-conductor material, the stage was set for the development of the microprocessor. But things didn't really take off until the early 1970's.

Several important events occurred in 1970:

- The development of *L*arge *S*cale *I*ntegration (LSI) techniques made it possible to fabricate a complete circuit on a single piece of silicon.
- Memory technology matured to the point that standard products became widely available.
- A huge market opened up for handheld calculators.

A year later Intel introduced a general-purpose IC that did just about everything necessary needed to support calculator-type operations. Intel called that IC the 4004; it had a four-bit data path, and it was the first microprocessor.

First generation microprocessors were designed for specific applications. The 4004 was designed to handle calculator logic, and the eight-bit 8008, introduced a year later, was designed to control an intelligent terminal.

Intel's IC's were designed at a time when memory was very expensive. Consequently, from the beginning, their microprocessors relied heavily on internal registers to store and transfer data. As shown in Fig. 1, the 8008's six storage registers are eight bits wide, and the program counter is fourteen bits wide. That limited the 8008 to 16K of directly addressable memory. Further, the internal stack is only seven words deep. That's fine for a controller, but it really limits use of the 8008 as a computer.

The microcomputer industry really came into its own with the second generation of microprocessors: Intel's 8080 and Motorola's 6800. Although both are microprocessors, their design philosophies are radically different.

Intel increased power in the 8080 by moving the stack itself to external memory, and by giving it a sixteen-bit stack pointer. As shown in Fig. 2, the 8080 also

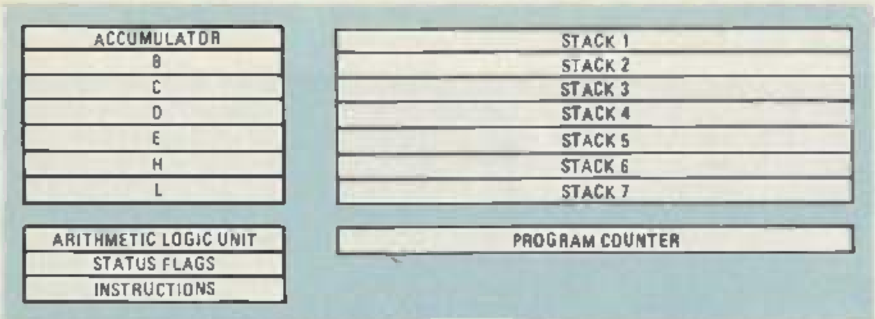


FIG. 1—THE FIRST 8-BIT MICROPROCESSOR, Intel's 8008, had an internal seven-byte stack, and it was limited to 16K bytes of memory.

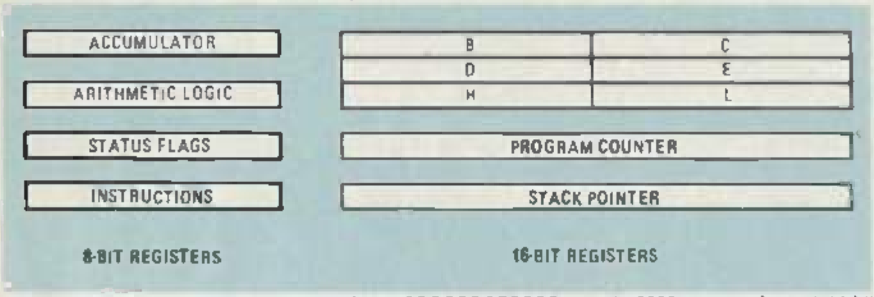


FIG. 2—THE FIRST GENERAL-PURPOSE MICROPROCESSOR, Intel's 8080, features an eight-bit accumulator and three general-purpose sixteen-bit registers.

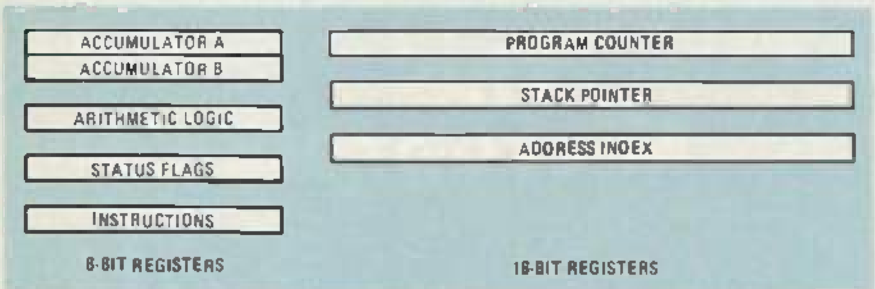


FIG. 3—MOTOROLA'S 6800 emphasizes quick memory access at the expense of few internal registers.

has three sixteen-bit registers in addition to the program counter, which was itself increased to sixteen bits. That gave the 8080 the capability of addressing the now-familiar 64K of external memory.

Motorola's 6800 was designed along different lines altogether. Instead of emphasizing internal registers, temporary data storage occurs in external memory, and the microprocessor has only enough registers to keep track of where things are. Other than the primary and secondary accumulators, the only "data" register in the 6800 is an index register that is used as a counter, and to do indexed memory addressing. The 6800's internal structure is shown in Fig. 3.

There are advantages and disadvantages to both design philosophies. For example, the 6800 must access memory much more often than the 8080, but it can do that much more rapidly than the 8080 can. But by far the most important consequence of the difference in those IC's is in overall memory organization.

To the 8080, all addresses are the same—it takes the same amount of time to access any location in its 64K range. Also, the processor goes to location 0000 for its first instruction after power up and after reset.

The 6800, on the other hand, has a special set of two-byte "zero page" addressing instructions that allow page zero—the first 256 bytes of memory—to be accessed rapidly. All other address instructions are three bytes long. That makes zero-page real estate valuable—the microprocessor can address page zero locations in two-thirds the time it can address locations in other pages. Since zero-page addresses are, in a sense, the 6800's substitute for registers, the operating system is put at the top of memory. When a 6800 is first powered up, it goes to address FFFE for its first instruction.

The Motorola and Intel design philosophies have shaped the architectures of just about all microprocessors that have followed, down to the latest sixteen- and thirty-two bit microprocessors.

CP/M

In 1973 the microcomputer industry was rather limited. First-generation micros like the Altair and the Imsai stored data on paper tape or cassettes. Floppy disk drives had just begun to appear when Gary Kildall, a consultant working for Intel, developed CP/M, a *D*isk *O*perating *S*ystem (DOS) for Intel's 8080. When Imsai licensed CP/M and began distributing it, the home computer market exploded. Since CP/M was just about the only DOS available, the 8080 became the microprocessor of choice for most home computers.

Because of the popularity of CP/M, any heir to the 8080's throne would have to have an instruction set compatible with that microprocessor. Since most of the software available for home computers was coded in the 8080's native tongue, microprocessor manufacturers realized that it was a matter of simple economic survival to make sure that such software would run on any new microprocessor.

By the time that the second generation of microprocessors began winding down, the home-computer market was an economic reality. CP/M gave birth to a variety of sophisticated systems-programming languages, and user-oriented application programs began to fill the market. That caused more CP/M computers to be sold and more programs to be written for them. Then, when major manufacturers like IBM and Xerox began adopting CP/M for use in their products, the stage was set for the birth of the third generation of microprocessors.

Intel introduced the 8085, an improved version of its 8080, and then upgraded that with the 8085A. The old 8080 required *three* voltages to operate: +12, +5 and −5. The 8085A required only +5 volts, and a much simpler clock circuit now sufficed. In addition, a series of new interrupt and I/O signals were tied to various pins on the IC—in an attempt, perhaps, to simplify the complex I/O set-up of the 8080.

Unfortunately, Intel paid a high price for that increased flexibility. Because they dedicated so many pins to I/O, and because they remained locked to a standard forty-pin package, the data bus had to be multiplexed with the lower eight bits of the address bus. And that meant that the 8085 would always need external latching. A big gripe with the 8080 was that it needed extra support IC's (an 8224 Clock Generator and an 8228 System Controller); and since the 8085 also needed at least an eight-bit latch and some decoding, the 8085 never became as popular as Intel had hoped. However, a CMOS version became available relatively early; Tandy used it in their portable computers, and that prevented it from becoming totally obscure. But perhaps the real reason for its lukewarm reception was that it was introduced three years after the Z80.

Zilog's Z80

From the moment it appeared, the Z80

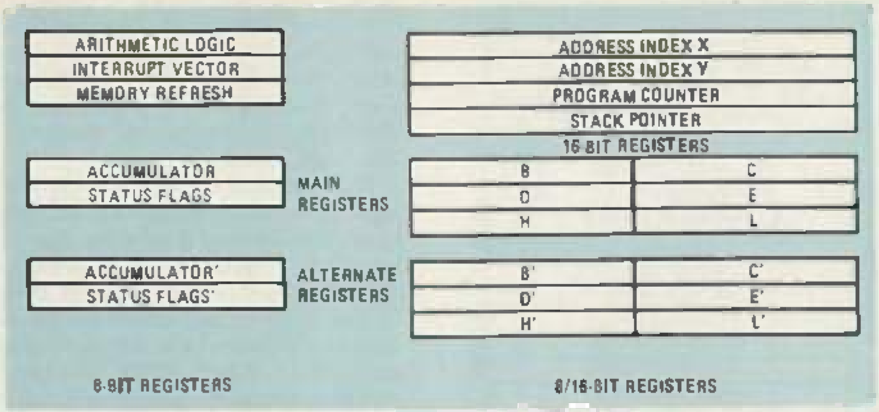


FIG. 4—ZILOG'S Z80 has the same registers as the 8080, but it provides a duplicate register set for quick response to interrupts.

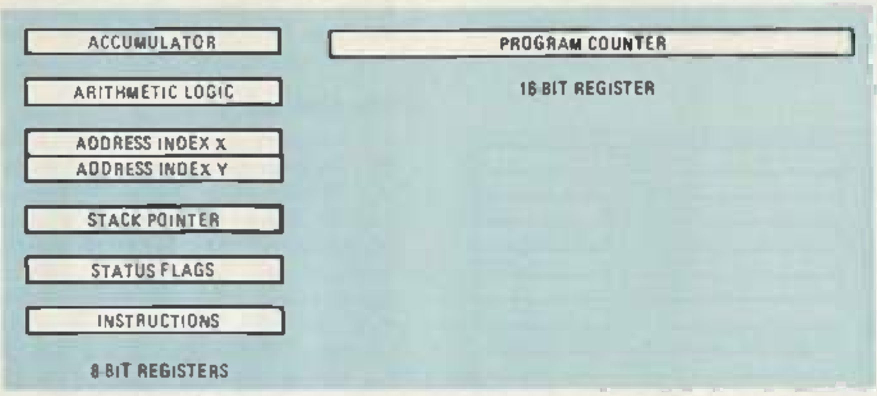


FIG. 5—MOS TECHNOLOGY'S 6502 has no general-purpose 16-bit registers, but it has the most flexible addressing schemes of all the early eight-bit processors.

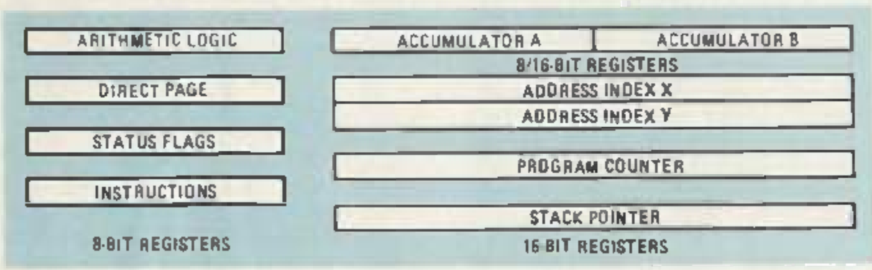


FIG. 6—MOTOROLA'S 6809 was intended to bridge the 8/16-bit gap; but it never really caught on, in spite of its having some really powerful features.

was a winner. It incorporated all the 8080 instructions as a subset of its own greatly-expanded instruction set. And that allowed it to run all the existing 8080-based software. In terms of hardware, the Z80 was designed according to the Intel philosophy. Zilog maintained the register structure of the 8080, but also added a set of alternate registers that duplicated the main set, as shown in Fig. 4. The alternate registers allow an increase in processing speed because, during an interrupt, the main registers can be swapped with the alternates by using a fast one-byte instruction.

Combined with the other advantages it had over the 8080—a single supply-voltage and a simple clock—the Z80 became *the* upgrade for the 8080. It had built-in features that required extra IC's in an 8080-based system. The Z80, for example, can refresh dynamic RAM IC's automatically.

One interesting point about the Z80 is that, when it was first introduced, Zilog believed that the huge new instruction set would be responsible for most sales of the IC. As it turned out, 8080 code had become *the* standard, and the Z80's extra instructions were, for the most part, ignored. Intel, on the other hand, showed awareness of that need for compatibility, because the 8085 added only two instructions to the 8080's repertoire.

The 6502

In 1975 MOS Technology introduced the 6502. Just as the Z80 is a high-performance version of the 8080, the 6502 is a souped up 6800—but with differences. You can run 8080 code on a Z80, but 6800 code is gibberish to a 6502. What the 6502 got from the 6800 was its design philosophy. The 6502 is a top-down processor; its strength is in powerful addressing modes, rather than a lot of internal registers. Among its advantages over the 6800 were: on-IC clock generator, an improved instruction set, new addressing modes, faster access to the stack, and built-in BCD arithmetic.

At first glance, the 6502's architecture might look like a step backward. As shown in Fig. 5, the sixteen-bit index register of the 6800 was split into two eight-bit registers, and the stack pointer is only eight bits wide. That limits the stack to 256 bytes, but the designers of the 6502 decided that a 256-byte stack is more than adequate for most applications. By limiting its length, it could be placed in a dedicated area of memory (100 to 1FF). And that allowed the stack to be accessed very quickly, which increased overall execution speed. Splitting the index register allows both halves to be used independently for some very powerful indexed addressing modes.

What saved the 6502 from obscurity was being chosen as the microprocessor for the Apple, Atari, and Pet computers. The huge successes enjoyed by those ma-

Microprocessor Speed

How fast a program runs on your computer depends on more than just its clock speed. The clock frequency determines microprocessor speed, but the instruction set, as well as the way a program is written, determine how fast a program runs.

Most of a microprocessor's time is spent accessing locations in your computer's memory, and the instruction that tells the microprocessor to do that can be two, four or even more bytes long. The overall speed of your computer is a function of how many cycles of the system clock it takes to complete a particular instruction.

A computer running at 8 Mhz will complete a four-byte instruction in exactly the same length of time that it takes a 2-MHz computer to complete a one-byte instruction. Overall program execution speed, therefore, depends on how much the microprocessor has to do and how quickly it can do it. The same program running on two computers with different microprocessors will undoubtedly run at two different speeds. Which runs faster depends on what the program is asking the microprocessor to do.

Some microprocessors have instruction sets that are quick at number crunching, while others are better at memory access. In general, microprocessors with internal registers, like the Z80, are better at number crunching because they have one-byte commands to manipulate register data. Microprocessors like the 6502, on the other hand, which do most things in memory, access that memory quicker than the register-oriented type of microprocessor. **R-E**

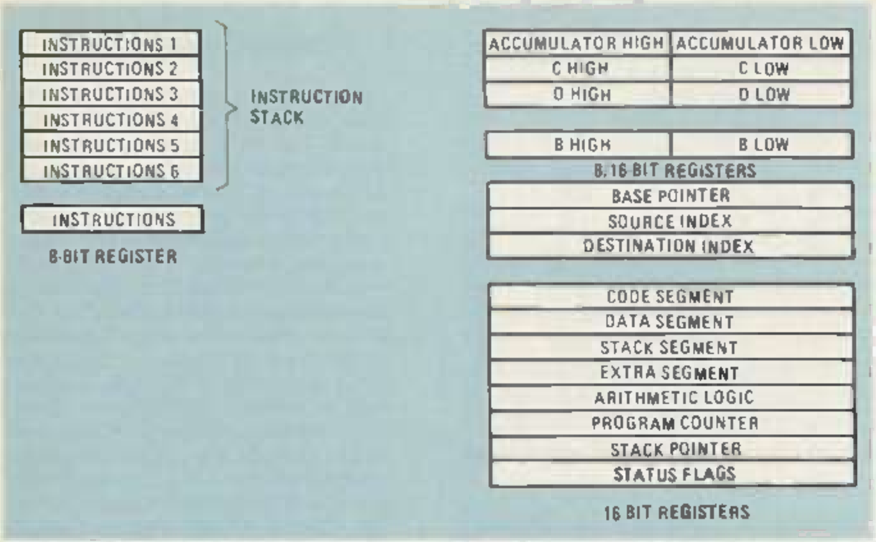


FIG. 7—INTEL'S 8088/86, workhorse of the IBM PC, provides one-megabyte memory addressing through the use of segment registers.

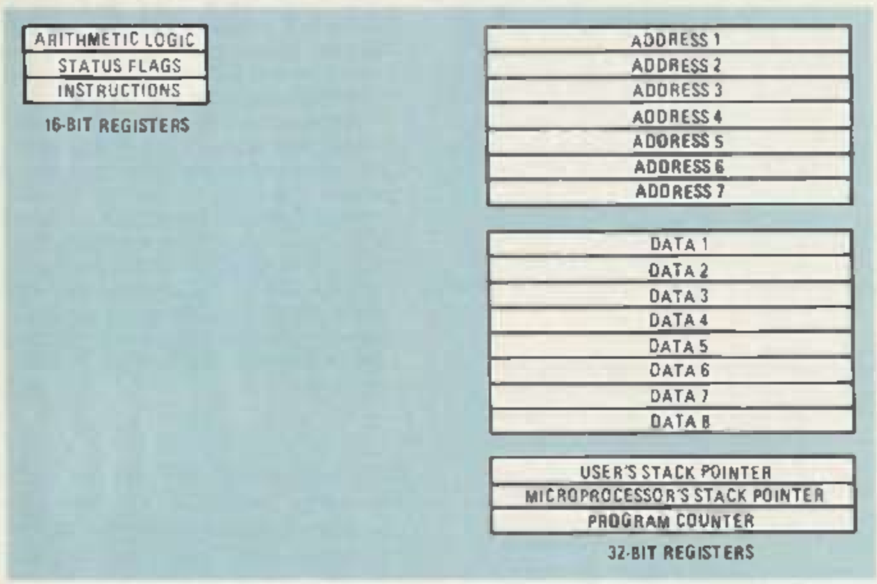


FIG. 8—MOTOROLA'S 68000, heart of Apple's Macintosh, is probably the most powerful sixteen-bit microprocessor on the market.

chines transformed the 6502 into one of the few silicon superstars.

The fourth generation of microprocessors began to emerge around 1980. The home-computer market was a mammoth economic reality by that time, and IC manufacturers were selling microprocessors as fast as they could make them. The third generation's last gasp was Motorola's 6809. It included advanced addressing and a multiply instruction. That instruction was innovative, unique, and it allowed a substantial increase in program execution speed. The 6809's structure is shown in Fig. 6.

Unfortunately for Motorola, the 6809 came late in the history of microcomputing, so few machines were designed around that IC. (Radio Shack's *Color Computer* is a notable exception.—*Editor*) One interesting footnote to computer history is that Apple was so impressed with the 6809 that they used it in early *MacIntosh* designs.

Fourth-generation microprocessors came about through refinements in IC technology. The advent of *V*ery *L*arge *S*cale *I*ntegration (VLSI) vastly increased on-IC component density. Results include sixteen-bit microprocessors, 64K (and larger) dynamic RAM's, as well as performance upgrades for the previous generation of microprocessors.

Sixteen bit microprocessors weren't really new. For example, TI's TMS9900, was a second-generation, top-down, sixteen-bit microprocessor with two sixteen-bit registers: a stack pointer and a program counter. All other data storage occurred in external memory. The TMS9900 has separate address and data buses because it comes in a 64-pin package. The TMS9900 is a powerful microprocessor, and the way it was marketed is a perfect example of how *not* to do it. TI used the IC in its home computer, the *TI99*, but TI did nothing to support outside developers. When the computer failed to catch on, Texas Instruments let it die, and the TMS9900, essentially an IC ahead of its time, died with it.

The second-generation design philosophies of the 8080 family and the 6800 family showed up in third generation sixteen-bit IC's. Intel released the 8086 and 8088: they're direct descendents of the original 8080, so they emphasize the use of internal registers for storing and manipulating data. Zilog's Z8000 is a more-powerful, sixteen-bit version of the well-established Z80. Motorola's 68000, a muscular, sixteen-bit version of the neglected 6809, is more powerful than either Intel's or Zilog's microprocessors. We'll look at each in turn.

The 8086 family

As we mentioned earlier, it takes more than good design to make a silicon superstar. Intel struck it rich when IBM jumped into the home-computer market with a machine based on the 8088. Intel was a bit surprised, as well. The 8088 is a watered-down version of Intel's more powerful 8086. As shown in Fig. 7, the 8086 has a number of 16-bit registers, but the 8088 has an eight-bit-wide data bus, and that means that sixteen-bit data must be loaded into the microprocessor eight bits at a time. That's why it's called an 8/16 bit IC. The 8086, on the other hand, is a true sixteen-bit microprocessor.

IBM's choice of the 8088 was a serious miscalculation of both their marketing ability, and the viability of the market. One of the forgotten oddities of the IBM PC is that it originally showed up in the market with only 16K of RAM. The incredible popularity of the PC led to the development of huge amounts of applications software, and much mainstream eight-bit software was rewritten to operate on the 8088. Once again, Intel had produced the microprocessor that became the industry standard.

Several new features showed up in the new sixteen-bit series that had no counterpart in their eight-bit predecessors. A multiply instruction was added (as Motorola had done with the 6809), but it could be used effectively only in the 8086. The 8088 had a tough time handling thirty-two bit results, so most IBM-PC programmers do multiplication with the traditional shift and add approach, and that slows the PC down drastically.

Although the 8086 and 8088 are stand-alone microprocessors, Intel has some support IC's that can speed things up. The 8087 Math Co-Processor, for example, does high-speed number crunching, and it substantially increases the computing speed of the 8086. Note that the eight-bit data bus of the IBM PC restricts the

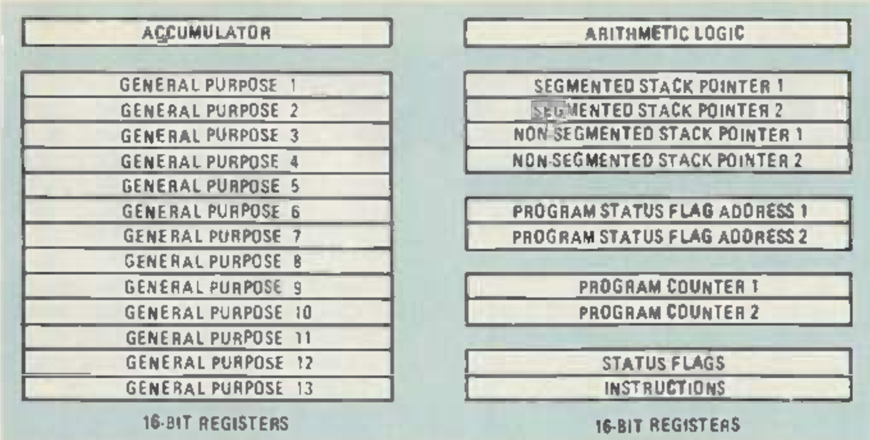


FIG. 9—ZILOG'S Z8000 has not been very popular, in spite of powerful register and memory-addressing structures.

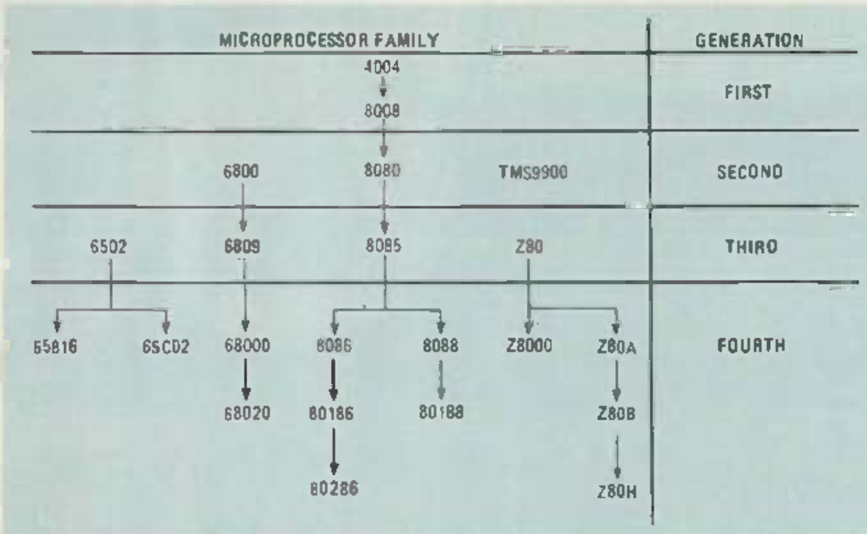


FIG. 10—THE GENEALOGY OF THE FIRST FOUR GENERATIONS OF MICROPROCESSORS is indicated here. What will be next? Stay tuned . . .

usefulness of the 8087 in that computer.

The 80186 and 80188 were introduced by Intel in 1983 as upgrades of the 8086 and the 8088, respectively. Those two IC's took advantage of new VLSI techniques, but didn't really represent any advance in performance. However, they include a lot of the support circuitry for timing and bus control that had to be done externally with the earlier IC's.

Intel's 80286, which IBM uses in its *PC/AT*, is a major enhancement of the 8086. Besides having an on-IC memory-management system, it has a "virtual memory" mode in which the internal registers can generate 24-bit addresses. In practical terms, this means that the 80286 can directly address as much as sixteen megabytes of memory. By contrast, the 8086 can generate only 20-bit addresses, and that allows it to address "only" one megabyte of memory directly.

The 68000

Motorola's 68000 is probably the most-powerful sixteen-bit microprocessor to show up on the market; Apple chose to use it for the ill-fated Lisa and for the MacIntosh. Because its design is similar to that of the 6800, it has a variety of powerful addressing modes. Motorola learned a few things from Intel, apparently, because they added sixteen thirty-two-bit registers, as well as two stack pointers—one for the user and one for internal housekeeping. Unlike most other microprocessors, the 68000 doesn't have a dedicated accumulator. Rather, any of the data registers can be used as an accumulator. The 68000's organization is shown in Fig. 8.

Motorola designed the instruction set so that there could be as many as 64,000 instructions. The Intel IC's, by way of comparison, continued the 8080's practice of limiting the IC to a maximum of 256 instructions. In fact, the 68000 has only 56 basic instructions, but the IC's addressing flexibility makes it easy for programmers to access the full power of the IC without having to remember separate instructions for each special case.

One strength of the 68000 is the width of its registers. If the 8088 is an 8/16 bit microprocessor, then the 68000 should be called a 16/32 bit microprocessor. It has, like the 80286, a "virtual memory" scheme, but its wider registers allow some versions of the 68000 to manage more than 4 *gigabytes* of memory.

The Z8000

The Z8000 from Zilog is a sixteen-bit version of the Z80. It is a well-designed, true sixteen-bit microprocessor with thirteen general-purpose sixteen-bit registers, several stack pointers, and the ability to address as much as sixteen megabytes of memory. The Z8000's organization is shown in Fig. 9.

In spite of its potential, however, the Z8000 has not enjoyed the popularity of its eight-bit predecessor. When the Z80 hit the market, it was successful because it was compatible with the 8080. Unfortunately, the 8086 and the Z8000 are totally incompatible.

Other improvements

The last major advance of the fourth generation had to do with IC technology. Faster versions of popular eight- and sixteen-bit microprocessors began to appear. The Z80, whose original operating speed was a mere 2.5 MHz, became available in 4- and 6-MHz versions (the Z80A, and Z80B, respectively). The original 6502 ran at 1 MHz; its upgrade, the 6502C, runs at 4 MHz. Rockwell, NCR, and GTE each came out with CMOS versions of the 6502, the 65C02, that uses less power, runs faster, and has a larger instruction set than the original.

The 65816

New microprocessors like Western Design Center's 65816 aim at higher speeds, better memory handling, and increased compatibility. The 65816 has a software-selectable mode in which it can emulate a 6502, and it's the first sixteen-bit microprocessor to use the mainframe technique of "cache memory," which is similar to the virtual memory modes we've already mentioned. In a cache system, intermediate data and program information are stored in high-speed memory, and less-important data is stored in a slower memory system such as a disk.

Conclusions

The overall genealogy of the important microprocessor families is outlined in Fig. 10. As you can see, the trend in new products is toward wider buses, higher speeds, and more flexibility. True 32-bit microprocessors are now showing up.

When the 8080 first appeared, it cost over $250. Today you can buy one for less than three dollars. And when you hold one of those twelve-year-old IC's in your hand, keep in mind that you're looking at more computing power and speed than was ever dreamed of in the pre-historic days of the Univac—all of twenty-five years ago. **R-E**

TECHNOLOGY

The time to eliminate EMI in your PC boards is during their design. These guidelines can help you do just that.

MICHAEL F. VIOLETTE

Part 4 HAVE YOU EVER DESIGNED and breadboarded a project, only to find that the circuit doesn't work properly once transferred to a PC board? The cause might be a faulty component or poor soldering, or it might be electromagnetic interference.

Often board layouts are done without any thought of the possible consequences of EMI. When the circuitry involved is either high-speed or high-frequency, at least *some* EMI problems are likely.

In this article we'll look at ways to reduce the chances that EMI will plague your PC-board designs. We'll also look at how to solve EMI problems after the fact: that is, interference to or from boards that are already in existence.

Note that we will not talk about actual circuit-board design. That topic is beyond the scope of this article, but has been presented in this magazine in the past; for instance, see "Designing Double-Sided PC Boards" in the September and October 1985 issues of **Radio-Electronics**. What we will show you are things to consider when doing your own design.

Component selection

Many EMI problems can be avoided if the consequences of selecting a particular component for an application are considered. For instance, when designing digital-logic circuits, most of us would first consider the fastest possible logic family for the job. But increased speed can lead to increased EMI problems. Let's see why.

For one thing, increased speed means increased frequency, and faster rise times. Consider Fig. 1-*a*, which shows one half-cycle of a squarewave. Take particular note of the fact that the "square"-wave is not square at all; rather, is shaped like a trapezoid—the leading and trailing edges of the pulse are not perpendicular to the baseline. That's because no high-low transition is instantaneous; there is always some *rise time*. If you were to examine any squarewave on an oscilloscope with a sufficient bandwidth, you would see that that waveform also is trapezoidal.

The amplitude of the squarewave is A. The rise time, t_r, is defined as the transi-

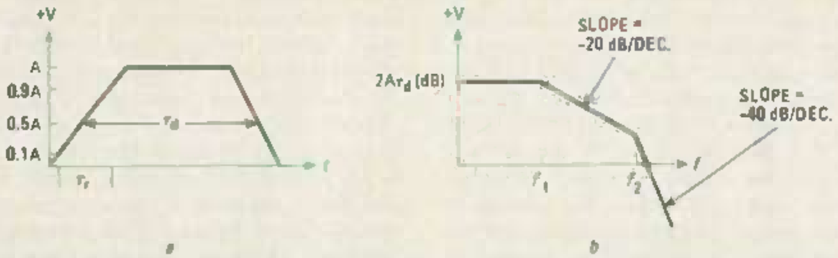


FIG. 1—THE FASTER THE RISE TIME of a squarewave, one half of which is shown in a, the wider the bandwidth. The frequency spectrum of the half-cycle is shown in *b*.

tion time between 0.1A and 0.9A (or between 10% and 90% of the peak amplitude). The pulse duration, t_d, is the interval between 0.5A on the leading edge and 0.5A on the trailing edge.

The frequency spectrum of the half-cycle of the squarewave is shown in Fig. 1-*b*. Note that any periodic waveform, such as a squarewave, ramp, triangular wave, etc., can be represented as a series of sinewaves. In that way, a time-domain signal, such as a squarewave, can be represented as a frequency-domain signal, as we have done.

Actually, the waveform in Fig. 1-*b* is the *envelope* of the frequency spectrum; it is the upper limit on all the frequency components contained in the half-cycle of the squarewave. Note that there are two frequency "breakpoints" where the amplitude of the frequency components change. Those breakpoints are determined by the speed of the logic and are found from:

$$f_1 = 1/\pi t_d$$
$$f_2 = 1/\pi t_r$$

At f_1 the amplitude of the spectrum "rolls off" at (or, has a negative slope of) 20-dB-per-decade (3-dB-per-octave), and at f_2 the amplitude rolls off at 40-dB-per-decade (6 dB-per-octave). The f_2 frequency is of particular importance because it determines the bandwidth of the logic; f_2 is the upper frequency limit of that band. That is important because EMI can be generated at any frequency up to that limit. At low frequencies EMI is relatively harmless, but at higher frequencies, radiation can be more of a problem. For instance, a rise time of 2 nanoseconds results in a bandwidth of $1/\pi\tau_r = 1/(3.14 \times 10 \times 10^{-9}) = 32$ MHz. That is definitely RF, and at that frequency it doesn't take a very long wire to create an efficient radiator. Table 1 lists some common logic families, their rise and fall times, and the bandwidth (in MHz) that results.

By the same token, high-speed logic is very susceptible to interference from external sources. The reason, of course, is that the same wide bandwidth allows for interference from a wide variety of sources. In the case of ECL logic, consider how many sources emit radiation that falls within the range of 0 to 160 MHz.

Of course, the selection of a logic family might be dictated by an existing design, or, perhaps the operation of the circuit requires high-speed clocking. But if you can get by with clock speeds of a few MHz or less, why use high-speed logic and increase the chances of EMI problems occurring?

Circuit layout

After the logic family is chosen and the schematic drawn, usually the next step is to work up a prototype of the circuit. After the prototype stage, a PC-board layout is created. In the discussion that follows, the location and layout procedures apply to both breadboarding and the final design. Also, while we are discussing PC-board layout here, wirewrapped projects should also be built following these guidelines.

Digital signals can wreak havoc if they get into an analog circuit. Always keep analog and digital circuits and signals separate and electrically isolated. As a rule, analog circuits are much more sensitive than digital circuits. Consider, for example, a TTL gate where the swing between a logic high and a logic low is approximately 3.5 volts. However, many analog circuits have sensitivities in the millivolt or or even microvolt range. If a TTL circuit that is adjacent to an analog circuit is happily switching away, and even mild coupling exists between the circuits, the digital signals could very easily swamp the analog circuit.

One of the most likely routes for such coupling is via the returns. The return traces in digital signals can be very noisy; and if analog circuits make use of the same returns, that noise can be coupled into them easily. There are two ways to reduce that coupling. One is to use separate analog and digital returns. The only common point should be the ground terminal of the circuit's power supply.

The other way to reduce coupling would be to use very thick traces, or ground planes, for the commons.

When laying out digital circuitry, if the fastest logic is slower than 10 ns (TTL), the layout of the board is unimportant from an EMI standpoint. Otherwise, follow the general scheme shown in Fig. 2. Group the circuitry by function, then locate the fastest logic as near the I/O connector as possible. Slower circuitry is located progressively farther from the connector. It is also good common sense to locate any I/O circuitry as physically close to the connector as possible.

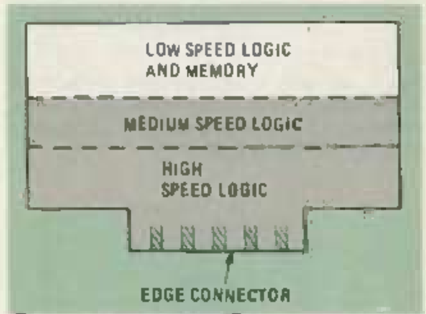


FIG. 2—DIGITAL PC BOARDS should be laid out so that the fastest logic is located nearest the I/O connector. Progressively slower logic is located progressively farther away from that connector.

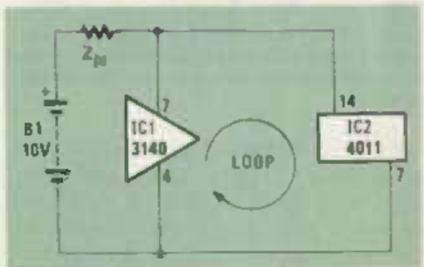


FIG. 3—WHEN THE LOGIC GATE (IC2) switches states, the increased current-draw will cause a noise voltage to disrupt the operation of the op-amp (IC1).

Power-distribution design

The key to a successful EMI-proof power-distribution system is to keep the impedance of the system as low as possible. A low-impedance supply provides enough current without an intolerable drop in the voltage of the supply system. A low-impedance supply is especially important when supplying the transient current to a component. That is the current that a single gate draws from the power supply when switching from low to high.

The importance of low power-distribution impedance is illustrated in Fig. 3. There, an analog op-amp, such as a 3140, is sharing the same power-supply rail with a digital gate, such as a 4011. There is an impedance, Z_{ps}, associated with the power-supply rail (due to trace inductance and resistance). During a switching operation, the gate, IC2, draws a transition current from the supply and a noise voltage develops across the power-distribution impedance. That voltage will appear at the input of the analog amp, IC1, and, if large enough, can disrupt its operation.

Another problem exists in the circuit of Fig. 3: There is a large loop between IC2 and the power supply. That loop can and will act like a radiating and/or pickup loop.

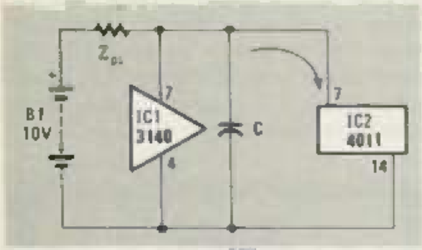


FIG. 4—ADDING A DECOUPLING CAPACITOR to the circuit of Fig. 3 will eliminate the noise problem and also reduce the size of the loop between IC2 and its supply.

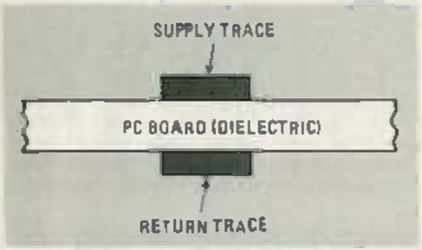


FIG. 5—BY RUNNING THE SUPPLY RAIL on one side of the board, and the return on the other, the PC board itself can be used as a decoupling capacitor.

A remedy for both of those problems is shown in Fig. 4. There, a decoupling capacitor has been installed across the power and return rails to IC2. The purpose of that capacitor is to supply current during the low to high transitions of the gate. As shown in Fig. 4, that capacitor also reduces the size of the loop between the "supply" and the gate.

It is important that the leads of decoupling capacitors are kept as short as possible. Otherwise, lead inductance could cause the capacitor to self-resonate and behave as an inductor.

Looking at the arrangement of power and ground pins on most digital IC's, it becomes obvious that EMI was not considered when pin 7 was established as ground and pin 14 as V_{CC}. That places the ground and power inputs at opposite corners of a 14-pin DIP, which is just about the farthest apart they can be. As a result, the job of keeping capacitor leads short is made just that much harder. For situations where lead inductance is particularly troublesome, it may be possible to use decoupling capacitors that have been designed to fit under the IC itself.

When designing digital circuits, the inclusion of decoupling capacitors is almost mandatory. But there is an alternative to using discrete capacitors. That is to use the board itself as the capacitor. That is done by running the positive rail on one side of the dielectric board and the negative or return rail on the other side as is shown in Fig. 5.

When that scheme is used, the supply and return traces act like the electrodes of a capacitor that are separated by a dielectric (the board material). The total capacitance is the sum of the distributed capacitance along the length of the trace. That capacitance can be increased by decreasing the separation between the supply and return (usually that is determined by the thickness of the PC board) and making the traces as wide as possible (wide traces also reduce the amount of trace inductance and resistance). One technique that is sometimes used, especially in crowded designs, is to leave as much copper as possible on one side of the board. That copper ground plane is used as the return trace. Of course, putting traces on both sides of the board means, by definition, that you will be making a double-sided board. Such boards can be more difficult and costly to produce than single-sided ones. On the positive side, double-sided boards allow you to reduce the physical size of the layout.

If the circuit is laid out on a single-sided board, then the power-supply rails should be routed as close to each other as possible, and decoupling capacitors should be used where required. Figure 6 shows two ways that the power and return rails could be routed. In Fig. 6-*a* we see one common layout. From our discussion thus far, you should now be able to see why that is a poor scheme from an EMI perspective. The relatively long distance between the rails can give rise to excessive lead inductance in the decoupling capacitor, as well as larger than necessary loops. The layout shown in Fig. 6-*b* is far better as it minimizes both problems.

Selecting decoupling capacitors

As a general rule, a good design will provide for one decoupling capacitor for every two IC's. That capacitor should be capable of supplying the maximum expected transition current of the logic being used. As a general rule of thumb, capacitance values between 0.01 and 0.001 should be adequate for most applications. Because of their excellent high-frequency characteristics, ceramic disc types should be used in most instances. In addition, a 1- to 10-µF tantalum capacitor should be installed at the point where power comes onto the board. Because of the poor high-frequency characteristics of a tantalum capacitor, it should be installed in parallel with a 0.01-µF ceramic disc.

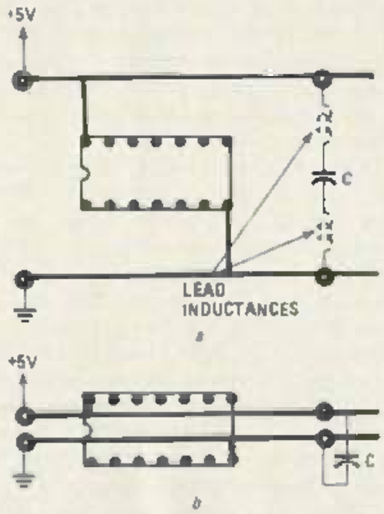


FIG. 6—THE RELATIVELY LONG distances between the supply rails in *a* can cause excessive EMI. Routing the rails as shown in *b* is much more satisfactory from an EMI perspective.

Routing signal traces

The final step is the routing of signal traces. Input/output lines should be routed first to minimize their length.

Clock circuits are one of the prime sources of EMI on digital boards. In many cases, as the clock signals are routed to the various components that require them, long traces and one or more loops result. Such traces make good radiators and can give rise to crosstalk problems.

One way to minimize that problem is to lay out the board in such a way that components are grouped together by function. Attention should also be paid to the location of the oscillator. Place it as near the circuitry that requires clock pulses as possible, but away from any sensitive analog circuitry. Finally, use ground planes to minimize any radiation from those traces.

Trace routing should also be designed to prevent common impedance coupling. That coupling occurs when two circuits share a common wire or bus, and the current from one circuit induces a voltage across the common impedance of the wire. To prevent common impedance coupling, ground returns should be isolated.

Wirewrap boards

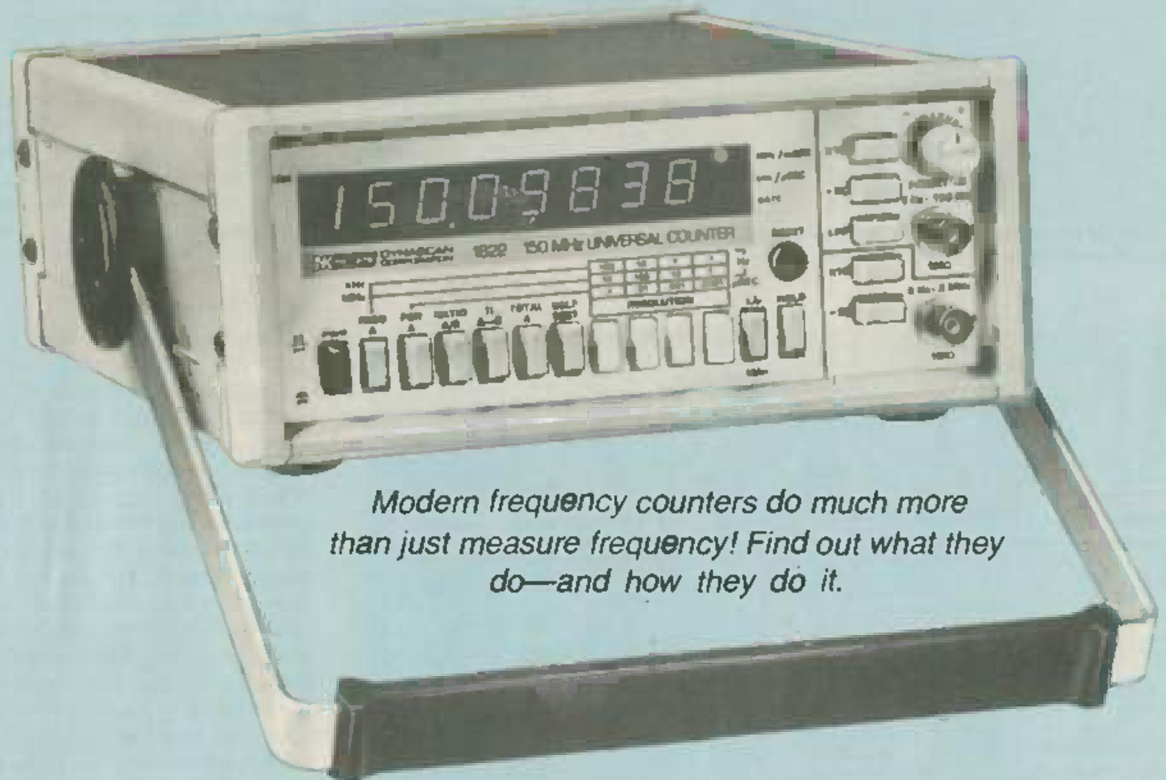
As you can well imagine, all those individual wires used on wirewrap boards can create a great deal of EMI. To eliminate EMI, a wirewrap board should be designed to reduce wire bundling, with everything connected point-to-point.

The first step in laying out the signal and power runs is to create an X-Y grid of ground lines. Those lines should be placed about 10 pins apart. Doing that creates a ground plane for the board.

Over those, you should connect all runs of wire that are greater than d/2 long, where d is the diagonal measure of the board. If the circuit uses high-speed components, the next step is to lay out a second X-Y grid of ground wires; that step is most likely unnecessary for home projects. Finally, connect all remaining lines.

With that procedure, and by following the layout recommendations we presented earlier, and with the proper use of decoupling capacitors, it is possible to build an EMI-immune wirewrap board. R-E

All About FREQUENCY COUNTERS



Modern frequency counters do much more than just measure frequency! Find out what they do—and how they do it.

VAUGHN D. MARTIN

IF YOU'VE CONSIDERED ADDING A FREquency counter to your test bench, but weren't sure whether the cost would be justified, you may be in for a pleasant surprise. Modern frequency counters do much more than merely measure frequency. In this article we'll talk about what they do, how they work, the circuits that compose them, and sources of measurement error. We'll also discuss several unusual applications of frequency counters, and how special instruments like reciprocal and microwave frequency counters work.

The frequency counter

In addition to frequency (f), most frequency counters these days can measure period (T), the frequency ratio of two signals, and the elapsed time between two events. Some frequency counters can count the number of pulses in a period of time defined by the user or the system under test. As we'll see, the circuitry used for each of those measurements is quite similar.

A simplified block diagram of a frequency counter is shown in Fig. 1. An input signal is first conditioned so that the digital processing circuitry can handle that signal. We'll have quite a bit to say about that input circuitry a little later, but for now let's just concentrate on the major functions.

The timebase oscillator is usually a very accurate crystal oscillator. The timebase divider scales the output of the timebase oscillator and provides a pulse train whose frequency is switch-selectable, usually in steps of a factor of ten (10, 100, 1000, etc.). The main gate opens for a period of time that is determined by the timebase divider. While the gate is open, pulses are counted and then scaled for output by the display circuitry. For example, if 45,500 counts accumulate in the counting register, and if the gate time is one second, then the frequency is 45.5 kHz. The same number of pulses in 0.1 second would correspond to a frequency of 455 kHz.

Period measurements are made by determining the amount of time a signal takes to complete one cycle of oscillation. In this mode, as shown in Fig. 2, the counting register counts pulses from the timebase oscillator, and the input signal

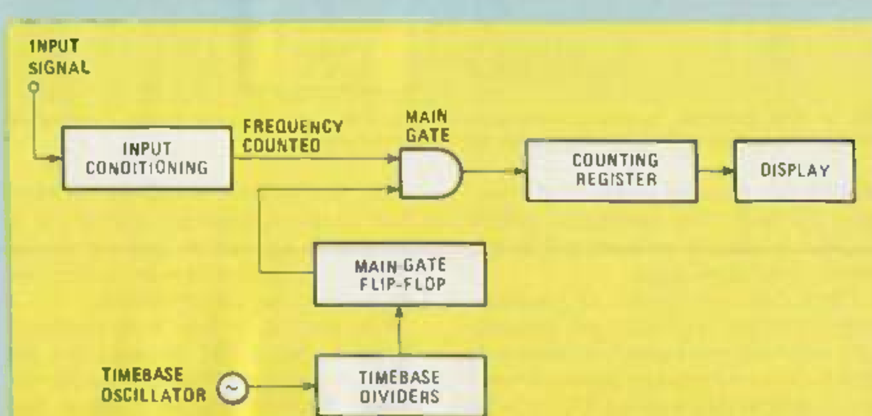


FIG. 1—FREQUENCY MEASUREMENTS are made by counting the number of pulses that occur in a period of time that is determined by the timebase divider.

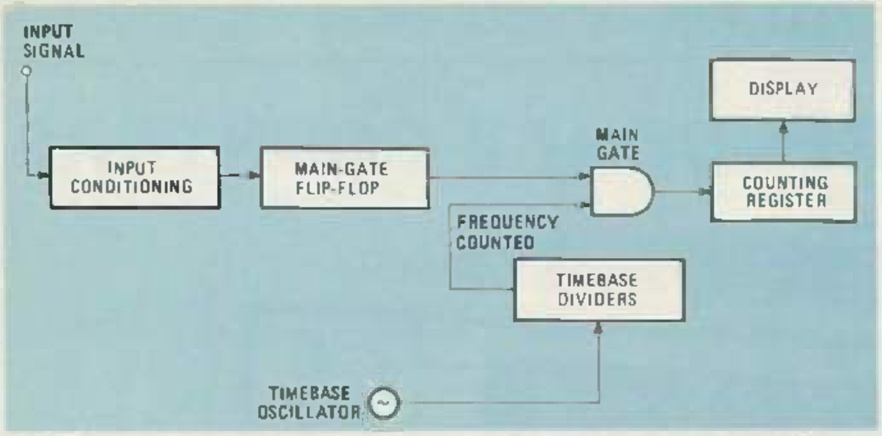


FIG. 2—PERIOD MEASUREMENTS are made by counting the number of pulses from the timebase oscillator that occur while the input pulse is active.

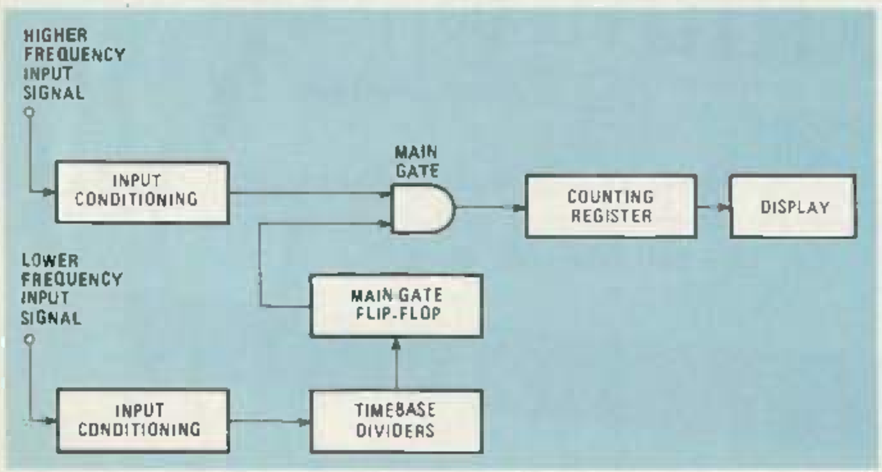


FIG. 3—RATIO MEASUREMENTS are made by disconnecting the timebase oscillator from the main gate. One signal is applied to the regular input, and the the second is fed through the timebase signal path.

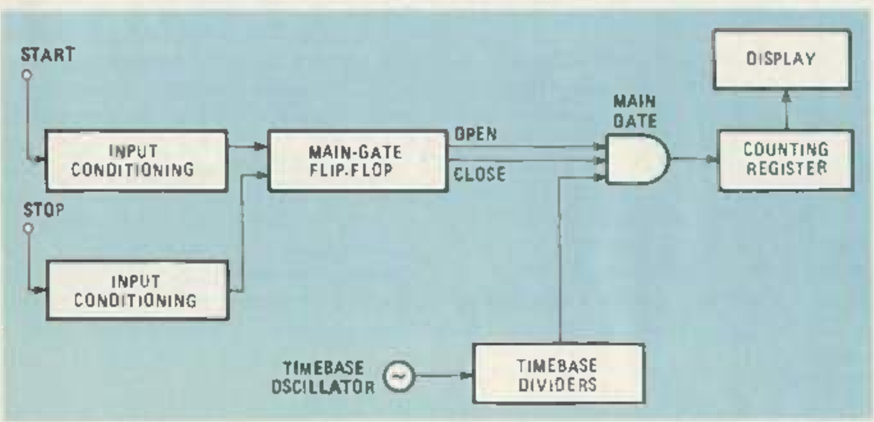


FIG. 4—TIME INTERVAL is measured by counting pulses from the timebase oscillator during an interval that is defined by externally-applied start and stop pulses.

enables that counting through the main-gate flip-flop. The number of pulses counted is directly proportional to the period of the input signal.

Clock rate and number of measurements affect the resolution and accuracy with which an input signal is measured. A higher clock rate provides greater resolution. For example, with a 1-MHz clock, one million pulses would be counted in one second, but with a 10-MHz clock, ten times that number would be counted. With very-low-frequency signals, it is often more accurate to measure several complete cycles and then display the average value of those measurements.

Frequency ratio may be measured, as shown in Fig. 3, by disconnecting the timebase oscillator from the gating circuitry. The lower-frequency signal then controls the gate, and the higher frequency signal is counted by the counting register. Accuracy can be improved by using the averaging technique we mentioned above.

Time interval is measured by using two control signals, START and STOP, to control the main gate, as shown in Fig. 4. The counting register then counts pulses from the timebase oscillator. Counting commences upon receipt of a START pulse, and counting ceases upon receipt of a STOP pulse.

Pulse counting is similar to measuring frequency, except that an external signal, such as an SPST toggle switch, determines the gate's time interval—that is, the length of time the gate is able to accept input pulses. The basic idea is shown in Fig. 5.

Other features

Frequency counters often include features like normalizing, presetting, and prescaling. A normalizing frequency counter multiplies the input signal by a preset constant. Normalization is often used to measure RPM and flow rate, where input transducers commonly provide more (or less) than one pulse per unit of rotation or flow. A presettable frequency counter provides an indication only when a preset number has been exceeded. Presettable counters are used in batch counting, RPM monitoring, and cardiac and respiratory monitoring.

Prescaling is useful for increasing the maximum frequency at which a counter can operate reliably. The prescaler divides the input signal by a factor of n before applying it to the main gate, as shown in Fig. 6. The tradeoff is that, to keep resolution from decreasing by n, the main gate must remain open for a period of time equal to n. However, that allows a slower, less expensive gate and counting register to be used.

That should give you some of idea of what frequency counters can do. Now let's look at how they do it. We'll begin at the beginning—the input-conditioning circuitry.

Input processing

The major components of the signal-processing block we have referred to in previous diagrams as "input conditioning" are shown in Fig. 7. First we notice a switch to select AC- or DC-coupling. Then we see an attenuator that is used to reduce the amplitude of the input signal if it is too great. Next there is a limiting circuit composed of a fuse and diodes D1 and D2. Then we see an impedance-matching network that is followed by a wide-band amplifier.

An optional AGC (Automatic Gain Control) circuit provides feedback from the amplifier to the input attenuator, and then the Schmitt trigger conditions any signal with a slow rise-time, a slow fall-time, or both (like a sinewave), to provide

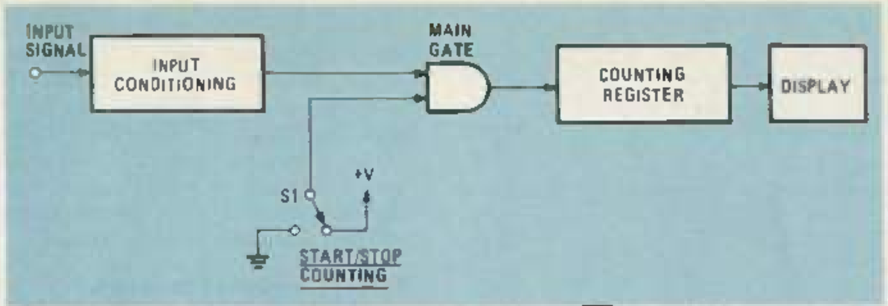


FIG. 5—PULSES ARE COUNTED by using a manual START/STOP switch to control the main gate. The input signal is applied to the regular input.

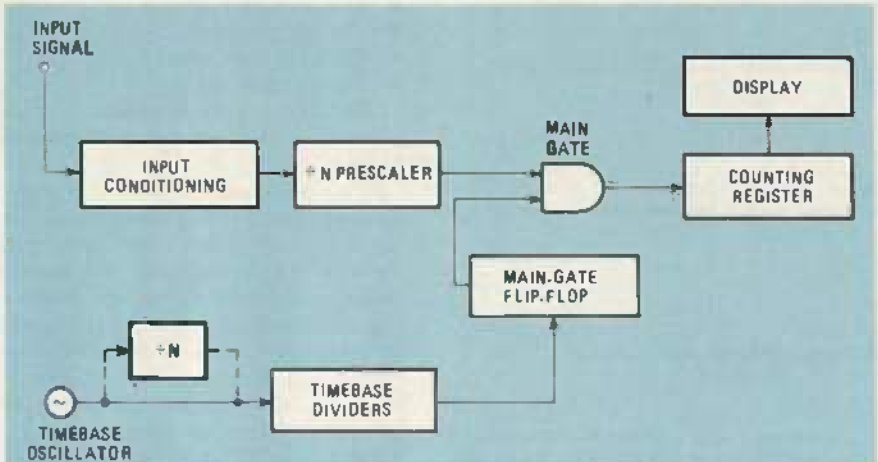


FIG. 6—A PRESCALER may be used to measure frequency higher than usual. For proper display, the output of the timebase oscillator may also be divided.

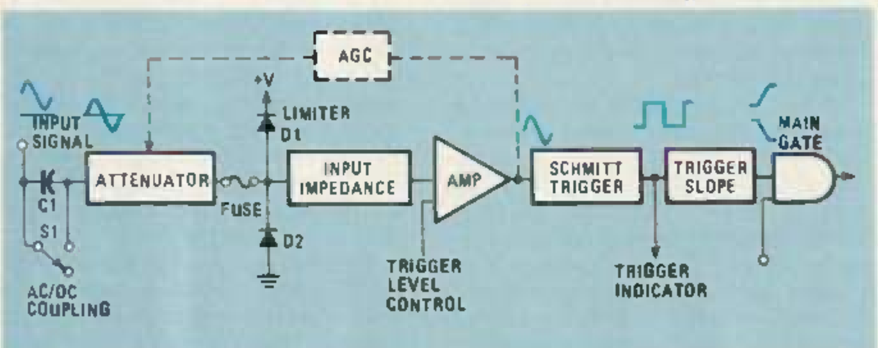


FIG. 7—THE INPUT-CONDITIONING CIRCUIT of a typical frequency counter is shown here. The circuit shapes signals to a digital form that is acceptable to the main gate.

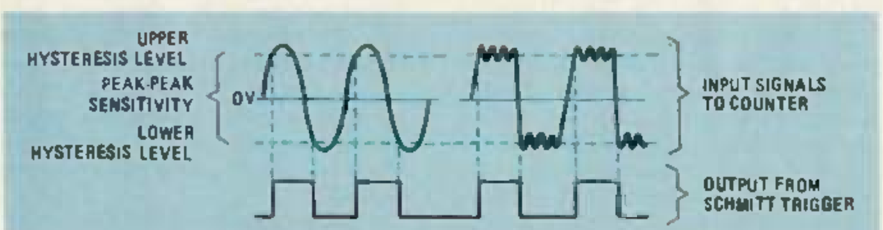


FIG. 8—NOISE RIDING AN INPUT SIGNAL can cause false triggering of a frequency counter's counting circuit.

a more rectangular output with fast risetimes and fast falltimes. Next we find a trigger-slope selector, and then the properly-conditioned input signal is fed to the digital counting and display circuitry.

While keeping those input components in mind, let's talk a bit about the sort of input signal that is required, and then look at each stage of that signal-processing circuit in more detail.

Sensitivity may be defined as the smallest input signal that can be counted reliably. Sensitivity is usually specified in terms of the rms value of a sinewave input. In general, pulses must have an amplitude exceeding $2\sqrt{2}$ (2.82) times the rms value of the specified trigger voltage.

It may appear that a more sensitive frequency counter is a better frequency counter. However, frequency counters usually have broadband input amplifiers, so high sensitivity can cause false triggering to occur. That is why a Schmitt trigger is used. As shown in Fig. 8, the peak-to-peak sensitivity, or hysteresis, of the frequency counter should prevent noise riding the input signal from triggering the counting circuit. Now let's look at the input circuitry.

Input-signal conditioning

Input coupling may be either DC or AC. As shown in Fig. 9-*a*, an AC signal with a large DC component can shift the level of the signal outside the usable range of hysteresis. By coupling the input signal through a capacitor, the DC is blocked, and the signal falls within the usable range of hysteresis.

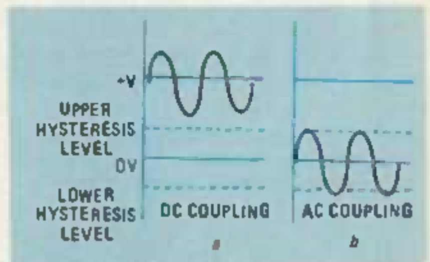


FIG. 9—A DC-COUPLED SIGNAL, as shown at *a*, can shift a signal completely out of the hysteresis range. AC-coupling, as shown at *b*, brings the signal in range.

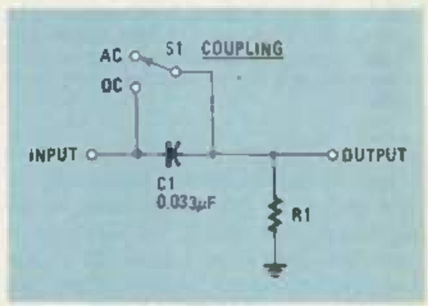


FIG. 10—THIS RC NETWORK is used with different values of R1 to generate the waveforms shown in Fig. 11.

AC coupling is of little value if the duty cycle—the ratio of the *on* time to the period of a waveform—is low, because the time constant of the input network may exceed the width of the input pulse. For the same reason, AC-coupling should not be used on variable duty-cycle signals.

Let's see what effect the input network can have on narrow pulses. The effects of the RC network (shown in Fig. 10) that we used are shown in Fig. 11. Trace *a* in Fig. 11 shows the input signal; trace *b* shows the output signal when S1 is closed—i.e., when the input is DC-coupled to the output. The remaining traces (*c–f*) show how

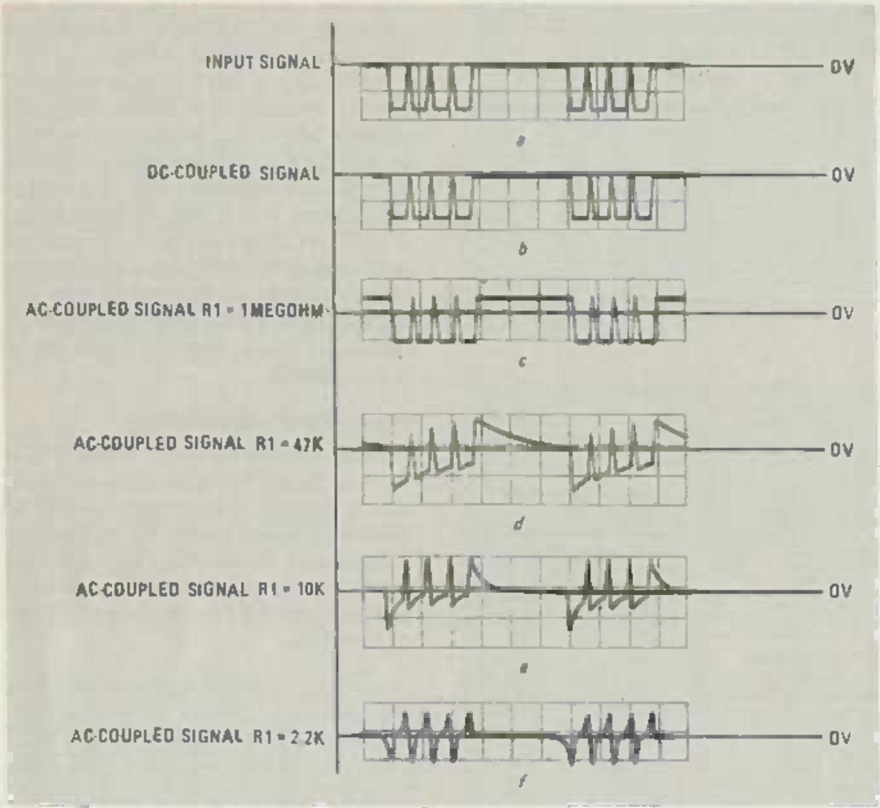


FIG. 11—THE INPUT SIGNAL to the network in Fig. 10 is shown at *a*. At *b* is shown the DC-coupled output, and at *c–f* are shown AC-coupled outputs with the value of R1 varying as indicated. The signal at *f* would cause drastic counting errors.

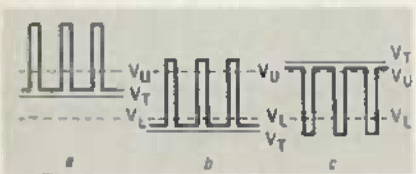


FIG. 12—TRIGGER LEVEL, if set improperly (*a*), can cause a pulse-train to pass undetected. Trigger level is set properly at *b*, a positive-going wave-train, and at *c*, a negative-going wave-train.

decreasing values of R1 affect the output signal. In trace *c* (where R1 has a value of one megohm), the voltage level of the signal has been shifted, but it retains its overall shape. As the value of R1 decreases, the signal becomes more and more distorted, until, as shown in trace *f*, (where R1 has a value of 2.2K), the circuit becomes a differentiating network, so erratic counting would result.

The attenuator is a voltage-dividing RC network that typically provides switch-selectable division by 1, 10, or 100. Variable attenuators are also commonly used. The attenuator is often followed by a limiting network which ensures that sensitive amplifier inputs are not overloaded. That could easily happen with a low-impedance, high-speed input signal like a glitch.

The input to the amplifier is generally high impedance (one megohm), but some frequency counters allow you to choose either high (one megohm) or low (50 ohms) input impedance. You can often get a sensitivity of 20 to 25 mV with a 50-ohm input. A sensitivity of one mV is possible, but noise may cause false triggering and erroneous counting.

Trigger level refers to the voltage at which the frequency counter will trigger—that is, deliver a pulse to the counting circuitry. If the trigger level is set too high, as shown in Fig. 12-*a*, the input signal well never fall below the lower hysteresis voltage, V_L, so no pulses will be counted. By lowering the trigger threshold, as shown in Fig. 12-*b*, the input signal traverses the complete hysteresis range, so each input pulse will be counted. The trigger level must be set correctly for negative input voltages too, as shown in Fig. 12-*c*.

The AGC circuit adjusts the sensitivity of the amplifier to accommodate inputs of different magnitudes. A tradeoff exists between the response of the AGC and the minimum frequency signal that can be counted, which is usually about 50 Hz with common AGC circuits. In addition, common AGC circuits are also limited in their ability to respond to high-frequency AM (*A*mplitude *M*odulated) signals. The reason is that the AGC circuit tends to respond to the peak voltage levels and ignore the valleys, and that can cause erroneous counting.

Now let's look at how circuits like those described have been implemented in a real-world frequency counter. The frequency-compensated input attenuator shown in Fig. 13 can reduce an input signal as high as 100 volts by a factor of ten, depending on the setting of switch S1. The network composed of R6, R7, C4, and C5 does the attenuating. The block labeled MARKER GENERATOR will be discussed later. But for now, let's find out how counting errors can arise in frequency counters, and how those errors can be reduced.

Error in frequency counters

The major sources of error in a frequency counter may be classified in four categories:

- The ± 1 count error
- The trigger error
- The systematic error
- The timebase error

The effects of those errors on various types of measurements are summarized in Table 1.

When a frequency counter makes a measurement, a *± 1 count* ambiguity exists in the LSD (*L*east *S*ignificant *D*igit). As with A/D converters, that error is called a *quantitizing error*. As shown in Fig. 14, depending on the precise instant the main gate opens and allows input signals to pass through to the counting circuits, a pulse may be missed. In the middle trace, the gate opens for time T_M, and one pulse passes. In the bottom trace, the gate also opens for time T_M, but it opens a little later, so a second pulse passes through.

The *trigger error* is caused by the random noise that accompanies an input signal. When measuring period, the input signals themselves control the opening and closing of the main input gate. Therefore noise can cause the hysteresis "window" to be crossed too soon (or too late), and that means the gate will stay open for an incorrect period of time.

The *systematic error* is caused by even the slightest mismatch between the risetimes or propagation delays of the start and stop channels. Mismatched probes and cable lengths can cause that type of error.

The *timebase error* is the greatest source of error in most frequency counters. The timebase is usually a quartz-crystal oscillator. Since the timebase oscillator controls the period of time the main gate is open, its importance in determining accuracy cannot be overstated. There are basically three types of crystal oscillator:

1. Room-temperature (RTXO)
2. Temperature-compensated (TCXO)
3. Oven-controlled (both switched- and proportional-oven types).

Oscillator type 1 simply ignores the effect of temperature; oscillator type 2 attempts to compensate for temperature drift by using components that drift in the direction opposite that of the crystal. The net effect is, hopefully, no drift with temperature.

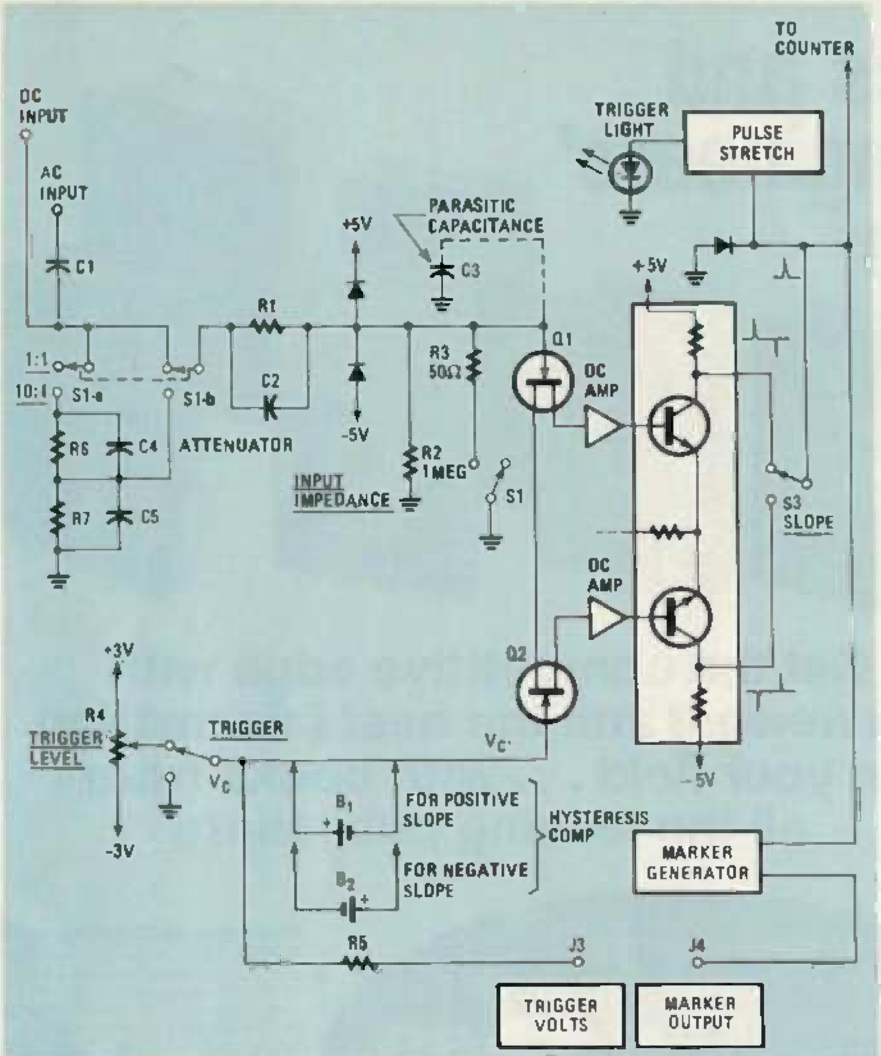


FIG. 13—INPUT-CONDITIONING CIRCUITRY serves to produce a clean digital output for the counting circuitry that follows.

TABLE 1—ERROR SUMMARY

Souce of errors	Frequency measurement	Period measurement	Time interval measurement	Remarks
± 1 Count	Yes	Yes	Yes	A Random error
± Time Base	Yes	Yes	Yes	
± Trigger	No	Yes	Yes	A Random error
± Systematic	No	No	Yes	

TABLE 2—CRYSTAL OSCILLATOR ERROR

	Room temperature crystal oscillators	Temperature compensated crystal oscillators	Simple switching oven oscillators	Proportional oven oscillators
Temperature (0°C – 50°C)	$<2.5\times10^{-6}$	$<5\times10^{-7}$	$<1\times10^{-7}$	$<7\times10^{-9}$
Line Voltage (10% change)	$<1\times10^{-7}$	$<5\times10^{-8}$	$<1\times10^{-8}$	$<1\times10^{-10}$
Aging	$<3\times10^{-7}$/mo	$<1\times10^{-7}$/mo	$<1\times10^{-7}$/mo	$<1.5\times10^{-8}$/mo or $<5\times10^{-10}$/day
Short Term (1 sec. avg.)	$<2\times10^{-9}$rms	$<1\times10^{-9}$rms	$<5\times10^{-10}$rms	$<1\times10^{-11}$rms

Oscillator type 3 doesn't attempt to compensate for variations in temperature; it attempts to control that temperature completely. It usually takes 24 hours after turn-on for an oven to attain its maximum specified accuracy, but an oven can usually attain an accuracy of 7 parts in 10^{-9} in 20 minutes. Precision frequency counters usually keep their ovens turned on constantly, whatever the state of the ON/OFF switch, so that maximum accuracy is always attainable at the instant that the instrument is turned on.

Besides temperature, there are three additional sources of error in a crystal oscillator: line-voltage variations, aging rate or long-term stability, and short-term stability.

The effect of line-voltage variation on crystal frequency is usually specified in terms of a 10% change in voltage. The effects of line-voltage variation can be minimized by careful power-supply design.

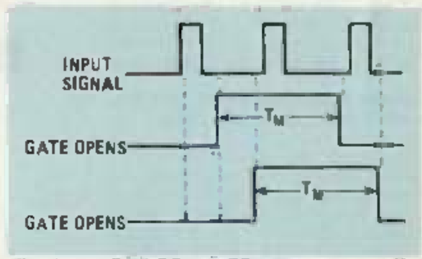


FIG. 14—A ONE-COUNT ERROR can occur if a frequency counter's main gate opens at the wrong time.

The physical properties of the crystal gradually change with time. That shift results in a cumulative frequency drift called aging. Aging is usually specified in terms of frequency change per month, since a factor like temperature would mask the small amount of aging that would occur in such a short period of time.

Short-term stability, also referred to as time-domain stability and fractional frequency deviation, results from noise (random frequency and phase fluctuations) generated in the crystal itself. The effect of each type of crystal-oscillator error is summarized in Table 2.

Now that we've discussed the basic theory of frequency counters, and sources of error therein, let's look at several interesting and unusual real-world applications for a frequency counter. In addition to basic frequency, time and counting measurements, you can use any frequency counter with adjustable START and STOP trigger-level controls to measure phase and risetime.

Unfortunately, that discussion will have to wait until next time as we've run out of space for this issue. At that time, we'll also look at some rather sophisticated counters and accessories, and how they are used. R-E

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Healing with Electronics

Although the concept is over a hundred years old, electrical stimulation of the body to promote healing has only recently been accepted. Here, we look at the techniques that are currently used, and some of the problems that had to be overcome to develop those techniques.

Dr. RAY FISH, PhD, MD

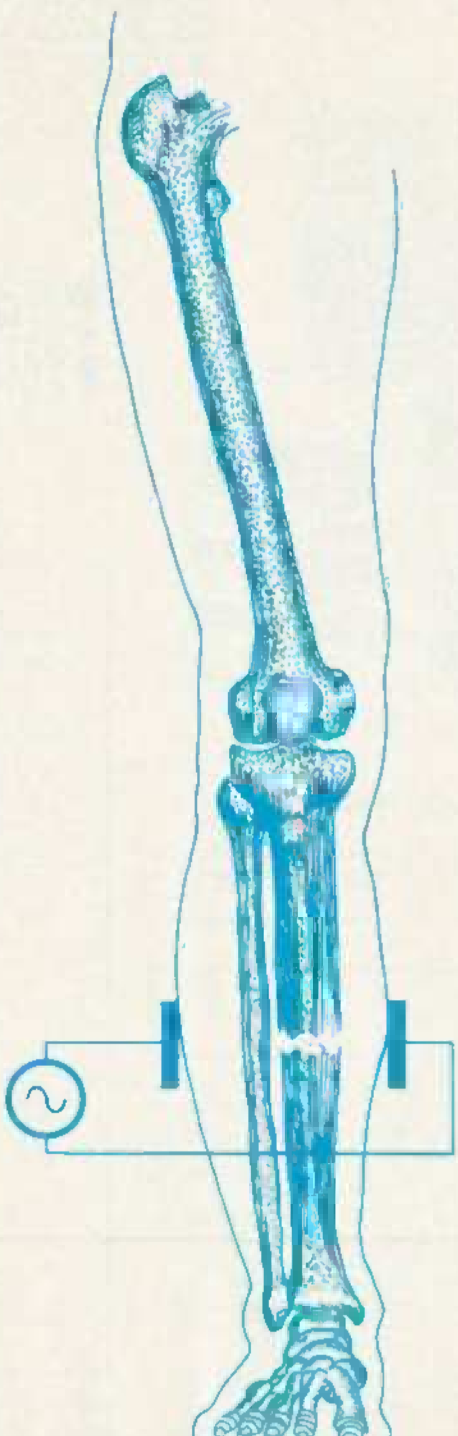
EACH YEAR, ABOUT THREE PERCENT OF the population of the United States suffers some type of bone break. In fact, that type of injury is the third leading cause of hospitalization in this country.

Normally, a broken bone heals. But in about 5% of the cases the bone either doesn't heal at all, or the healing process takes an abnormally long time. In recent years, those problem cases have been treated with electronics.

The idea of using electronics to promote healing is not new. In the 1840's, it was discovered that electric currents could sometimes cause healing in fractures that were not healing on their own. In more modern times the phenomenon came under closer scrutiny, and in 1979, the U.S. Food and Drug Administration (FDA) approved the use of weak-pulsed magnetic fields to promote healing.

Since then, weak-pulsed electromagnetic fields have been used to treat over 15,000 patients in this country alone. Although the patients selected for such treatment generally had fractures that failed to heal normally over a period of months or years, a success rate of 80% has been achieved with electronically stimulated healing.

In addition to causing a fractured bone, such as that shown in Fig. 1, to heal, electromagnetic fields may be helpful in stimulating the healing of skin ulcers and other defects in soft tissues. It is even felt by some people that electromagnetic fields may also prove to be useful in reducing the growth of cancers.



Electric fields and healing

Electric fields can interact with body tissues in a number of ways. One of those ways is heating. When the energy put into a tissue is greater than one-watt-per-kilogram of tissue, significant heating occurs.

There are several possible ways that heat-producing electric currents can promote healing. Thermal stimulation of blood vessels causes blood flow to increase because such stimulation dilates those vessels. It also makes it easier for nutrients in the blood to pass through blood-vessel walls to the tissues. Finally, it increases the metabolic rate of tissues.

Heating can also relax muscles, reducing muscle spasms and pain. Connective tissues may be softened by heat, allowing for less painful movement. For those reasons, deep heating usually plays an important part in the treatment of orthopedic injuries, such as injuries to joints, tendons, and muscles.

Heat can damage tumors because they sometimes have a marginal blood supply, which is overloaded when the metabolism is increased by local heating. Also, the uptake of toxins (chemotherapy drugs) can be increased by heating.

Healing fractures

Weak electric fields are sometimes used to stimulate bone healing. The applied fields try to imitate the distribution and magnitude of the electric fields that are naturally generated within bones. Bone is a piezoelectric material; voltages are produced when bone is stressed or bent. The growth and shaping of bones is controlled by the voltages caused when the bones are loaded. With exercise, bones generate electric fields; the strength of those fields is usually a few millivolts-per-centimeter.

The fields are part of a natural feedback system that changes the shape of bones as they grow and repair themselves after injury. Naturally, bone grows in such a way as to reduce mechanical stress on the bone. When compressive forces are applied to bone, a negative potential results, leading to bone growth; when tension is applied to bone, a positive potential results, leading to absorption of bone. Also, bone grows in such a way that the shape is one that can handle the load placed upon it with the least strain.

Although many other factors contribute to bone growth and shaping, there is no doubt that weight bearing strengthens bones. Decreased weight bearing causes loss of bone mass. In extreme cases, such as when astronauts do not exercise in space, the loss of calcium from bones can be significant.

A bone injury alters the natural electrical fields. That is, the field strength at such sites increases markedly. Although researchers are not certain of the mechanisms involved, one theory is that the increased field strength attracts certain types of "healing" cells.

If healing is not proceeding satisfactorily, or has stopped, it is possible to assist the natural process by applying an

FIG. 1—THE BONE THAT most often fails to heal is the tibia, the large bone between the knee and ankle. Here are two x-rays of the same leg taken at different angles to show more detail. The smaller bone next to the tibia, the fibula, is also broken. The knee and ankle joints are just out of the picture.

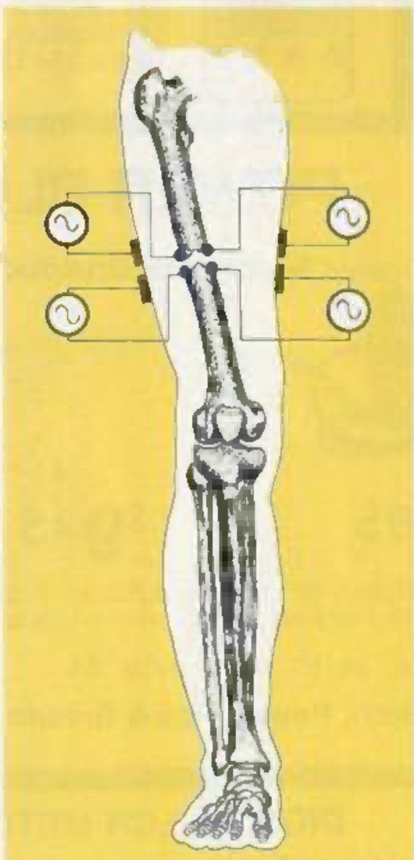


FIG. 2—HERE, THE NEGATIVE ELECTRODES are implanted directly on the bone. The positive electrodes are located on pads on the surface of the skin.

electrical field to the injury. Such non-healing can be caused by several factors. A fracture may not heal if its ends are too far apart (half the diameter of the bone) or if certain types of tissues have grown between the fracture fragments. The latter causes a "false joint" (in medical terms, a synovial pseudarthrosis) to form.

A field can be applied to the injury site in several ways. One of those is direct application. In that method, shown in Fig. 2, electrodes are implanted directly in the bone. With implanted electrodes, bone formation (osteogenesis) is stimulated at the negative electrode (cathode). Bone-cell death (necrosis) often occurs at an implanted anode. Thus, the cathode is implanted in the bone while the anode is placed on or implanted in the skin.

A variety of different electrode materials have been tried. The most common are stainless steel and titanium, but platinum alloys and silver/silver-chloride electrodes also have been used. The voltage used to drive the electrodes can be DC, pulsed DC, symmetric AC, or asymmetric AC (usually under 3 kHz).

In the case of large, weight-bearing bones, it is not uncommon to use four electrodes, each carrying up to 20 microamperes to the fracture site.

One thing that must be guarded against is the possibility of wires coming loose. To prevent that from happening, the fracture site is covered by a cast. To aid in mobility, the power supply may be made part of that cast.

It is of course possible to deliver a current to the fracture site without physically locating electrodes there. One such method is induction. In the method shown in Fig. 3, pulsed magnetic fields are generated by a pair of coils that are placed so that they share a common axis, which passes through the fracture site. An AC voltage of 10 to 100 is applied to the coils, which in turn sets up a time-varying magnetic field at the fracture site. The magnitude of the magnetic field is between 0.1 and 20 gauss. Experiments have shown that such magnetic fields induce current densities of 1 to 20 microamperes-per-centimeter. The corresponding peak voltage density is about one millivolt-per-centimeter. To aid healing, the magnetic field is applied continuously for 10 or more hours a day, over a period of several months.

Finally, a current can be induced via capacitive coupling. As shown in Fig. 4, the electrodes are placed on the skin on opposite sides of the fracture site. Potentials of 1 to 10 volts at 20 to 200 kHz are then applied to the electrodes.

Another application of electric fields in healing is in the treatment of skin ulcers. Those ulcers are caused by poor circulation, leading to the loss of skin and most commonly occur on the leg. To treat such ulcers, currents of 200 to 1,000 microamperes have been used. In one study, a negative electrode made of a copper mesh embedded in saline-soaked gauze was first placed on the wound for about a week to inhibit infection. Then a positive electrode was applied to stimulate growth.

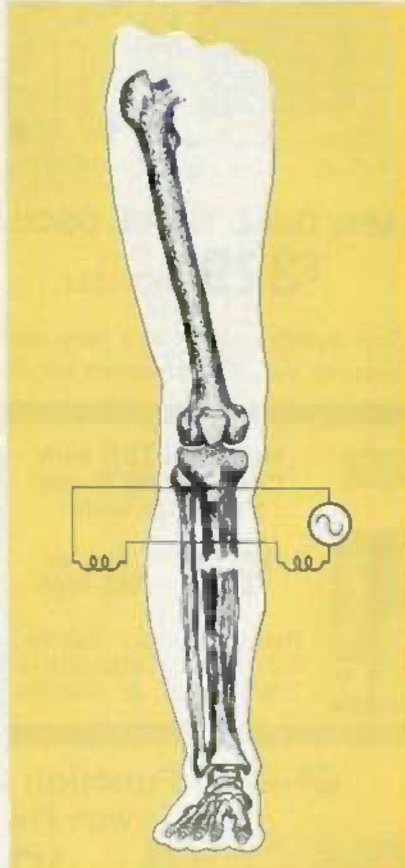


FIG. 3—CURRENT CAN BE DELIVERED to the fracture site via induction. Here, the two coils share a common axis, and that axis passes through the fracture site.

Although the use of electrical stimulation to promote healing seems promising, there are a number of complications that can arise when such stimulation is carried out for prolonged periods of time.

Medical-electronics research

The clinical success of bringing fracture healing to thousands of people with otherwise hopeless cases leaves no doubt that electronically-assisted bone healing works. However, finding the right current levels, electrode placements, and other parameters was not easy.

Proving the value of a treatment method does not usually come easily because one does not try unproven methods on large numbers of subjects. If tried on small numbers of subjects at first, something often goes wrong, making the method look worthless. In general, years of initial research are done on animals to define the types of conditions (e.g. fracture types) that might respond to treatment, the treatment methods that might work, and the safety of the methods. It did take well over 100 years for electrically stimulated frac-

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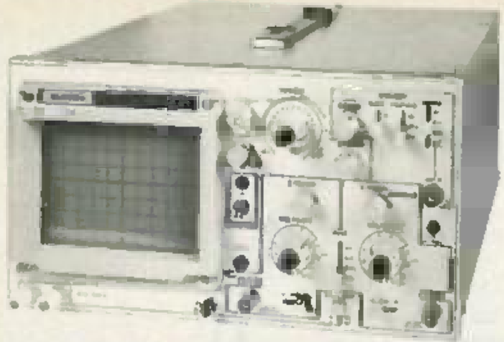

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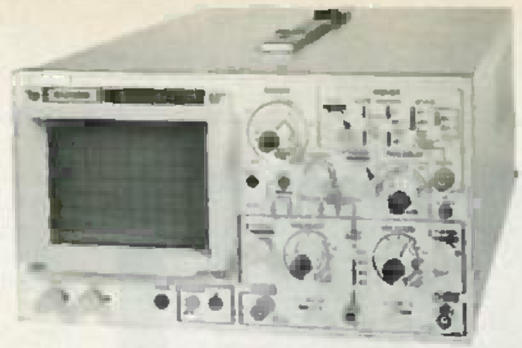

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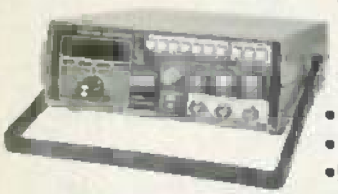

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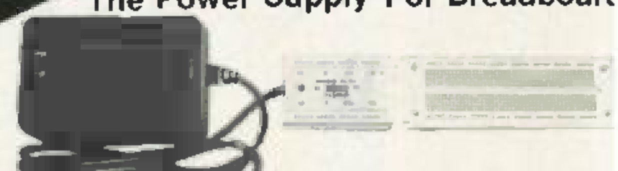

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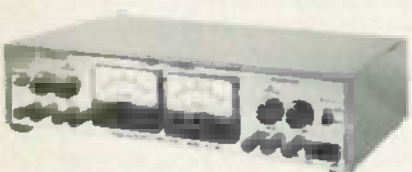

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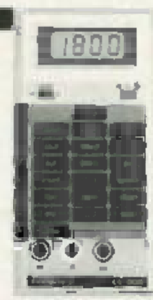

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ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Mystery computer revealed

LAST MONTH WE DISCUSSED SOME OF the requirements of a portable robot controller. We found that a CMOS microprocessor, plenty of RAM, and a flexible I/O structure were among the most important of those requirements. I also dropped a few hints about a super controller that meets those requirements and that needs only four AA cells to operate. This month I'll let the cat out of the bag—it's Radio Shack's *Model 100*. Before I talk more about it, let's examine some alternatives.

The portable-computer market is filled with battery-operated machines. Some are IBM-compatible, and some aren't. Prices for today's portables split into two corresponding ranges. The IBM-compatibles generally go for about $2000, while the non-compatibles go for about $1000, or less, and sometimes much less. A robot needs a good processor, good I/O (*I*nput/*O*utput), and a flexible control language that's easy to learn and apply; but that doesn't necessarily mean it needs to be IBM-compatible.

So, in my opinion, Radio Shack's *Model 100* is the computer to use for robot control, especially since prices for both models (8K and 24K RAM) have been dropping almost monthly.

The *Model 100* was the first laptop computer to hit the scene, and it was truly revolutionary. NEC and Olivetti followed with machines that were based on the same design; and, if you shop around, you can pick up either an NEC or an Olivetti for about $200.

The *Model 100* has an 80C85 microprocessor, parallel and serial interfaces, provision for a bar-code reader, and RAM that can be expanded on-board to as much as 32K. Third-party vendors even sell add-ons that allow as much as ½-megabyte of (bubble) memory! If those features sound familiar, it's because they perfectly match the requirements we've been discussing the past couple of months.

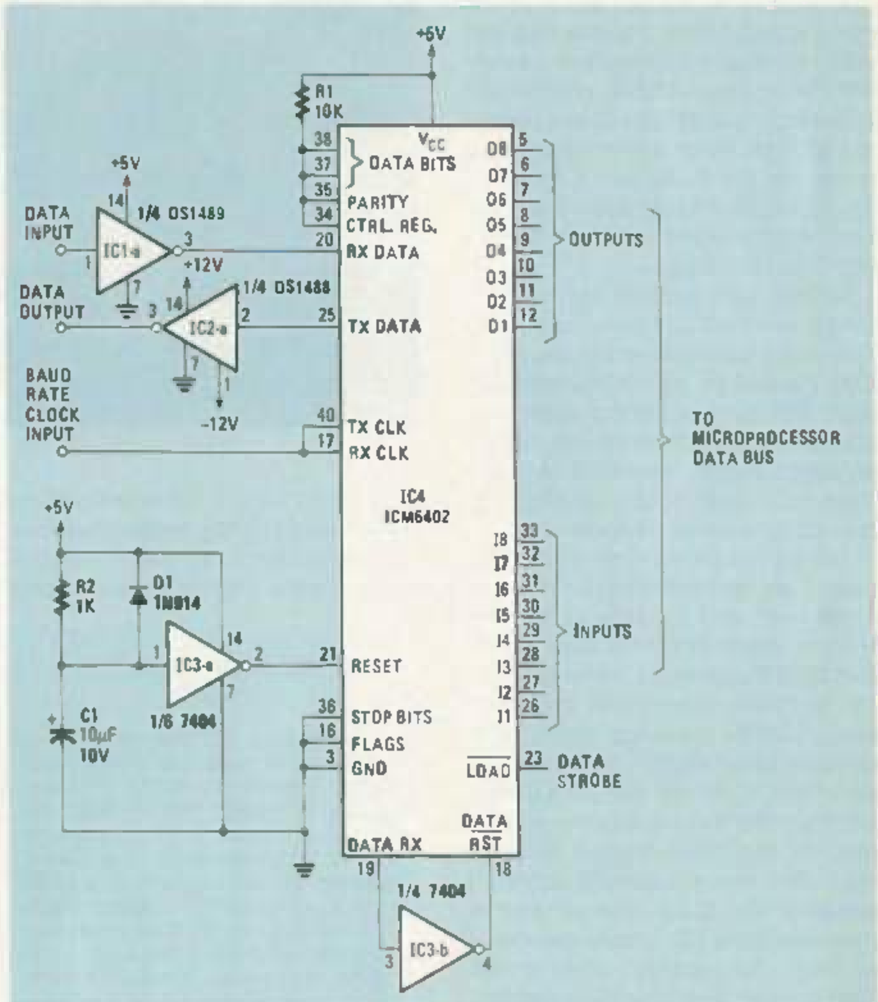

FIG. 1

A serial connection

How do you interface a computer to a robot? You can use the parallel interface, the RS-232 interface—or both, if necessary. What do you do if you have no serial interface? The circuit shown in Fig. 1 could be used with just about any computer with an 8-bit data bus.

continued on page 104

SATELLITE TV

BOB COOPER, JR.
SATELLITE-TV EDITOR

The "Kate" test

LAST MONTH WE TALKED ABOUT WHAT can happen when a storm like last fall's Hurricane Kate strikes a satellite-TV antenna. I have experience with such disasters because I operate an extensive antenna-testing range on the Turks and Caicos Islands, located some 650 miles east southeast of Miami in the extreme northern Caribbean.

Before Kate passed by our test range, we had 25 operational and 15 non-operational antennas. After Kate passed by, only two antennas from the former group were still standing and operational. Some required minor repairs, but more than half were totally destroyed, including several 20-footers.

In our consumer-antenna range, we had antennas as small as eight feet, and as large as sixteen feet in diameter. Not one solid-metal dish antenna survived the storm totally unscathed, and only one could be repaired. Mesh-type designs fared slightly better. Most antennas suffered mount failure, whether the mount was the single-post or the three-legged (tripod) type. The mounts simply couldn't support the loads the antennas presented the 100+ mile-per-hour winds. Typically, the wind damaged or destroyed the mount, the antenna broke free, and the wind slammed the antenna into the ground and other nearby objects.

No solid fiberglass antenna survived, either. Again, the mounts bent and collapsed because they simply couldn't handle the winds. Five-inch steel pipes that supported twelve-foot fiberglass dishes simply bent under the stress. Smaller pipes split open and shattered into strips. Concrete-filled pipes fared slightly better, but they still split open as the antennas twisted back and forth and ripped the pipes into bent-spaghetti shapes.

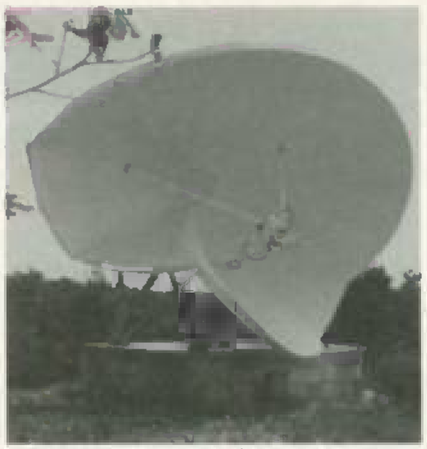

FIG. 1

Of the 40 antennas under our direct care, those that survived with either minor damage or no damage at all were of special interest. As we reported last month, the two that survived unscathed were both Paraclipse horizon-to-horizon driven antennas. Eight other antennas survived with relatively minor damage: broken ribs, broken drives, feed supports that snapped loose. One of those was an eleven-foot Harris Delta Gain antenna, known for its very-heavy-duty construction. The other seven were all mesh antennas. What follows is a breakdown of what happened, by manufacturer.

1. Conifer's twelve-foot screen-mesh is supplied by the manufacturer with the mesh already attached to the panel sections. Three antennas were involved in the Kate Test and all had relatively minor damage. The damage sustained was typically related to the motor-drive units (which are separate from the antennas proper), although one antenna was significantly damaged when a chunk of a nearby house plowed into (and through) about one third of the screen mesh surface. Obviously, we can't blame Conifer for that.

2. Ranger's eleven-foot screen-mesh dish (of relatively light-weight construction, by the way) broke loose from its pipe mount and free-wheeled in the winds. Damage was confined to the support structure and amounted to about 25% of the antenna's original cost.

3. Uniden's 10.5-foot screen-mesh antenna with slide-in pan-

TVRO dealer "Starter Kit" available

Bob Cooper's *CSD Magazine* has arranged with a number of TVRO equipment suppliers to provide a single-package of material that will help introduce you to the world of TVRO dealership. A short booklet written by Bob Cooper describes the start-up pitfalls to be avoided by any would-be TVRO dealer. In addition, product data and pricing sheets from prominent suppliers in the field are included. That package of material is free of charge and is supplied to firms or individuals in the electronics service business as an introduction to the 1984/85 world of selling TVRO systems retail.

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els: We had three of those antennas, and, to our surprise, none lost their panels. Before the Kate Test, we suspected that, when slide-in panels were beaten by strong winds, the panels would pop out, and that, though the user might lose panels, the dish's super-structure would remain intact. The feeds on those antennas were damaged where the feed inserts into a sleeve at the hub of the dish. Damage amounted to about 20% of the original cost.

4. Hero's thirteen-foot screen-mesh antennas bent their five-inch steel pipe mounts, but only after the mesh had been stripped from the surface of the dish by the wind. The screen mesh is fastened to the ribs of the those older-style antennas with metal screws. The wind simply yanked the screen mesh off the ribs by decapitating the screws. Both antennas were un-salvageable, so we cannot recommend any antenna whose mesh is fastened with screws.

5. ECI's eleven-foot screen-mesh antenna with slide-in panels: The surface made it through the storm but the mount bent over and pointed the antenna toward the ground. Steel plates attaching the dish-mount to the pipe-support bent badly and allowed the antenna to flip over and yank the motor drive out of its socket. The repairs were all mechanical, and the antenna probably would have survived had the steel in the mount been stronger and the pipe support larger—a 6-inch-thick wall, for instance.

6. AMD's eleven- and thirteen-foot all-aluminum solid-surface antennas: The mounts gave away, so the antennas free-wheeled and beat themselves into crumpled piles of useless junk.

7. We had ten of Paraclipse's nine- and twelve-foot screen-mesh antennas, only one of which was a total loss. That one was a very early design without something called a "hurricane strap," a safety cable designed to keep the antenna from whipping in the wind should the motor-drive breaking system fail. In our case, the motor-drive failed, and, since there was no hurricane strap, the antenna free-wheeled and beat itself to death, spraying parts over an area several hundred yards wide. The other nine Paraclipse antennas suffered minor panel or support-strut damage, and repairs typically amounted to about 10–15% of the original cost.

8. Three screen-mesh Aristocom antennas suffered rib and mesh-surface failures, but their mounts held. Repairs amounted to about 20% of original cost.

Failure trends

There were trends in the way those antennas failed that may escape casual reading. Virtually all mesh-antenna failures resulted from mount failures. When a mount fails, the antenna's dish area acts as a sail, and the wind drives that sail until something stops its forward motion. When that happens, the antenna disintegrates. But when the mounts do not give way, the antenna usually survives with minor damage.

The solid surface (metal or fiberglass) antennas had similar

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causes of failure: The mounts failed to hold the antenna upright, and once the mount bent or gave way, the antenna self-destructed.

Very large antennas (sixteen feet and greater) suffered extreme structural damage when their circumference rings collapsed and the dishes folded up like clams—see Fig. 1 for an example. Smaller dishes didn't "clam-shell" but their mounts did give way. Very small dishes (for our part of the world), in the eight- to nine-foot range, generally survived because their mounts were designed for eleven- and twelve-foot units.

The place where the linear-actuator drive attaches to the dish was the most common point of failure. Typically, a rotating ball-joint attachment connects the antenna end of the actuator arm to the dish's surface through a bracket attached to a strut. Those brackets failed on perhaps one-third of our antennas, and left them unsupported and at the mercy of the hurricane-force winds. **R-E**

MEDICAL ELECTRONICS

continued from page 79

ture healing to come into use after it was discovered.

Many types of electronic devices will be implanted in people in future years. There are already pacemakers, drug and hormone infusion pumps, arm and leg muscle stimulators, artificial hearts, heart-assist devices, defibrillators, brain-stimulation devices, and artificial ears. And more devices will be developed in the future, but electronics engineers will encounter many challenging problems before those new devices become successful and accepted.

One problem is that electronic devices must be shown to be safe and effective before being tried on people. Thus, almost all medical-electronics devices are tested on animals first. For instance, animal testing of artificial hearts was conducted for over a decade before approval was gained for a test on a human subject.

Another problem is that the course of a disease or injury can be greatly different in different people. One reason is that each patient is different. Each differs in his physical conditioning, ability to tolerate pain, adaptability to change, and motivation. Further, each injury or illness is unique. Each fracture is at least a little different from any other; each heart is

continued on page 94

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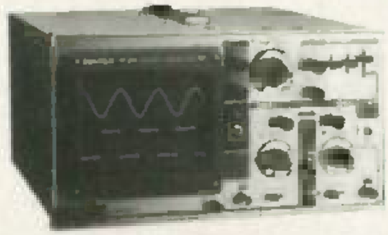

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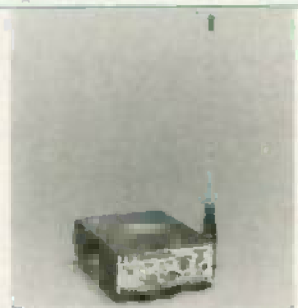

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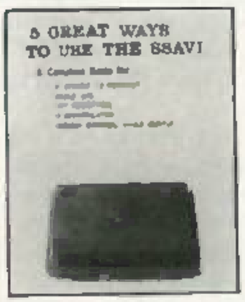

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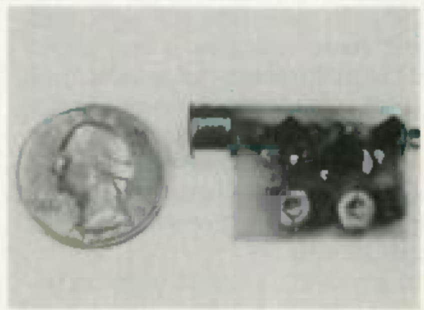

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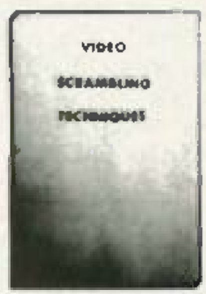

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SERVICE CLINIC

JACK DARR,
SERVICE EDITOR

Hot resistors and shorted capacitors

OFTEN YOU RUN ACROSS A TV SET WITH one or more high-wattage *bleeder* resistors. We're not talking about the resistors that are used to discharge electrolytic capacitors when power is removed from a set, but those that are used to stabilize the power supply. They turn up mostly in tube-type TV sets, and their basic function is to "bleed off" a small amount of current, and thereby make the power supply less susceptible to variations in load current. Bleeder resistors usually run pretty hot—and sometimes they even do what they're supposed to do!

If you find a set with incorrect—or no—B+, the first thing you should check is the bleeder string, as shown in Fig. 1. One tool that is useful in checking high-wattage resistors is the WCFT (the *Well-Calibrated FingerTip*). Just be careful; some resistors are supposed to run hot, and one could easily blister your WCFT! So bring it close, but don't touch. If you can feel some heat, but not too much, the resistor is probably OK. If the resistor is cold, it—or another in the bleeder string—may be open.

If it's too hot, you've got a short somewhere that's allowing too much current to flow through the bleeder string. That sort of short is often, but not always, caused by a bypass capacitor. Bypass capacitors in older sets are often made of paper, and they usually have values of about 0.25 or 0.5 µF. They're much more likely than today's plastic capacitors to become leaky, shorted, or open. You may have several bypass capacitors to check, because every resistor in a bleeder string may be bypassed individually.

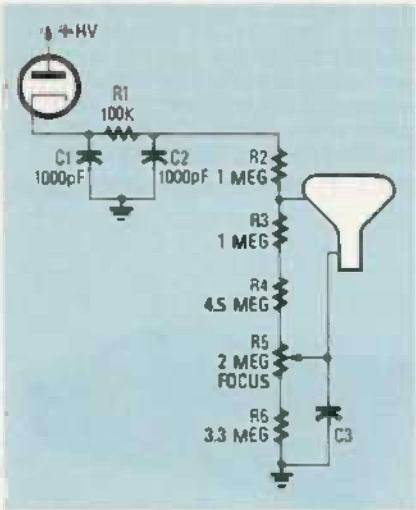

FIG. 1

When you find a leaky capacitor, replace it, and then check the rest of the capacitors in your circuit. You may find a marginally-functional capacitor that will fail soon—according to Murphy, as soon as you return the set to the customer! In general, a good paper capacitor will have resistance well over 50K; if you find one with a resistance of 50K or so, replace it on general principles.

Particularly watch out for the type of paper capacitor that has been rolled from a thick sheaf of paper, and that has the case folded over on the ends. That type is especially prone to leakage, and you can usually rely on one to fail once the set has been taken home! If, while servicing an older set, you see any rolled-paper capacitors, it's a good idea to replace them with modern capacitors. (As we used to say in the Air Force, CYA.)

We seldom have trouble with early "molded" capacitors or mica capacitors (of the original "sandwich" type). They seldom, if ever, develop opens, because of their construction.

Oscillator problems

If a capacitor in an oscillator circuit develops an open, you'll get no feedback, and the oscillator won't work. So, if you find a set with a dead horizontal or vertical oscillator, look for an open capacitor.

A TV set that uses a switching power supply may appear to be totally dead because of a bad capacitor. If the switching circuit doesn't oscillate, there will be no output voltage at all.

A TV set with bad convergence may also be suffering from an open capacitor; that will prevent the convergence pulses from getting to the proper places, so the picture won't converge. To find the source of the trouble, just trace the pulses through the circuit until you find where they stop.

In short (no pun intended), start by troubleshooting the most logical component. If you find a resistor that looks burnt, or that runs very hot, that's an almost-sure sign that somewhere on its "load" side there is a shorted or leaky capacitor. Usually the fastest way of finding the problem is by making resistance checks with an ohmmeter. And remember to discharge any capacitor with a value greater than about 0.1 µF before trying to measure its resistance. Otherwise you may have to troubleshoot your ohmmeter!

If you find an open capacitor don't just replace it and turn the set on; measure the resistance of the circuit to ground. That resistance should always be high (50K

or more) if the circuit has no shorts. If you measure less than that, find out why before turning the TV set on. Just follow logic and common sense; you'll find the problem! R-E

SERVICE QUESTIONS

SONY STATIC CONVERGENCE

I had trouble with a Sony KX-2501 monitor. I fixed some intermittent "flagging" at the top of the screen by setting the horizontal hold. However, the horizontal static-convergence drifted badly. I checked DC voltages; they looked OK. Incidentally, the emitters of Q1502 and Q1503 should be at 147.7 volts, not 48.7 volts, as shown on some copies of the schematic.

So I finally gave up and ordered a new horizontal-voltage regulator control (for $45!). When it came about three weeks later, I installed it, and lo and behold: perfect convergence. The adjustments were easy to make. My dealer told me that he had ordered several of those controls lately. I wonder why they fail like that—moisture? So, just for luck, I ran a bead of silicone around the shaft, hopefully sealing out dust and moisture. If future adjustments are needed, the silicone can be peeled off easily.—M. D. Chepko, M.D., Raleigh, NC.

Thanks for the useful hint, doc!

WHAT KIND OF SCOPE FOR TV?

I want to buy an oscilloscope for TV servicing. What's the best kind to get for that purpose?—M. R., Lutherville, MD.

I've always said that it's easy to pick out a wife, a suit of clothes, etc., but you've got to be careful in choosing test equipment. Seriously, there are a lot of good scopes available. Heathkit, B & K, Hickok, Tektronix, and many others all make scopes, and you can't go too far wrong with any of them. I've got six of various makes, and they're all good. My suggestion would be to try the Old Professor's *Famous Test for Whisky:* Pour some in a glass and drink it! In other words, arrange for a demonstration in your shop and try different several models. R-E

LETTERS

continued from page 25

sitizers of positive and negative types, some with dyes to aid the user. However plentiful all those goodies are in New York, here in the hick city of Tulsa I found one spray can of GC positive sensitizer at the oldest electronics supply house in town and one bottle of developer for it at another supply house. I couldn't make them work, though I could get a faint image. I think one or both items had spent too many years on a shelf. I wrote to GC and they sent me a very nice handbook, but I had no idea where to order the materials then or now. Electronics supply houses are somewhat less than eager to special order $10 items—especially if you don't know for sure what you want.

So I followed the advice you magazine people like to give—write to your advertisers—and came up with Datak ER-71 *negative* photo resist and ER-8 developer. Those products are very easy to use and appear to be a quality system, but my results have been spotty. I do single-side boards quite well, but have trouble with the resist standing up long enough on double-sided boards. I would like to try some of those potions that Grossblatt described, but still don't know where to get them. Some advertisers occasionally show materials, kits, and sensitized boards, but describe them so poorly, incompletely, and often erroneously that one must essentially buy blind. What I am getting at is that, although you obviously avoid mentioning brand names and such, you would be doing the neophyte board maker a beautiful service if you would list what's available, how it works, and where to get it.

As for my trying your method, I cannot try it with my Datak ER-71 because the ER-71 requires a negative mask.

While not precisely on the subject of exposing boards through a sheet of paper, I would like to briefly describe a method of board layout which way be of interest to you.

Ferric chloride is a convenient etchant to use because it can be purchased at Radio Shack stores, where it presently costs $2.50 a pint. I discovered the hard way that when it gets tired it suddenly stops etching, obviously due to absorbing all the copper it can accommodate. Just as obviously, boards with a few copper traces and large bare areas not only deplete the etchant rapidly, but tend to over-etch delicate areas while the etchant works on the large spaces. So, to make the etching quicker and more uniform, and to save etchant, I changed my board design to where, instead of running narrow copper connecting lines, I reversed the system and run etched lines to separate connected areas. The result is exactly as desired: boards etch quickly and uniformly and a minimum amount of copper is removed. I don't consider board layout any more difficult than the conventional way, though it does require getting one's mind working in the right direction.

H.C. DOENNECKE
Tulsa, OK

SERVICING B.I.C TURNTABLES

I have gotten many inquiries from owners of B.I.C. turntables, and other B.I.C. audio equipment going back as far as the Garrard days. Those owners say that they are having a difficult time locating service and parts, and they have heard that B.I.C. has gone out of business. That distresses me because B.I.C. always supported its products with a strong service organization.

The good news is that a company called "South Street Service" has taken over all the service and parts for B.I.C. equipment. I have spoken to the owner, Alan Ruthkowksi (former national service manager at B.I.C.), and he confirms that virtually all parts are still available through his company. In fact, they have re-manufactured many parts that previously were not available, such as grilles for speakers, turntable motors, head swells, etc.

The address of the South Street Service Company is 202 South Street, Oyster Bay, NY 11771.

ARTHUR M. GASMAN
Port Washington, NY R-E

ANTIQUE RADIOS

RICHARD D. FITCH

Back to the present

WE'VE SPENT THE LAST COUPLE OF months looking at the overall history of the radio arts and sciences. Let's return now to the present—the 20th century. First we'll look at the Antique of the Month, then we'll go on to discuss the WW1 era and the 1920's.

A classic collectable

The Stewart Warner radio shown in Fig. 1 (serial number A399897) is interesting in that it has a molded, simulated wood-veneer cabinet. It also has seven pushbuttons, one of which can be used to tune in a police-band station. Although the radio doesn't really qualify as an antique, its classic appearance would make it a valuable member of any collection. The Stewart Warner belongs to Kerry Swanson of Ellensburg, Washington. I'd like to thank him for the fine photo.

FIG. 1

WW1 and beyond

World War One was no exception to the rule that, during every national conflict, there is a surge of technical and economic progress. The slow but steady advancement of radio came to a standstill around 1915, at least as far as the civilian was concerned. For the next three years all research was directed toward the war effort. I hope to discuss, in a future column, some WW1 communications equipment for those of you who collect it. But for now, let's stick to civilian gear.

By the end of WW1, development of civilian gear again began to roll. In fact, it began to develop so fast that it was running over itself. By that time numerous broadcasts could be picked up by anyone with a working receiver. There were many receivers around, and most of them were home-made. The time was ripe for the appearance of regularly scheduled broadcasts.

All antique-radio buffs are familiar with the Westinghouse Station in Pittsburgh, KDKA. That station actually made the first pre-scheduled radio broadcast: the results of the Harding/Cox presidential election of November 1920. Although there were probably fewer than 1000 listeners, regularly scheduled broadcasting had gotten its start.

The apparatus used to receive radio waves in the early 1920's was usually housed in a square box with a hinged lid on top. Or it might simply have been mounted on a breadboard—and I don't mean one of those plastic jobs with a matrix of socket holes, but a real chunk of wood that bread was cut on! Receivers in that era were mostly powered by batteries, and we listened to those radios with earphones. Later those battery-powered receivers were often adapted to operate from the AC lines and with a loudspeaker.

Receivers, radios, sets

For the many readers who are sexagenarians (those who are sixty years old, or older), the use of the terms receiver, radio, and set should be familiar. In that era, the receiving unit itself was never referred to as a *radio*. If the word radio was used at all it encompassed the entire wireless operation—transmitter, receiver, and everything in between.

A popular dictionary from 1924 doesn't even mention the word radio. Reference books as far back as 1910 also make no mention of the word radio. I don't know just when the ornate cabinet in the parlor became a *radio*; maybe one of you oldtimers can enlighten us about the origin of the term.

Portables

Radio had become so popular that people wanted to hear broadcast radio everywhere: at home, at camp, in boats, in automobiles, and even on vacation. The sets were still most often battery-powered, so both manufactured and homemade portables were in great demand.

Some manufacturers recognized the need for true portable receivers. Radiola offered a completely self-contained portable in a long, skinny box that resembled a suitcase. There were compartments in the ends for batteries and phones. That Radiola "portable" weighed a ton, and it had a totally inadequate handle on top for carrying it about. In spite of its limitations, though, the Radiola was

VOL. 3 NO. 4 April 1986

COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

PACKET RADIO
What Cellular Did For The Telephone...

A GERNSBACK PUBLICATION

COMPUTER CARE
Preventive Maintenance Extends Computer Life

GRAFEX-32
Part 3, The Conclusion

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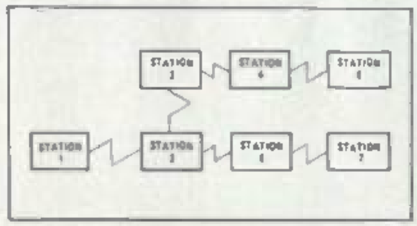

See Page 10

ON THE COVER

Sitting atop that beautiful Heath computer terminal, is their brand-new HD-4040 Packet Radio Adapter. For more detailed information, turn to page 10.

COMING NEXT MONTH

We're going to show you how to use a TI-99/4A keyboard with your Sinclair ZX-81, and we'll have an excellent program that lets you use your computer to select power supply components. To round things off, look for an article on power control with your Commodore-64 that lets you "automate" your home!

EDITORIAL

Wonderful idea #1275

I've had another wonderful idea that I want to share with you, in the hope that it will be brought to the attention of some of the manufacturers in the computer business. I'm in the process of setting up a new computer system. It isn't an especially large or complex system, and should ordinarily pose no problems.

But this computer comes with—not one, but *two* large loose-leaf tomes. In order to get up-and-running, you've got to read both of these books which seem to have been written by engineers. Now engineers, as we all know, write to *impress*, not to *express*. The writing is confused and convoluted, hard to follow, full of digressions and fishbacks, and the books are laden with charts and diagrams, rife with "If..." "However..." "Refer to..."

The result is total frustration, utter confusion and complete disgust.

Oh, you can fight your way through the books if you have sufficient patience and a friend who knows a little more than you do. But Wonderful idea #1275 is going to solve the problem once and for all.

Each manufacturer should hire a *writer* to write his instruction books. I realize that this is an unheard-of concept, and one that no manufacturer thinks is viable. After all, a writer is liable to make sense out of the instructions. With an easy-to-understand book, the user might even wind up knowing what in heck he's doing. Surely, we wouldn't want *that* to happen!

Of course, this might lead to fewer service calls, saving the manufacturer a lot of money, but that is not important in the overall scheme of things. Then too, the engineers who now write these semi-literate instructions might get their noses out of joint.

So what is really needed, is an *additional* instruction book which will serve to translate the existing instruction books into more-readable (and understandable) prose.

Now take the books I'm currently fighting my way through. One volume deals with the hardware, the other with operating instructions. You can get just so far with the operations, when you learn that you've got a DIP switch set incorrectly. To *locate* that switch, you've got to put this manual down and pick up the *other*. The instructions for setting that switch are no easier to understand than the rest of the manual, with diagrams that just don't help. Now I'm not stupid. And I'm supposed to be computer-literate. But I keep thinking of the poor boob that has less knowledge than I do, and wonder how he's going to make out!

C'mon Wonderful idea #1275!

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

Help!

I'd be happy to pay any costs for a service or theory manual for the Timex-Sinclair ZX81. I'm a beginner in the electronics field and any help would be appreciated. Write to Juan Bonilla, 42 Baldorioty St., Sabena Grande, PR 00747.

We don't usually print addresses Juan, but this seemed to be the best and fastest way to get aid to you.

Penance!

Yours is the only large-circulation magazine that has ever carried serious coverage of the Timex/ Sinclair 1000. In a recent issue you told a reader that support for this wonderful machine had died. Tain't true! There are a lot of firms providing support to these units, and a lot of people still using them. Thanks for the best electronics magazine around. Keep up the (almost always) good work!—B. C. T., Tucson, AZ.

Thank you sir. Humble pie can be delicious. We got lots of letters just like yours, so here's what we're going to do: Any firms out there that provide service, parts, literature, software, whatever for the TS/1000 and ZX-81, please write to the Editor. We'll compile a complete listing (on our own time, boss) and make the list available to all our readers at no charge. Are we friends again?

Noisy Printer

How can I reduce the noise level from my printer? It's working properly, but it does seem awfully loud.—S. K., Abilene, TX.

Start by placing a sound-absorbing pad under it. Often, the surface on which a printer is placed acts like a reverberator and amplifies the sound. If that doesn't help sufficiently, try using a soundproof housing over the printer for air-transmitted noise.

Computer Chess?

Has anybody worked out a program that will enable me to play chess using a computer and a modem? I'm certain that a lot of people who are involved in both chess and computers would be interested.—R. C., Denver, CO.

Sounds fascinating. Can anybody help?

New Software

I've developed an interesting new software package that just about every computer user will want. What's the best way to market such a product?—L. W., St. Louis, MO.

Begin by writing to our advertising sales department who will be happy to send you a media file and rate card!

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

SPEECH SYNTHESIZER, the *Voice Master*, a hardware/softwear system for mircocomputers that provides speech and music synthesis as well as voice-recognition capabilities, can use almost any spoken language for its operation. Unlike other speech devices for microcomputers, the *Voice Master* does not depend on a speech chip to create its vocabulary. The user digitally records his or her own voice to provide the vocabularies of up to 64 words or phrases for the unit. Those recorded vocabularies are then played back to reproduce the words or phrases as directed by the user in high-quality sound that closely resembles a tape recording of the user's voice and can record in any language.

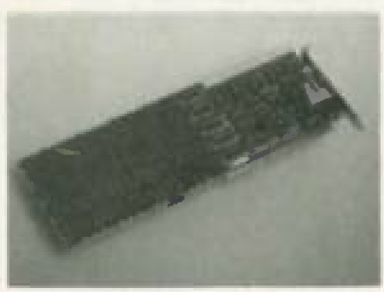
The *Voice Master* is also capable of highly-accurate *voice recognition* and can recognize and store vocabularies of up to 32 words or phrases each on floppy disk. Vocabularies for both

CIRCLE 11 ON FREE INFORMATION CARD

speech and recognition may be instantly called and loaded from disk.

The *Voice Master* is available in models for the Commodore 64/128, Apple II series, and Atari computers for a suggested retail price of $89.95, which includes the *Voice Master* module, program disk, headset/ microphone, connecting cables, and a comprehensive documentation booklet.—**Covox, Inc.,** 675-D Conger Street, Eugene, OR 97402.

ADD-ON MEMORY BOARD, the *Cheetah Card*™, is designed for the IBM PC-AT and compatibles. It not only adds 2.5 megabytes of memory per card, but also allows the AT to run



CIRCLE 17 ON FREE INFORMATION CARD

up to 30% faster with its *no-wait* state.

The *Cheetah Card*™ comes with a full 3-year limited warranty and is priced at $945.00.—**Cheetah International, Inc.,** 107 Community Boulevard, Suite 5, Longview, TX 75606.

SOFTWARE REVIEW

Best Friend...$84.95.

■When our company switched over from a CP/M system to MS-DOS, the *last thing* anybody wanted was to have to put down the instruction manuals and do a software review. After offering the package around to several of my co-workers, I found it back on my desk.

Let me tell you something. I'm glad it worked out like that. Best Friend, as the program is called, is precisely that and is worth all of the gibberish instruction manuals that ever came with *any* computer. I casually glanced through the brochure, flipped through the book, and then inserted the disk in my A: drive. Typed in A: and return, then (as the book told me to, I typed "BF" and enter. A menu appeared.

Using the function keys, you select any of the ten items on the menu or ESC to go back to your regular applications. Arbitrarily, we selected the calculator function and pressed that. The screen informed us that it was "being loaded," and then the calculator appeared. Knocked our socks off. This isn't a calculator any more than a Rolls Royce can be described simply as a "car." It's a full-function scientific *printing* calculator that will do anything you can expect any calculator to do.

The system provides six basic functions: File Services (copying, deleting, and renaming files), Disk Services (formatting, copying and comparing disks), I/O options (lets you specify printers to ports and set serial port parameters), Typewriter Emulation (gives you the equivalent of a full-featured electronic typewriter), Scientific/Business Calculator (many easy to use functions including "tape," printer control, ability to return results to a program), and finally, Output Redirection (gets reports on disk that until now could only be output to the printer). And Best Friend can be run as a "stay resident" program so all its features can "pop-up" behind whatever else you are doing!

Suddenly, the sub-title on the instruction book, "Makes PC-DOS easy to use" had new meaning. We started playing with the other available files. I want to tell you something: I could sit here and fill up space talking about the different available functions, about how well thought-out this program is, and how it's probably the best thing to come down the pike since sliced bread. But you didn't just fall off the turnip truck either. Best Friend is available in a demo package for a mere $14.95 or the full package for $84.95. Since they have tailored systems to exactly suit the computer you have (Yes, even CP/M) it would be a good idea to send for their descriptive brochure first which contains an ordering coupon. There's no charge for that brochure.

Of equal importance in this day and age, is the fact that it is *not* copy protected.

The bottom line is that Best Friend has and continues to perform a valuable service here. It has made our new computer easier for me to use, thereby making me a more-valuable asset to my company. It has eased the transition into the new computer as well. But the fact is that even if I were an old hand at the new computer, I'd still value Best Friend, for it has been able to show me some features I didn't know existed. To order or send for a brochure (you should!) write to Elite Software, P. O. Drawer 1194, Bryan, TX 77806. If you're out that way, you can telephone. (409) 846-2340.

COMPUTER CARE

It doesn't take much, and it pays off.

HERB FRIEDMAN

The way it appears in the mail order catalogs of data processing supplies, at least 26 hours of each workday should be spent cleaning, checking or adjusting your personal computer. In fact, we are fast approaching the point when the different kinds of "computer care" products will outnumber the the books on personal computing.

The desktop personal computer and its peripherals are among the most reliable of consumer products, requiring a minimum of attention to keep them going. A quick pass with a brush now and then, a wipe with a cleaning pad, a check of frequently moved cables and connectors is all that's needed to insure years of trouble-free operation, assuming a "chip" doesn't break down. While a failure at the "chip level" generally is catastrophic, short of using common sense when you initially install and service the computer there is little you can do to avoid it.

Fresh air first

Assuming the power supply doesn't blow up and take a handful of components with it, it is primarily heat that destroys chip-level components, so the first step in computer care is to install the equipment in such a way that there is an air flow through the enclosure(s). Even when a computer (or a peripheral) is equipped with a cooling fan or blower it is assumed there will be a known minimum rate of air exchange within the enclosure when the device is located on top of a table. Hiding the computer from view inside a cabinet or a desk restricts air flow, sharply elevating the operating temperature in the cabinet. Even if you employ an accessory fan or blower fan for a computer installed within a decorative cabinet it usually ends up recycling warm air (which gets even warmer) (Fig. 1).

An auxiliary fan is rarely required for computers as initially supplied by the manufacturer. But if you load the computer with several internal accessories the build-up of ambient heat can easily exceed the original design limits, and a cooling fan might be required to avoid shortening the life of the internal components, and reduce or eliminate intermittent glitches caused by heat overload. (It is not uncommon for socketed integrated circuits to develop intermittent contacts after a few years of cooking in the heat. The problem is usually due to the heat-sensitive metals used for contacts in cheap sockets.) Both the Apple and Radio Shack Color Computers are good illustrations of how accessory hardware raises internal ambient heat above safe limits. As initially equipped by the manufacturer neither computer needs a fan when located on a table, but both are known to "glitch out" when loaded with accessories if the "extra" heat isn't vented by an accessory fan.

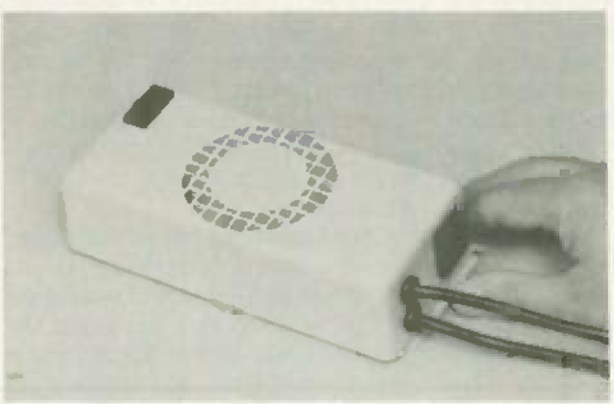


FIG. 1—IF YOU HAVE LOADED your computer with internal accessories beyond what the manufacturer originally supplied, or age is causing intermittent glitches after hours of operation, an accessory fan might be the cure for heat-caused gliches. A fan such as this for the Osborne computer is enclosed in a housing that either slides into place or is easily secured with sticky-tape or a few screws.

FIG. 2—AN UNSHARP, FUZZY SCREEN display is usually the result of dust on the face of the CRT rather than an electrical breakdown. You can save an expensive "overhaul" service charge if you simply clean the CRT with a common household glass cleaner. (Special CRT cleaning products don't justify their extra cost.)

Except for esthetic reasons, dust covers are rarely needed for modem personal computers. They might be needed to keep coffee and paper clips from falling into a printer, but that's about it. The modem keyboard uses sealed keyswitches so dust can't affect the keys, and no commonly-used personal computer puts a foam filter in front of a fan to catch dust, and thereby restrict the air flow as the filter gets clogged (one of life's dumber ideas). In fact, most internal computer fans and blowers simply pass the dust inside the cabinet where it settles out on the components—and causes no problems.

Dust creates problems only when it settles on the CRT or a disk, or gets picked up on a disk when the disk falls on the floor, or it takes the form of oxide flake-off from magnetic media and collects on the read/write head of a cassette recorder or a disk drive.

Dust on a CRT is insidious because it destroys the sharpness of the image: it's the reason why many terminal operators start to complain about tired eyes or blurred vision. The static charge on the face of a CRT attracts dust, and within days a relatively thick film can build across the face of the CRT. The dust in turn diffuses the screen display, causing the image to bloom. The heavier the film of dust the greater the bloom, and, therefore, the fuzzier the image. Blooming produces the same kind of tired eyes as looking through eyeglasses having the wrong prescription. As a general rule, the problem is avoided by cleaning the CRT every few days with a window cleaner such as Windex. (Fig. 2) Dust that settles out on a disk, or which adheres to a disk when the disk falls to the floor, is a problem not because it can ruin the mechanism, but because a "solid particle" can scratch the disk itself and destroy data bits. The way to get rid of the dust is to blow it off with either air or a neutral gas. While there are several pressurized products in the marketplace, some employ freon, which is a refrigerant. It not only chills the disk, possibly deforming the substrate (the disk itself), the change in temperature can cause moisture on the disk. The safest products are those used by photographers to clean negatives because they usually come out at room temperature. Two such products are OMIT, which is a neutral "gas," and Falcon, which is filtered air. Neither will chill a disk nor cause moisture. (Fig. 3)

The only dust that normally causes a problem in computers is the oxide flake-off from magnetic media: cassette tape and disks. Much of the low cost cassette tape is cheaply made and has excessive flake-off, which can cause an oxide build-up on the head that actually lifts the tape off the head. While "tape lift" generally interferes primarily with *reads*, if the lift is severe it can drop bits on a *write*.

There are many "head cleaning" chemicals which, as far as we know consist of denatured alcohol and some "magic" additive. The best head cleaner is a cotton Q-tip dipped in ordinary denatured alcohol. If you want to clean the entire tape path—which includes the tape guides and the capstan pinch roller—use a "cleaning cassette," a conventional cassette having a mildly abrasive cloth tape instead of magnetic recording tape.

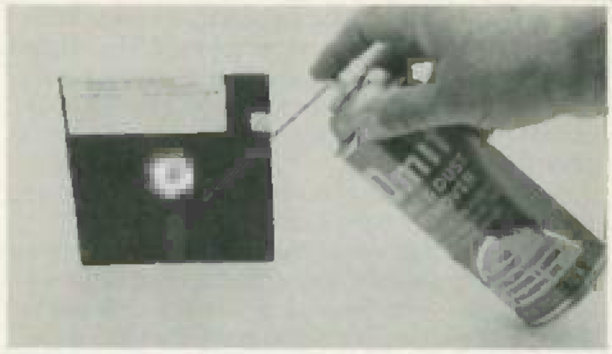


FIG. 3—IF YOU DROP A DISK on the floor, or dust has settled out, don't try to blow it away with your breath or a Freon-based aerosol product—either way you can cause moisture on the disk itself. Instead, blow the dust away with one of the "neutral" products photographers use to blow the dust off negatives.

You squirt a few drops of head cleaning fluid on the cloth tape and run the machine for a few seconds. The fluid loosens the accumulated oxide crud and the cleaning tape lifts it off and traps the particles. (The saturated cloth beats just about anything, no matter how expensive, when it comes to cleaning a cassette recorder.)

Disk drive read/write heads are something else. Regardless how it's packaged, the actual cleaning device comes down to a mildly abrasive disc (usually fiberglass) packaged in a sleeve that closely resembles a conventional disk. (Fig. 4) Generally, a cleaning chemical is squirted on the disk to loosen whatever has supposedly accumulated on the head(s). Running the drive causes the cleaning disk to scrub the head(s) clean. Since a cleaning disk is abrasive (otherwise it wouldn't clean the head), there is considerable debate whether the cleaning disk can do more damage than it cures. (The service department of at least one major disk drive manufacturer will tell you not to clean the head at any time.) In fact, it's questionable whether disk drives ever need cleaning because data disks do not usually shed excessive oxide; if there should be some flake-off it is usually trapped in the microscopic pockets of the liner inside the disk sleeve: That's why the liner is there in the first place. Cleaning of disk drive heads should only be done when you are certain there

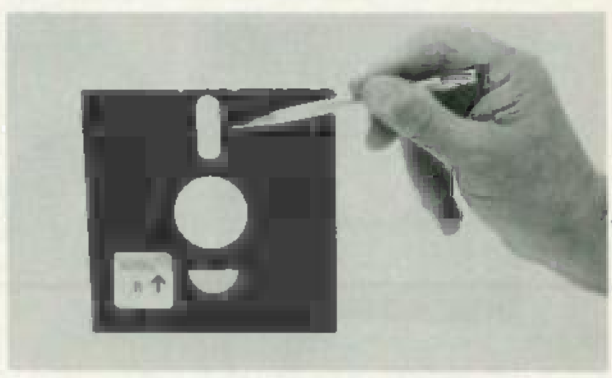


FIG. 4—A CLEANING DISK contains a mildly abrasive pad that contacts a disk drive's read/write head through a window in the sleeve. The pad is usually soaked with a "cleaning fluid."

is a problem that might be caused by an oxide build-up on the head—a really rare occurrence. How do you know when it happens? Iif you start to get frequent read errors cleaning the head is worth a try. But make certain the cleaning disk has the correct number of open "windows."

A cleaning disk has two windows corresponding to the two windows in the sleeve of a conventional floppy disk through which the read/write head contacts the magnetic disk itself. Unlike the floppy disk, which has two open windows, as a general rule only one window of the cleaning disk is open, the other is covered by a peel-off tab. If you have dual-sided drives you peel off the tab so both heads get cleaned. If you have a single-sided drive you must leave the tape in place, else you end up scrubbing the small pressure pad that squeezes the disk against the read/write head, and this can cause trouble because it allows the cleaning disk to grind grime and dust into the pad; and the dust ground into the pad can cause the pad to drag and possibly slow the disk speed outside the normal tolerance range. (Fig. 5)

Don't clean the heads for too long. Entering DIR (for directory) will cause the drive to work for a few seconds, and that's all the cleaning that's needed. If that doesn't correct the *read* problem the trouble is probably in the hardware, and the most common problem is incorrect drive speed, which is usually checked with an "analyzer" disk that tells you the actual disk speed in rpm. If you don't have an analyzer disk you can check the speed by aiming a neon or flourescent lamp at the small strobe pattern on the disk drive's motor. If the pattern doesn't appear rock steady the speed is off. Adjust the disk drive's motor speed trimmer screw until the pattern "freezes." If the pattern is steady and you still get *read* errors it's time for an overhaul by a shop specializing in disk drives. (Fig. 6)

If a drive drops out suddenly, if you get messages such as "I/O ERROR," or "DRIVE NOT AVAILABLE," check the small drive select programming plug; it might have come loose or fallen out. Possibly, vibration worked it loose. (This is not an uncommon problem when an independent dealer starts pinching pennies.Some of

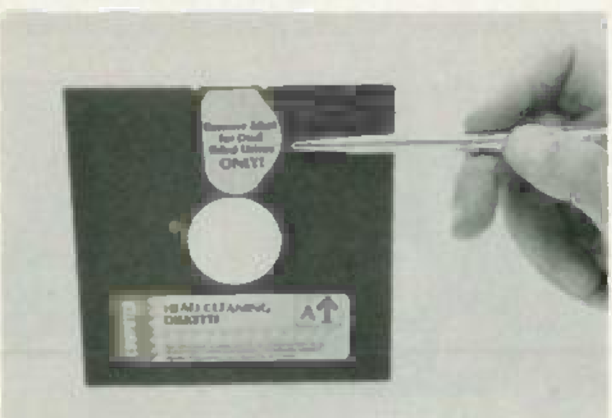


FIG. 5—THE WINDOW on the flip side of a cleaning disk is usually covered by a label. The label must not be removed if the drive is single-sided (one head). If the drive is double-sided (two heads) the label must be removed so both heads are cleaned at the same time.

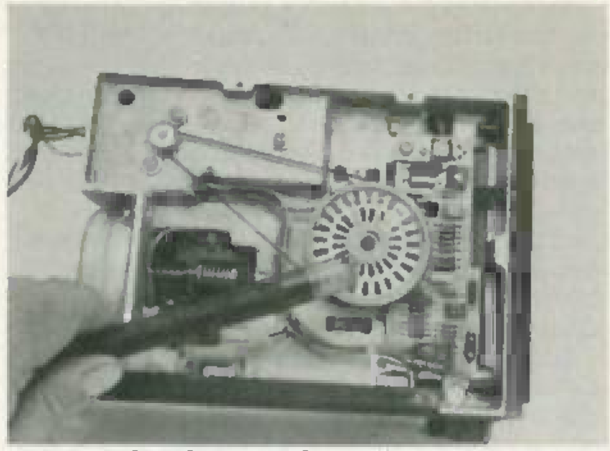


FIG. 6—IF A DISK DRIVE PRODUCES I/O errors after cleaning check its speed by holding a small neon or flourescent test lamp near the strobe pattern "painted" on the drive's flywheel. If the speed is on-the-mark the strobe pattern will freeze. If the pattern's "bars" drift adjust the drive's speed control until the pattern freezes.

the dealers who put together their own "IBM computers" from conventional parts save .001 cent by using anything other than the proper programming plug. In the illustration shown, the jumper was one section cut from a conventional 4-section plug.) (Fig. 7.)

Many intermittent computer problems can be traced to card edge "fingers" and their connectors which aren't gold plated. Many card edge fingers are simply tinned with lead and they eventually develop an insulating oxide. All that's usually needed to get rid of the oxide is to simply remove and reapply the connector, whose contacts wipe the oxide from the card edge fingers. Unfortunately, the cheap sockets usually used for the unplated fingers aren't all that good either, and over a period of time will lose sufficient tension to clean the fingers. If just removing and restoring the connector doesn't provide a reliable contact wipe the oxide off the fingers with a "game cartridge" cleaning stick: A small stick with a mildly abrasive plastic pad at one end that is saturated with alcohol. The cleaning stick was originally intended for

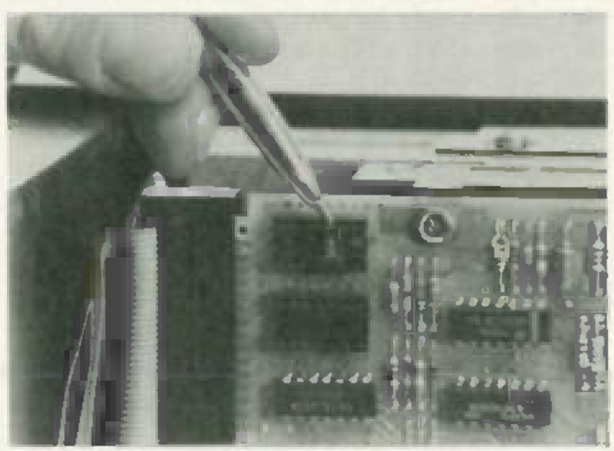


FIG. 7—SOME DISTRIBUTORS save a penny or two by shipping an "IBM type" drive with a "drive select jumper" cut from a larger DIP shunt. It's been known to work loose, so check that it's seated if the computer doesn't recognize a drive exists.

FIG. 8—SOME COMPUTERS and peripherals don't use gold plated edge connectors. If the fingers are simply tinned with solder or even tin plated they can develop intermittent contacts. If you suspect the fingers, just scrub them clean with the same kind of cleaning wand or stick used to clean game cartridges (game cartridges use similar edge connector).

FIG. 10—THE WEIGHT of the relatively heavy shielded hoods commonly used on monitor cables often works them free after several months. Simply tightening the hood's locking screws (if you didn't use them—which is not unusual) is often the cure for an intermittent monitor.

cleaning the contacts on game cartridges, many of which use the same cheap construction as "leaded" computer card edge connections. The stick usually works even better than scrubbing the contacts with a pencil eraser. (Fig. 8)

Use the same procedure with intermittent cassette recorder connections. Usually, the recorder goes untouched for months, and plugs and jacks can develop the same kind of insulating oxide as finger contacts. As a general rule, moving a plug in and out of its jack a few times will wipe the oxide free. If it doesn't, dip the plug in alcohol and run it in and out of the jack a few times—that will usually get rid of the most stubborn dirt. (Fig. 9) If you still have an intermittent connection when you wiggle the plug it's more than likely the jack's "tip" connection has lost its tension (it happens to cheap jacks after a few years), which means the jack itself will have to be replaced because even if you bend the tip connection it will simply deform the next time the plug is inserted: You cannot restore tension to the cheap jacks used on cassette recorders. (Fig. 10)

The modern desktop printer can run for years with no maintenance other than cleaning a daisy wheel print element that's used with a fabric rather than a "one time" (polyethylene) ribbon. About the only required maintenance is an infrequent cleaning of the rubber platen of a letter quality printer. Over a long period of time just normal grime can cause a hard film to accummulate on the rubber, which can interfere with the character impression. Most stationary stores sell platten cleaners, which are small pads containing a crush-tube that releases a premeasured quantity of alcohol into the pad when squeezed. A few passes of the pad over the platen and the hard coating is removed. (Fig. 11)

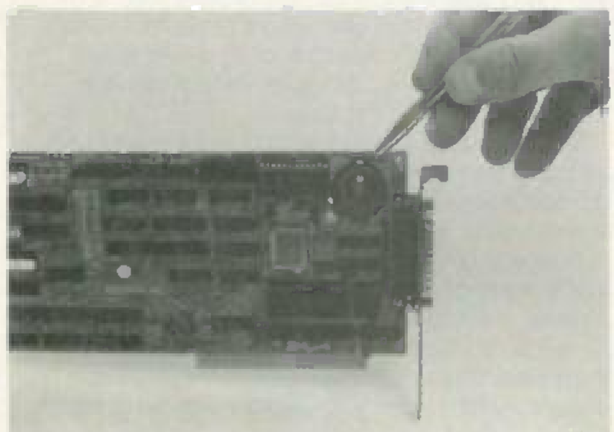


FIG. 11—ACCESSORY BOARDS powered by Mercury or Lithium batteries often develop intermittents not because the battery is dying but because it is leaking electrolyte: actually a microscopic film that gets between the battery and the socket's contact. Usually, a wipe with a cloth will restore operation, but the battery should be replaced immediately, before the electrolyte permanently damages some components.

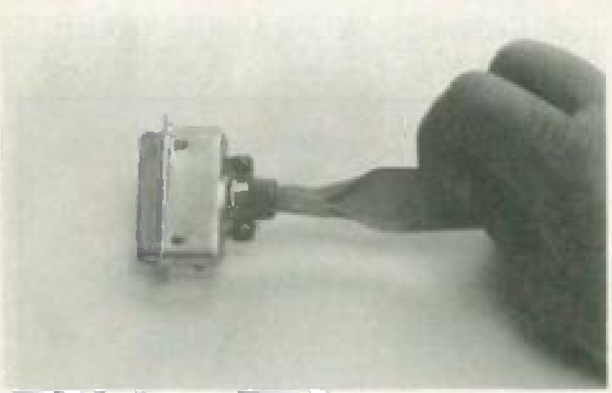


FIG. 9—FREQUENT REMOVAL of large insulation-displacement connectors, such as those used for Centronics-type printer connections, often cause the wire to pull loose inside the connector. If your cable develops intermittent connections replace the insulation displacement connector with a conventional solder-type connector. The ribbon will be firmly locked in place if you fold it on itself and wrap a heavy layer of tape where the wire passes through the connector's cable clamp.

In general, computer care is more common sense than anything else. If the system was installed properly, if all cables are secured and someone doesn't drop a jelly sandwich into the printer, it will probably keep going for years with the least amount of service and attention. Just remember the golden rule of personal computers: "If it ain't broke, don't fix it."

PACKET RADIO

What cellular did for the telephone...

Marc Stern

■One of the most exciting phenomena to hit Amateur Radio in the last 15 years is packet radio. It represents the marriage of the personal computer and communications technology.

The growing interest in packet radio is an outgrowth of the availability of small-computer systems as the Commodore VIC-20 or C-64; the desire to use the computer for communications, and the availability of interface software and hardware. It's a case of the right pieces being in place at the right time.

Over-the-air links

The result has been a rapidly spreading over-the-air computer network that is linking cities all over. When you think about this network, you begin to realize it has a great deal in common with packet-switched, local area networks (LAN). The difference is, that this network is linked via radio. (See Fig. 1)

Like a LAN, each outlet is called a node and special hardware is needed to enable the interface between the Amateur Radio station's computer, transceiver and the network.

In a LAN, special software is needed to enable the interface. Each piece of data entered into the network is preceded by special address coding—Amateur Radio callsigns, among other data—which tells the system where to send the data.

The packet radio network functions like a giant LAN. So it's easy to underestimate the importance of packet radio technology, but it represents an important step in the transmission of data.

It frees you of the constraints imposed by the wireline telephone system. Because of bandwidth limitations, the top speed that can be accommodated now is 9,600-bits per second (baud) of data transmission. Experiments going on in the Amateur realm are pushing speeds toward the 56K-baud barrier, or about a 600 percent increase in speed and a manifold increase in data density.

And this information is delivered free of errors thanks to the error-recovery nature of the packet radio network. Because of the unique packet data encoding, if the transceiver for which the information is destined doesn't receive the entire message or the checksum error-checking code is incorrect, the network will keep trying to get that information through until it receives an acknowledgement that it has been sent correctly, even if the error occurs mid-word or mid-sentence.

Finally, this system is secure and spectrum efficient. Because it depends on unique addressing, messages that aren't intended for your node go unread by your terminal program. You may see a record of activity on a frequency, but, unless a message is broadcast as a bulletin to many Amateur stations or nodes, you won't see its contents because the system will prevent it. Spectrum efficiency is ensured because it uses frequency modulation and digital packets.

One of the functions of FM radio is the capture effect. When a signal has captured or saturated the discriminator circuitry of an FM transceiver, that radio hears no other signal. With the distances involved between packet radio system nodes, it is unlikely that any transceiver will "capture" the system for more than a transmission or so and this will allow several stations to be on frequency at once, each using the system in turn. (Local stations working in packet, likewise, won't bother the overall network because they are unlikely to be transmitting with the amount of power needed to do it. Therefore, the overall network won't hear them and will continue to move data. Again, the capture effect is at work.)

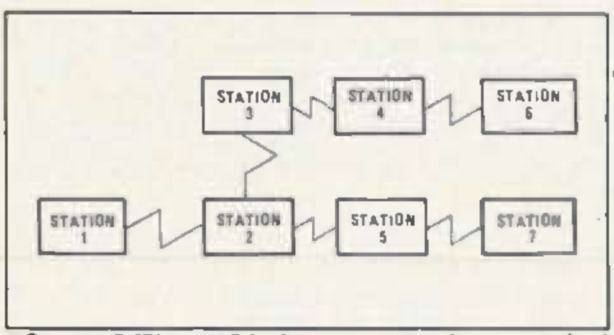


FIG. 1—PACKET RADIO is like an over-the-air computerized Local Area Network, each node communicating with only those it is seeking. Its attraction is high speed, secure communications.

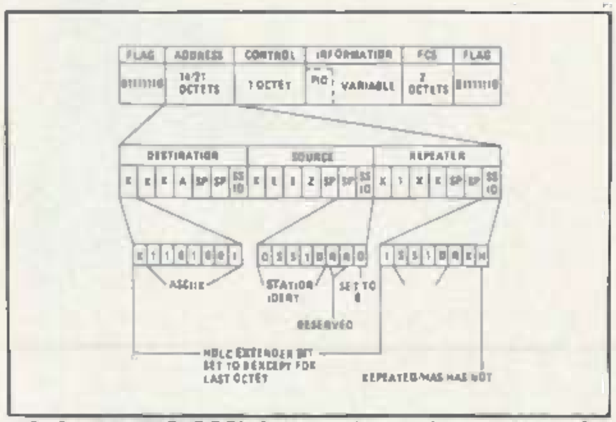


FIG. 2—OSI PROTOCOL is seven layers deep and was developed to promote compatible communications among devices. Solid lines are interfaces between layers, arrows indicate how like layers attract.

When two stations transmit simultaneously, part of the protocol which drives the packet network checks periodically to see if the network is busy or free. If it is busy, the node refrains from activity until it is free. When it is free, that station can slip its packets into the data stream and they will move along it until they arrive at their destination.

Seven layers

One of the plans which packet networks adopted early on was the Open Systems Interconnection (OSI) model on which to base network interaction. OSI, developed by the International Organization for Standardization (ISO), was developed to ensure compatibility between communications devices.

The OSI model specifies a seven-layer structure, each with its own protocol. Within each layer, the structure is modular, allowing differences in design and in the validation of protocols. (See Fig. 2.) Level 1 is the Physical layer which is concerned with bit-level data. The RS-232 and CCITT standards apply here. Hardware is impacted by this layer. Level 2 is the Link layer which arranges the bits into frames. At this level, the most common packet protocol is the ISO High-Level Data Link Control. This layer establishes a link (circuit) through supervisory frames and performs error checking and recovery. Level 3 is the Network layer which handles the addressing; routing; multiplexing, as well as flow control. At this layer, packet describes the message structure.

Level 3 can establish two types of network, virtual and datagram. The virtual circuit establishes a logical connection between the end points and then uses an abbreviated packet header. The datagram uses complete header information.

This layer can be further subdivided into internet or Sublayers A and B.

Level 4 is the Transport layer. It arranges the information in the correct order in the event that packets arrive out of order after traveling through a network. It also reassembles any packets scrambled as they move through the network.

Levels 5—Session layer, which handles log-on, logoff and authentification; 6—Presentation Level, which performs code conversion, control data structure and display formats and manages data interchange with peripheral storage devices, and 7 the Applications layer, which is user software and interface, handle various housekeeping and interface chores.

For our purposes, the important levels are 1, 2, 3, 4 and 7. They define the packet system.

Packet hardware, software

Although packeteers could have used the EIA RS-232 standard, they chose the CCITT V.24 and V.28, which specified the pinouts in the network connector. They also used the Bell 202, as opposed to the newer 212A modem standard, because there were some 202 models available on the surplus market. These modems use a 1200 Hz mark and 2200 Hz space.

Encoding in a packet radio system is predominantly a baseband technique. Called nonreturn to zero, inverted, a 0 causes a change in signal level at the beginning of a bit interval, while a 1 causes no change.

This type of encoding is supported by such controller chips as the Intel 8273; Zilog 8530, and Western Digital 1933. All of this is housed and implemented by a device which is called a terminal node controller (TNC). A combination modem-computer, the TNC and its protocol senses when a network is free; turns digital information into analog data so it can be sent across the network, and takes analog information and turns it into digital information so it can be used at a node.

The Amateur packet network uses a version of CCITT standard X.25 called A(mateur)X.25 and it defines how digital information is framed into a packet. The frame consists of the beginning flag, address field, control field, information field, frame-check segment and ending flag. (This data are sent with 16 inversions so it can be synchronized with the network.)

The flags are always represented by 01111110, while the address field consists of two or three specially encoded ham call signs, the destination, source and, optionally, the repeating stations used to get the information from A to B. The last octet of each address element is reserved for a secondary station identifier. The control field is used to identify a frame's type and also signals a connection request, ready-not ready conditions, frame numbers and modes of operation. As you'd expect, the information field is used to convey the message and the frame-check sequence is the checksum.

As these frames and others move through a radio packet system they head for their designation nodes. It is up to each node to assemble or disassemble the information. The TNC not only acts, therefore, as the modem, but also as a special-purpose microcomputer. Software to handle the assembly or disassembly is stored in Programmable Read-Only Memory. It implements the HDLC.

Importance of system

Such is the reliability and security of the Amateur packet system that commercial manufacturers and the military are studying it closely. Amateurs have proved that it is possible to use radio to enable a high-speed, dense information flow. It also opens some interesting commercial possibilities.

Imagine using an FM station's SCA for data communication. Or using a business band frequency for secure, high-speed, close-of-business data transmission. In minutes an entire day's transactions can be reliably sent from point A to B, securely and without error. It's an interesting concept, especially as Amateurs work for higher speed levels, such as 19.2K-baud and 56K-baud. Further, it provides a cost-effective alternative to satellite or terrestrial links. In fact, it looks so attractive that commercial providers are already bringing their own TNCs to market.

So, once again, the Amateur Radio community is at the cutting edge of communications technology, making the inevitable marriage of computers, radio and communications work and work well, too.

BUILD THE GRAFEX-32

PART 3

High-Resolution Graphics for your Apple II.

RAY DAHLBY

This article was begun two issues ago, continued in the last issue, and is concluded here. We'd recommend that you go back to the February, 1986 issue and re-read the entire story from beginning to end, and if you elect to build this unit, do so, knowing that you now have all of the required information.

A word about monitors

Before I set out to design this project, I went looking for a video monitor with two essential characteristics; a high video bandwidth and a long persistence phosphor screen. The Sanyo 9-inch B&W monitor I had been using with my Apple did a satisfactory job displaying the Apple's 40 column text and 280 by 192 graphics screens but blurred noticeably when displaying 80 column text, an indication of its rather poor video bandwidth of 5Mhz or so. In order to display 640 dots in a 40 µs line, the required video bandwidth should be about equal to the dot clock frequency of 16 Mhz. Another characteristic of the Sanyo, which is common to all video monitors using a standard short persistence phosphor screen, is a flicker effect when displaying interlaced computer graphics images. This flicker is the result of the non-spatially limited bandwidth nature of computer generated images as compared to images from a video camera. Since interlace is necessary to get a vertical resolution above about 200 lines and still stay within NTSC television timing, (and thus retain monitor-compatibility with the Apple II), I had to find a screen with a longer persistence. Fortuitously, Apple Computer Inc. came to my rescue when they introduced the Monitor III. This screen has the necessary combination of high bandwidth, long persistence, and modest price. I wondered if they anticipated my needs since the Apple II does not normally require these.

A peculiarity of the 7220 when generating interlaced video is a timing skew between sync pulses responsible for even and odd video fields. The effect on some monitors, is line-pairing which shows up as an uneven spacing between horizontal lines. This effect can be eliminated on the Monitor III as well as other monitors by a slight adjustment of the vertical hold control.

The Grafex sub-interpreter software includes a command to switch the display from 640 by 400 interlaced video to 640 by 200 non-interlaced. This command can be useful for those users who do not have a long persistence screen. The 400 line vertical resolution can still be used by programs to address to complete bit-map and the display scrolled vertically to view it. In effect, the screen shows a window of 640 by 200 on a 640 by 400 "world." If 64K by 4 bit RAM chips are substituted for the 16K by 4 bit 4416's, this "world" will be 640 by 1600. The sub-interpreter has a command called "SCROLL" which accepts a parameter in the range of 0 to 1599 for this purpose.

Conclusion

The 7220 is the first graphics co-processor chip to become widely available in the microcomputer marketplace. Now in volume production, it has dropped in price to about $40.00 in single units from over $100.00 a year ago. The Grafex board serves as an evaluation and development tool for this chip, in addition to its main use as a graphics expander for the Apple II. As more sophisticated graphics co-processors and larger memories become available, the open-architecture of the Apple II will likely play host to these products as well, allowing Apple users the opportunity to stay abreast of the latest technology while expanding and enhancing the utility of their machines.

It was not the intention of this article to provide a complete tutorial on programming the 7220. Such a tutorial alone would take several times the size of this article. A software package has been written to facilitate the use of the Grafex circuit board from BASIC programs. This package is in the form of a sub-interpreter to Applesoft and adds about thirty commands relating to drawing points, lines, rectangles, arcs and circles as well as text, from within Applesoft BASIC programs. Please check the end of this article for prices and ordering information. Those readers interested in writing their own drivers for the 7220 are urged to buy, borrow, or steal a copy of the "7220 DESIGN MANUAL." This 138 page book is an excellent source of information on both the hardware and software aspects of this chip. It is available for $10.00 from NEC Electronics U.S.A., One Natick Executive Park, Natick, Massachusetts 01760.

PARTS LIST
SEMICONDUCTORS
D1, D2—1N914 or 1N4148 diode
IC1—PD7220D graphic display controller
IC2, IC3—74LS00—Quad NAND gate
IC4—74LS02—Quad NOR gate
IC5—74LS86—Quad exclusive OR gate
IC6—74SO4—Hex inverting amplifier/buffer
IC7-IC9—74LS74—duel-D flip-flop
IC10, IC19—74LS174—Hex-D flip-flop IC11—74LS245—Octal transceiver
IC12—74LS374—Octal D-type flip-flop
IC13-IC16—TMS4416-20NL Dynamic RAM
IC17, IC18—74LS166 Paralle-to-serial shift register
IC20—74LS163PNP Binary Counter
Q1—2N3906 PNP Silicon Transistor
Q2—2N3904 NPN Silicon Transistor
XTAL—16MHz quartz crystal

CAPACITORS
C1-C5—0.1+microF, 50-volt ceramic disc

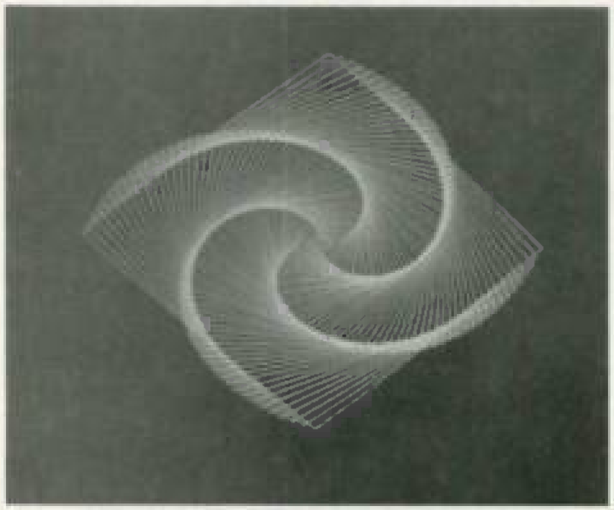
RESISTORS
(All rersistors ¼-watt 5%)
R1, R2, R9—100-ohm
R3, R10—1000-ohm
R4—1500-ohm
R5—3300-ohm
R6—2200-ohm
R7—5100-ohm
R8—200-ohm
R11—75-ohm

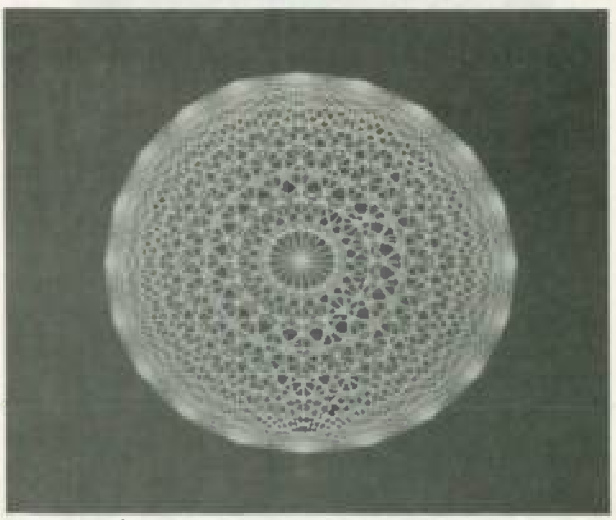
MISCELLANEOUS
J1, J2—PC-mount phono jac
RY1, RY2—SPST N.O. 5-volt reed relay

KITS AND SOFTWARE AVAILABILITY
The following kits and software packages are available for the Grafex-32: a) Printed circuit board (professionally made with plated-through holes, solder-mask and gold-plated edge connector) $45.00. b) Kit of all parts for above $125.00. c) Assembled and tested board $195.00. d) Sub-interpreter software and demos on 5¼" diskette, Apple DOS 3.3 $45.00. e) Color software package on 5¼" diskette. Apple DOS 3.3 (requires three Grafex-32 boards and RGB monitor) $95.00. Please add $4.00 per order for Air-mail postage and handling. Payment accepted by check or money order in U.S. funds to: Ray Dahlby Electronics, Dept. #255, Box C 34069, Seattle, Washington 98124-1069, or: Ray Dahlby Electronics, Dept. 255-810 West Broadway, Vancouver, B.C. V5Z 4C9, For technical inquiries, phone (604) 732-1080 (no phone orders please).

The screen photos

The screen photos reproduced here were taken from an Apple Monitor and show text and graphics at 640 by 400 resolution. The displays were generated with a Grafex board installed in an Apple IIe running under Applesoft Basic with the Grafex sub-interpreter software. The text displayed in these examples comes from a software character set loaded into system RAM by the sub-interpreter. All Grafex displays are bit-mapped; there is no hardware character generator on the board. The character font stored in system RAM can be read into the 7220 GDC which then writes it into the screen bit-map in any of eight directions and 16 sizes. In addition, derived character sets can be displayed by





THE AVAILABLE DETAIL at 640 by 400 resolution. These are common examples of computer graphics. Start with a figure, and repeat at different rotations and sizes.

shifting the position of characters and writing them on top of themselves using the set, clear, and complement modes of the GDC.

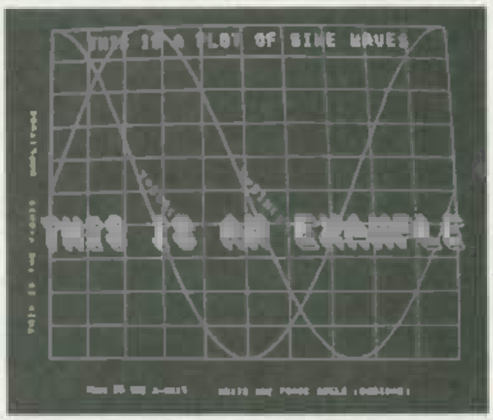
Photograph #2 shows a barberpole effect of 80 columns by 50 rows of text. The character set used in this and the other examples, is made from a 5 by 7 dot matrix in an 8 by 8 box.This character set includes the complete 128 character ASCII set. The Monitor /// screen displays highly readable text in this 80 by 50 format and, in fact, I find it to be preferable to the Apple 80 column display.

The 8 drawing directions are shown in photograph #3.The title for this display was produced by writing the string "DIFFERENT DIRECTIONS" at a magnification factor of 2, and then writing it again but with the x and y starting position shifted by 1 pixel and the mode set to complement.

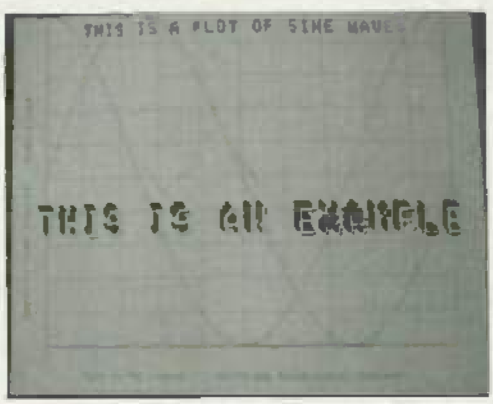
Photographs 4, 5 and 6 show off the detail available at 640 by 400 resolution and are quite common examples used in computer graphics. Photos 4 and 5, for example, are simply the result of repeatedly drawing a triangle and a rectangle, at different rotations and sizes.

Photograph #7 is a good illustration of the detail available when graphing mathematical functions. The 3-D effect of the titling is again produced by writing a shifted text string on top of itself. Photograph #8 is the same screen image complemented.The GDC can perform an exclusive-or of this type on 32K bytes of memory in under 16ms, obviating the need for hardware reverse video capability.

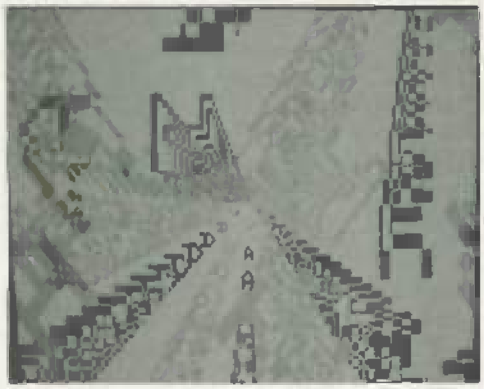
The last two pictures, #8 and #9, show a fancifull "video art" example I wrote by accident. This effect is produced by writing the letter "A" at different magnifications, rotations, and modes (set, clear, and complement). The program, written in Applesoft Basic, is just a few lines in length yet produces videotape-like animation.

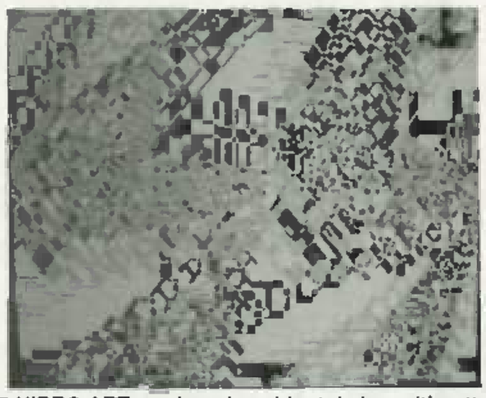


GOOD ILLUSTRATION OF THE DETAIL available when graphing mathematical functions. The 3-D effect of the titling results from a text string written on top of itself.



THE SAME SCREEN IMAGE COMPLIMENTED. The GDC can perform an exclusive-OR of this type on 32K-bytes of memory in under 16 ms.





SOME VIDEO ART produced accidentaly by writing the letter "A" at different magnifications, rotations and modes. The program, written in Applesoft BASIC, is just a few lines in length yet produces a videotape-like animation.

References

1—"High Resolution Sprite-Oriented Color Graphics:" Steve Ciarcia: Byte Magazine, August 1982.
2—"Polish Your Apple With A Luminance Board:" Ray Dahlby: Computers and Electronics magazine, November 1982.
Further Reading
1—"Display Controller Simplifies Design of Sophisticated Graphics Terminals:" Jeffery L. Wise and Henryk Szejnwald: Electronics magazine April 7, 1981.
2—"Super Graphics Hardware from NEC :"Steve Levine: Byte magazine, April, 1983.
3—"MOS Memory Data Book": Texas Instruments:1984.
4—"Output-enable feature a must on fast common I/O memories": Al Reddy and Sherri Craig: Computer Systems Equipment Design magazine, January, 1985.

quite advanced for its day, so it was very popular.

Home-built portables

Portable receivers could be built from instructions that appeared in radio papers and magazines. For example, my friend Daniel Hoffman II, who is quite a radio historian, sent information on the one-tube (UV199) Goodreau spiderweb portable. Instructions for building one appeared in a tabloid called *Radio In The Home* that was published by one Henry Neely. The Goodreau receiver appeared in the April 1924 issue, and complete instructions, a parts list, a schematic, and pictorial diagrams were included. Even a pattern for the coil form was provided.

The Goodreau receiver was typical of many homemade receivers that appeared in early radio publications. With the information provided, and the usual hobbyist's ground-floor knowledge of radio, there was little problem building one's own receiver.

Publications like *Radio In The Home*, as well as various early Gernsback publications, contributed much to the development of radio. And those early papers and magazines are as collectable as the equipment itself is.

Popular early receivers

Of course, station KDKA was not Westinghouse's only venture in the radio business; they were an early producer of quality receivers. For example, one early set uses three 01A tubes. The operating controls and output jacks are on the front panel, and binding posts for antenna, ground, and battery protrude from the back of the cabinet.

A good-looking receiver, the *Melody 5 Receiving Set*, was made by Better Radio Products of Muncie, Indiana. That receiver also uses 01A tubes—five of them. It could also use 201A's or 301A's. Like the Westinghouse, the controls and output jacks are on the front panel, but the seven binding posts for antenna, battery, etc., are concealed inside the box. For an antenna, the manufacturer recommended using 75 feet of insulated wire mounted as high as is convenient.

An old friend gave me one of the ever-popular Crosley *51's*. He believes that that set was on the market before the 1920 KDKA broadcast. That Crosley may have received some of the phonograph music broadcasts that were sent out two months before the presidential returns. Dr. Frank Conrad also made his experimental transmissions at that time. Those who wanted to listen could purchase a receiver at a department store in Pittsburgh.

The pioneering activities of Dr. Conrad are well documented. He broadcast from his own station, 8XK, located in his two-story two-bay heated garage located in the Pittsburgh suburb of Wilkinsburg, as well as from station KDKA. In his home lab Dr. Conrad and others laid much of the foundation of broadcast radio.

Store-bought receivers

Home-made receivers continued to plague the budding radio industry for some years. The early hobbyists didn't need store-bought receivers that they knew nothing about when their own receivers worked perfectly well. If maintenance was necessary, that was no problem for people who had built their set from the ground (no pun intended) up.

But, as the years passed, the old-timers began to fade away. Their faithful home-made sets were stored in attics or basements, or perhaps they were simply discarded. By the late 1920's broadcast receivers were being manufactured by the thousands. I guess that was when it became possible to go into a store and buy a *radio*.

Thanks

Let me say a few words to everybody who took time to write. I appreciate all those letters, and I will answer each one personally. I enjoyed hearing from everyone who relished the photos we've printed here. The Majestic model *70*, the Crosley *51*, and the Arvin *444* are very popular among collectors. My family-heirloom Silvertone must have been one of the most popular radios ever made. And thanks for the photos you've sent; I'll try to work them in as space permits.

Some of you "antiquers" had really difficult technical questions about restoring your antique apparatus. Those questions require considerable research. So, if you don't receive an answer from me right away, please have patience. And don't forget those stamped, self-addressed envelopes!

Haves and needs

This section is a service for readers who have or need antique equipment, parts, or other information to share. Readers are asked to contact each other directly, as I have no way of evaluating items that are offered.

Schematics—3000 of them. Inquire with an SASE to Scaramella, 37 Earl Street, P. O. Box 1, Woonsocket, RI 02895-0001. Books, Magazines & Schematics—Send SASE with $0.44 in stamps for list to Alvin Sydnor, 806 Meetinghouse Rd., Boothwyn, PA 19061. **R-E**

MEDICAL ELECTRONICS

continued from page 86

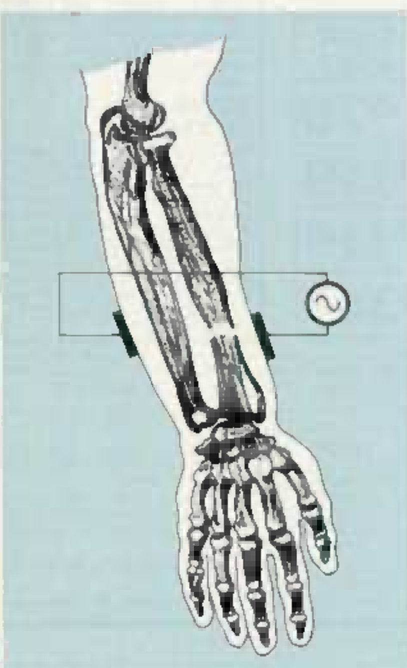


FIG. 4—CAPACITIVE COUPLING can also be used to deliver current to the fracture site.

weak in a different anatomical area, and each tumor grows and spreads differently.

There are a wide variety of problems that have to do with technique and technology. Although some may appear simple or obvious at first, failure to properly deal with them can doom an otherwise promising treatment to failure.

Problems may arise during the implantation of the device itself. For instance, if certain ear structures are damaged during the implantation of a device to stimulate the inner ear, that device would appear to be useless. Thus, the surgical techniques required to properly insert a device or probe must be perfected and understood by all involved in the procedure.

Even if implantation is carried out correctly, later body movements may cause problems. For instance, an electrode implanted to stimulate bone growth may be pulled away from the bone.

Also, any implanted object is subject to "rejection" by the body's immune system. If that occurs, the result is an infectious or inflammatory reaction.

There are also problems in evaluating the effectiveness of a technique. Due to human nature, feedback from the patient himself is usually not reliable. People often want to please others who are trying to help them. It is common for people to say that a device is of assistance to avoid hurting the feelings of the investigator, even when the device developed is of no use. Further, the *placebo* effect must be considered. Current applied to the head may lessen depression or bring sleep because the impressive-looking equipment convinces the person that a cure is at hand. The tissues with implanted electrodes may heal more quickly because the person is more careful about protecting the area from further injury.

When investigating the benefits of electrical stimulation, the researcher must deal with the number of different types of stimulation that might be effective. Thousands of different combinations of stimulation parameters may seem reasonable, yet only a certain combination of parameters may work. Finding that combination is made even more difficult by the response times involved. For instance, the healing of bone takes place over months. Among the parameters that can be varied are current level, waveform, polarity, coupling method, electrode material, and duration of the application.

Finally, there are problems that have little or nothing to do with medicine or technology at all. It is complicated, costly, time-consuming, and expensive to get any medical product approved for sale, or even human testing. And even if approval is received, and many lives are saved, if just a single person is harmed by a device a costly lawsuit is very probable. Companies have lost millions in such suits, even in cases where they've won.

Despite all of that, the area of electronic stimulation is most promising. In the years to come, researchers are sure to come up with even more applications for that technology. **R-E**

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- Trigger: DC – 35 MHz (0.5 div.)
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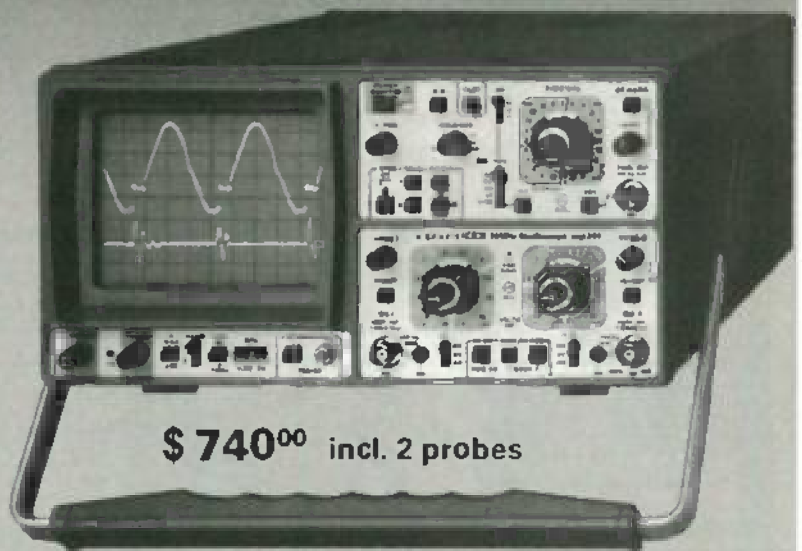
- TV sync. separator

Digital Storage:

- max. sampling rate 100 kHz
- Refresh-, Single-Mode
- Storage: 8 bit x 2048 points
- Timebase: 5 s – 0.1 ms/div.

CRT 8 x 10 cm, int. graticule, 2 kV



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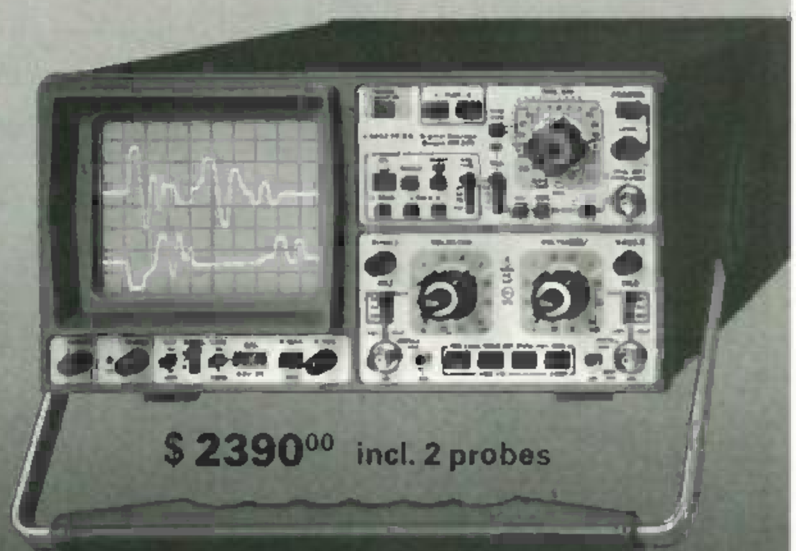
- Timebase 0.1 s – 20 ns/div.
- Trigger: DC – 40 MHz (0.5 div.)

Digital Storage:

- max. sampling rate 20 MHz
- Roll-, Refresh-, Single-, XY-Mode
- Storage: 8 bit x 4096 points
- Timebase: 50 s – 1 µs/div.
- Pretrigger: 0-25-50-75-100 %

CRT 8 x 10 cm, int. graticule, 14 kV
IEEE-488 Interface Option



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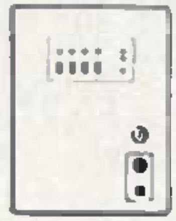

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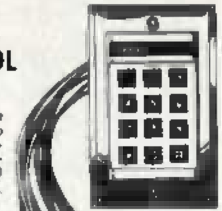

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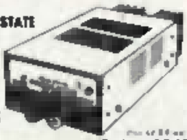

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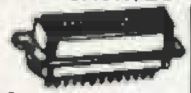

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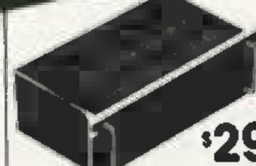

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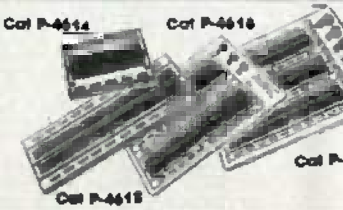

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DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Voltage doublers

WE'VE TALKED A LOT ABOUT POWER SUPplies in past columns. We've presented handy circuits that do everything from generating a negative voltage from a (single-ended) positive supply to warning you when your batteries were ready to roll over and die. We even presented a circuit that monitors the charging of Ni-Cd cells. Since I still receive a lot of mail about the subject of power-supplies, this month's entry for our growing notebook also deals with power supplies.

Anybody who has ever designed a power supply knows that it is often difficult to find a transformer that can generate all the voltages needed by the circuit being powered. It's easy to use a voltage regulator to drop a higher voltage to a lower one, but it's not as easy to go the other way. There are some IC's that can do the job, but they're hard to find, and, as we all know, when a problem comes up we need a solution right away.

TABLE 1—VOLTAGE DOUBLERS

	Half-wave	Full-wave
Output voltage	$< 2\ V_{IN}$	$\approx 2\ V_{IN}$
Ripple voltage	High noise	Low noise
Output current	Low	High
Connections	Common ground	Isolated output

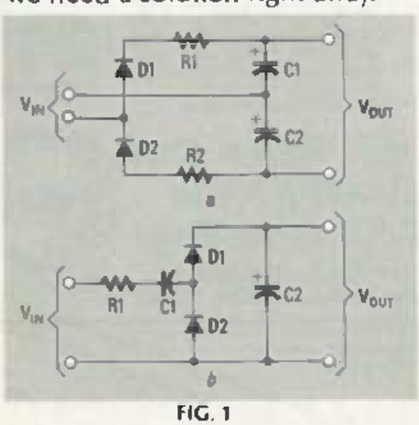

FIG. 1

How they work

As its name implies, the full-wave doubler uses both positive and negative excursions of the incoming AC voltage, just as a full-wave *rectifier* does. During the positive half-cycle D1 is forward biased, so it charges C1. During the negative half-cycle D2 conducts, so it charges C2. Since the diodes alternately conduct and block the current on each half cycle, the voltage at the output of the circuit is (theoretically) twice the input voltage.

A couple of solutions to the step-up problem are shown in Fig. 1. Both circuits are standard voltage doublers. A full-wave doubler is shown in Fig. 1-*a*, and a half-wave doubler is shown in Fig. 1-*b*. You can use either to boost an AC input voltage, but each has unique advantages and disadvantages. Let's discuss how each circuit works, and then let's compare their performances.

Component values aren't critical. The capacitors should be at least 22 µF each, and each should have a voltage rating about twice the input voltage. The diodes must be able to handle the current passing through them and they must not break down when they're reverse-biased. Although you can use diodes that have a PIV equal to the output voltage, it's a lot safer to double that value.

The two resistors are optional current limiters to protect the capacitors, diodes, and whatever you're powering. You can pick resistor values by applying Ohm's law. Use either the maximum current capability of the diodes or, preferably, the current requirements of the circuit you're powering. In any case, R1 and R2 should have the same values, as should C1 and C2, and D1 and D2.

The half-wave doubler works pretty much the same as its full-wave cousin. The diodes alternately conduct and block on each half-cycle of the incoming AC voltage. Output capacitor C2 charges to ½ V_{OUT} during one half of the AC cycle, and its stored voltage is added to the AC input during the other half cycle. The result, of course, is a voltage across C2 that's approximately twice the input voltage.

You can calculate the values of the diodes and the resistors in the same way as for the full-wave doubler; however, the capacitor values have to be calculated differently. Since the entire doubled voltage appears across C2, its voltage rating should be at least *four* times the input voltage. And C2 is usually much smaller than C1—C2 might be 0.47 µF, and C1, 47 µF. Just be sure not to make C2 so

continued on page 116

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ASK R-E

continued from page 14

and assembly, it is possible to build a simple filter that provides as much as 30 dB of attenuation at the desired frequency. If you wish, two filter sections can be used to sharpen the notch and provide up to 80 dB of attenuation.

The operation of a transmission-line stub filter is based on some unique characteristics of a transmission line. A section of line that is one-half wavelength long and shorted at one end will appear as a short at the frequency of interest at the other end of the line. The basic idea is shown in Fig. 4-*a*. Purists may insist that the spacing between stubs be ¼ wavelength, but we have found through experimentation that, when using those filters to treat TVI problems, the stubs can be used as close together as is mechanically practical.

The physical length of a half-wave stub will be shorter than its electrical length because of the velocity factor, or propagation constant, of the cable from which the stub is built. The velocity factor, K, for RG-59/U 72-ohm coax is 0.66, and it's 0.83 for 300-ohm twin lead. The formula for a half-wave stub of coaxial line is:

$$L = (5906 \times K)/f$$

In that equation, L is the length in inches, K is the velocity factor of the transmission line, and f is specified in MHz. So, to build a 103.9-MHz notch filter, L = (5906 × 0.66)/103.9 = 37.5 inches.

Build the filter as shown in Fig. 4-*b*, with the stubs an inch or so longer than the calculated value. Connect the filter in the line between the antenna and the receiver, and then tune in the unwanted station. Now, starting at the far end of the stub, use a needle or a sharp pin to short the outer braid to the inner conductor in ¼-inch steps until you find the point of maximum attenuation. Mark that point, increase the stub length about ¾ inch and cut off the excess. Strip off ½ inch of insulation and solder the core to the braid. That should do it! **R-E**

NEW IDEAS

An easy-to-build flood alarm

IF YOU LIVE IN A LOW-LYING AREA, flooding can be a big problem. Indeed, awareness of rising water is sometimes a matter of life and death. (It's at least a matter of wet or dry items in the basement!) You can use the circuit described here to warn you of an impending flood condition. The circuit is very easy to build, and it's easy to modify to suit your application and the components in your junkbox. In addition, it can be adapted for use in other applications.

How it works

My circuit is a very simple switch that sets off a buzzer when the sensor shown in Fig. 1-*a* gets wet. The sensor is built from a salt-impregnated cloth sandwiched between two copper plates. When the sandwich gets wet, the salt provides a high-conductivity path for electricity to flow.

My circuit is shown in Fig. 1-*b*. I used a 2SC106 transistor because I happened to have one in my junkbox, but any medium- to high-power transistor will do. I used a variable resistor for R1, but a fixed resistor could be used. You can calculate the value that resistor should have from the following formulas, where I_B is the transistor's base current, h_{FE} is its DC current gain, I_C is the required load current, and V_{CC} is the supply voltage:

$$I_B = (2 \times h_{FE})/I_C$$

$$R_B = (V_{CC} - 0.7)/I_B$$

My sensor has a resistance of 200–300 ohms; you'll have to take that resistance into account when calculating the value of the base resistor.

Construction

The sensor can be built from two pieces of PC-board material

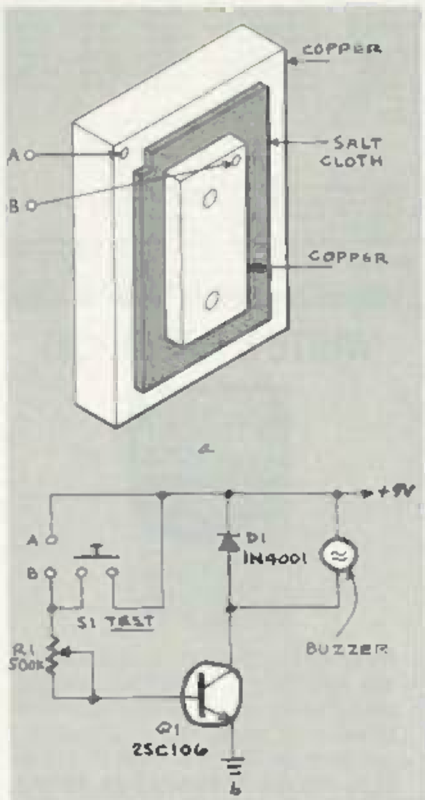


FIG. 1

about 1-1/2" on a side. Drill several holes through one piece to admit water. Soak a piece of cloth in a saturated salt solution, let it dry, and then sandwich it between the two pieces of PC board. Solder one wire to each inner face of the sandwich. Last, fasten the assembly together with nylon bolts or plastic electrical tape.

Run the wires from the sensor to the place where the circuit will be mounted, and connect them to the points marked *A* and *B* on the schematic. There is nothing at all critical about construction of the circuit, and you should feel free to experiment with different transistors and output devices.

For example, if you drive a small piezo-electric buzzer you may be able get by with a small transistor

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Memory expansion

A FEW MONTHS AGO WE DISCUSSED memory circuits, and our discussion generated a lot of mail. The most-often-asked question was how to put large amounts of memory together—how to organize it. Now how you go about managing large amounts of memory depends on what kind of memory you're going to use and what you plan on doing with it. In our demonstration circuit, management wasn't much of a problem because we only used one memory IC, and all we wanted was to see how it worked. But if you wanted to use more memory you would have to think about how to organize it.

A good example of memory management can be found inside a typical personal computer. In the usual 64K machine, eight 4164's will be put side by side to get a memory system that is eight bits (or one byte) wide. All kinds of great things can be done with that memory if it's managed properly. The video can be mapped directly into memory, soft switches can be set up than can be "thrown" one way or the other by accessing certain locations in memory. But before we get to the exotic stuff, let's take a look at the basics.

In Fig. 1 I've connected four 5101's (the IC we used in our original memory demonstration circuit) and arranged them in two different ways. Two IC's are placed side by side to widen the bus to eight bits, and two other IC's are put in parallel with the first two. That gives us a memory system that's 512 bytes long and eight bits wide. It should be obvious that that arrangement won't work if we simply leave the outputs of each pair-member connected together.

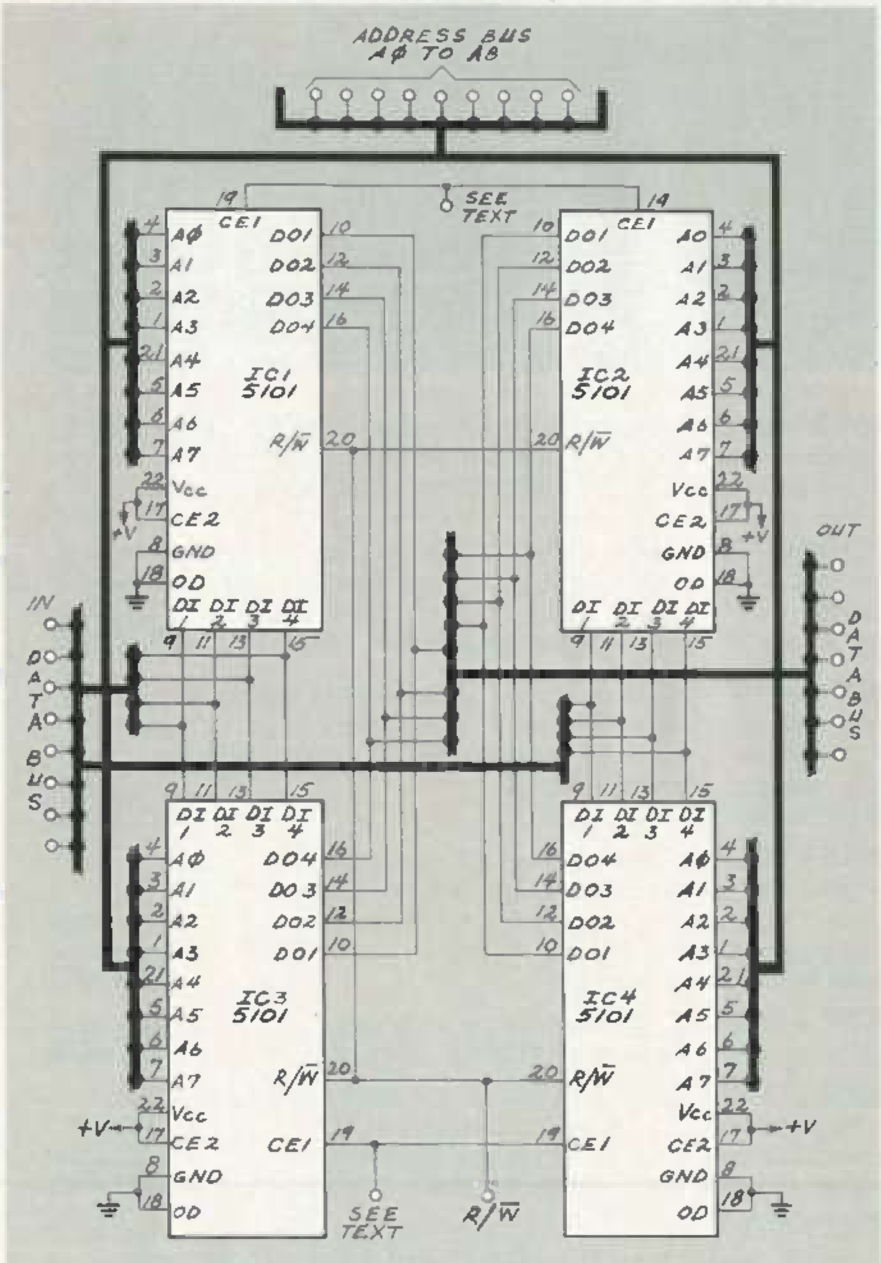
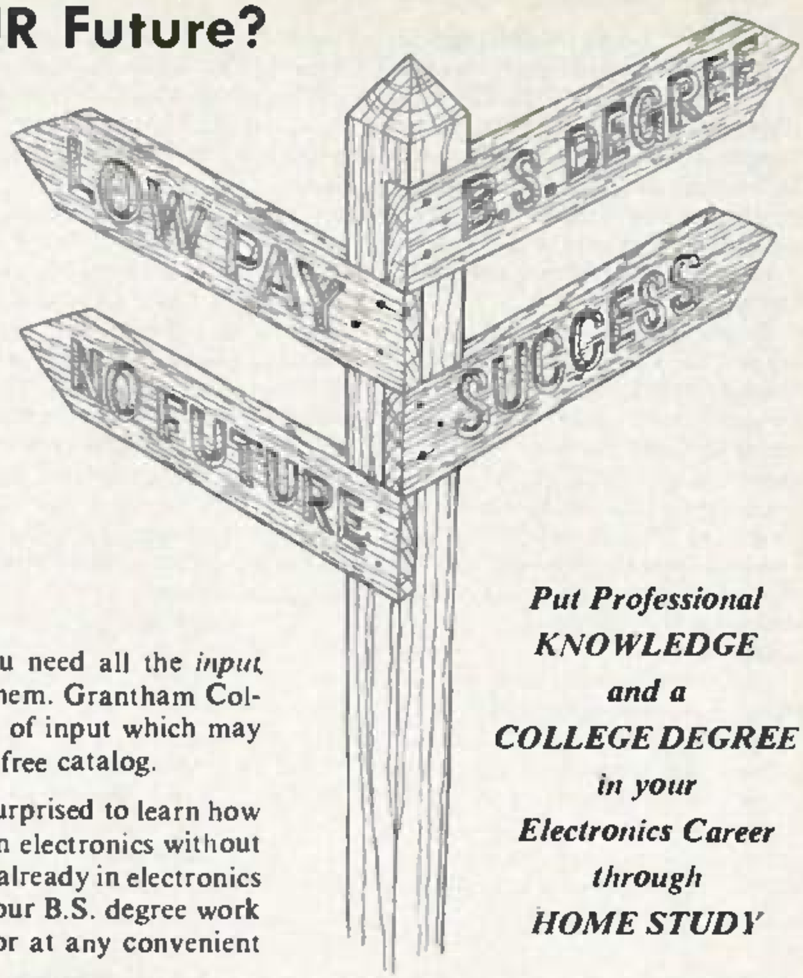


FIG. 1

Hence we need some circuitry to manage the system.

Memory management is really an old problem. In the early days

Which Way To YOUR Future?



Are you at a crossroads in your career? Have you really thought about it? Are you *planning* for your future, or perhaps refusing to face the subject? Which way will you go — down the same old road? Or are you ready for something else?

In electronics you can't stand still. If you are not moving ahead, then you're falling behind. At the crossroads of your career, various choices are available — and, yes, *decisions* have to be made.

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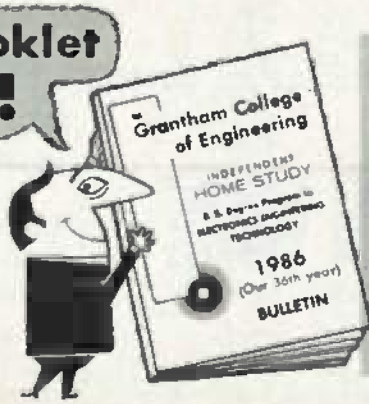

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bus contention was avoided by ORing parallel outputs. Most modern IC's, including our 5101, can float (three-state) their outputs, so arranging the bus setup is easy. But before we talk about how we'd solve the problem here, let's get a clear idea of exactly what we want to do—and let's define a few terms along the way.

By putting the IC's in parallel, we're "banking" memory. Bank 1 consists of IC1 and IC2, and Bank 2 consists of IC3 and IC4. The way we select one bank or the other depends on what the system is supposed to do and how we want to use it. We can switch between banks with something as crude as a mechanical switch, or, as is common, let the circuit do it for us automatically.

The advantage of the latter is that we can make our system operate exactly as if we had 512 bytes of continuous memory. If you think about the problem for a moment, it becomes obvious that the key to banking the memory is careful use of each IC's enable pins. Only one bank can be enabled at any one time or the whole system will go up in smoke. What we have to find is a trigger that we can use to switch between banks automatically.

The best trigger is the address of the desired location. We'll assign Bank 1 addresses from ØØØ to ØFF (0 to 255 decimal), and Bank 2 addresses from 1ØØ to 1FF (256 to 511 decimal). Now our problem is well defined. Any address placed on the bus that's less than or equal to ØFF will automatically access Bank 1, and any address above that will access Bank 2. As you can see, our problem in memory management has turned into a problem in simple logic design.

The easiest way to accomplish the desired bank selection is shown in Fig. 2. Since we have a 512-byte system ($512 = 2^9$), there will be 9 address lines. Any address above ØFF will place a high level on the most significant bit, so that's what we'll use to select between our two banks. The 5101 has three *C*hip *E*nable pins (17, 18, and 19), but, as you'll remember from our last examination of that IC, they do different things to the IC.

Pin 17 switches between normal and low-power standby operation; pin 18 enables the outputs; and pin 19 enables the IC as a whole. In our circuit we want to control the entire IC, since when a bank is switched off we want to inhibit both reads and writes. A look at the IC's data sheet reveals that we have to keep pin 17 high, pin 18 low, and we must use the high address (A9) line to control pin 19.

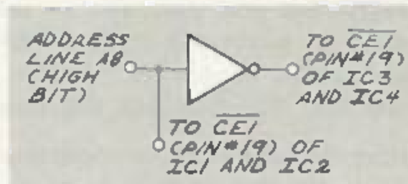


FIG. 2

The inverter in Fig. 2 does the bank switching for us. When bank 1 is selected, bank 2 is deselected. And it's all done automatically.

continued on page 108

COMMUNICATIONS CORNER

HERB FRIEDMAN
COMMUNICATIONS EDITOR

Broadband amplifiers

IT'S AMAZING HOW MUCH WE TAKE FOR granted about tuned circuits nowadays because of the nature of modern solid-state devices. When I was an active experimenter, almost everything involving radio frequencies was done with tuned circuits; and that generally meant that extensive mounting, switching and shielding hardware had to be used. Today we can toss a 50-cent solid-state device, along with a few resistors and capacitors, into a plastic box, and we'll end up with a broadband amplifier with a gain that's more stable than I could ever hope to attain from an old-style tuned circuit.

In the good old days, receiver preselectors and outboard RF preamplifiers needed lots of extra gain to receive signals that today would be considered at least S7. And most of the legendary shortwave receivers in the old days were really dogs compared to modern transistorized shortwave radios.

Most of the gain in those circuits was provided by the tuned circuit rather than the amplifying device, a vacuum-tube with an input impedance between 1 and 100 megohms. In the circuit shown in Fig. 1, L1 is supposed to match the impedance of the antenna system to the impedance of the resonant circuit created by L2 and C1.

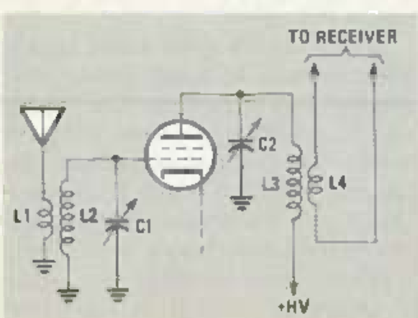


FIG. 1

The turns ratio of L2 to L1 was often 60/1, 100/1, or even higher. That's called an "infinite-impedance matching transformer." In any case, since L2 and C1 are resonant, the effective voltage across C1, hence, the input to the amplifier, can easily be 20 to 40 dB greater than the voltage attained by a simple step-up transformer. You can see why RF preamplifiers were so popular with shortwave listeners!

What about L3 and L4? Their primary function is impedance transformation, rather than power transformation. They match the high-impedance output of the preamplifier to the low-impedance input of the receiver to which the preamplifier is connected. The point is that, especially in the less expensive and unsophisticated boosters used for shortwave listening, most of the signal gain came from the L2/C1 circuit.

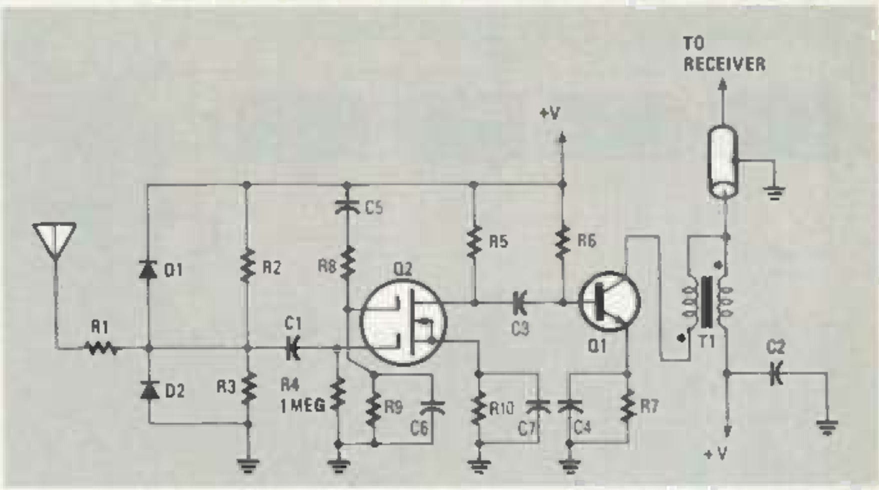


FIG. 2

For the experimenter, the major problem with the tuned preamplifier was that the input and output coils interacted with each other. Since the overall stage gain was so high, the circuit became unstable and broke into self-oscillation if even the smallest amount of energy from the output coil fed back to the input coil.

Another problem with tunable preamplifiers was the tuning itself. The tuning range was limited by the values of the coils and capacitors, so an all-band HF preamplifier would require four, five, or even more band-switched coils to cover the frequency range from the broadcast band through 30 MHz. And every extra switch and coil increased overall circuit losses and made the device more susceptible to instability.

The broadband amplifier

Thanks to solid-state devices, today's shortwave preamplifiers can dispense with input coils and tuning circuits when used at frequencies as high as 30 MHz, and

STATE OF SOLID STATE

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

Temperature-alarm IC

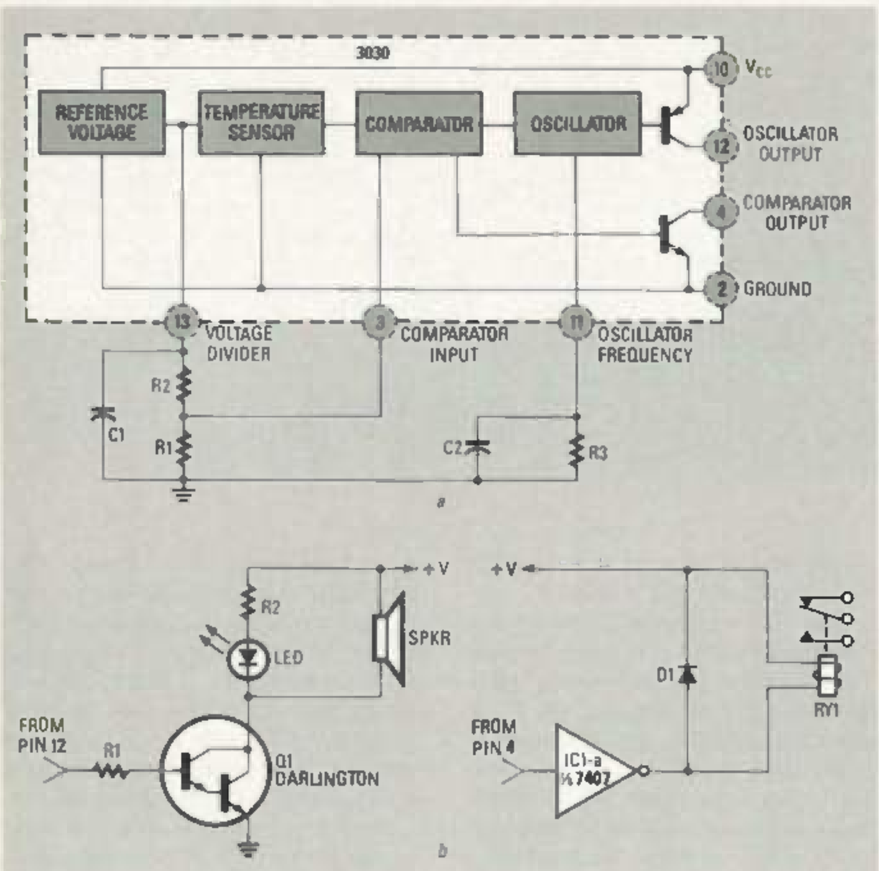


FIG. 1

DETECTORS, MONITORS, AND ALARMS make up an interesting line of monolithic devices from Intech. One of those is the 3030 temperature alarm that can flash a light, sound an alarm, or shut down equipment when the temperature of the IC's package exceeds a preset level. Features include a wide temperature range and excellent repeatability; an oscillating output tone that, with proper interface circuitry, can drive a speaker; a TTL-compatible output; low current drain; and an accurate, externally-available, temperature-compensated reference voltage.

The 3030 may be used as a fire-alarm temperature sensor; in addition, it may be used to shut down power supplies or other equipment automatically; and it can be used as a temperature controller in heating and refrigerating appliances.

A block diagram of the 3030 is shown in Fig. 1-*a*, along with the off-IC components that determine its mode of operation: R1–R3, C1, and C2.

The reference circuit develops a voltage that is independent of temperature and power-supply voltage. That voltage drives the off-IC voltage divider, composed of R1 and R2, and an on-IC temperature sensor that consists of two diodes. When the power-supply voltage drops below the reference voltage set by the voltage divider, the comparator activates the oscillator, which delivers an alternating signal to pin 12 of the IC; a steady-state output current is also delivered to pin 4. The comparator has a small amount of hysteresis to ensure positive snap action.

Resistor R3 and capacitor C3 control the oscillator's frequency and duty cycle. Capacitor C1 stabilizes the reference voltage and prevents transients, glitches, and spikes from interfering with the operation of the sensitive comparator.

Intech provides information on several methods of calibrating the alarm for the desired temperature trip-point. Accuracy is +4°C when the recommended type of high-precision resistor is used.

Using the 3030

Both outputs (pins 4 and 12) are low-powered to keep power dissipation to a minimum. The steady output works at normal TTL-gate levels. The oscillating output can provide about 0.5 mA to drive a Darlington transistor. Sample output circuits are shown in Fig. 1-*b*.

When monitoring the temperature of critical or sensitive components, you can mount the 3030 in direct contact with the component's heatsink. The steady output can be used to deactivate the circuit when it overheats, and to restore power later when temperature drops to a safe level.

The 4-page data sheet and application note for the 3030 temperature alarm contains full electrical specifications for the device, along with diagrams showing applications like a delayed alarm; a low-power temperature controller that turns a heater on when the temperature goes below the set point, and off when the temperature rises above the set point; and a cooler control to turn on a fan, a low-power compressor, or a refrigerator when the temperature rises above the trip point.

The 3030 costs $19.00 in quantities ranging from 1 to 24. For data sheets and information on availability, write to Intech Inc., Micro-Circuit Division, 2270 Martin Ave., Santa Clara, CA 95050.

Thyristor handbook

Thyristor Device Data is a comprehensive new book containing over 600 pages of data on SCR's, Triac's, GTO's (*G*ate *T*urn-*O*ff thyristors), SIDAC's (Triac-like devices), and triggers. It includes sections on theory and applications, cross-reference tables, a device-selector guide, and a complete set of data sheets. It is available through all Motorola sales offices and distributors. For further information contact Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036. **R-E**

COMMUNICATIONS CORNER

continued from page 105

sometimes even higher. What we use instead is a broadband (or wideband) preamplifier. An example of such a circuit is shown in Fig. 2; that schematic is a simplified version of MFI's *Remote Active Antenna.*

First, notice that there is no tuned network at the input to the circuit. The antenna is coupled directly to the high-impedance input of the FET. The two diodes, D1 and D2, and resistor R1 serve only to protect the FET against excessive input voltages. Direct coupling is possible because the solid-state devices used in modern shortwave radios provide sensitivity approaching 0.1 µV, which is much more sensitive than that provided by tube receivers. Therefore, we don't need the extra gain provided by the tuned circuit to reach the theoretical sensitivity limits of such circuits.

Between the FET and Q1, which matches the medium-impedance output of the FET to the low-impedance of the associated receiver's antenna input, we can easily attain an overall untuned—wide-band—gain of 20 to 30 dB. And when that gain is added to the typical 0.1 or 0.25 µV sensitivity of modern shortwave receivers, it becomes easy to dig out signals that usually can't be heard.

And because there aren't any tuned circuits, the wideband solid-state preamplifier is much less susceptible to instability. In fact, modern homebrew RF preamps hardly ever break out into self-oscillation. If there is a problem with instability, it is generally caused by the antenna input of the shortwave radio radiating RF energy back to the preamplifier.

Although it is possible to design wideband preamplifiers for just about any frequency range without tuned circuits, in reality most preamps *do* require some form of tuned circuit, if only for impedance matching. For experimenters and hobbyists interested primarily in frequencies from 100 kHz to 30 MHz, it's possible to avoid tuned circuits and still get 10 to 20 dB of extra gain. More than 20 dB requires the use of tuned circuits.

You might be asking, "Why does a solid-state device provide greater gain at VHF frequencies than a tube?" One major reason is inter-electrode capacitance. In solid-state devices like the 40673 FET, which is used in many RF preamplifier circuits, the small amount of inter-electrode capacitance between gate and source is simply not enough to bypass much of the RF signal to ground. That small amount of capacitance also increases stability by reducing feedback between input (gate) and output (drain). **R-E**

NEW IDEAS

continued from page 100

like a 2N2222, or perhaps no transistor at all. You could use a PNP transistor simply by reversing the polarity of the diode and the battery supply.

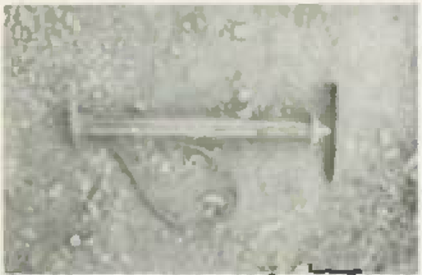
You could also drive a relay to provide a higher-current or more-isolated output. Just be sure to include a reverse-biased diode as shown.

I included a small momentary push-button switch as a battery test; unless you're prone to a lot of flooding, your battery should last its entire shelf life.

For use as a flood alarm, the sensor should be mounted horizontally near the floor of your basement. But the circuit can also be used in other applications. For example, the sensor could be mounted vertically in a sump-pump hole, horizontally on the floor of your freezer, or vertically as a boat's "bail-out" alarm.—*Jim Cook* **R-E**

NEW PRODUCTS

continued from page 43



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where eventually enough of them accumulate for lasing to take place. Time-to-lase is given as between two and 14 hours, depending on weather, season, and latitude, and on the stamina of the operator.

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ROBOTICS

continued from page 81

The IM6402 is a CMOS UART (*U*niversal *A*synchronous *R*eceiver/*T*ransmitter). It converts parallel data from the microprocessor's data bus to serial data that can be transmitted according to RS-232 signal levels. Similarly, it converts incoming serial data to parallel data that is acceptable to the host microprocessor. Level translation is handled, in Fig. 1, by IC1-a, a 1489 line receiver, and by IC2-a, a 1488 line driver.

The parallel connection

Of course, you can connect devices like motors to the *Model 100*'s parallel interface. Just be sure to provide appropriate interface circuitry—you can't control a 6-HP motor with a CMOS buffer! The power supply for the interface, the motor, and the sensors should be separate from the *Model 100*'s internal supplies. Just connect the grounds of all circuits together. The *Model 100*'s ground is available at pin 7 of the RS-232 connector.

More memory

The *Model 100* comes with 8K (or 24K) of battery-backed-up CMOS RAM. That means that, when the power switch is off, the RAM modules still receive power, so the contents of the RAM are not lost forever.

I say *modules* because the *Model 100*'s RAM IC's are not industry-standard parts. The reason is that, when the *Model 100* was designed, the 8K- × -8 RAM did not exist, so the *Model 100*'s designers built small modules, each of which contained four 2K- × -8 RAM's. You can get a 24K *Model 100* from Radio Shack for several hundred dollars more than the 8K unit, or you can buy extra RAM modules from third-party vendors for about $30.00 each.

You could also build your own RAM expansion using several 6264 8K × 8 RAM IC's. Don't tackle that unless you know what you're doing. Radio Shack sells a technical reference manual for the *Model 100* that should help you figure out the proper address decoding for that computer.

Programming

For those of you who are familiar with BASIC, you may be surprised by some of the *Model 100*'s control features. For example, the *Model 100* supports interrupts; in fact, several of the machine's I/O devices are treated as interrupts! You can write programs that will respond to interrupts from the communications port, the built-in MODEM, the built-in clock, and even the keyboard's eight function keys, using the following statements:

- ON COM GOSUB
- ON MDM GOSUB
- ON TIME$ GOSUB
- ON KEY GOSUB

In case you're wondering, I don't work for Radio Shack. It's just that I am so impressed with the *Model 100* that I had to tell you about some of its special features. I am currently working on a number of intelligent interfaces for the machine, and I have interfaced it to a Heath *HERO-1*. If you are interested in learning more about that, drop me a line. **R-E**

DRAWING BOARD

continued from page 102

If you want to add memory to the system, you can build on that technique. The only limitation is the width of the address bus. We've got to have a spare address line around to do the switching for us. However, nothing stays simple forever

Consider this scenario: You have a 64K memory system that's controlled by an eight-bit microprocessor. Consequently, all the address lines are used to do real addressing. Suppose you want to add some more memory to the system. There are several reasons for doing that:

- As an alternate 64K bank for data storage, etc.
- To increase continuous memory in the system to 128K.

The problem then is to control the memory when the address bus is limited to sixteen bits (2^{16} = 65,536), or 64K. And *that*, as you know, is a real-world problem. We'll show you how to tackle that problem next time. **R-E**

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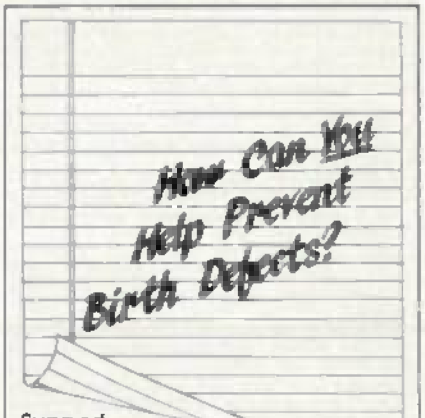

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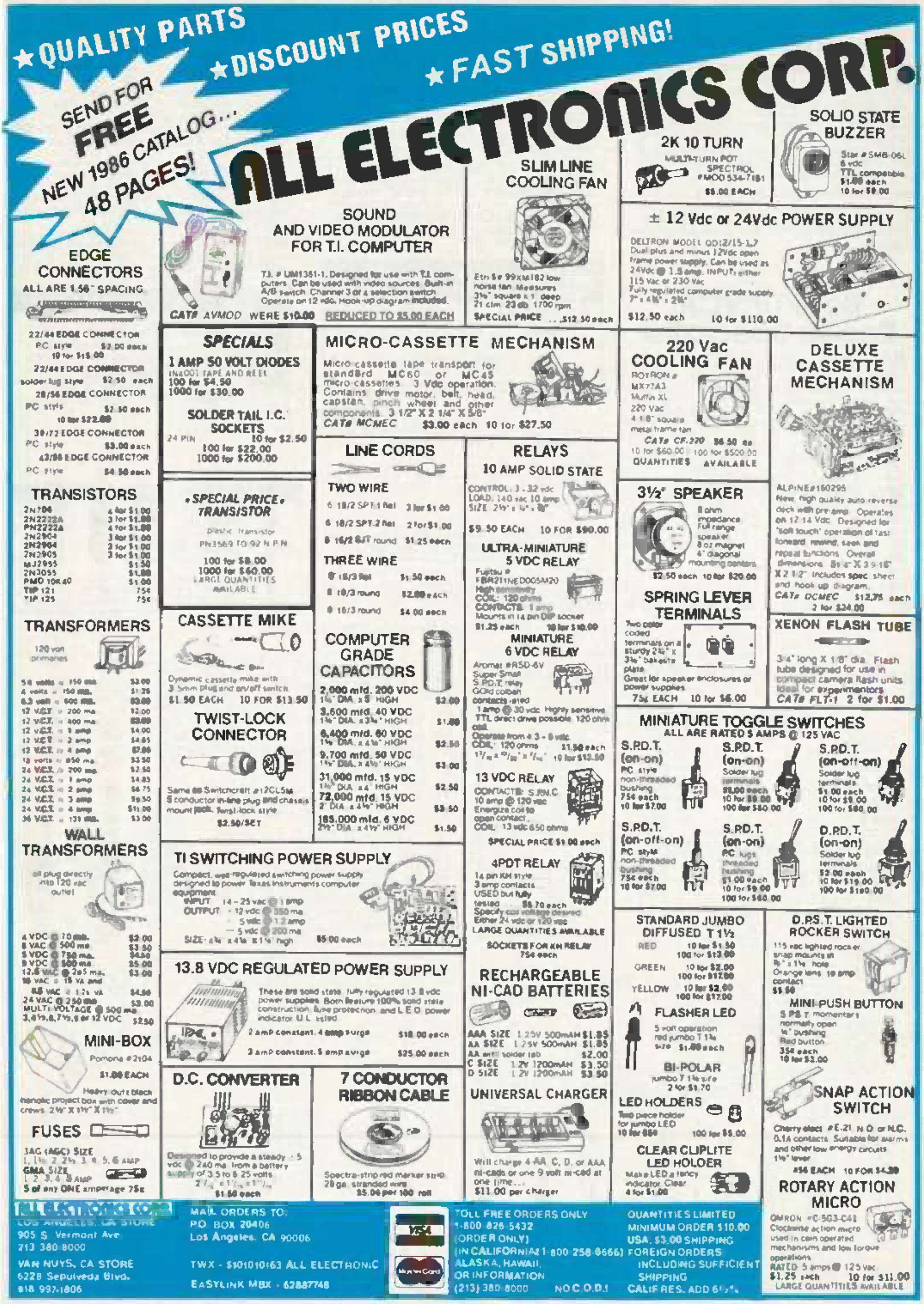

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DESIGNER'S NOTEBOOK

continued from page 98

the 60-Hz input—or whatever the input frequency being fed to voltage doubler happens to be.

Now we know how diode-capacitor voltage doublers work—but which of the configurations should we use in a given circuit? Well, there are pros and cons to each. I've summarized them in Table 1 so that you can make an intelligent decision about which of the voltage doublers is best for your application.

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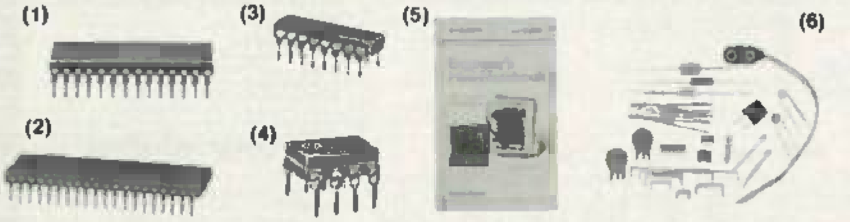

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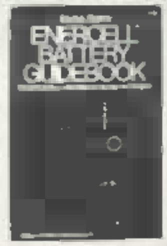

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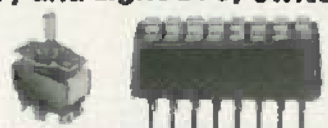

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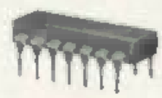

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2764-20	8192 x 8	(200ns) 21V	3.95
2764A-25	8192 x 8	(250ns) 12.5V	2.95
2764-45	8192 x 8	(450ns) 21V	2.19
27C64	8192 x 8	CMOS 21V	6.95
27128-25	16,384 x 8	(250ns) [illegible] 21V	2.95
27256-25	32,768 x 8	(250ns) [illegible] (12.5V)	7.95
27C256-25	32,768 x 8	(250ns) [illegible] (CMOS) (12.5V)	13.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
74S387	256 x 4	PROM O.C.	1.89
74S471	256 x 8	PROM T.S.	4.95
82S123	32 x 8	PROM T.S.	2.95
82S129	256 x 4	PROM T.S.	2.95

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8 pin LP	.13	.12	.11	8 pin WW	.55	.49	.45
14 pin LP	.15	.13	.11	10 pin WW	.65	.59	.55
16 pin LP	.17	.15	.13	14 pin WW	.69	.65	.59
18 pin LP	.25	.23	.21	16 pin WW	.75	.69	.65
20 pin LP	.28	.26	.23	18 pin WW	.85	.79	.75
22 pin LP	.30	.25	.26	20 pin WW	.95	.89	.85
24 pin LP	.31	.30	.29	22 pin WW	.99	.95	.89
28 pin LP	.39	.37	.35	24 pin WW	1.19	1.09	.99
40 pin LP	.49	.46	.43	28 pin WW	1.39	1.29	1.19
				36 pin WW	1.49	1.39	1.29
				40 pin WW	1.79	1.69	1.59

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Part No.	Function	Price
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Part No.	Description	Price
DT1050	Digitalker™	$24.95
MM54104	Processor Chip	$12.95

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74C02	.29	74C175	.89
74C04	.25	74C221	1.19
74C08	.35	74C240	1.59
74C10	.29	74C244	1.59
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74C74	.49	74C912	7.95
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68	50V	.05	.02	50V	.07
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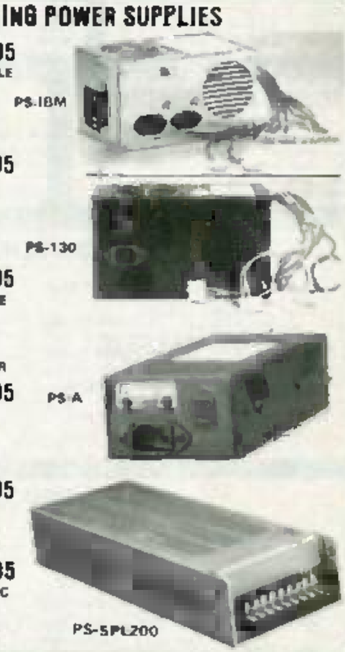

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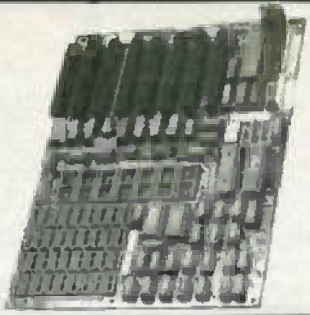

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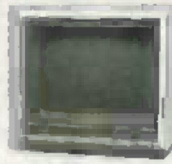

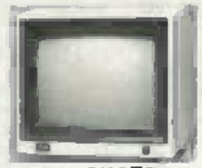

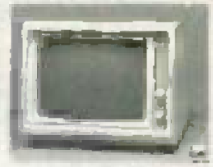

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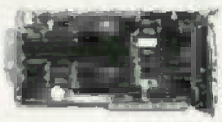

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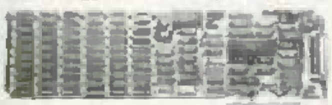

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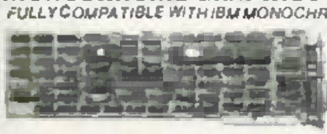

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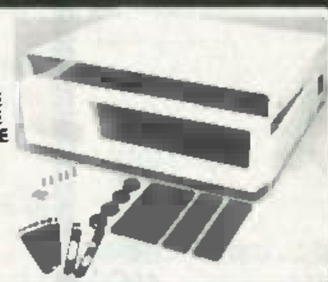

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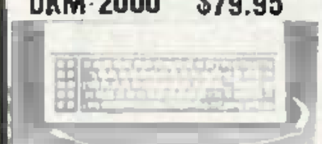

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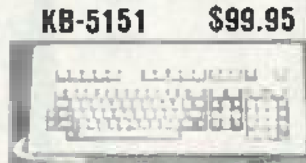

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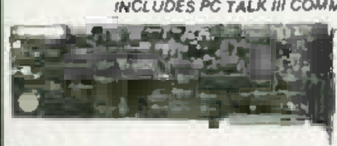

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