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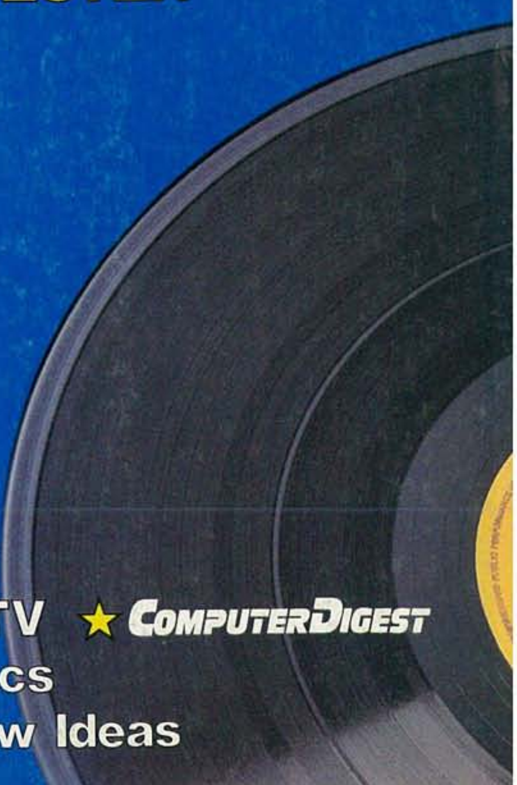

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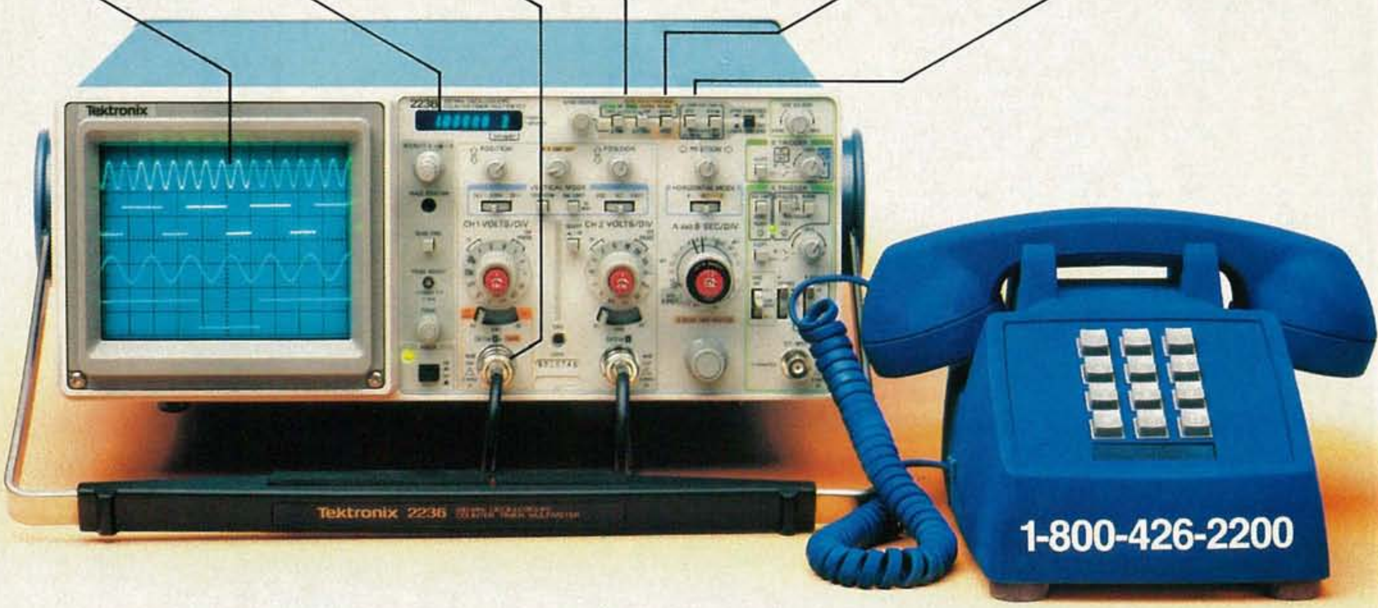

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Radio-Electronics, (ISSN 0033-7862) May 1986. Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735 Second-Class Postage paid at Farmingdale, NY and additional mailing offices. Second-Class mail registration No. 9242 authorized at Toronto, Canada. One-year subscription rate U.S.A. and possessions $15.97, Canada $20.97, all other countries $23.47. Subscription orders payable in US funds only, international postal money order or check drawn on a U.S.A. bank. Single copies $1.95.
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COVER 1

Can a conventional LP ever sound like a compact disc? Well, not exactly, but if you build this click and pop filter for your hi-fi, you can make your LP's sound almost as noise-free! The filter lets you rid your LP's of clicks and pops caused by scratches in the vinyl. Yet it still lets you enjoy the full frequency range as recorded.

This month, we'll give you the full circuit details and describe the theory of operation. We'll conclude the article next month with complete construction details. Turn to page 46.

NEXT MONTH

THE JUNE ISSUE IS ON SALE MAY 1

A SPECIAL SECTION ON LASERS
After we introduce you to lasers, we'll show you how to build a helium-neon laser for yourself!

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Radio-Electronics is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature*.
Microfilm & Microfiche editions are available. Contact circulation department for details.

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WHAT'S NEWS

AES prints new standards for audio measurements

The S4 Committee of the *A*udio *E*ngineering *S*ociety (AES) has now been accredited by the American Standards Institute for the development and publication of standards in the audio engineering field. As a result, AES has published five ANSI-approved standards:

AES2-1984 (ANSI S4.26-1984). Recommended practice for specification of loudspeaker components used in professional audio and sound reinforcement;

AES5-1984 (ANSI S4.28-1984). AES recommended practice for professional digital audio applications employing pulse-code modulation—preferred sampling frequencies;

AES7-1982 (ANSI S4.6-1982). Method of measuring recorded flux of magnetic sound records at medium wavelengths;

AES6-1982 (ANSI S4.3-1982). Method for measurement of weighted peak flutter of sound recording and reproducing sound equipment;

AES3-1985 (ANSI S4.40-1985). AES recommended practice for digital audio engineering—serial transmission format for linearly represented digital audio data.

Those documents are available at $15 each from the Audio Engineering Society, 80 East 42nd St., New York, NY 10165.

Video cassette recorders making record increases

Over 11 million VCR's have been purchased in 1985, a 55 percent gain over 1984, according to Stephen Stepnes of RCA Consumer Electronics. By 1988, he says, there will be 50 million VCR's in American homes.

The proportion of high-fidelity table-model stereo VCR's is also increasing. Those comprised about 10 percent of the total VCR market in 1985—up from 5 percent in 1984—and will rise to more than 14 percent in 1986, according to Stepnes.

Justice Dept cracks down on interference

The Department of Justice has filed suits against two CB operators and one commercial company in Philadelphia for sums totalling more than $4,000. In addition the suits seek court orders mandating that the violators comply with FCC regulations.

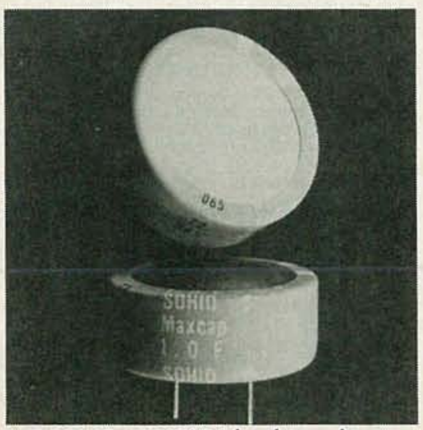
F.C. Roberson was operating a CB radio that caused interference to numerous residents of a Philadelphia neighborhood. The equipment appeared to be operating far over the four-watt legal limit. Roberson repeatedly refused to allow FCC inspection of the radio, thereby accumulating fines totalling $900. The suit seeks payment of the fines, and a court order directing Roberson to permit inspection of his equipment and to operate it at legal power levels.

Henry O. Jackson was using his CB radio at an estimated power level of 47 watts, interfering with local television reception over a period of several months. A fine of $750 was levied against him. The suit seeks payment of the $750, and a court order directing Jackson to bring his equipment within FCC guidelines.

The Department of Justice has also filed suit against Comp-Art, Inc., for unlawfully interfering with TV reception with a computer. The interference occurred over a period of 18 months. Fines of $3,000 were accumulated. The suit seeks payment of the fines and a court order directing Comp-Art to shield or otherwise modify its computer so that it will not interfere with local TV reception. **R-E**

New capacitor used as energy storage device

"A new energy-storage device that never needs replacement" is the way its manufacturer describes the Maxcap *D*ouble-*L*ayer *C*apacitor (DLC), a unit with up to 500 times the energy density of an aluminum electrolytic capacitor of similar dimensions.It is intended to replace batteries in applications requiring low drain, such as CMOS RAMS, microprocessors, and timers.



THE SOHIO MAXCAP 1 farad capacitor.

The secret of the new capacitor is the electrode material: activated carbon, which can have a surface area of 1,000 square meters per gram. The working voltage is low, necessitating the double-layer principle, in which up to six activated-carbon, liquid-electrolyte units may be stacked to reach the 5-volt rating of the capacitor illustrated.

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PEST-REPELLER QUESTIONS

We thank the many readers who responded to the article "Ultrasonic Pest Repellers" that appeared in the July 1985 issue of **Radio-Electronics.** *We will attempt to answer some of the more common questions below. We especially want to thank readers Parke S. Barnard of New Haven, CT, and Harold J. Read of Grove City, FL, for sending copies of the article "Bug Zappers that Don't" that appeared in the July/August 1985 issue of* Science *magazine.*

• 1. How can I modify one of the circuits to attract mosquitoes to fly into an electric bug killer? Many flying insects are attracted to it, but mosquitoes seem to ignore it.—S. E., Sacramento, CA.

Personally, I'm not convinced that mosquitoes ignore the UV lights found in typical electric bug killers. During the last week or so, during a particularly heavy infestation of mosquitoes, I've studied the operation of the bug killer at close range. Mosquitoes don't seem to be lured to the UV light as easily as other flying insects, but they are attracted nonetheless. Mosquitos are small, compared with the size of the charged grid, so many are able to fly in to and out of the charged area without harm.

One researcher on bug killers claims that mosquitos are not easily attracted to the UV light source in most bug killers, and that a UV light of 80 to 100 watts is needed for the killer to be effective in attracting mosquitos.

Recently I read the article "Build a Better Mosquito Trap" in *Home Mechanix,* August 1985. The author suggested that mosquitoes are attracted to man and animals by odor, moisture, and heat, and he proposed using a candle to heat and thereby evaporate water from a small container placed near the bug killer. As I recall, the author also suggested adding a drop or two of some chemical to create an enticing odor.

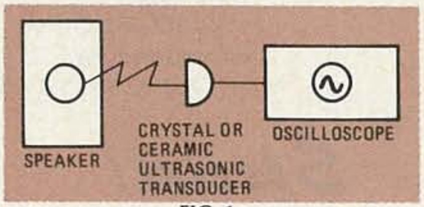

FIG. 1

• 2. I'm looking for a good tweeter to use in my electronic pest repeller. Radio Shack's piezoelectric tweeter only responds to about 30 kHz. Your circuits oscillate as high as 65 kHz, so it doesn't appear that the Radio Shack unit will work.—S. Z., Brooklyn, NY; J. S., Taunton, MA; and J. N., Morristown, NJ.

There is a lot more to the acoustic output and frequency response of a loudspeaker than you'll find in a Radio Shack catalog. Speakers are usually rated to reproduce either speech or music. Frequency response is often quoted in terms of the low- and high-frequency points where response drops to a specific—and often unspecified—level. In fact, even the manufacturer's performance curves don't tell the full story unless you are also given a full run-down on all test conditions.

A speaker's response is generally tested by applying a constant voltage of a varying frequency in series with a resistance that represents the equivalent source resistance of the driving amplifier. As the speaker's impedance increases, the voice-coil current and acoustic output decrease. By applying constant power across a band of frequencies, acoustic power output will be much higher at high frequencies than at, say, 400 Hz.

There are a number of mail-order suppliers that sell inexpensive speakers and tweeters suitable for use in the pest repeller. Among them are MCM Electronics, 856 Congress Park Drive, Centerville, OH 45459, and McGee Electronics, 1901 McGee St., Kansas City, MO 64108. The latest MCM catalog lists dome-type tweeters ranging in price from $4.50 to around $26.00, and piezoelectric tweeters made by Motorola ranging from $7.00 to $11.00.

• 3. In an attempt to get rid of some pesty black ants, I built the "French" circuit in Fig. 2 of "Ultrasonic Pest Repellers;" that circuit uses a 4011. I finished construction, but I can't tell whether my circuit is oscillating. The 4011 is a delicate CMOS IC, so I'm afraid I may have zapped it. To test my circuit, we caught several ants, placed them in a pail, and aimed the tweeter at them. They scampered around like crazy, so I think the device is working—but I'd like to be sure. Can you suggest a method of testing it? Incidentally, the schematic specified 560 pF capacitors, but I used 680 pF units. I suppose that that altered the frequency. Could the values of those capacitors be a problem?—J. W. D., Corning, NY.

By using a 680-pF capacitor the frequency will be a little lower, but still within the effective ultrasonic range. You can measure frequency with a scope or a frequency counter. Shown in Fig. 1 is a simply way to use a scope to measure both frequency and amplitude.

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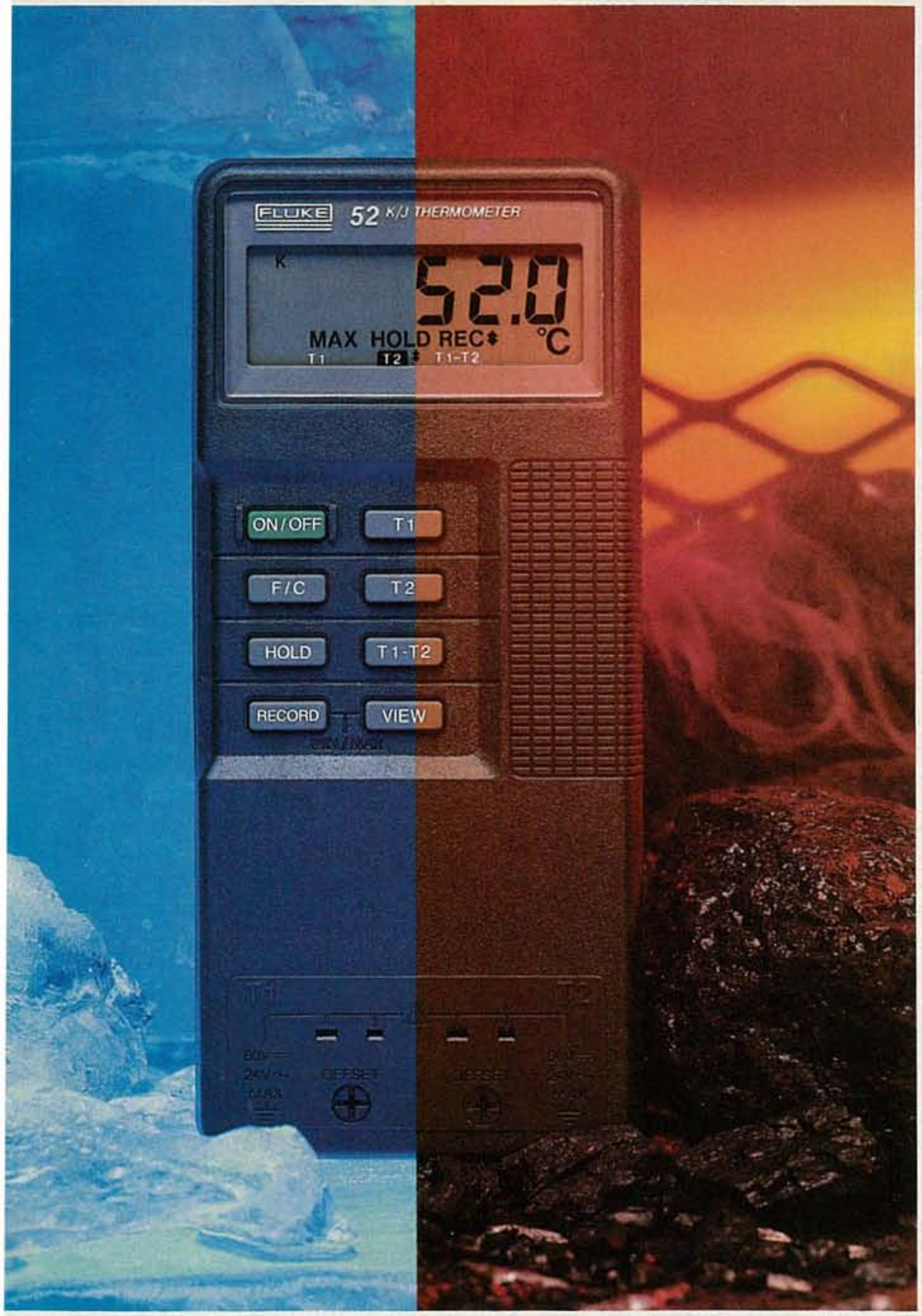

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• 4. Can you supply the names of firms selling low-cost pest repellers like the one shown in Fig. 1 of "Ultrasonic Pest Repellers?"—C. C. D., Hesperia, CA; E. T., Wilkes Barre, PA; W. V., Clifton, Park, NY; and J. M., Santa Barbara, CA.

A number of firms advertise electronic pest repellers. We can endorse neither products nor manufacturers, so—buyer beware.

Bently's, Box 31445 San Francisco, CA 94131; Hanover Square, Building No. 51, Hanover, PA 17333; Bug-A-Way, Phone (800) 222-0354, or Drawer M, Columbia, SC 29250; The Shelburne Co., 110 Painters Mill Rd., Owings Mill, MD 21117; Fina Merchandise Center, 6310 North Western Ave., Chicago, IL 60659.

• 5. I want to build a pest repeller to use outdoors in order to get rid of bees, gnats, flies, etc. Can you help?—J. A., Forest Hills, NY.

I understand that ultrasonic devices have been used outdoors experimentally. They use special transducers and they have much higher power than the repellers described in our story. In some outdoor units sounds in the audible range are emitted, so the devices are not practical for use around people. However, they do have some agricultural applications. You may be able to get more information on outdoor pest repellers from AV-Alarm Corp., 675-D Conger St., Eugene, OR 97402.

• 6. After breadboarding the circuit in Fig. 1 of *Ultrasonic Pest Repellers,* I removed the modulating voltage that is applied to pin 5 of the 555 from the junction of R3 and R4. I measured the un-swept frequency at about 50.5 kHz. How can I measure the overall sweep range?—R. S., Creve Coeur, MD.

Here's one way. Use a scope or multimeter to measure the peak-to-peak value of the modulating voltage at the junction of R3 and R4. Rig up a DC power supply whose output is equal or higher than the peak value of the modulating voltage—a couple of 9-volt batteries in series should suffice.

Connect a potentiometer across the batteries and connect the wiper to pin 5 of the 555. Vary the voltage from zero to the maximum p-p sweep voltage mesured earlier, and monitor the 555's output with a frequency counter. Then reverse the polarity of the supply and measure the frequency swing in the opposite direction.

• 7. I built the circuit in Fig. 1 of *Ultrasonic Pest Repellers* and it works, except that it emits a high-pitched tone that drives some people from the room. What can I do to eliminate that tone?—F. C., Winter Haven, FL.

Evidently, the low end of the sweep frequency is audible and annoying to some people. You can eliminate that annoyance by raising the 555's base frequency of oscillation. Do that by decreasing the value of C1. Try values of 910, 820, or even 750 pF.

SIMPLE POWER SUPPLY

I need a power supply that delivers plus and minus nine volts to replace two nine-volt batteries in a project I'm building. Do you have a suitable design?—N. J. S., Greensboro, NC

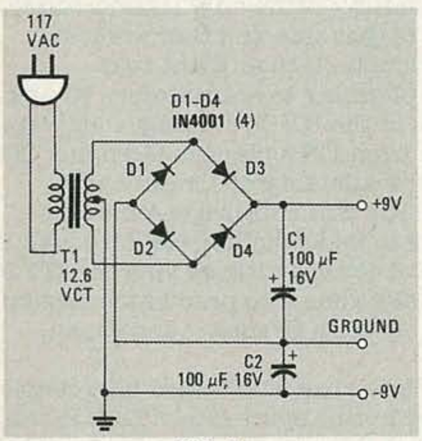

FIG. 2

A ±9-volt supply is shown in Fig. 2. The rectifier circuit is actually two separate full-wave rectifiers fed from the secondary of the transformer. One full-wave rectifier is composed of diodes D1 and D2, which develop +9 volts, and the other is composed of D3 and D4, which develop −9 volts.

Each diode of each diode pair rectifies 6.3 volts AC (half the secondary voltage) and charges the associated filter capacitor to the peak value of the AC waveform, $6.3 \times 1.414 = 8.9$ volts. Each diode should have a PIV (*P*eak *I*nverse *V*oltage) rating that is at least twice the peak voltage from the transformer, $2 \times 8.9 = 18$ volts. The 1N4001 has a PIV of 50 volts. **R-E**

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Competition for 8mm.** The camcorder wars are heating up, as JVC has completely miniaturized its VHS-C system, tripled its recording time to a full hour by adding an EP speed, and added a CCD pickup to compete with the new 8mm-video camcorders. (You'll recall that VHS-C is JVC's miniature VHS format. VHS-C cassettes can be played back by a standard VHS deck through the use of an adapter.) JVC's new little wonder is a complete record-and-playback unit with electronic viewfinder, autofocus, and power zoom; it weighs 2.9 pounds without cassette or battery. The comparable Sony *Video 8* camcorder weighs 4.5 pounds. Sony's little 8mm *Handycam* weighs only 2.2. pounds, but it doesn't play back, and lacks zoom and autofocus.

• **Pocket-TV grows up.** The first major TV brand to introduce a mini set with a color LCD screen is Panasonic, whose *Pocket Watch* uses a 3-inch color LCD. It has an audio-video input for use with a VCR and a pop-up screen with a backlight for night viewing. Its suggested list price is $300. Sharp and Toshiba are also expected to enter the color LCD fold. Meanwhile, some manufacturers are planning some not-so-mini LCD color sets. Citizen has shown a 10.6-inch set and Casio both 6- and 12-inch versions.

• **All networks now in stereo.** With CBS joining the fold in February, all four major television broadcast-networks now are broadcasting at least some programs in stereo, and some 250 TV stations are equipped to pass those programs through to viewers. The EIA estimates that some 240,000 TV sets with built-in stereo reception capability were sold in 1984 and 1,500,000 in 1985. The manufacturer's group forecasts that 2,800,000 will be sold this year. Those figures don't include the sales of other devices that can also receive stereo telecasts, such as stereo-equipped VCR's.

• **1985 records.** Americans bought a record 17,261,312 color TV-sets in 1985, including 265,645 projection-TV systems. That total was up 6 percent from 1984, when the previous record was set. They also bought 11,853,188 home VCR's, an increase of 55.6 percent from 1984.

• **Made in the U.S.A.** Two major components, formerly made only abroad, will soon be manufactured in the U.S. RCA says it will make giant 35-inch direct-view color-picture tubes, with production quantities due in 1988. Mitsubishi currently is the only manufacturer making tubes of that size, and they are just starting production on their giant tube.

Also, ITT is planning to manufacture IC sets for digital TV sets in the U.S. Previously, they were available only from ITT's plant in Germany. ITT hopes that the availability of domestically manufactured IC's will encourage American manufacturers to make digital sets. Although U.S. set makers have developed sets using the ITT IC's, none has actually gone into production. Digital sets are being made in Germany and Japan.

• **Update.** Here's the latest word on a couple of items reported in this space lately: Last February, we reported that Eastman Kodak would market a video-image printer that could make prints from any video source. That project was put in limbo as a result of the court ruling that Kodak was infringing on Polaroid's instant-photography patents. The color printer was designed to use the Kodak instant film now banned by the court. However, Kodak still plans to test-market a companion product—the video floppy disc, which can record or play back up to 50 TV fields.

We originally reported here that General Electric will end its manufacture of color-TV sets and instead buy them from Matsushita Electric. Since that report, GE has agreed to purchase RCA. The two events are unrelated. Even though GE is expected eventually to own RCA and its TV-manufacturing facilities, it still plans to buy its sets from Matsushita, which will build a special plant in Mexico for the purpose. Both companies say that they will continue to market sets under their own brand names in two separate marketing organizations after the merger. **R-E**

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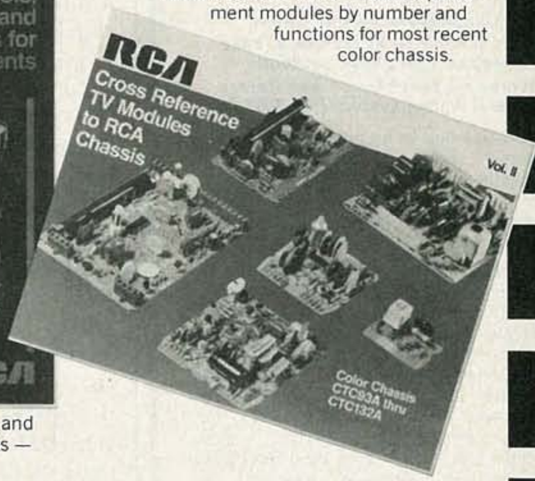
☐ **1F6870** Cross Reference TV Modules to RCA Chassis Vol. II — Lists replacement modules by number and functions for most recent color chassis.



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LETTERS

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I challenge the video and cable-TV industries to establish a standard logic interface for connecting a leased Pay-TV decoder to a subscriber's VCR. The channel selection programmed into the VCR's memory timer would tune the decoder, which would then deliver the baseband video and audio signals to the VCR.

Think of the advantages: 1. Single-point control of channel selection. 2. Elimination of moving parts in the decoder. 3. No need for selector switches or splitters. 4. Better-quality signal due to baseband connection. 5. Simple option to tape one channel and watch another. 6. VCR's with remote controls would have full control.

The technology exists today, since most VCR's and many cable decoders use digital channel selection already. If a simple LSTTL logic interface could be agreed upon, one of cable subscribers' most common beefs would be satisfied.

ERIC G. LEMMON
Lompoc, CA

DIGITAL TV CIRCUITS

Recent articles have appeared discussing the various TV formats such as PAL, SECAM, NTSC, advances like HDTV, new PBS proposed formats such as MAC, and associated signal-handling methods. It seems to me that the TV designers are spending a lot of energy in the wrong direction. I refer mainly to the domestic TV receiver designs using analog methods. Let me explain briefly, and perhaps spark some thought.

If the received broadcast signal were digitized right out of the first IF filter, then the format could be transparent to the display system used. Indeed, the display could be scanless, mapping the data extracted from the signal only as necessary to create the picture; and it would be void of the many interferences caused by relationships between various frequency components in the normal scan and signal elements.

The processor would discover the transmission format, the related color and audio signals, process the data and feed it to the output devices. Thus the TV receiver could be updated easily (with ROM perhaps) to process any new formats and features.

The technology is here today. Why aren't such TV's on the market? Maybe they are, and just not advertised. How about an article on digital TV circuits? I don't mean digital control, I mean real full-scope digital TV from the IF out.

I enjoy **Radio-Electronics!**

GENE SIMMONS
Riyadh, Saudi Arabia

A HAPPY NEW SUBSCRIBER

I am a new subscriber to your magazine and just wanted to let you know what a great surprise your magazine is for me. For years I subscribed to *Popular Electronics,* which became *Computers & Electronics,* and then became extinct. My interest has always been in the digital electronics area, and I thought that *Popular Electronics* was the only magazine that covered the subject. I knew that your magazine existed, but I had always assumed it was strictly for those interested in analog electronics. Well, at the demise of *Popular Electronics* I began to look

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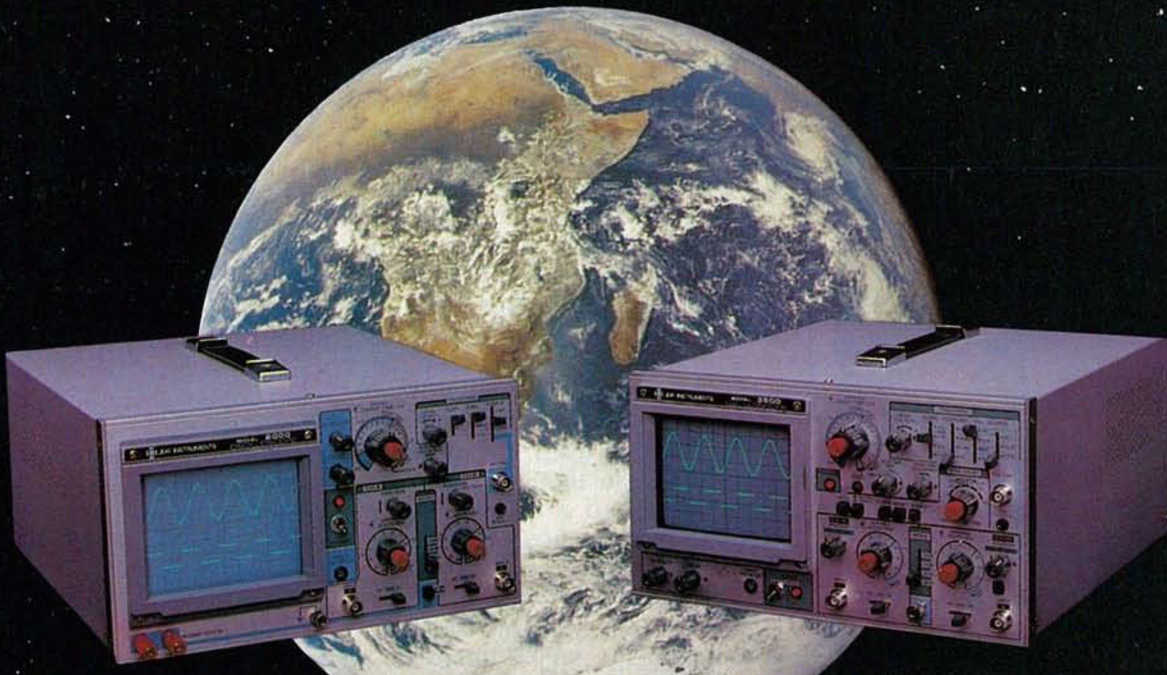

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for an alternative; a friend assured me that my assumptions were wrong and that **Radio Electronics** was for me—and the rest is history.

I am up to my third issue and I haven't been disappointed yet. As a matter of fact, I'm quite pleased and excited. I have a great interest in home-control system design and I'm planning some experiments using the Commodore-64 as the development and control processor, with additional hardware and software that I have designed. I'm looking foward to building the Printer Buffer and EPROM Burner covered in your August and September 1985 issues. I am hoping to download custom software to EPROM's to be used in my control system. Could you recommend kits for making circuit boards from the foil patterns that are included in your articles? I designed circuit boards in college, but the process was tedious, and it involved very expensive equipment. I would greatly appreciate any information you could send me on PC-board design and construction. Is it possible that you will do something on that subject in a future issue?
THOMAS F. DUNIGAN
Plymouth, NH

We may do an article on that subject, Tom, but to tide you over, you might check the December 1982, January 1983, and February 1983 issues of **Radio-Electronics** *for an excellent three-part article by Robert Grossblatt on that subject. A shorter treatment by the same author appears in the September and October 1985 issues of* **Radio-Electronics.** *In addition, we have a reprint of several articles on designing and etching PC boards available. See the reprint order form elsewhere in this issue.—Editor*

RESTORING AN OLD MARCONI

I am trying to restore an old Marconi TV set (TV 500 chassis) to its original working condition, but I am unable to find a schematic or repair manual from the usual sources. The chassis appears to have a problem in the horizontal phase detector circuit, which is a type I have not encountered before. I would appreciate any help you or your readers could give me in locating information about that chassis.
P.G. DODD
18 Lakeland Cres.,
Scarborough, Ontario,
Canada M1G 2L3

SMALL LOW-COST PROJECTS

I have been enjoying **Radio Electronics** for about a year now, and I find it to be a worthwhile and enjoyable expenditure of time and money. I read with interest the flap about **Radio-Electronics**'s turning into another computer magazine, and I think you are doing rather well on that subject. Ignoring computers at this time would as ludicrous as leaving out TV because this is a "radio" magazine; but I hope you continue to stick to computer "electronics" and leave the software to someone else.

My reason for writing, however, concerns some of the projects you've published lately. While the $2500 IBM look-alike ("PC Compatible Computer," July, 1985) would be great to build, and was fun to read, and while a $200 see-in-the-dark doo-hickey ("See-In-The-Dark Viewer", August, 1985) would be fun for a few weeks, how practical is it really, and how many of your thousands of readers have hundreds of bucks to spend on that type of "tinkering?"

I think I speak for a number of people who would like to see some small, low-cost, beginners' projects for those of us who are still new at this. One suggestion would be tuning and construction of garage door-opener transmitters and receivers. I have two or three of each, but none match. Building a 12-volt transmitter to permanently mount under the hood and match to your existing receiver would be a great little project. Home security seems to be pretty popular right now, also. I don't believe that projects have to be on the cutting edge of technology to be useful and timely.
TROY B. LAMINACK
Dumas, Texas

Troy, we sympathize with you, and that's why we created **Hands-on Electronics,** *our sister publication. We like your garage-door-opener idea; get busy, designers! And, by the way, for an interesting*

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approach to a complete home-security system, see the December, 1985, and January, 1986 issues of **Radio-Electronics.**—*Editor*

INTERESTED IN OLD-TIME RADIO EQUIPMENT

Since **Radio-Electronics** readers are interested in old-time radio equipment and pioneers like Tesla, Marconi, DeForest, and Armstrong, I have a request. Does anyone anyone know where to borrow, rent, or buy an Alexanderson Alternator that could be made to work?

How those things operate fascinates me, so any written material on the subject would be welcome. If my understanding is correct, one could get one of those things on the air with little more than a big carbon microphone, and without vacuum tubes. Is that so?

The Alexanderson is a relatively unknown item from radio history, and as such it would make a good display at the Tesla "Unconvention" here in California next July. The attendees will definitely be interested in that type of demonstration.

PETE LEFFERTS
1640 Decker Ave.
San Martin, CA 95046.

COMB FILTERS FOR YOUR TV

In Neil W. Heckt's August, 1985 article, "Comb Filters for your TV," Mr. Heckt derives 3,579,485 Hz. as the chrominance subcarrier (S.C.) frequency. As you can see from the FCC's *Rules and Regulations*, Section 73.682, paragraph five:

The chrominance subcarrier frequency is 63/88 times precisely 5 MHz (3.57954545...MHz). The tolerance is ±10 Hz and the rate of frequency drift must not exceed 0.1 Hz per second (cycles per second squared)

The chrominance subcarrier is the only number that is specifically enumerated (3,579,545 Hz.) and all other values are derived from it, not the other way around.

If Mr. Heckt is just using the figures in his article for the sake of clarity in his explanation, he should indicate that usage.

ARBY SCHUMAN
Megazap Telemetry Systems

You are indeed correct regarding the derivation of the horizontal-scanning frequency from the specified color-burst frequency rather than the other way around as I stated in my article.

The relationship of horizontal, vertical, and color burst frequencies, rather than their exact values, is the most important aspect of the spectral nature of the NTSC signal; those relationships define how to separate chrominance from luminance information.

I simplified the values of the frequencies and their derivation, and I concentrated on their relationship, most important of which is that the color burst flag is 455/2 times the horizontal sampling frequency (i.e., CBF=(455/2)HSF.

You are correct in pointing out that the inverse mathematical relationship is specified by the FCC, (i.e., HSF=(2/455)CBF, and that the actual CBF=3.57954545 MHz.
—Neil W. Heckt

THANKS FOR THE HELP

My recent request for help in your magazine resulted in three responses, one of which was a complete owner's manual for the Sansui AM/FM receiver I was having trouble with! Another response was a full-page typed letter describing practical approaches to trouble-shooting and fault location in the absence of a schematic.

Now I need an address where I can obtain operating instructions for a DORO 311 telephone-answering machine manufactured for Dictran International by Victor Co. of Japan.

M. MCDANIEL
940 Temple ST.
San Diego, CA 92106

CORRECTION

Sharp-eyed reader Chris Bassett, of the Bronx, NY, called my attention to an error that crept into the text of my article, "All About Multipath Distortion" in the October, 1985 issue of **Radio-Electronics**. On page 76, in the center column between the first and second paragraphs, the formula for horizontal spacing (H) is given as $(\lambda/2) \sin \theta$. The parentheses were wrongly placed; the formula should be:

$$H = \lambda/(2 \sin \theta)$$

BOB SCOTT
Darlington, SC

R-E

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EQUIPMENT REPORTS

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Finds cable shorts and opens in a flash

CIRCLE 5 ON FREE INFORMATION CARD

ANYONE INVOLVED WITH ELECTRONICS knows that one of the toughest problems to troubleshoot is a cable problem. Often, the only time-effective solution is to junk the cable and replace it.

But what if you are a CATV contractor who has just spent the better part of a week wiring up a new complex, only to find out that a cable fault somewhere along the way is depriving half of your new customers of their signal? Troubleshooting each run of cable using conventional methods, if even possible, can take forever, and ripping out the cable and starting over means a great deal of wasted effort and money.

A better solution would be to use Triplett's (One Triplett Drive, Bluffton, OH, 45817) new model *6500* cable-fault locator. That device can track down the location of a short or open in a cable to within one foot.

Finding faults

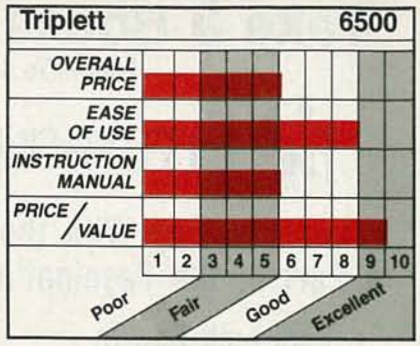
The model *6500* can detect and identify the location of faults, and measure cable length, for cables that range from 15 to 6000 feet (5 to 2000 meters). It can be used with a variety of cable types including, but not limited to, coax, twisted

pair, power cord, and multi-conductor shielded cable (although in high-density, multi-conductor cables, the range may be somewhat restricted due to high inter-conductor capacitance).

Measurements are displayed on a 4-digit LCD readout. Annunciators on the readout indicate whether a cable fault is a short or open, and whether the displayed distance is in meters or feet.

The cable to be measured is connected to the unit via a front-panel BNC jack. If more convenient, the cable can be connected via binding posts if the included binding-post-to-BNC adapter is used.

In most ways, the unit is very easy to use; we'll get to the exception in a moment. All operation is controlled via four front-panel controls. Three pushbuttons are used to turn the unit on or off; set the measurement units, either meters or feet, and to set the range, either short (15–600 feet) or long (600–6000 feet).



The fourth control, a pushbutton counter, requires a bit more explanation. It is used to select the cable's NVP (*N*ormal *V*elocity of *P*ropagation). That quantity is equal to the reciprocal of the square root of the cable's dielectric constant ($1/\sqrt{\text{dielectric constant}}$, and is different for different types of cables. For instance, coax using a polyethylene dielectric usually has an NVP of 66. Often, the NVP can be found in or derived from the cable's data sheets. If not, the value must be determined experimentally. That's the exception that was referred to previously.

To find the NVP of the cable to be tested, a 15- or 30-foot length of the same cable must be connected to the *6500*. Then, at an ambient temperature of 23°C (±5°C), different settings of the NVP switch are tried until the readout displays 15 or 30 feet (depending on the length of the test cable). Once the NVP of the cable is determined, it should *definitely* be written down for future reference.

Housed in a black high-impact plastic stand with bale-type handle, the *6500* is powered by 6 C-sized nickel-cadmium batteries. Also included is an AC adapter/battery-charger, and car-cigarette-lighter adapter.

The manual that accompanies the unit is a bit sketchy and sloppily done. It provides a fair explanation of how the unit is used, and gives some specifications, but does little else. Notably, there is no schematic, theory of operation, or similar information.

At a list price of $550, this is not a product aimed at the hobbyist market. But if you are involved with the installation, maintenance, or repair of cables, the time and aggravation that the *6500* can save you is well worth its cost. **R-E**

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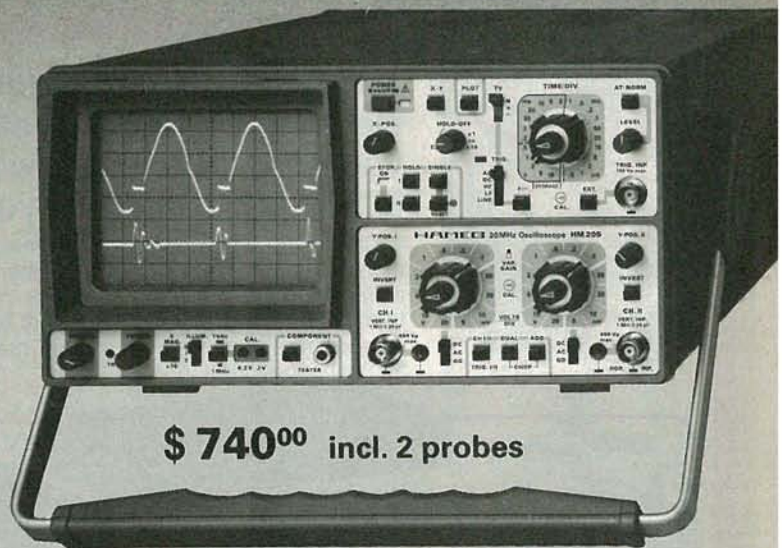

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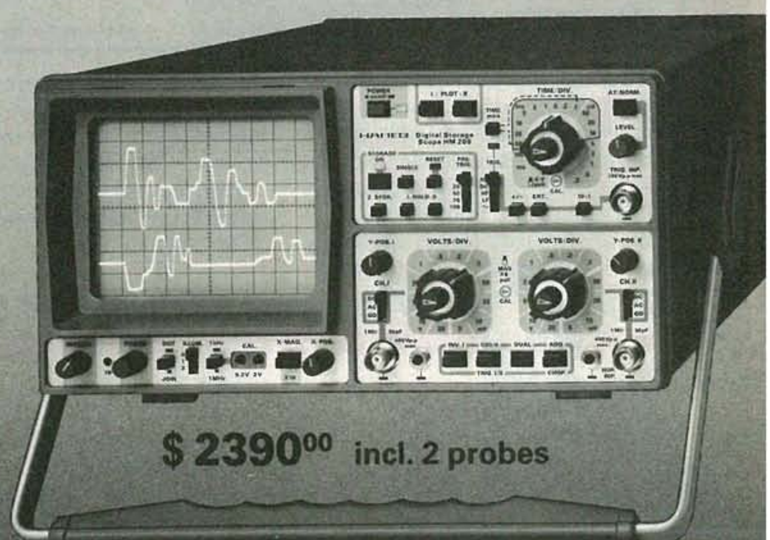

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Regency MX-7000 Scanner/Receiver

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CIRCLE 6 ON FREE INFORMATION CARD

WHEN WAS THE LAST TIME YOU TOOK A close look at a scanner? Granted, they've been around long enough now to be taken for granted. But some of the new ones, like the Regency (7707 Records St., Indianapolis, IN 46226) *MX-7000* merit a closer look; those units feature some innovative uses of state-of-the art technology.

The *MX-7000* is a microprocessor-controlled scanner/receiver. That unit's PLL tuning section features continuous coverage of the frequencies between 25 and 512 MHz, and 800 MHz and 1.1 GHz. Among the scanner's more unusual features are memory retention for up to a week without battery backup, and adjustable bandwidth. Other features include a 20-channel memory, dual scanning speeds, and a built-in clock.

A powerful package

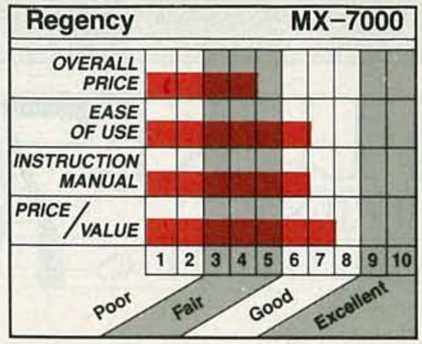
The *MX-7000's* technology is packed in a case that measures just $5.4 \times 3.1 \times 7.9$ inches. The unit weighs a light 2.4 pounds. A nice touch is the slanted front panel. That design places the front panel, with its membrane keyboard and LCD readout, at a convenient angle for viewing and use. The front panel also sports a power switch; volume control; squelch control; display-light switch, which allows you to illuminate the readout in less-than-optimum lighting conditions; and keypad lock, which

when activated locks out the key-pad to prevent accidental entries.

The keypad is used to select operating modes as well as frequencies. The available modes include scan, search, frequency lockout, priority and clock. Further, the upper and lower search-limits, receiver bandwidth, scan delay, scan speed, time of day (for the clock), and memory selection are set using the keypad.

The selectable bandwidth is an especially useful feature as it helps ensure clean, clear reception. On scanners that use fixed bandwidths, distortion and adjacent-channel interference are common problems, especially when monitoring narrow-bandwidth FM transmissions. With the *MX-7000*, if you are listening to an area of the spectrum where most communication is done using 5-kHz narrowband FM, you can program the scanner for a 5-kHz bandwidths. Other available bandwidths are 12.5 and 25 kHz.

The unit offers 20 memory-locations, or channels; those are preprogrammed for some of the most popular listening frequencies. However not all frequencies are equally popular in all areas. To



change the frequency stored in one of the channels is not difficult, but the procedure is more complicated than with most other scanners. It involves three different keying sequences, selecting the programming mode (narrowband FM, wideband FM, or AM), frequency, and channel.

On the rear panel of the scanner are found the power, antenna, and external-speaker connectors. The unit requires 13.8-volts DC. For fixed use, that power is provided by the included wall-plug power supply.

Rather than the traditional Motorola connector used by most scanners, the antenna connector on this unit is a BNC type. The advantage of that type of connector is that it is more secure.

Though the unit features its own built-in speaker, a connector is provided if you wish to use an external unit. Note that for best performance only eight-ohm speakers should be used.

Also, a 10-dB attenuator is switch selectable from the rear panel. That allows you to deal with signal-overload problems, such as those that occur when you are near a powerful transmitter.

As to specifications, they are impressive for a unit of this type. For starters, receiver sensitivity is 1.0 μV at 12 dB SINAD on the narrowband-FM setting and 1.5 μV at 12 dB SINAD on the wideband-FM setting. On AM, the sensitivity is 1.5 μV at 10 dB S/N.

Selectivity is 7.5 kHz at 6 dB down for narrowband FM; 50 kHz at 6 dB down for wideband FM, and 5 kHz at 6 dB down for AM.

Image and spurious-signal rejection is better than 50 dB down, while intermodulation rejection is better than 50 dB down.

The instruction manual is com-

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AN EXCELLENT VALUE! Don't be fooled by someone else's "low" price on a "dish" that is SMALLER than ours... NOT as high-tech... or is INCOMPLETE and requires costly purchases of additional components. With our KLM 8-ft. "dish" you get a complete, superior quality system from a leader in the industry... at a remarkably low closeout price!

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INCLUDES ALL THIS, TOO!

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Uncomplicated, easy operation! Fast fingertip selection of channel, polarity, audio tune. Relative signal strength meter lets you hit station right on the button. Separate AFC on/off selector allows precision tuning, even of weak channels.

INCLUDES blockdown converter (an expensive option on competitor's models). This splits signals so 2 TV sets in your home can "tune in" on 2 different channels of same satellite at same time. However, you need another receiver (available from regular KLM dealers) for the second TV set.

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This special mount delivers 180° range for maximum degree of "dish" rotation for access to TV satellites in western hemisphere. 120 feet of cable also included.

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HOW TO SELECT A PROPER SITE

Stand in your yard, look due South and side to side. You should have an unobstructed view of the sky. Tree branches and power lines diminish quality of reception.

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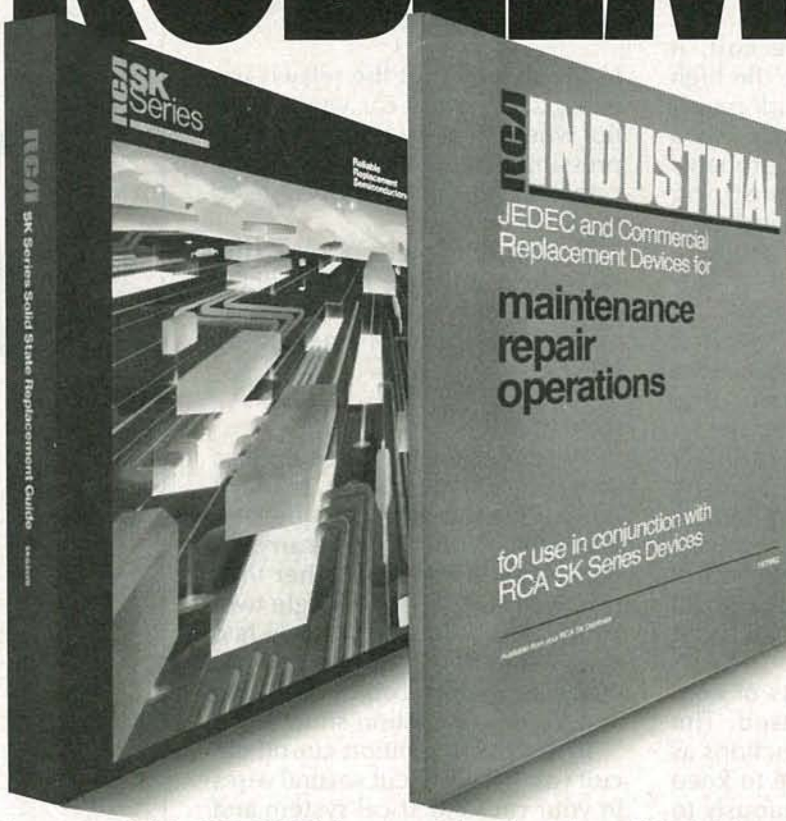
plete and covers the major features of the scanner completely. It also touches on the major specifications. Overall, it's well done.

As to the price, at a suggested list price of $699.95, the scanner is not cheap. Even with discounting, it's cost will likely limit the *MX-7000's* appeal to only the most serious of scanner enthusiasts. But for those serious scanner enthusiasts, the *MX-7000* is worth a listen. With its extended frequency coverage and its ability to tailor each receive channel to the particular requirements of the radio service being monitored, it's a powerful unit. **R-E**

2 SIMPLE SOLUTIONS TO 227,000 PROBLEMS.



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*Joint Electron Device Engineering Council

RCA SK Replacement Solid State

NEW IDEAS

Simple circuit foils car thieves

IF YOU LIVE IN A HIGH-CRIME AREA AND operate an automobile, you're probably afraid that someday your car will be stolen. Well, so was I—until I built and installed the ignition cutoff circuit described here. Since then I sleep much easier. And the circuit has another benefit: Many insurance companies will reduce your rates if you install a cutoff circuit like mine.

What my circuit does is give you manual control over the voltage that goes to your car's coil. If 12 volts doesn't reach the coil, it won't be able to provide the high voltage that fires the spark plugs. The starter will still work, so a would-be car thief will probably think that there's something wrong with your car—and he'll leave it alone.

How it works

As shown in Fig. 1, the heart of the circuit is a 4PDT relay and a hidden pushbutton switch. That switch, the relay's coil, and the ignition switch are all wired in series, so both switches must be closed simultaneously to energize the relay. And since the coil current flows through the relay's contacts, the relay must be energized or current won't get through to the coil.

The relay has four sets of contacts and all four are used. The lowest set of contacts functions as a latch so you don't have to keep your finger on S2 continuously to keep coil current flowing. Those contacts simply keep S2's terminals shorted after the relay has been energized; that short ensures that the relay will remain energized until the ignition switch is opened.

Working upward, the next set of contacts is used to provide visual indication of what's happening. After closing the ignition switch

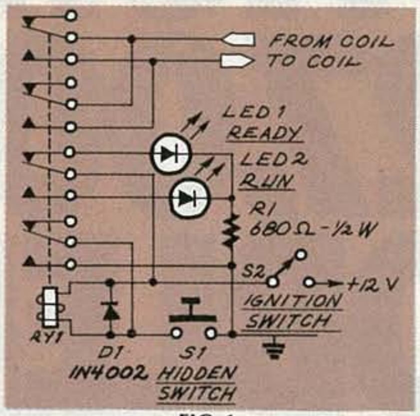


FIG. 1

LED1 turns on, but the relay is unenergized, so the car won't start. But when the relay is energized by pressing S2, LED2 lights up to indicate that you should be able to start the car now.

The upper two sets of relay contacts are simply wired in parallel to provide plenty of current-carrying ability for the coil-energizing pulses.

Construction

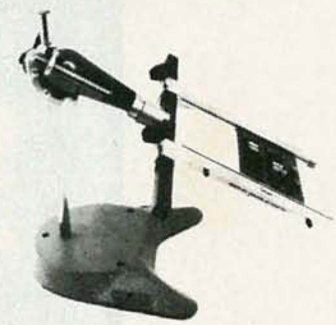
The circuit can be wired up on a scrap piece of perfboard. None of the parts are critical; just be sure that the relay you use can carry the required coil current. Rather than use two LED's, I used a single two-color device. That way I only had to drill one hole. Be sure to wire a diode across the coil of the relay, and in the orientation shown.

To install the ignition cut-off circuit you'll have to cut several wires in your car's electrical system and splice in leads to your circuit board. You'll have to cut the 12-volt ignition-switch wire and the 12-volt coil-supply wire. When you connect your patches to the circuit board, make sure to use wire that is *at least* as large as the wires you just cut. And make sure to make good connections—electrically and mechanically—to the coil wires.—*Ronald L. Goers.*

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.



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Super Disk™ Diskettes

Now...Diskettes you can swear by, not swear at.

Lucky for you, the diskette buyer, there are many diskette brands to choose from. Some brands are good, some not as good, and some you wouldn't think of trusting with even one byte of your valuable data. Sadly, some manufacturers have put their profit motive ahead of creating quality products. This has resulted in an abundance of low quality but rather expensive diskettes in the marketplace.

A NEW COMPANY WAS NEEDED AND STARTED

Fortunately, other people in the diskette industry recognized that making ultra-high quality diskettes required the *best* and newest manufacturing equipment as well as the best people to operate this equipment. Since most manufacturers seemed satisfied to give you only the everyday quality now available, an assemblage of quality conscious individuals decided to start a new company to give you a new and better diskette. They called this product the *Super Disk* diskette, and you're going to love them. Now you have a product you can swear by, not swear at.

HOW THEY MADE THE BEST DISKETTES EVEN BETTER

The management of *Super Disk* diskettes then hired all the top brains in the diskette industry to make the *Super Disk* product. Then these top bananas (sometimes called floppy freaks) created a new standard of diskette quality and reliability. To learn the "manufacturing secrets" of the top diskette makers, they've also hired the remaining "magnetic media moguls" from competitors around the world. Then all these world class, top-dollar engineers, physicists, research scientists and production experts (if they've missed you, send in your resume to *Super Disk*) were given one directive...to pool all their manufacturing know-how and create a new, better diskette.

HOW SUPER DISK DISKETTES ARE MANUFACTURED

The *Super Disk* crew then assembled the newest, totally quality monitored, automated production line in the industry. Since the manufacturing equipment at *Super Disk* is new, it's easy for *Super Disk* to consistently make better diskettes. You can always be assured of ultra-tight tolerances and superb dependability when you use *Super Disk* diskettes. If all this manufacturing mumbo-jumbo doesn't impress you, we're sure that at least one of these other benefits from using *Super Disk* diskettes will:

1. TOTAL SURFACE TESTING - For maximum reliability, and to lessen the likelihood of disk errors, all diskettes must be totally surface tested. At *Super Disk*, each diskette is 100% surface tested. *Super Disk* is so picky in their testing, they even test the tracks that are in between the regular tracks.

2. COMPLETE LINE OF PRODUCTS - For a diskette to be useful to you and your computer, it must be compatable physically. *Super Disk* has an entire line of 5¼-inch and 3½-inch diskettes for your computer.

3. SPECIALLY LUBRICATED DISK - *Super Disk* uses a special oxide lubricant which is added to the base media in the production of their diskettes. This gives you a better disk drive head to media contact and longer head and disk life.

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6. DISK DURABILITY - *Super Disk* diskettes will beat all industry standards for reliability since they will give you more than 75% of the original signal amplitude remaining even after an average (Weibul B-50) of 30 million passes. They are compatible with all industry specifications as established by ANSI, ECMA, ISO, IBM and JIS.

7. CUSTOMER ORIENTED PACKAGING - All *Super Disk* disks are packaged 10 disks to a carton and 10 cartons to a case. The economy bulk pack is packaged 100 disks to a case without envelopes or labels.

8. LIFETIME WARRANTY - If all else fails, remember, all disks made by *Super Disk* Inc., have a lifetime warranty. If any *Super Disk* diskette fails to meet factory specifications, *Super Disk* Inc. will replace them under the terms of the *Super Disk* warranty.

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Now, you can buy Super Disk brand diskettes directly from Communications Electronics at prices less than "unbranded" generic diskettes. Your data is valuable, so why take chances using a diskette that could be so unreliable that the manufacturer refuses to put their name on it. To save you even more, we also offer Super Disk bulk product where 100 diskettes are packed in the same box without envelopes or labels. Since we save packaging costs, these savings are passed on to you. 5¼" diskette envelopes are also available from us. These super strong and tear-resistant envelopes are only $10.00 per pack of 100. Use order # CV-5 for a 100 pack of 5¼" diskette envelopes.

39¢ per disk Quantity One

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SAVE ON SUPER DISK™ DISKETTES Product Description	Part #	Super Disk price per disc ($)
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5¼" SSDD Soft Sector w/Hub Ring	**6481-FA**	0.68
5¼" Same as above, but bulk pack w/o envelope	**6487-FA**	0.43
5¼" DSDD Soft Sector w/Hub Ring	**6491-FA**	0.74
5¼" Same as above, but bulk pack w/o envelope	**6497-FA**	0.49
5¼" DSQD Soft Sector (96 TPI)	**6501-FA**	1.09
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5¼" DSHD for IBM PC/AT - bulk pack	**6667-FA**	2.07
3½" SSDD (135 TPI) - bulk pack	**6317-FA**	1.67
3½" DSDD (135 TPI) - bulk pack	**6327-FA**	1.99

SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; DSQD = Double Sided Quad Density; DSHD = Double Sided High Density; TPI = Tracks per inch.

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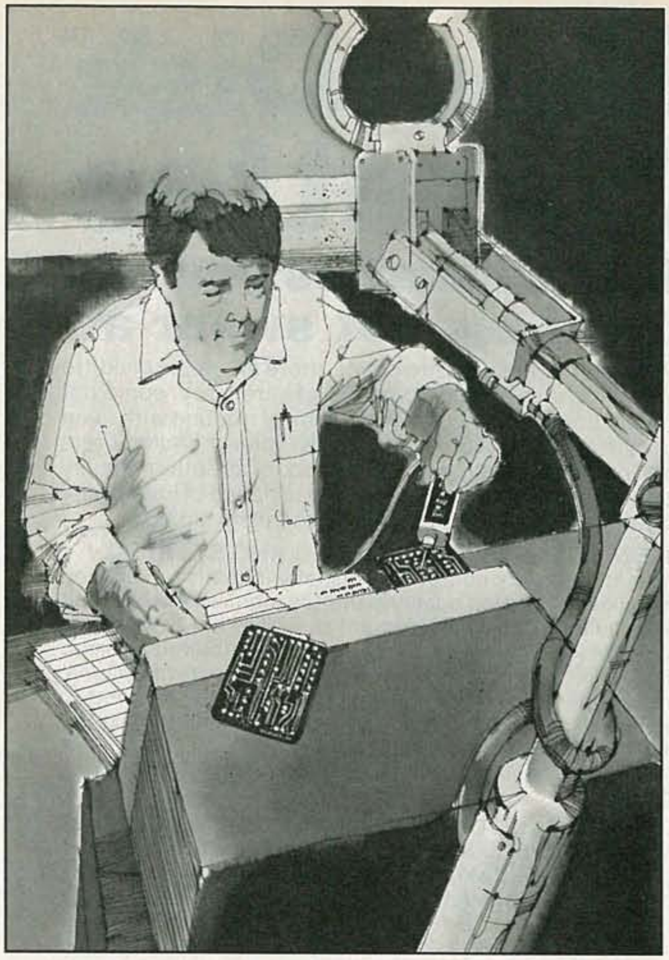
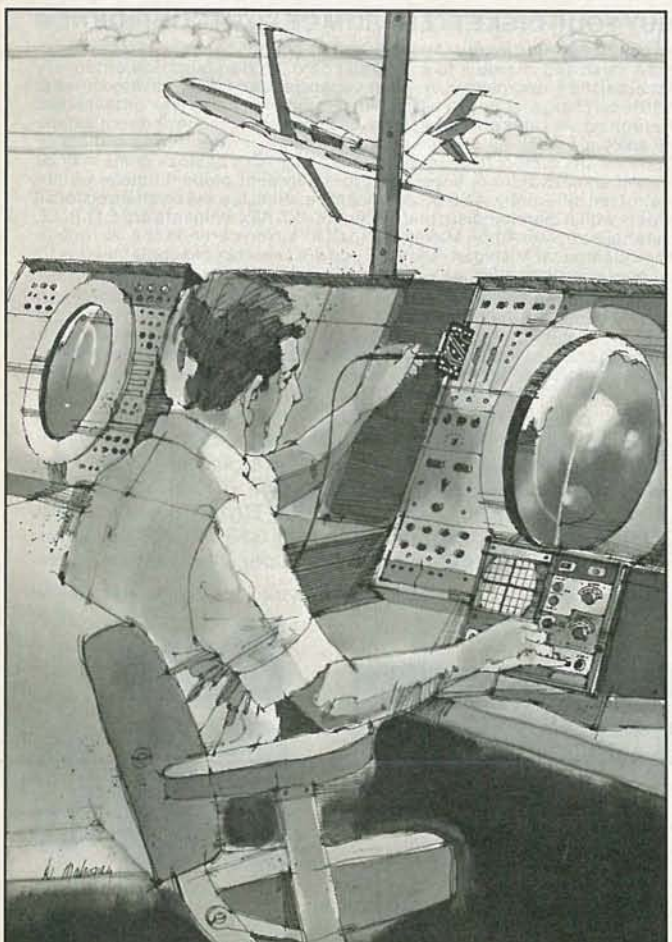
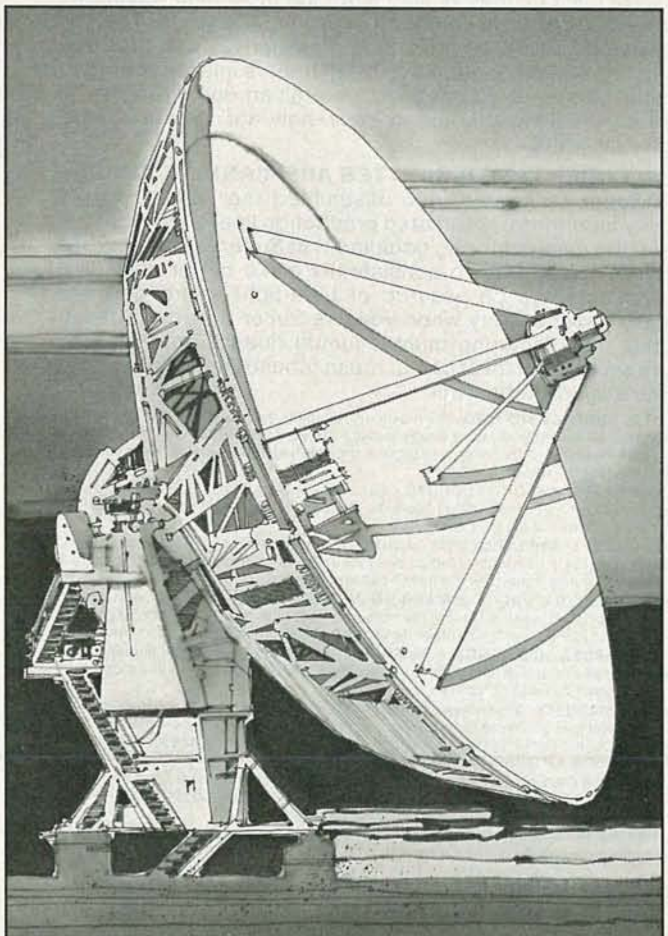
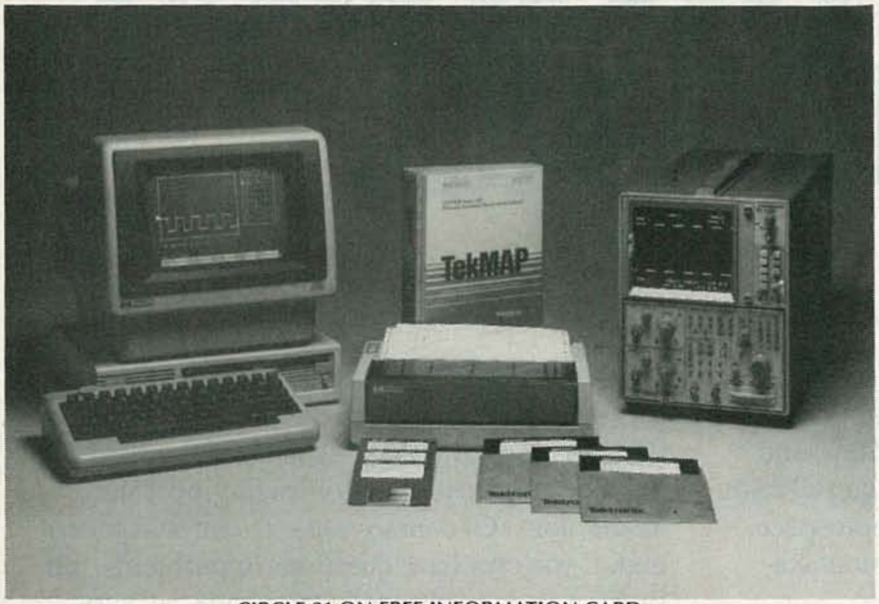




NEW PRODUCTS



CIRCLE 21 ON FREE INFORMATION CARD

SOFTWARE PACKAGES link the Tektronix model *7854* Digital Storage Oscilloscope and the model *7D20* Programmable Digitizer (shown) to IBM and Hewlett Packard computers. The software packages are designated the *7854/HP* Series 200, the *7D20/HP* Series 200, and the *7D20/IBM PC* time and amplitude measurement software.

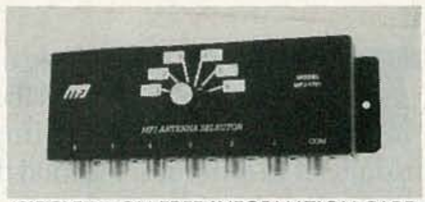
With the *7854/HP* Series 200 software, laboratories can build programs and issue commands to the *7854* from the computer. Programs can be stored in the computer memory or on disk. Like the other HP program, up to six waveforms can be shown simultaneously in different colors on the *HP 9836C*. The program is priced at $950.00.

With the *7D20/HP* Series 200 software, laboratories can use the computer to store front-panel setups on the *7D20*. When needed, the setups can be recalled for automatic waveform acquisition or other test and measurement functions. The software for the HP computers is written in HP BASIC 3.0. The programs are written in modules, enabling users to break out subroutines, such as the functions necessary for propagation-delay measurements, and append them to their own programs. The package is priced at $950.00.

The TekMap *7D20/HP IBM PC* time and amplitude measurement software operates with autoranging routines that automatically set up the *7D20* for positive or negative edge triggering, or for several repetitions of a signal for period measurements. Hence users can avoid spending time finding optimal settings. Calculating functions for waveform analysis include adding, subtracting, multipying, dividing, offsetting, integrating, differentiating, or smoothing test and measurement data.

The menu-driven software runs on MS-DOS 2.1 or higher. It is written in C and executes all functions quickly. It is priced at $450.00.—**Tektronix, Inc.**, P.O. Box 500, Beaverton, OR 97077.

ANTENNA SWITCH, the model *MFJ-1701,* has six positions that enable the user to switch antennas with the turn of a knob. It has SO-239 connectors and there is negligible insertion loss, as well as low VSWR and low crosstalk between adjacent outlets. All unused terminals are automatically grounded for static/lightning/RF protection.



CIRCLE 22 ON FREE INFORMATION CARD

The model *MFJ-1701* can be used with 52- to 75-ohm systems, and it can be mounted with equal ease on a desk or on a wall. In addition, it handles 2000 watts SSB, 1000 CW. It is priced at $29.95, plus $5.00 shipping and handling.—**MFJ Enterprises,** Inc., P.O. Box 494, Mississippi State, MS 39762.

DIGITAL MULTIMETER, model *4800,* can measure DC and AC voltage and current, resistance, frequency (channel A, 10 Hz to 100 MHz; channel B, 10 Hz to 1000 KHz), period, dBm, diode test, continuity test and temperature (with K-type thermocouple). Also

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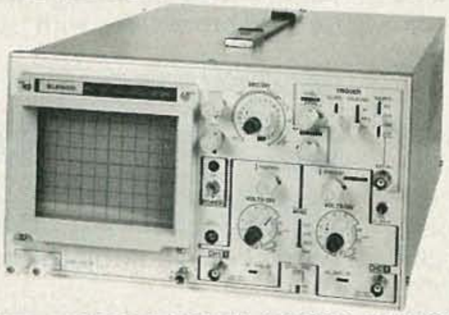

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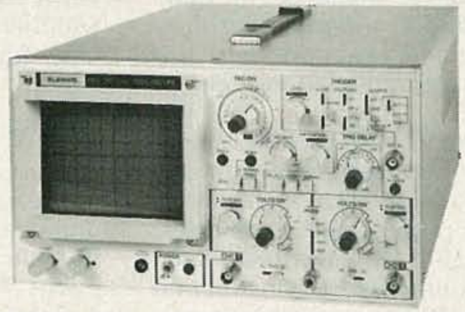

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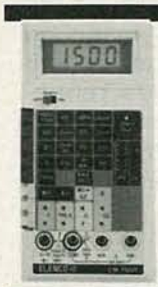

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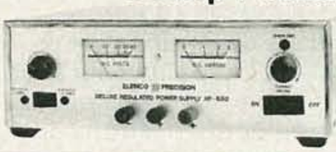

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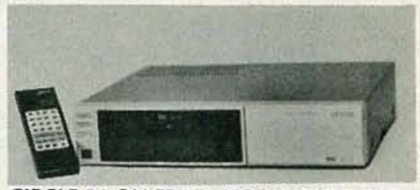
included are comparative, data hold, peak hold, relative, and auto-ranging functions. The 5-digit LCD display indicates pushbutton-selected functions and low line voltage and overrange conditions.

The model *4800* provides multiple-fuse overload protection and recessed lead jacks. Accessories include: power cable, spare fuses, signal cable, alligator test leads, and a comprehensive instruction manual. Optional accessories include various K-type thermocouples, bench "hold" probe, and 10-amp measurement probe.

The model *4800* is priced at $600.00.—**Triplett Corporation,** One Triplett Drive, Bluffton, OH 45817.

REMOTE-PROGRAMMABLE VCR, the model *VR4100,* is designed to deliver sharper pictures, more natural colors, and less video noise. Its features include a 14-day, eight-event timer that can be programmed, using an onscreen display, with the VCR's infrared wireless Computer Space Command remote-control transmitter; built-in MTS decoding circuitry (for TV broadcasts with stereo-



CIRCLE 24 ON FREE INFORMATION CARD

sound or second-language programming) that makes it possible to upgrade any non-stereo TV set to stereo-TV sound, and a 178-channel quartz tuning system.

Recordings made on the model *VR4100* can be played back on any VHS deck, and tapes made on other VHS machines can benefit from the model *VR100's* refinements. Its suggested retail price is $1099.95.—**Zenith Electronics Corporation,** 1000 Milwaukee Avenue, Glenview, IL 60025.

ANTI-STATIC BINDERS are standard 3-ring notebook binders in static dissipative and conductive polyethylene material. They are designed for use anywhere that static may cause problems. Available in blue, black, or yellow matte (non-glare) finishes, the binders are embossed with the words "ESD PROTECTION," and carry the military static/RFI insignia on the front cover.

CIRCLE 25 ON FREE INFORMATION CARD

Standard dimensions are 9" × 11½" in 1" or 3" capacity, with a variety of custom sizes and optional multi-ring configurations available. Customer-specified front-cover embossing is available for an additional charge in minimum-quantity orders of 500. Otherwise, in 500-piece quantities, binders are priced at $4.28 each.—**Controlled Static,** 9820 Jersey Avenue, Santa Fe Springs, CA 90670. **R-E**

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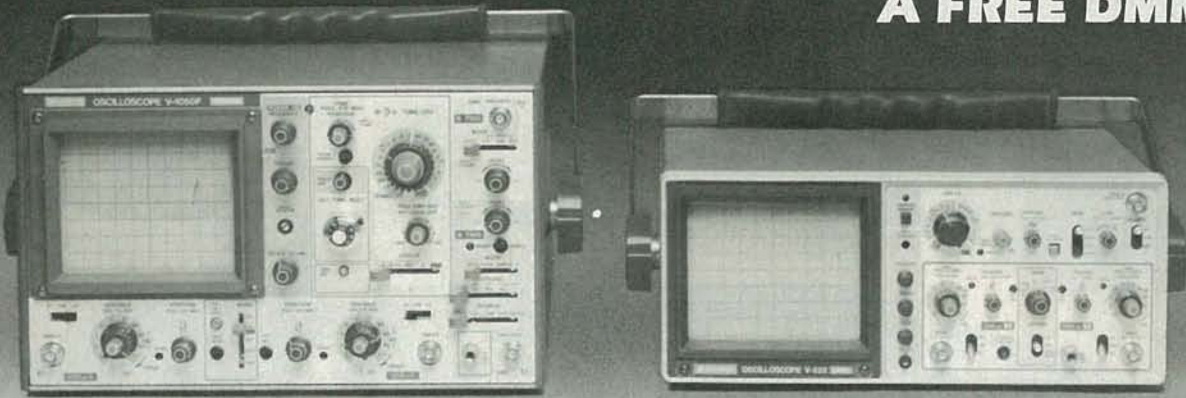

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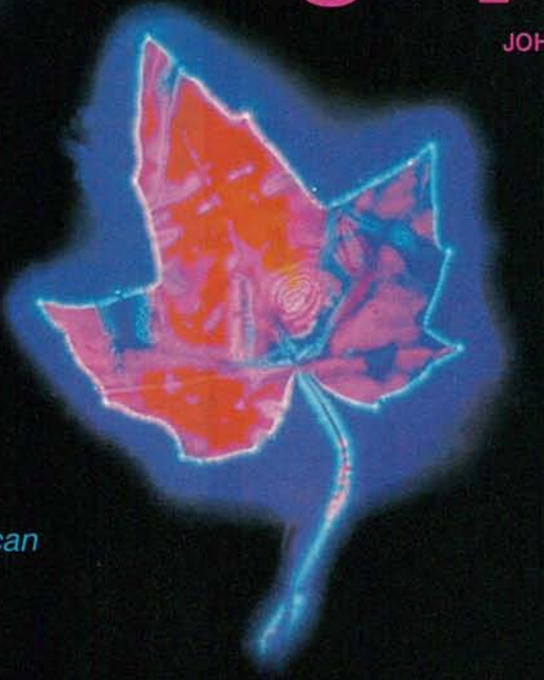
Make Kirlian Photographs

JOHN IOVINE



In this article we explore the mysteries of Kirlian photography and show you how you can investigate the phenomenon yourself!

LABORING IN RELATIVE OBSCURITY, SEYMON KIRLIAN (pronounced keer-lee-an) began his work in electrophotography in 1939. Over 40 years later, that work is still the source of much speculation and controversy. That's because it has been claimed that Kirlian was able to use auras that surround the subjects in his electrophotographs to detect illness in plants and animals before any other outward symptoms were visible. True or not, those claims sparked a great deal of interest in the field of electrophotography; so much so that electrophotography is today commonly called Kirlian photography.

What is it?

In Kirlian photography a high-frequency, high-voltage source is used to produce images on photographic film. It does so without the benefit of a camera, lenses, or light, so it can, in some ways, be likened to X-ray photography.

The only thing that is known for certain about the Kirlian auras is that they exist. The nature of those auras is the subject of much conjecture.

Many of the theories used to explain the effect read like excerpts from a science-fiction novel. One theory is that all substances, and in particular living organic matter, contain and are surrounded by what can be described as a matter-energy field. When a high-frequency, high-voltage charge is introduced in that field, it becomes, or behaves like, a superconductive plasma. The laws of physics that govern such a plasma are complex, involving an extended form of Einstien's Theory of Relativity. The aura that surrounds objects in Kirlian photographs then might be that plasma.

Whatever the nature of the auras, Kirlian photography is getting some serious attention in some very serious places. And the U.S. government has even gotten into the act—one of the leaders in the investigation of the Kirlian aura was the Biochemistry Laboratory at the Naval Air Development Center, in Warminster PA. (Unfortunately, that unit is now disbanded).

While a great deal of research has already been done on the subject, a great deal more still needs to be done before we'll know for certain what Kirlian auras are, and whether or not they can be useful in some applications. Nonetheless, those images have been used experimentally as diagnostic tools in medicine and for non-destructive testing of materials in engineering.

One interesting aspect of Kirlian photography is that while all objects appear to have a Kirlian "aura," the aura of inanimate objects appears to be constant over time, while living creatures give off an aura that is time-varying. In humans, emotional stress, illness, and consumption of alcohol or drugs all appear to have an effect on the aura.

One of the U.S. government's studies in the area involved using the Kirlian aura to ascertain the physical and mental health of military personnel, and to determine their level of fatigue. That was done by measuring the diameter of the Kirlian aura, or corona, at the fingertip. At the end of the test, the results were analyzed and two statistically valid conclusions could be drawn. One was that the corona of those suffering physical stress (exercise) was larger in diameter than the test average; the other was that those suffering mental stress (fatigue, etc.) had Kirlian coronas that were smaller in diameter than the test average.

While the results of that test were interesting, there is still not enough data to hail Kirlian photography as a "fool-proof" diagnostic tool. Although other similar tests have been reported, the results have been incomplete. For instance, in one study, the fingertip coronas of 120 adult humans were photographed. Of the sample, 20% had a corona diameter that was markedly below the average. Of those, 50% it was later determined suffered from some sort of medical problem.

There are several obvious flaws with that study. For one, no report was made on the health of the 80% whose corona diameter was not reduced; it would have been informative to know what percent if any of those also suffered from some medical problem. Also, no follow-up appears to been done on those whose corona diameters were decreased and who had no ascertainable medical problems. It would have been interesting to see how many of those later developed some type of difficulty, and in what time frame following the experiment.

One of the most dramatic experiments in Kirlian photography, and one of the ones that has garnered the most attention, is the so-called phantom leaf experiment. In that experiment, a small part (approximately 2% to 10% of the total surface are) is cut off. Kirlian photographs subsequently taken will sometimes show the energy pattern or aura of the missing section. The reason for that is unknown, and the subject of much speculation, but although the effect is exceptionally rare, it has been demonstrated enough times to prove its existence. There have even been studies attempting to correlate the ancient art of accupuncture and the auras seen in Kirlian photographs.

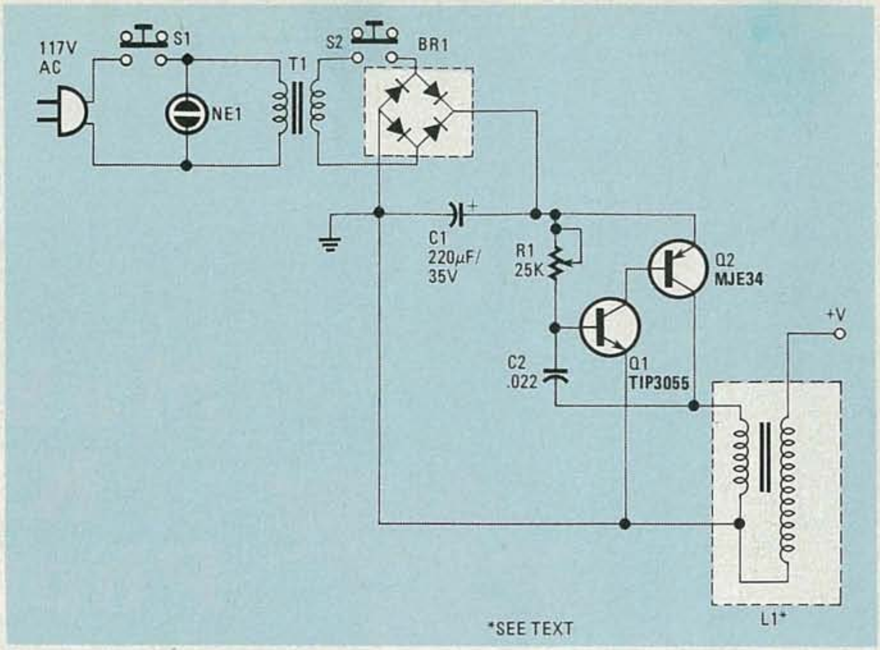


FIG. 1—YOU CAN MAKE YOUR OWN Kirlian photographs using this circuit. Coil L1 is an automotive ignition coil that can be obtained cheaply from almost any automotive junkyard.

Making your own

There are probably quite a few doubters still out there. To those we offer the following challenge: Why not build your own Kirlian photography unit and prove or disprove the existence of the effect to yourself? In the balance of this article we will present a simple set-up that will allow you to do just that. Although the equipment is not on a par with those used in research labs, it is still more than sufficient to provide startling results. The color photographs that accompany this article, showing the Kirlian aura of some common leaves, were produced using the apparatus described.

The circuit for the set-up is shown in Fig. 1. The heart of the circuit is a simple oscillator whose output is fed to a standard 12-volt, three-terminal automotive ignition coil, L1.

Construction is straightforward, and the circuit is simple enough that a PC board is not required, although one can be used if you wish. Note that the transistors can get pretty hot, so they should be adequately heat sinked. The only other point that merits special mention is that if a metal chassis is used, special care should be taken to isolate the circuit from the chassis. Otherwise a serious shock hazard could exist.

To further minimize the potential for shock, the ignition coil, L1, should be housed in its own non-conductive chassis. One suitable chassis is shown in Fig. 2. It is fashioned from a cardboard tube, such as those large rolls of gift-wrap paper come on; the ends are circular pieces of plexiglass.

Figure 3 shows the construction details of the coil chassis. The ignition coil is mounted by simply gluing it to one side of

FIG. 2—THE "CABINET" for L1 can be fashioned from a cardboard tube. The endcaps can be made of plexiglass.

the tube so that the high-voltage terminal will protrude slightly when the end caps are installed. A ground lead is provided by soldering a wire to the body of the coil; the other end is terminated in a case-mounted binding post. Note that the inputs from the main part of the circuit enter the coil chassis from the rear and are routed along the body of the coil through a length of plastic tubing. That tubing is used to insulate the leads from the body of the coil. Although the coil could be hard-wired to the balance of the circuit, the use of plugs and sockets allows for greater convenience. Further, the use of the polarized connectors mentioned in the parts list eliminates the guess work when reconnecting the circuit.

Three-terminal ignition coils can be ob-

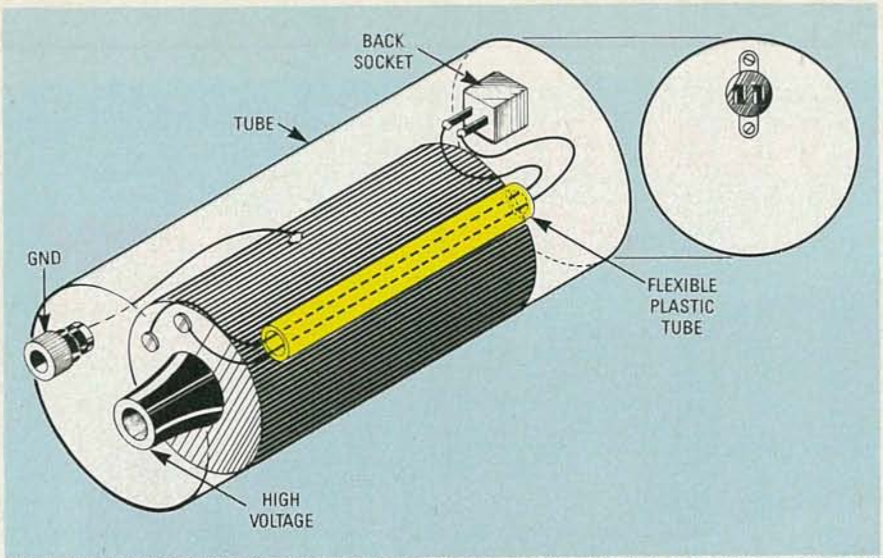


FIG. 3—THE AUTOMOTIVE IGNITION COIL is mounted inside its cabinet by gluing it to one side. Make the ground connection by soldering a wire to the side of the coil housing and connecting the other end to the cabinet-mounted binding post.

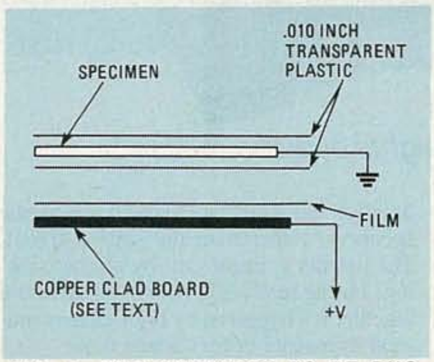


FIG. 4—THE SPECIMEN TO BE PHOTOGRAPHED should be sandwiched between two sheets of thin (.010-inch) transparent plastic.

tained from any automotive supplier. A much cheaper alternative is to pay your local automotive junkyard a visit. A coil can be obtained there for as little as $5.00. Just about any 12-volt, three-terminal ignition coil will work, so get the least expensive one you can.

There is nothing particularly exotic about the parts required and most can be obtained from your local supplier. With some careful shopping, total cost should not exceed $60.00 or so. If you have a well stocked junk box, that cost can be reduced further. If you wish, complete kits, as well as wired and tested units can be purchased from the supplier mentioned in the Parts List.

The set-up used in making a Kirlian photograph is shown in Fig. 4. The bottom plate is made from a single-sided piece of copper-clad PC-board material. The board should measure at least 4 × 5 inches so that standard 4- × 5-inch sheet film can be accommodated; more on the film in a moment. That plate is placed inside a thin, transparent plastic bag, copper side up, the bag is taped to prevent slippage, and a piece of the photographic film is placed upon it. If the specimen to be "photographed" is inanimate, such as a plant leaf or a piece of metal, it should be grounded (connected to the ground terminal on the coil chassis) for best results (see the important note that follows). In any event, the specimen is placed between two sheets of thin (.010-inch) transparent plastic, and the "sandwich" is then placed on the film. The copper-clad board is connected to the high-voltage terminal of L1 via a length of wire.

PARTS LIST

R1—25,000 ohms, potentiometer
C1—220 µF, 35 volts, electrolytic
C2—.022 µF, polyester film
Q1—TIP3055 NPN transistor
Q2—MJE34 PNP transistor
BR1—1.5-amp, 50 PIV full-wave bridge rectifier (Radio-Shack 276-1151 or equivalent)
NE1—neon-lamp assembly (Radio-Shack 272-704 or equivalent)
S1, S2—SPST pushbutton switch
T1—117-volt primary, 25-volt 450-mA secondary (Radio-Shack 273-1366 or equivalent)
L1—three-terminal, 12-volt, automotive ignition coil

Miscellaneous: Case; case for ignition coil; perforated construction board, PC board, or prototyping board; single-sided copper-clad board; polarized plugs (Radio-Shack 274-201 or equivalent); polarized sockets (Radio-Shack 274-202 or equivalent); heat sinks for transistors; strain relief; power cord; knob for R1; wire; solder, etc.

A kit of all parts, including connectors, cords, cases, and prototyping board (no PC board is available) is available from Images Co., PO Box 313, South Richmond Hill Station, Jamaica, NY 11419. The cost is $90.00. A wired and tested version is available for $125.00. Add $2.50 for shipping and handling. NY residents add 8¼% sales tax.

Important! Never, never ground a living creature, including yourself. Doing so can subject that "specimen" to a very nasty shock. When dealing with living creatures, take special care to prevent any contact with ground.

One note about the ignition coil's high-voltage terminal: To the uninitiated, the location of that terminal may not be apparent at first glance. It is located within the tube-like protuberance at the top of the coil housing. When the coil is used in its normal application, a heavy-gauge spark-plug wire is placed in the opening at the top of the tube so that it contacts the terminal inside; the wire is held in place by friction. For our application, the lead from the copper-clad board must be placed within the terminal opening such that a sure contact with the high-voltage terminal is maintained at all times.

You will note from Fig. 1 that the circuit uses two ON/OFF switches, S1 and S2. Switch S1 is the unit's main power switch; when it is in the ON position, power is supplied to the neon lamp, NE1, and the circuit is placed in the stand-by mode. The neon lamp does more than give a visual indication of the state of the unit. Since we will be working with photographic film, the circuit must be used in a relatively dark, light-tight room. Obviously, that can present problems in using the unit (you can't use what you can't see). If the controls are clustered about the lamp (as shown in Fig. 5), the lamp gives off just enough light to make identification of the controls possible in a dark room without adversely affecting the film. Switch S2, the DISCHARGE switch, is used to control the operation of the balance of the circuit.

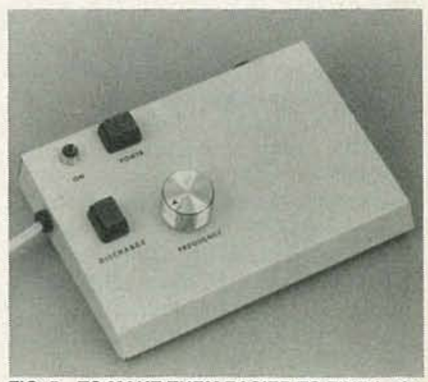


FIG. 5—TO MAKE THEM EASIER TO FIND in the dark, cluster the unit's operating controls around NE1.

To make a Kirlian photograph, turn on the unit using S1, turn out the lights, place the film and the specimen on the electrode as discussed previously, and make the ex-

continued on page 94

BUILD THIS

Click and Pop Filter for your STEREO

JOE GORIN

By eliminating unwanted pops, clicks and other surface noise, this inexpensive scratch filter brings you to new heights of audio realism!

THE PROLIFERATION OF DIGITALLY-MASTERED record albums might make you think that surface noise is a dead issue. However, even the best modern pressings contain some amount of noise, and, even with scrupulous care, all vinyl recordings deteriorate with age.

You might think that you could avoid the surface-noise problem by buying only compact discs (CD's), which suffer none of the problems endemic to vinyl recordings: hiss, rumble, clicks, and pops. However, many new recordings are unavailable on CD, and thousands of already-released recordings may never be re-issued on CD. So, if you're after the utmost in high-fidelity sound reproduction, you'll want to build our scratch eliminator. It's easy to assemble, and it requires no alignment. Just plug it in and give your ears a treat!

Why it works

Since commonly-available stereo equipment easily achieves distortion levels below 0.1%, you might think that chopping up a musical signal to delete an occasional scratch would be foolish because of the distortion it would add. However, we have found that even the simplest scratch filters produce a notable improvement in sound quality. The reason is simply that the human ear responds slowly to fast-changing audio signals. One indication of that slowness is the fact that even the best magnetic tape has numerous dropouts of a greater duration than most scratch deletions—and tape dropouts are seldom noticeable. So deleting a scratch in the midst of a complex musical passage is easily done with no noticeable effect.

The real problem is this: What happens when a large musical transient (like a cymbal crash or closely-miked plucked strings) occurs? Wouldn't it be deleted and thereby take the "bite" out of the transient? The answer is no, given the right design. High-energy musical transients might trigger the detector, but the deletion should be inaudible because the transient usually lasts at least 50 ms, whereas the deletion lasts for only 0.5–1.0 ms. The ear can't react that fast, so the deletion is inaudible.

The human hearing system reacts to transient signals according to a parameter called the "pitch recognition interval." For most frequencies, that interval is about 10 ms. If a signal lasts much less than 10 ms, it sounds pitchless or atonal—you cannot identify its tone. So all very short signals sound like clicks. Musical instruments are designed to make pleasing sounds, so they have decay times long enough to get them through the pitch recognition interval. So even if you delete a fraction of a tone at the beginning of a transient, the tone will still sound natural.

You may find it interesting to know that one commercially-available scratch filter uses the "click" effect to mislead the listener intentionally. That filter has an INVERT button that is used to "evaluate" the unit. In INVERT mode, only the shortened deletion intervals are passed on to the speakers, rather than the source signal. The listener is impressed by all the clicking, but he really has no way of knowing whether it's triggered by high-energy musical transients or by surface noise.

The point is that pops and clicks can be eliminated, so the question is, how? The answer is somewhat complicated, so let's step back for a moment and examine other ways of cleaning up the sound of vinyl disks.

Noise-reduction techniques

Essentially, there are three methods of improving the quality of any phonographic recording:

- Noise filter/expander
- Rumble filter
- Scratch filter

A noise filter serves to remove broadband, high-frequency noise, and an expander helps restore the original dynamic range with which most music is performed, if not recorded. The theory behind those signal processors was covered in depth in the author's articles in the January and February, 1981 issues of **Radio-Electronics**; the March and April issues of that same year carry a two-part construction story that details building a noise filter/expander.

A rumble filter removes subsonic signals (less than 20 Hz), and combines somewhat higher frequencies (ranging from 100 Hz to 200 Hz) into a monaural signal. Doing that reduces noise without reducing intelligible program material. For more information on rumble filters, consult the author's article in the November, 1981 issue of **Radio-Electronics.** That article describes construction of a rumble filter. Kits for both the noise filter/expander and the rumble filter are still available from the source mentioned at the end of this article.

Of the three phonographic noise-reduction techniques the first is probably the most useful for discriminating audiophiles. The second is good for audiophiles whose systems have extended bass response and who have already eliminated most noise with a noise filter. Last, a scratch filter can help reduce unwanted noise from any phono system, and it will be particularly useful to people with large collections of old records. With that under our belts, let's find out how to build a scratch filter.

Circuit operation

As the block diagram in Fig. 1 shows, the basic idea behind a scratch eliminator is simple. By delaying the input signal for a short time (about 40 microseconds), the detector can "see" a scratch before it

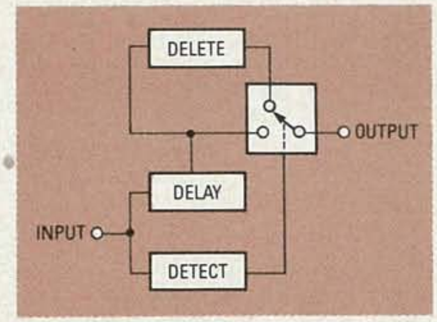


FIG. 1—THE ESSENCE OF THE FILTER is the delay unit that allows the deleter to remove high-energy transients like pops, clicks, and scratches before they have a chance to reach your ears.

reaches your amplifier. The detector activates a switch that prevents the input signal from passing through to the output. The switch remains open for the short time that the scratch is present, usually 100–200 microseconds, but sometimes as much as a millisecond, or even more. And rather than leaving a "hole" in the output sound, it would be nice if the deleter could substitute the signal that would have been there, had there been no scratch.

From an engineering point of view, it's easy to design the delay unit. The delay unit's function is simply to delay all frequencies of interest by 40 microseconds or more. In the process, it should not change the amplitude of any frequency beneath 20 kHz (the limit of human hearing). The circuit may, however, reduce the level of higher frequencies. Delay is accomplished by phase-shifting the input signal and sending it through a low-pass filter.

As shown in Fig. 2, the first three op-amps in each channel, along with their associated passive components, perform the low-pass filtering and phase shifting. We'll talk about the right channel, but bear in mind the fact that the left channel functions identically. Incidentally, corresponding components in the left and right channels are numbered offset by a value of 100. For example, R101 in the right channel corresponds to R201 in the left.

Capacitors C101, C102, and C104–C106 and associated resistors provide low-pass filtering. They pass the audio signal, provide some phase shift, and attenuate ultrasonic signals. In addition, C101 and C105 add controlled amounts of positive feedback to help re-

PARTS LIST

All resistors ¼-watt, 5% unless noted.
R1–R4, R11, R12, R26, R54, R102, R103, R118, R202, R203, R218—22,000 ohms
R5, R107, R207—2400 ohms
R6—7500 ohms
R7, R24—4700 ohms
R8, R9, R14, R43, R44, R50, R51, R114, R115, R214, R215, R301-R304—1000 ohms
R10, R34, R35—150,000 ohms
R13—150 ohms
R15—1200 ohms
R16, R39, R56, R104, R204, R305, R306—2200 ohms
R17, R18, R25, R29, R30, R37, R38—10,000 ohms
R19—4.7 megohms
R20, R57, R59, R121, R221—560 ohms
R21—470 ohms
R22, R106, R206—1800 ohms
R23—68,000 ohms
R27, R60—180,000 ohms
R28—3300 ohms
R31—330,000 ohms
R32—220 ohms
R33—15,000 ohms
R36—470,000 ohms
R40, R49, R62–R100, R123–R200, R223–R300—not used
R41, R46—39,000 ohms
R42—22 megohms
R45—100,000 ohms, linear potentiometer
R47, R101, R201—100,000 ohms
R48, R61, R122, R222—270,000 ohms
R52, R116, R216—36,000 ohms
R53, R58, R111, R117, R211, R217—6200 ohms
R55, R119, R219—91,000 ohms
R105, R205—100 ohms
R108, R208—2700 ohms
R109, R209—3000 ohms
R110, R210—12,000 ohms
R112, R120, R212, R220—33,000 ohms
R113, R213—8200 ohms
R307, R308—22 ohms

Capacitors
C1, C15, C16—0.0033 µF, 10%, polyester film
C2, C5, C20, C22, C107–C109, C207–C209—0.001 µF, 10%, polyester film
C3, C4, C8, C24, C111, C113, C211, C213, C305, C306, C308—10 µF, 25 volts, aluminum electrolytic
C6, C7, C14, C18, C103, C203—0.033 µF, 10%, polyester film
C9—3.3 µF, 35 volts, aluminum electrolytic
C10–C12, C301—0.1 µF, 10%, polyester film
C13, C17, C23, C25, C26, C110, C112, C210, C212—0.01 µF, 10%, polyester film
C19, C21—680 pF, 10%, ceramic disc
C27—see text
C28–C100, C114–C200, C214–C300—not used
C101, C201—330 pF, 10%, ceramic disc
C102, C106, C202, C206—220 pF, 10%, ceramic disc
C104, C204—0.0047 µF, 10%, polyester film
C105, C205—0.022 µF, 10%, polyester film
C302—1000 µF, 35 volts, aluminum electrolytic
C303, C304—1000 µF, 25 volts, aluminum electrolytic
C307, C309—0.1 µF, ceramic disc

Semiconductors
IC1–IC3, IC5—RC4136, quad op-amp
IC4—LM301A, op-amp
IC6—LM393, op-amp
IC7, IC8—4016, quad analog switch
Q1, Q2—2N3904, NPN transistor
D1–D10—1N4148, switching diode
D301–D304—1N4002, power diode
LED1—standard LED

Other components
J1–J8—RCA Phono Jacks
S1, S2—DPDT toggle Switch

Note—The following parts are available from Symmetric Sound Systems, Inc., 856 Lynn Rose Ct., Santa Rosa, CA 95404, (707) 546-3895: Complete Kit (No. PS-1) $79.95; PC Board (No. PS-1PC) $12.00; All semiconductors (No. PS-1SC) $13.00; All resistors and capacitors (No. PS-1RC) $16.00; Transformer (No. PS-1XF) $7.50; Chassis, endpanels, switches, hardware, jacks and instructions (No. PS-1ETC) $42.50. Free UPS shipping in U.S. with check; MasterCard and Visa orders must add shipping. PS-1SC, PS-1RC and PS-1ETC will not be available after January 31, 1987. California residents must add appropriate sales tax.

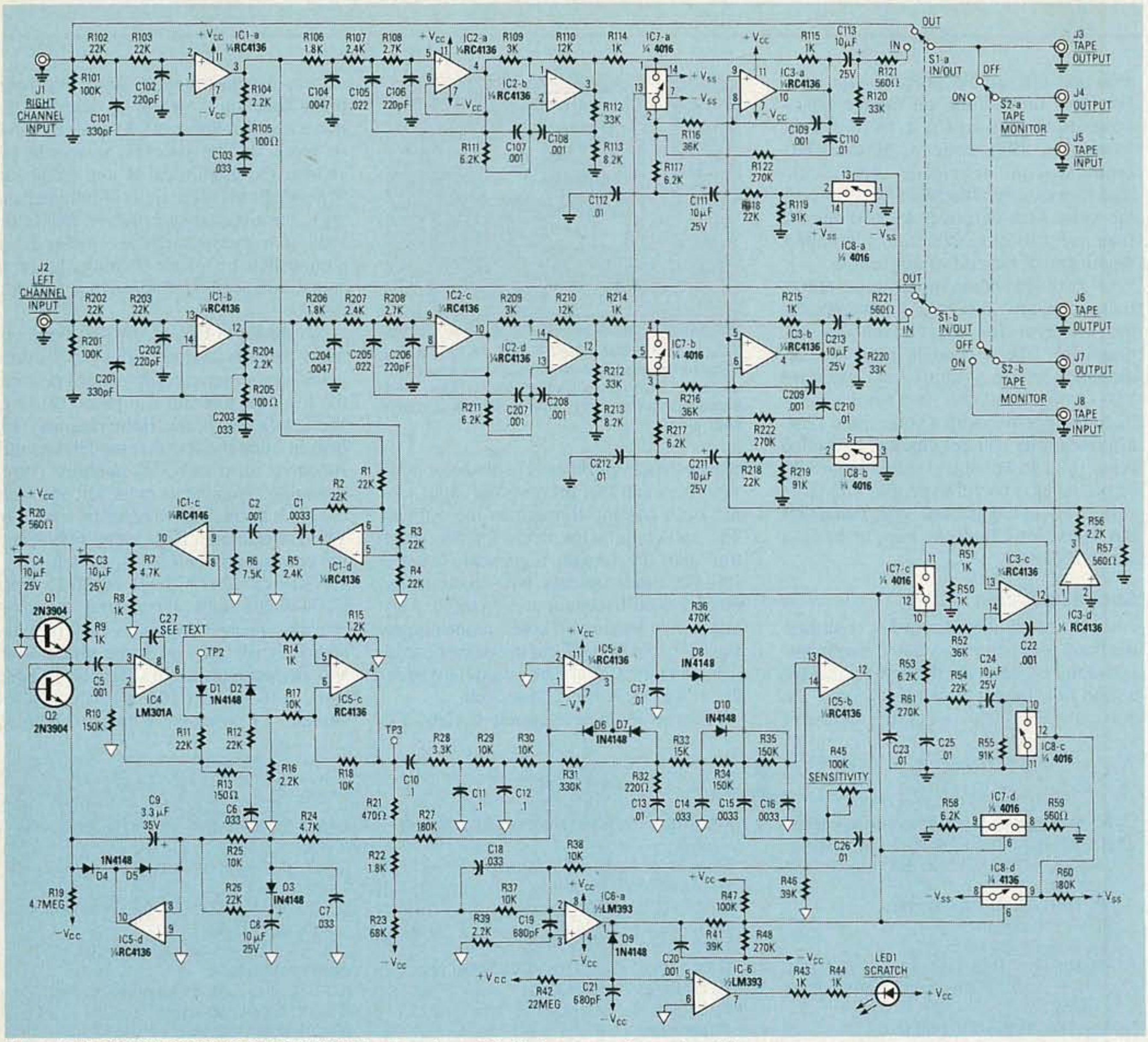


FIG. 2—THE CIRCUIT OF THE SCRATCH FILTER is shown here. Note that components numbered from 0–99 refer to the detector circuit, 100–199 refer to the right channel delay/delete section, and 200–299 refer to the left channel. The triangular symbols here provide a separate "ground" reference for the detector circuit.

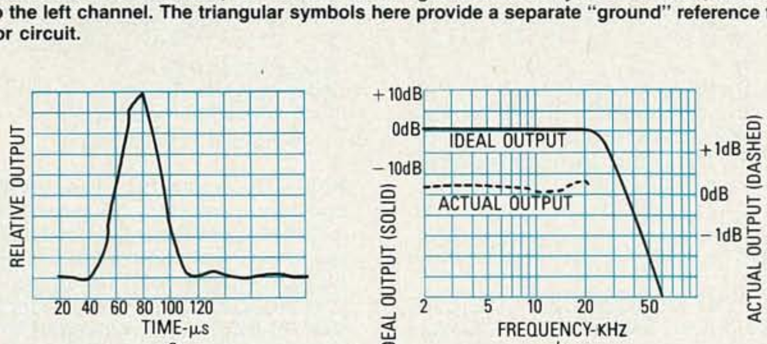


FIG. 3—TIME- AND FREQUENCY-DOMAIN responses of the Filter are shown here. Note that the circuit doesn't respond before at least 40 μs have passed, and that output is flat (within ½ dB) to 20 kHz.

sponse. Further, the network formed by C107 and C108 functions as an "all-pass" network that provides lots of phase shift with little change in amplitude.

Our circuit was simultaneously computer-optimized for both its frequency-domain response, which is flat to 20 kHz, and its time-domain response: no reaction to a triangular, scratch-like pulse for at least 40 microseconds. Figure 3-*a* shows the time-domain response curve, and Fig. 3-*b* shows the frequency-domain response curve. The latter is presented with both ideal and actual curves; you can see that the actual output is flat within ½ dB all the way to 20 kHz.

Scratch deleter

The deleter has a somewhat more difficult task to accomplish than the delay/phase-shift network. In addition to completely blanking out the scratches found by the detector, it should replace the deleted signal with a signal that sounds as little as possible like a scratch, and as much as possible like the original program material, had there been no scratch. Since the circuit can't know what that signal was, it must predict it.

Actually, the deleter's first job is accomplished in the input circuitry discussed above. A 75-microsecond pre-emphasis is provided by R104, R105 and C103. That pre-emphasis boosts audio signals above the corner frequency of

2122 Hz. Explaining the need for that pre-emphasis requires a lengthy digression.

The RIAA curve

In order to optimize signal-to-noise ratio, phonograph sound-reproduction systems are designed to operate with pre-emphasis at the recording end and de-emphasis at the playback end. The playback response used in your phono pre-amplifier is the RIAA (*R*ecord *I*ndustry of *A*merica *A*ssociation) curve shown in Fig. 4. That curve is designed to respond correctly to the output of a magnetic cartridge. Most high-quality cartridges are magnetic, and the output of a magnetic cartridge is a voltage that is proportional to the velocity of the stylus.

Since higher frequencies have higher velocities for the same amplitude, a velocity transducer effectively imparts a 6-dB/octave treble boost over the entire bandwidth. The resulting signal is shown in Fig. 5. Because of that treble boost, the circuit stores energy and releases it slowly. If a pulse of displacement (change in position from center) occurs on the record, as shown in Fig. 7-a, the response exhibits a settling tail that decays exponentially with a time-constant of 75 microseconds. The breakpoint in the curve is at the reciprocal of $2\pi \times 75$ microseconds, or 2122 Hz.

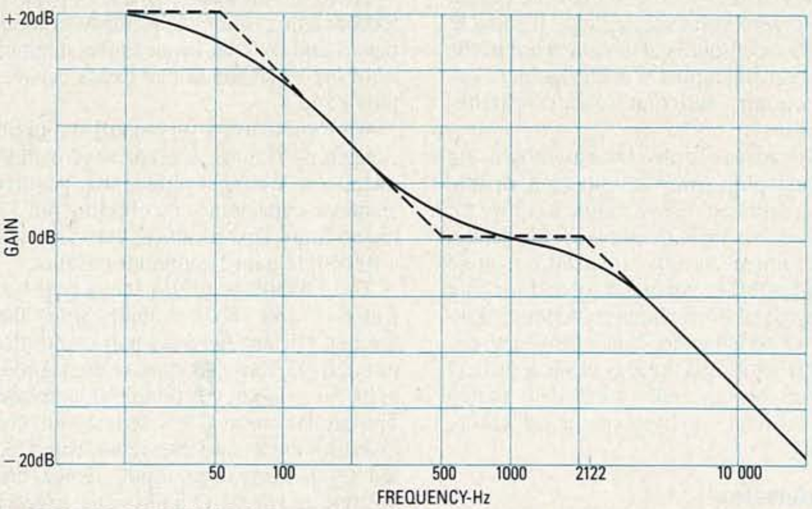


FIG. 4—THE RIAA DE-EMPHASIS curve necessary for processing signals from standard magnetic cartridges.

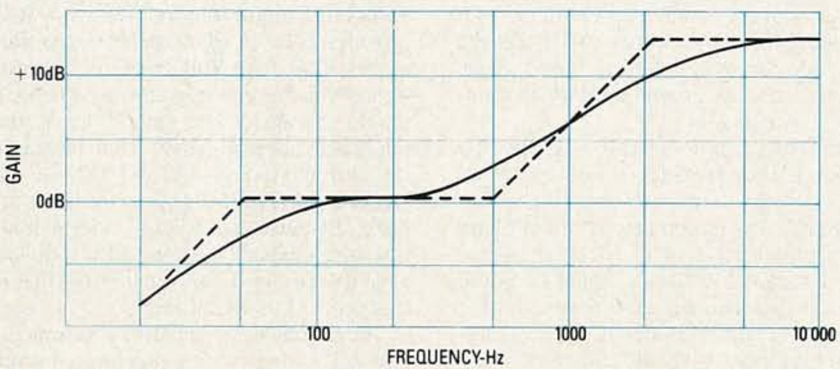


FIG. 5—OUTPUT OF A STANDARD MAGNETIC CARTRIDGE increases at a rate of 6 dB/octave over the audio frequency range.

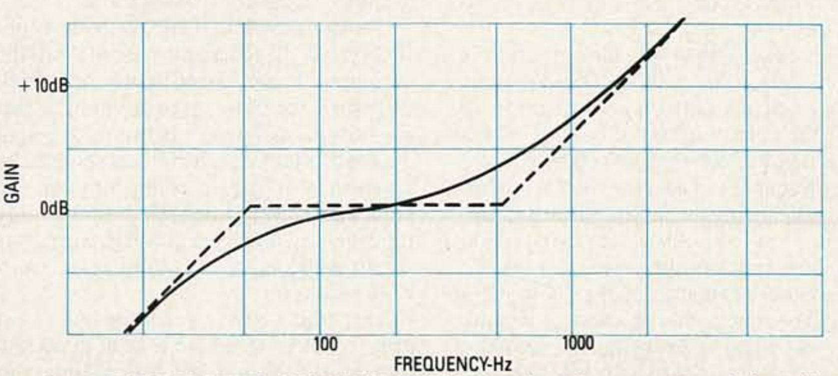


FIG. 6—OUTPUT OF A MAGNETIC CARTRIDGE SHIFTS when the stylus encounters a deformation in the vinyl surface.

Because of that settling time, deleting a scratch can be tricky. If the deletion time isn't long enough, some scratch energy may pass through as noise. But if the deletion time is too long, a distracting audible "hole" would be created.

Our solution is to pre-emphasize the signal before it reaches the deleter. Doing that would cause an input signal like that shown in in Fig. 7-*a* to appear as in Fig. 7-*b*. A pulse (or scratch) input would appear as in Fig. 7-*c*. Observe that, although the pulse is larger, it is now constrained to a much shorter period of time.

Pre-emphasis is desirable for another reason besides the elimination of settling tails. The treble boost caused by pre-emphasis reduces the number of scratch-prediction errors in the deleter.

The deleter

The deleter is the last op-amp stage in each channel (IC3-a). Its operation is controlled by the two analog switches IC7-a and IC8-a. The op-amp in conjunction with R116 and C109 forms an integrator. When the switches close, R114 and 115 apply negative feedback to the integrator. The result is a filter with a de-emphasis corner at the desired 2122Hz.

If that were the entire circuit, when a deletion occurred, the charge stored by feedback capacitor C109 would cause it to act as a sample-and-hold circuit, which works well for short deletions during low-frequency waveforms. However, several components are added to the deleter that improve its operation in two different ways.

First, just before the deletion begins, capacitor C112 stores the input waveform by charging to the voltage at R116. Then, when the deletion begins, switch IC7-a opens. That prevents the signal from the previous stage from getting to IC3-a, so the voltage across C112 is fed through to the output, and that keeps the output at a level approximately equal to the level just before the scratch.

That improves low-frequency performance, but it doesn't help high frequencies at all. However, that's OK, because, even though low-frequency signals mask deletion-errors poorly, high-frequency signals mask deletion well.

To prevent C112 from storing high-frequency signals, R117 limits the charge that can build up on C112. If that charge extended over more than a fraction of a cycle, it could cause severe errors in the deleter. When a deletion occurs, R118 and switch IC8-a discharge C112 rapidly so that the slope estimated by C112 isn't

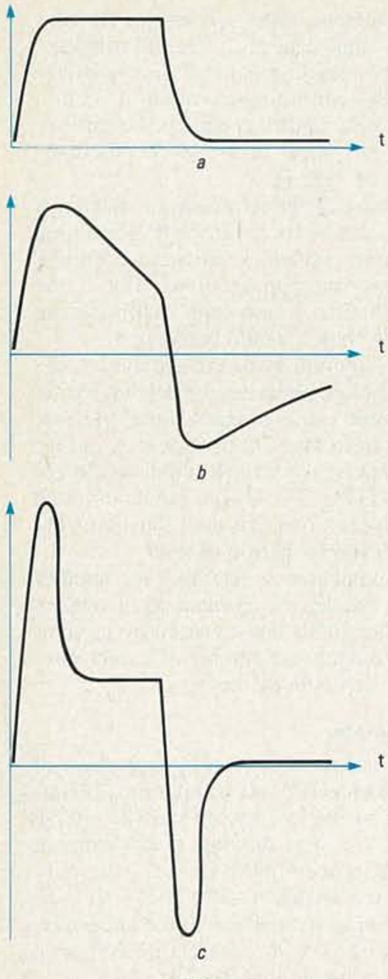


FIG. 7—EXPONENTIAL DECAY of an input signal (*a*) is lengthened by pre-emphasis (*b*). Additional pre-emphasis increases the amplitude, but decreases the duration of a scratch (*c*).

over-corrected. Capacitor C111 prevents IC3's outputs from causing switching transients when IC8-a changes state. Resistor R119 does the same thing for the leakage currents in the switch.

The second means by which the deleter is improved is through the combination of R122 and C110. If the deletion lasts long enough, the sample-and-hold and slope-extension techniques become ineffective. We guard against that condition by using C110 to store the long-term average of the input signal. So, after a long deletion, C110 re-charges C109 to that average voltage, and that prevents the audible "holes" mentioned above from marring the output signal.

Glitch cancellation

The combination of sample-and-holding, slope extension, and long-term-average circuits makes most deleter errors inaudible. However, there is another source of error: the signal required to turn the switches off and on. Although that signal is 14-volts p-p, ideally the error at the integrator output is less than 1 mV, a ratio of 14,000/1. Since C109 is 1000 pF, the capacitor that couples the switching waveform into C109 must be 1000/14,000, or about 0.07 pF—a very small amount. That's achieved by circuit and layout matching.

Circuit matching works by using IC3-c and associated components to duplicate the deleter stage. We call the duplicate the "example" circuit. When the switches change state, they inject transients into the example circuit. Then IC3-d compares the output of the example circuit to ground, and it injects the opposite signal into the "glitch injection" terminal of the example circuit, the non-inverting input (pin 13) of IC3-c. That forces the output back to zero volts via negative feedback. The glitch output is also connected to the non-inverting inputs of each channel's deleter circuit, and that cancels glitches there too.

Performance is also increased by using matched parts (they're matched in that they're fabricated on the same IC chip) for the switches and op-amps in the deleter and example circuits. In addition, great effort has been expended toward making the layout of each channel identical. Further, we added guard traces between sensitive IC pins, and the legs of some critical resistors are specially formed to match each channel's pickup of the switching signals.

The detector

The detector circuitry consists of three parts: a differential amplifier and filter, a full-wave detector with ALC (*A*utomatic *L*evel *C*ontrol), and a comparator with masking-threshold setting. Note that the detector circuit's ground is raised above the main chassis ground by R308 to minimize noise pick-up.

The *differential amplifier* is formed by IC1-d. It is used to detect scratches, which are 180° out of phase between the two channels. The reason they're out of phase is that the surface of a disk that has had vinyl removed causes a negative-going pulse in one channel, and a positive-going pulse in the other. Hence IC1-d is configured to respond to the difference between the two channels. Next, C1, C2, R5, and R6 form a high-pass filter that passes only the highest audible frequencies, as well as any ultrasonic signals.

The reason for passing the high audible frequencies is that, although the energy in most scratches rolls off slowly above 10 kHz, the energy in music rolls off much more rapidly, but that roll-off starts at a lower frequency. Thus, the "noise-to-signal" ratio is higher in the ultrasonic frequency region. Also, the vinyl that normally contacts the stylus damps the mechanical resonance of the stylus. But during a scratch, that resonance (usually at 20–30 kHz) is excited, and damping decreases because the stylus loses contact with the groove.

The *full-wave detector* (with ALC) is composed of Q1, Q2, IC4, IC5-c and IC5-d. The base of Q1 is biased at the detector reference, so the currents flowing through Q1 and Q2 is controlled by the voltage applied from IC5-d. Hence, those devices form a current-controlled attenuator whose output is fed to IC4, an LM301A op-amp.

Normally the LM301 requires 30 pF of capacitance between pins 1 and 8 for stability. That capacitance completes an internal negative-feedback loop that rolls off the gain at high frequencies and keeps the op-amp stable.

There is, however, internal positive feedback due to the capacitance between pins 5 and 6. That capacitance subtracts from the capacitance that exists between pins 1 and 8.

We want to use a very small stabilizing capacitor—0.3 pF, implemented with PC traces—so we must reduce that positive-feedback capacitance by clipping pin 5 of the op-amp. That results in a op-amp with a 100-MHz gain-bandwidth product.

The LM301 amplifies the signal by a factor of 150. Positive half-cycles flow through D1, and negative half-cycles flow through D2; those signals are then applied to IC5-c, another differential amplifier. The signal from D1 is fed to the non-inverting input, and the signal from D2 is fed to the inverting input. Since both positive and negative half-cycles appear at IC5-c's output as positive-going, IC5-c is a full-wave rectifier.

The ALC loop is closed by IC5-d and associated components. Resistor R21 provides a 100-mV voltage reference. Resistors R24, R25, and capacitor C9 configure IC5-d as an integrator, so if IC5-c's output averages more than 100 mV, the integrator goes negative. That increases the current through Q1 and Q2, so the signal level is reduced via negative feedback. Because the voltage-current relationship is exponential, the ALC loop has a bandwidth (or readjustment rate) that is independent of signal level.

The human ear's sensitivity to scratch-type noise varies with signal level; it is the job of the ALC loop to simulate that variation. That makes the front-panel SENSITIVITY adjustment less critical.

The *comparator*, IC6-a, is the last subsection of the detector. Recall that the output of IC5-c is the level-controlled, full-wave-rectified, high-frequency version of the difference between the right and left channels. If we compared the junction of R22 and R23 to ground, the comparator would register a scratch any time the level there exceeded five times its recent average level, so additional circuitry is necessary.

That's all we have room for now. Next time, we'll finish up our look at the detector circuit and show you how to build our filter. **R-E**

Capacitor Leakage Tester

GARY McCLELLAN

Find the leaky capacitors that many testers miss with this easy-to-build leakage checker. You can use it to test cables, appliance insulation, and high-voltage diodes, too!

THOSE NEW DIGITAL CAPACITANCE TESTers make capacitor checking quick and easy, but they have shortcomings. For instance, does the following sound familiar to you?

You are troubleshooting a piece of equipment and replace some defective capacitors with units from the junk box. After hours of additional troubleshooting you discover that those replacement capacitors are no good after all, even though they checked out OK on your tester. That's because they are leaky, and your meter is one of the many that has no leakage-test function. That "missing feature" wound up costing you much time and aggravation.

Or perhaps you just bought some electrolytic capacitors from your dealer, installed them, and watched as the power-supply fuse blew. You later find that the cause was those "new" capacitors; they had become leaky after sitting on your dealer's shelf for the better part of a decade. If you had only known, those capacitors could have been rejuvinated with a shot of current from the proper source. Instead, you have a blown fuse and some fried capacitors.

Assuming it does everything else well, don't trash your capacitance tester just because it doesn't have a leakage-test function. Instead, supplement it with the leakage tester described here. Our tester checks the all-important leakage parameter quickly and easily, weeding out defective capacitors that otherwise test good. It can also brings those elderly "new" capacitors back to life fast.

Besides checking capacitor leakage, the circuit has many other uses on the bench and in the field. For example, use it to test insulation resistances on power tools and appliances. If you find just one tool or appliance with a dangerous fault before it finds you, you'll be very glad you took the time to build and use the circuit. You can also test suspected lossy cables, as well as high-voltage diodes, rectifiers, neon lamps, and other high-voltage components that are often difficult to troubleshoot with conventional DMM's.

And in a pinch the circuit can serve as a regulated power supply. The output voltage spans 3 to 100 volts, which may make the project useful for temporarily powering devices drawing under 10 mA or so.

The circuit is easy to build and is fairly inexpensive, too. A small PC board holds the active components, including two IC's, three transistors, and some diodes, while the remaining switches and a meter mount on the cabinet. Parts costs will run about $45.00 or so, depending upon how well you can shop or scrounge for them. The PC board, and a few harder-to-get components, are available from the source mentioned in the Parts List.

How it works

The project is basically a regulated DC power supply with a metering circuit to indicate leakage current. Refer to the block diagram in Fig. 1 for details.

There are several noteworthy features of which you should be aware. First, a novel power supply design permits the unit to charge test capacitors with a constant current source. That means they charge faster, saving you testing time, particularly for large capacitors. In addition, an analog meter is used for leakage-current measurements. That allows you to see the charging action and monitor the leakage current easier than with a digital meter. And analog meters are generally much cheaper than digital ones!

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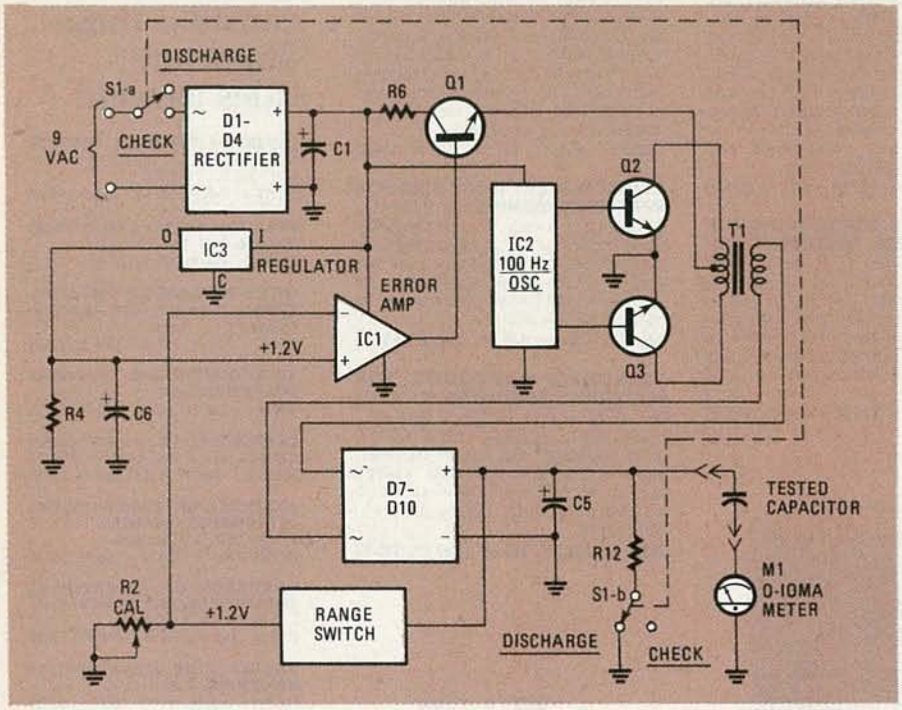


FIG. 1—THIS BLOCK DIAGRAM makes it easier to see how our little leakage tester works.

In operation, 9 volts from a plug-in transformer passes through switch S1-a and is rectified by diodes D1-D4. If field operation is required, it is possible to substitute a 12-volt battery for the plug-in transformer. The switch is a DPST unit that selects either power ON or capacitor DISCHARGE. From the rectifier, the output is filtered by capacitor C1, and is then used to power the rest of the circuitry.

Part of the power output is fed to IC3, a positive voltage regulator, which is used to provide a stable 1.2 volt reference for IC1. That ensures that the output voltage will be stable regardless of how much voltage is used to power the project.

Op-amp IC1 serves as an error amplifier. Its job is to ensure that the voltage applied to the capacitor under test is regulated. It does that by "sampling" the voltage at capacitor C5 through the range switch. The range switch is nothing more than a resistive attenuator network reducing the output voltage to about 1.2. The op-amp simply adjusts the power supply until its minus (inverting) input equals 1.2 volts. That regulates the output voltage.

Transistor Q1 serves as a control element for the rest of the power supply. Since the op-amp can't provide enough current to do the job directly, a Darlington power-transistor is used here to boost the current. Resistor R6 limits current to the rest of the circuitry, preventing transformer damage.

Moving on, the DC output from capacitor C1 powers IC2, which is a CMOS programmable one-shot wired as a 100-Hz oscillator with complimentary outputs. The outputs from IC2 alternately drive transistors Q2 and Q3, which serve as switches. They alternately switch each side of the transformer T1 winding to ground, generating current pulses.

Transformer T1 performs two purposes. First it steps up the current pulses so that they can be rectified. Second, under heavy load (as from a charging capacitor) it saturates, limiting the output current to the capacitor to about 20 mA. That forms a constant-current type power supply, which is especially effective in charging test capacitors.

The output from transformer T1 is rectified by diodes D7 to D10 and filtered by capacitor C5. From that point the DC output feeds back to the range switch, which is used along with op-amp IC1 to set the output voltage. The DC output also drives the test capacitor, which is connected to the project through binding posts.

Meter M1 is included in the minus leg of the test capacitor for monitoring the charging and discharging currents. Note that resistor R12 and switch S1-b are included to discharge the test capacitor when the power is turned off.

That takes care of the basics. Now turn to the schematic diagram of Fig. 2 for some details on the finer points of the circuitry. You should be able to identify the parts we just discussed on the schematic diagram.

First let's look at the error amplifier, IC1. Basically, that amplifier is set up as an inverting, gain-of-100 unit. Resistors R3 and R5 set the gain value. Although that practice is rather unusual for a power supply (R5 is usually not included), the reduced gain is necessary to permit stable operation when testing very large capacitors (say 15,000 μF). Diode D5 serves as

PARTS LIST

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

R1—8200 ohms
R2—5000 ohms, potentiometer, PC mount (Circuit Specialists 32JQ305 or equal)
R3—100,000 ohms
R4—270 ohms
R5—10 megohms
R6—10 ohms, 2 watts
R7—2200 ohms
R8—1 megohm
R9, R10—10,000 ohms
R11—18,200 ohms, ⅛-watt, 1%, metal-film
R12—100 ohms, 2 watts
R13—10 ohms
R14—68 ohms
R15—30,100 ohms, ⅛-watt, 1%, metal film
R16—40,200 ohms, ⅛-watt, 1%, metal film
R17—49,900 ohms, ⅛-watt, 1%, metal film
R18, R19—100,000 ohms, ⅛-watt, 1%, metal film
R20—150,000 ohms, ⅛-watt, 1%, metal film
R21, R22—249,000 ohms, ⅛-watt, 1%, metal film

Capacitors

C1—1000 μF, 16 volts, axial leads, electrolytic
C2, C6—0.1 μF, 50 volts, polyester
C3—0.001 μF, 50 volts, polyester
C4—100 μF, 16 volts, radial leads, electrolytic
C5—2μF, 450 volts, axial leads, electrolytic

Semiconductors

IC1—LF356N op-amp (National)
IC2—4047 CMOS one-shot (RCA)
IC3—LM317LE adjustable voltage regulator (National)
Q1–Q3—TIP120 NPN Darlington (Radio Shack 276-2068 or equivalent)
D1–D4, D7–D12—1N4004 rectifier diodes, 400 PIV, 1 amp
D5—1N4148 silicon signal diode
D6—not used

Other components

M1—1-mA DC meter
S1—DPST miniature toggle switch
S2—12-position, 1-pole rotary switch (Radio Shack 275-1385 or equivalent)
S3—SPST normally-closed pushbutton switch
T1—117 volts/12.6 volts, 1.2 amps, center tapped (see text)
T2—117-volts/9 volts, 300 mA, wall-plug transformer

Miscellaneous: PC board, plastic case (Radio Shack 270-627 or equivalent), knob, hookup wire, 4-40 hardware, press-on decals, etc.

An etched and drilled PC board plus all 1% resistors listed above and voltage reference IC3 are available for $17.50 postpaid from: Mendakota Products, PO Box 2296, 1001 W. Imperial Hwy., La Habra, CA 90631. When ordering request part LC1 and enclose a check or money order for the appropriate amount. California residents include 6% sales tax. Sorry no COD's or credit card purchases.

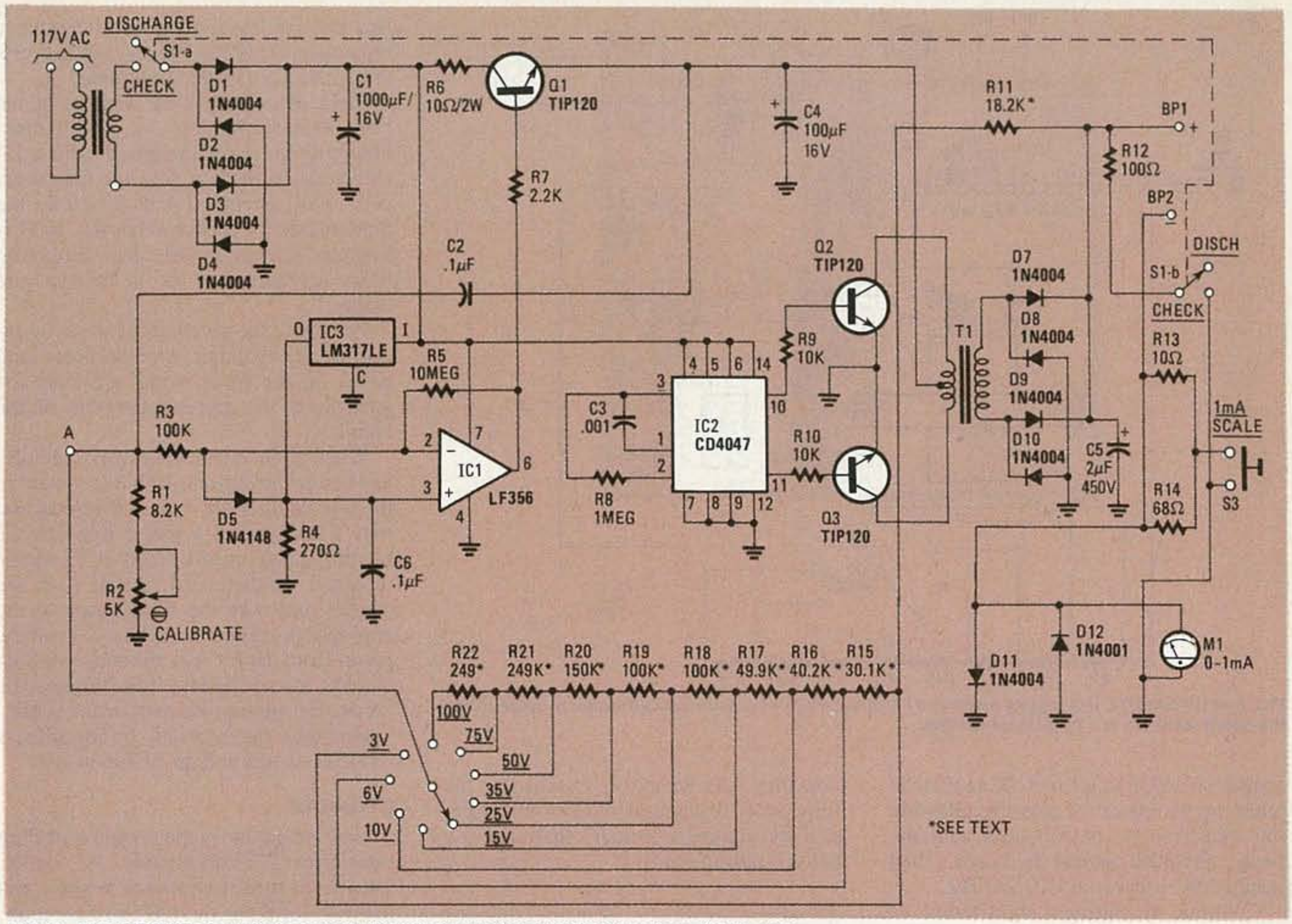


FIG. 2—THE CIRCUIT of our leakage tester is seen in greater detail in this schematic diagram.

overload protection, preventing excessive voltage from RANGE switch S2 from damaging IC1. That condition might occur if you were to switch rapidly from 100 volts to 3 volts. And finally, capacitor C2 provides some AC feedback, insuring stable operation over a wide range of capacitor loads.

Moving on, let's look at IC2. Resistor R8 and capacitor C3 set the operating frequency to 100 Hz. That frequency, while not critical, was chosen to prevent "beats" with the 60 Hz power line and permits increased output from transformer T1.

And finally, let's look at the metering circuit. Diodes D11 and D12 are included to protect the meter from harmful overloads, especially when a large capacitor is being discharged. A 10-mA current shunt consisting of resistors R13 and R14 is also included for measuring currents in non capacitor-testing applications. That shunt can be selected via pushbutton switch S3.

So much for the theory. Now why not get started building your project?

Construction

We'll describe assembly shortly, but first a few words about obtaining the parts. The circuit uses no exotic parts, and most should be available from Circuit Specialists (PO Box 3047, Scottsdale, AZ 85257), Radio-Shack, or your favorite electronics parts supplier. If you order the PC board from the supplier listed in the Parts List, you will also get the harder-to-find 1% resistors and voltage regulator. If you have trouble locating some items, try the suppliers that advertise in the back pages of this magazine. If after all of that you are still having difficulty locating a particular part, mail two first class stamps and a self addressed, stamped envelope to the PC-board supplier mentioned in the Parts List for assistance.

A word about T1: The board was designed to accommodate a transformer that was available from a parts supplier that had nationwide outlets. Since then, however, the transformer has been discontinued by that supplier. Fortunately, any 12.6-volt, 1.2-amp center-tapped transformer will do fine, although it likely will have to be mounted off the board.

Substitutions for other parts are also acceptable, providing they are equal or better in quality than the parts specified.

For the sake of both convenience and safety, you should use a PC board. If desired, you can buy one form the supplier listed in the Parts List, or else make one from the artwork provided in the PC-service section, found elsewhere in this magazine.

Once you have assembled the parts and obtained or made the PC board, you can start construction. Refer to Fig. 3 for details as we discuss assembly.

Start by placing the board in front of you with the foil side down. Then install a 100 µF capacitor at C4 along the top left-hand corner.

Continue by installing a wire jumper below C4. If you have been able to obtain a transformer that will fit on the board (see the preceding discussion), install it next. Otherwise, that transformer will have to be mounted off-the-board; in that event the wiring between the transformer and the board will be the among the last steps in the construction process.

Next, install 1N4004 diodes at D7 to D10 as shown. After that, install a 2-µF capacitor at C5, and a 100-ohm resistor at R12.

Finish up the top half of the board by installing a 18.2K (usually marked 1822F) resistor at R11, then a 10-ohm unit at R13. Also install a 68-ohm resistor at R14 and two 1N4004 diodes at D11 and D12.

Move back to the left edge of the board and continue assembly. Install TIP120

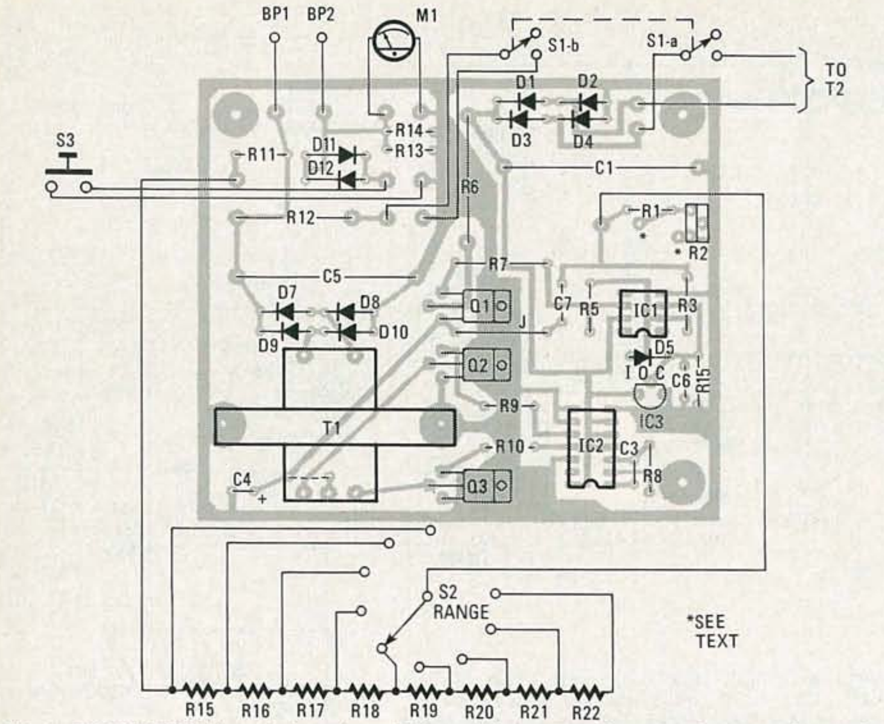


FIG. 3—FOR SAFETY, this project requires a PC board. Here we see the parts-placement diagram for the board shown in our PC Service section.

transistors at Q3 to Q1 first. Note that the leads are bent back 90 degrees, allowing the transistors to be mounted with the metal tabs flush against the board. Then install 10K resistors at R10 and R9.

Continue by cutting a short length of insulated wire and installing it between Q2 and Q1. Position the wire so it doesn't touch the transistors. Then install a 2.2K resistor at R7 and a 10-ohm unit at R6.

Install a 14-pin IC socket at IC2, then an 8-pin unit at IC1. Do not install those IC's until later. Next, install a 0.001-μF capacitor at C3 and a 1-megohm resistor at R8. After that, install a 270-ohm resistor at R4, a 0.1-μF capacitor at C6, and an LM317LE at IC3.

Finish the board by installing a 1N4148 diode at D5 and a 0.1-μF capacitor at C2. Then install a 10-megohm resistor at R5 and a 100K unit at R3. Next install a 5K potentiometer at R2. If the single-turn unit specified in the parts list is used, position the potentiometer with the adjustment screw next to the board edge. The additional pads have been provided around R2 so that a ¾-inch, multi-turn potentiometer (Radio-Shack 271-343 or equivalent) can be used if desired. After R2 is in place, install an 8.2K resistor at R1 and the 1000-μF capacitor at C1. Complete your work by installing 1N4004 diodes at D1 to D4.

Check your work carefully, especially diode and capacitor polarities before continuing. Fix any mistakes now, because they will be harder to correct later.

Refer to Fig. 4 to see the construction details for S2 and its associated resistors. Note that it is easier to wire the switch now than later when it is installed on the front panel. You might find assembly easier if you clamp the switch's shaft in a vise before starting work.

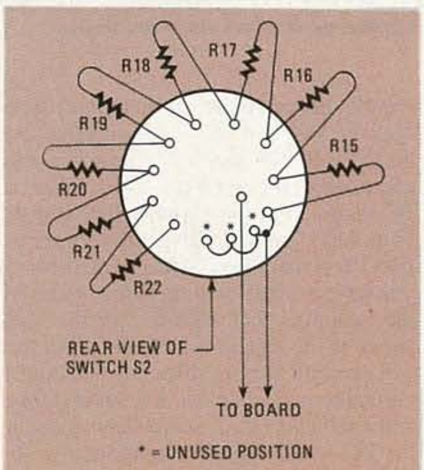


FIG. 4—RESISTORS R15–R22 are mounted on the rear of S2 as shown. Be sure to tie any unused switch positions to R15.

Wire the resistors on the back of switch S2 as shown. Note that most 1% resistors are marked in code; for instance, R15 would typically appear as "3012F."

When the resistors are wired in place, use a piece of bare wire to connect any unused terminals to R15 as shown. That prevents dangerously high voltages from appearing at the output terminals if S2 is set to an unused position. Finish the switch wiring by attaching 6-inch leads.

Set the board and switch aside for a moment and prepare the chassis. Note that the PC-board (and T1 if required) mounts inside of the chassis, while everything else goes on the front panel.

Place the board in the bottom of the box, against the top side. Drill three mounting holes for the board, plus a 1/4 inch hole in the top side for the power cord. Drill another 1/4 inch hole in the bottom side for access to pot R2. If T1 is mounted off-the-board, drill mounting holes as appropriate for the unit you are using.

Complete the mechanical work by installing the switches, binding posts, and meter on the front panel. Connect the switches to the appropriate points on the board.

When done, check your work carefully and correct any errors. Install the board in the box using 4-40 × 1-inch screws and nuts. Use a nut as a spacer between the board and box on each screw. If T1 is to be mounted off-the-board, install it in the chassis and wire the transformer to the appropriate points on the board. Feed the power cord (from T2) through the hole that has been drilled for it and connect the cord to the appropriate pads on the board.

Finish up the assembly by installing a CD4047 at IC2 and an LF356 at IC1.

Checkout

Now we get to try the project out. Plug transformer T2 into a nearby AC outlet. Then set S1 to the DISCHARGE position and likewise set S2 to the 100-VOLT position. Set your DMM to its 200-volt DC range and connect it to the binding posts (BP1 and BP2).

Flip S1 to the CHECK position and the DMM will read somewhere between 85 and 120 volts. If so, the project works and you can go to the calibration.

If you are having problems, disconnect the power and discharge capacitor C5 with a jumper wire. Then check over your wiring for errors. Remember—when troubleshooting, always discharge C5 after turning the power off; that can prevent a dangerous shock.

Calibration

Calibration is easy to perform. First set S1 to DISCHARGE, and then set S2 to the 100-VOLT range. Then set your DMM to its 200-volt DC range and connect it across the binding posts. Flip S1 to the CHECK position and adjust R2 until the DMM reads 100 volts.

To be on the safe side, you should check the output voltage for each position of S2; it should be within 2% of the panel value. If not, the 1% resistor associated with that position should be checked.

Using the project

Danger, high voltage! This project can provide a dangerous electrical shock if misused. Avoid a harmful shock by using

continued on page 94

A Revolution in IC Packaging

We're in the midst of a revolution now—a packaging revolution! Find out what it's all about, and get a glimpse of what lies ahead.

TJ BYERS

WHAT IS IT ABOUT ELECTRONICS THAT fascinates so many people so deeply? There are probably as many answers to that question as there are people to answer it, but no one could deny that part of our fascination is due to the rapid rate at which innovations are thrust upon the marketplace.

The problem is that today's innovations soon become tomorrow's commonplaces. Consumers quickly learn to take new products for granted, so that what was once superfluous soon becomes necessary. And as users master the use of those now-necessary products, their needs become more sophisticated. In order to meet those needs, electronic circuits must become more complicated. Hence designers find it increasingly difficult to fit the components that are required into the space that is allotted for those components. The space problem is particularly acute in the computer industry where standardized card sizes and limited numbers of expansion slots set artificial limits on expandability.

In order to alleviate space problems designers are constantly on the lookout for ways of cramming more circuitry into the same—or even less—space. The first major breakthrough occurred in the late 1940's when the transistor was invented. The second breakthrough occurred in the early 1960's when the integrated circuit was invented. We're in the midst of the third stage right now; it comes in two parts: VLSI (*V*ery *L*arge *S*cale *I*ntegration) and SMT (*S*urface *M*ount *T*echnology).

VLSI refers to the design and manufacture of IC's that contain great numbers of transistors and other circuit elements. SMT refers to extra-small components (resistors, capacitors, transistors, IC's—in fact, most components) that are soldered to the surface of a PC board—but with no legs penetrating to the opposite side of the board! We won't discuss VLSI any further in this article, but we will discuss various SMT packages, how to mount them to PC boards, and how to troubleshoot and repair PC boards built with SMT devices.

DIP *vs.* SMT

The success of the semiconductor industry is due, in great part, to the standardization of the DIP (*D*ual *I*nline *P*ackage) IC. Basically, a DIP is a rectangular block of plastic, ceramic, or other material that encapsulates the silicon chip on which the actual circuit elements are etched. Access to the chip is via metal leads that protrude from both sides of the case at intervals of 0.100 inch. That spacing arose from the need to have a lead strong enough to withstand the rigors of automatic insertion machinery.

The DIP has served the industry well, but as the encapsulated circuitry has become more complex, the package has become larger. The problem is not the size of the silicon chip; it's that highly complex IC's need more connections to the outside world. Since lead spacing is a fixed quantity, the package grows larger while the chip itself increases very little. We end up with a very small chip in a very large container.

SMT to the rescue

IC's packaged in the SMT manner have legs spaced on 50-mil (0.050-inch) centers, and that alone allows us to reduce the size of an SMT package from 30 to 60 percent over a comparable DIP device. This means that more IC's can fit in the same amount of PC board space. In fact, we might mount two or three IC's in the space formerly occupied by one. Further, using standard packaging techniques, surface-mount assemblies can approach the density of hybrid circuits, which are the most densely-packed assemblies currently in production. And SMT assemblies can be repaired, whereas hybrids cannot.

The advantages of SMT IC's become apparent when they are used with double-sided PC boards. Using surface-mounting techniques, it is possible to have two completely different circuits on one PC board—one on each side. That, of course, is impossible with through-hole technology. The equivalent of two cards can now occupy the space of one, and signals can be passed from one circuit to the other using jumpers from one side of the board to the other, and that reduces outside wiring requirements. And since the legs of an SMT device don't penetrate the PC board, boards are both cheaper to manufacture and more reliable in operation.

Types of SMT devices

There are, basically, three different types of surface-mounted IC's: the SOIC (*S*mall *O*utline *I*ntegrated *C*ircuit), the PLCC (*P*lastic *L*eaded *C*hip *C*arrier), and the LCCC (*L*eadless *C*eramic *C*hip *C*arrier). See Fig. 1 to get an idea how each looks in comparison with a standard DIP package.

The SOIC is probably the most popular SMT package; it was developed in Europe in the mid 1970's for use in electronic watches. The SOIC resembles a small DIP with its leads bent out gull-wing style and spaced at 50-mil intervals. The gull-wing design permits the tips of the leads to lay flat on the surface of the PC board; it also allows easy access to those leads for troubleshooting and repair. The SOIC comes in 8-, 14-, 16-, 20-, 24-, and 28-pin packages, and it can be handled by the same automatic insertion equipment that is used for DIP packages. That makes SOIC the preferred choice when several packaging technologies are used on the same PC board.

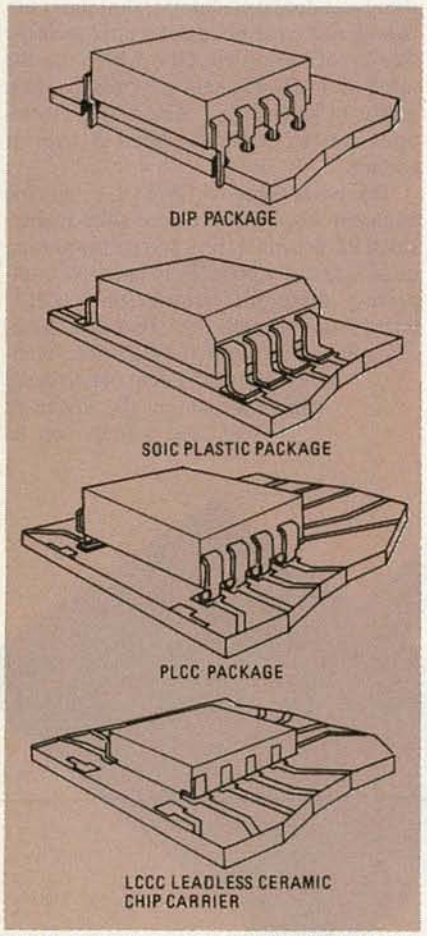


FIG. 1—THE THREE MAIN TYPES OF SMT DEVICE are shown beneath a standard DIP device. The drawing is not to scale.

The PLCC

The leads of a PLCC package are formed in a way that is similar to the way SOIC leads are formed. The difference is that the leads are rolled up under the molded plastic body in a *J*-like shape. Tucking the leads beneath the package reduces the size of the IC; that allows greater component density, and it also provides protection from lead-handling damage. But the tucked-in leads are harder to get at, so PC boards are harder to troubleshoot and repair.

The PLCC's biggest advantage over the SOIC is that a PLCC can have leads on all four sides. To understand how important that can be, consider this: The DIP package grows disproportionately larger than the chip it houses because of the additional width required to route interconnecting wires from the silicon die to the outside world. The more leads a DIP contains, the wider it must be to avoid the possibility of two leads shorting together. Four-sided carriers help alleviate that problem by connecting leads to the previously unused ends of the package. PLCC's have another advantage in that they can be socketed, but SOIC's cannot.

PLCC's are available in 18-, 20-, 28-, 44-, 52-, 68-, and 84-pin packages; they're footprint-compatible with LCCC's, discussed below; and they conform to JEDEC (*J*oint *E*lectronic *D*evices *E*ngineering *C*ouncil) standards. PLCC's currently cost about the same as standard plastic DIP's.

LCCC's

The third major type of SMT IC burst upon the scene in the early 1970's. The most notable feature of the LCCC is that it has no leads; rather, metallic contacts are molded into its ceramic body. Like the PLCC, the LCCC can have from 20 to 84 contacts on all four sides. LCCC's are the most rugged members of the SMT family, and that explains their preference by the military. An LCCC device mounted on a PC board is shown in Fig. 2, and an LCCC with its "hat" off is shown in Fig. 3.

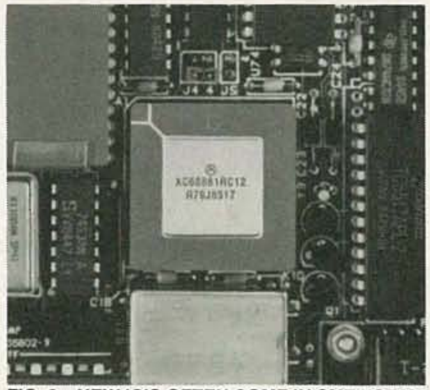


FIG. 2—NEW IC'S OFTEN COME IN SMT FORM, but the bulk of many circuit boards will continue to be DIP IC's.

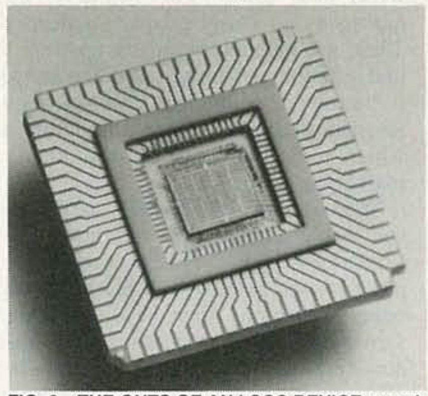


FIG. 3—THE GUTS OF AN LCCC DEVICE reveal the closely-spaced wires that connect the chip to the outside world.

There is one problem with LCCC's. An LCCC must be bonded to its circuit board rigidly. Although that is desirable mechanically, it creates thermal problems. All things in nature—circuit boards and IC's are no exception—change in size as temperature changes, and different materials have different coefficients of expansion. That is, some things expand more than others for the same change in temperature. For example, the ceramic of an LCCC and the glass epoxy of typical PC boards have different coefficients of expansion. The shearing force that develops because of those different amounts of expansion can cause solder bonds to snap. In comparison, SOIC and PLCC packages aren't affected by thermal expansion because the stress is absorbed by their resilient metal legs.

The problem of thermal expansion has plagued the LCCC since its introduction, and it's the major reason why the LCCC has had so little impact on the commercial market. Only by using expensive, thermally-compensated PC boards, made with such exotic materials as Invar, are LCCC's really practical.

To avoid thermal expansion problems, an LCCC can be mounted in a socket. Sockets, however, have problems of their own, and actually defeat some of the advantages gained by the LCCC package.

Now that we've got an idea of the different kinds of SMT IC packages that are available, let's take a look at how we can use them.

Using SMT IC's

Since SMT devices are soldered directly to PC boards with no additional mechanical support, special handling is required. First, you must realize that the only mechanical bond between the device and the board is the solder connection itself. Consequently, the solder joints must be not only electrically sound, but mechanically strong.

Unfortunately, only the SOIC, with its

gull-wing design, lends itself well to conventional soldering methods. Both the PLCC and the LCCC packages have their solder contacts tucked under the body of the device where they are relatively inaccessible.

Manufacturers have overcome that obstacle by using techniques like reflow soldering. In that process both the pads on the PC board and the leads of the SMT device are pre-tinned. Next, a flux is applied to the solder pads on the PC board; that flux contains a quantity of granulated solder (85-90% by weight) that is held in suspension by the thick flux paste.

The IC is aligned with the solder pads and pressed into place. The entire assembly—PC board, components, and all—is then heated to a temperature where the solder melts and the flux evaporates. At that temperature, the solder on the leads of the device, the solder on the PC pads, and the solder in the paste flow together and become one. Cooling the assembly solidifies the molten solder, and that forms a connection that is (hopefully) electrically and mechanically sound.

Several methods of heating are currently in use, including infra-red, vapor phase, and convection. With minor adjustments, conventional wave-solder machines can also be used for SMT components, but those components must be glued to the PC board prior to immersion.

Part alignment, of course, is critical to the success of reflow soldering. With no leads projecting through holes in the PC board to secure them in place, leads and solder pads can become misaligned. Manufacturers try to counter that problem by adding an adhesive compound to the flux so that the part is held tightly in place until the reflow process heats the flux to the point of evaporation. Most types of flux adhesive are hardened using ultra-violet light, but some permit air drying.

Of the three major types of SMT packages, the LCCC is the most forgiving of misalignment. In fact, as much as 25% misalignment is permitted because the surface tension of the molten solder allows the LCCC to align itself with the PC board's solder pads. SOIC and PLCC devices are not so forgiving. Unless the error is very small, any misalignment in parts of those types could be disastrous. How can we correct such errors?

SMT troubleshooting

It is estimated that, by 1990, 70 percent of all electronic equipment throughout the world will be manufactured with SMT devices. Consequently, the hobbyist as well as the service technician will soon be faced with a whole new set of fabrication and repair problems.

Size is one such problem. SMT pins are spaced 50 mils apart, so troubleshooting with standard test probes will be like knitting with telephone poles! The narrow width of an SMT lead makes it difficult to get a probe into the test area, and it makes it easy for the probe to slip and to short adjacent pins. The result of such a slip could be devastating to the circuit.

The actual mounting technique itself is the source of another problem. Often, much of the interconnecting circuitry—the etched copper traces—lies buried beneath the SMT components. That makes it hard to perform standard signal tracing. The problem is compounded further by high component density, which leaves few traces between components exposed.

One way of getting at LCCC leads is with an IC test clip, like the one shown in Fig. 4. Since the contacts in the clip are precisely spaced and rigidly fixed, the danger of shorting pins together is reduced. Unfortunately, you need a different test clip for each package size. One thing that could help the IC test-clip crunch is to place strategic test points on the PC board in easily-accessible places.

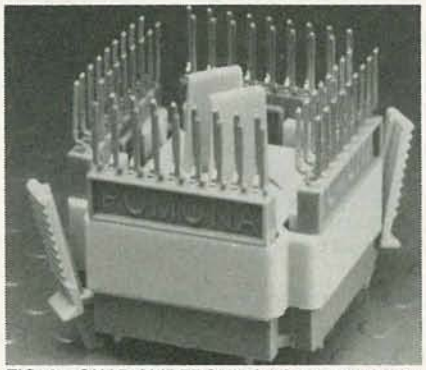


FIG. 4—*QUAD CLIP* FROM POMONA attaches to a 68-pin PLCC and allows the user easy access to the closely-spaced leads of the device.

Test equipment will also be affected by increased use of SMT devices. For example, we'll need equipment with faster clock speeds and faster rise times. The reason is that, by reducing the size of components, and thereby shortening the signal paths between them, rise and fall times become sharper, and clock rates can increase. You'll find that test equipment that worked well with DIP devices can't monitor the faster events of SMT units.

SMT repair procedures

Tracking down a bad SMT device will be difficult, but it will be even more difficult to remove that device and mount a new one in its place. One useful tool for SMT removal, the heated collet, is shown in this story's opening photo.

A heated collet is quite similar to a desoldering tool used to remove DIP devices. A DIP-desolderer is a bar of metal that makes contact with, and thereby heats, all pins of a device at the same time. After the solder melts, the part can be removed from the board easily.

SMT soldering collets work somewhat differently than DIP desoldering tools. First, the collet clamps around the device itself, rather than contacting the through-hole pads of the PC board. So a separate collet is required for each package size. In addition, the collet must heat the entire SMT device, along with the pads on the board, so precise heat regulation is required in order to avoid destroying a heat-sensitive part. And that, of course, results in an expensive tool.

A heated collet can also be used to attach a replacement device. However, the PC board and the SMT devcice must be prepared for reflow soldering.

Begin by removing excess solder from the pads on the PC board. Braided solder wick works well for that chore. After the pad is completely clean, apply a dab of reflow soldering flux to each pad. Only reflow flux (which contains solder) can be used; conventional flux compounds will not work. The amount of flux that is required varies from brand to brand, so you should read the directions that come with the product. Most surface-mounted devices are pre-tinned, but you should make sure that your device is properly tinned before trying to mount it. If necessary, tin the leads of the new component. In any case, tarnished leads should be thoroughly cleaned and freshly tinned.

Now align the part with the solder pads, *taking careful notice of pin orientation.* Although at room temperature many reflow fluxes are sticky enough to prevent an SMT device from moving, as the flux is heated, the device may begin to creep. Therefore, you should glue the part in place with a quick-setting adhesive (from a hot-glue gun, for example) to keep things aligned. You must be extremely careful to align the leads with the solder pads perfectly before the glue sets—otherwise you may have a *real* problem!

After the glue has set, apply the heating collet to the replacement IC. Within a few seconds the flux should vaporize and produce a small puff of smoke. Keep the collet pressed against the IC for a second or two longer and then release it. This ensures that the solder from all three sources will flow together smoothly. Don't heat an SMT device for more than about 10 seconds or the device may be damaged. You can remove excess flux from the board with denatured alcohol.

Removing an SOIC device is easier because the gull-wing leg design allows the legs to be accessed individually with a low-powered soldering iron. The problem is that, even though SOIC devices are easy to replace, the industry tends to use PLCC devices more often because they have a smaller footprint, and because they are easier for automatic insertion equipment to handle.

As we mentioned above, IC's aren't the only devices that come in SMT packages. Let's take a look now at how several other devices are packaged.

One-megabit DRAM

The semiconductor industry is on the verge of perfecting a 1-megabit *D*ynamic *R*andom *A*ccess *M*emory IC, so manufacturers are designing an appropriate package. To arrive at a standard, manufacturers are looking beyond just package design. Trends indicate that sales of both 256K DRAM's and one-megabit DRAM's could be the largest the semiconductor industry has ever seen. So the configuration arrived at now will affect future DRAM designs considerably.

The problem is simply that the standard DRAM package, which has satisfied memory needs for ten years now, has run out of space. When that package was created, it had more pins than were needed. But as memory chips grew in size, more and more of those pins were used, and the 256K DRAM has claimed the last pin.

In addition to running out of pins, designers also want to take advantage of the benefits provided by SMT packaging. One design that is receiving critical review is the *S*mall *O*utline *J*-lead, or SOJ, surface-mounted package that Texas Instruments has proposed; it is shown in Fig. 5.

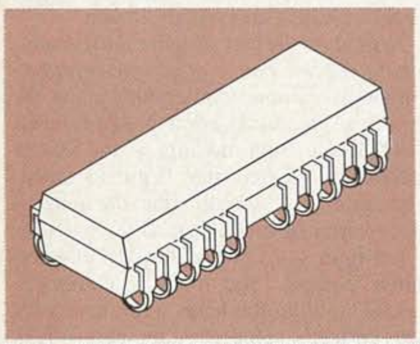


FIG. 5—TI'S PROPOSED ONE-MEGABIT DRAM allows an SMT bypass capacitor to be mounted beneath the IC.

Calling on its years of surface-mount experience, TI has introduced an IC carrier that is a radical departure from mainstream PLCC designs. TI's SOJ device is a 26-pin package in a 300 × 675 mil (width × length) configuration. Since the IC uses only 20 pins, TI reasoned, six pins could be removed—from the middle of the carrier. TI thought that, by removing the pins from the center of the carrier, there would be space to mount a decoupling capacitor beneath the IC, as well as to provide room for routing PC traces.

The concept quickly gained wide approval, and the outline has been accepted by JEDEC (*J*oint *E*lectronic *D*evices *E*ngineering *C*ouncil) as the standard configuration for one-megabit DRAM's. The only factor that remains to be decided is the final size of the SOJ device.

Surface-mounted transistors

Two standard packages, the TO-236/SOT-23 and the TO-243/SOT-89, already exist for surface-mounted transistors and diodes. The TO-xxx is the designation used in North America, and the SOT-xx is used in Europe. The designations mean the same thing, but SOT is the popularly-accepted nomenclature both in the U.S. and abroad. TO is the acronym for *T*ransistor *O*utline, and SOT for *S*mall-*O*utline *T*ransistor.

Originally designed for use in hybrid-circuit construction, SOT packages are normally used to house small-signal transistors; the package can dissipate up to 200 mW in free air. The performance of SOT devices is equal to that of conventionally-packaged ones.

As shown in Fig. 6, the SOT-23 package has three leads, two on one side, and

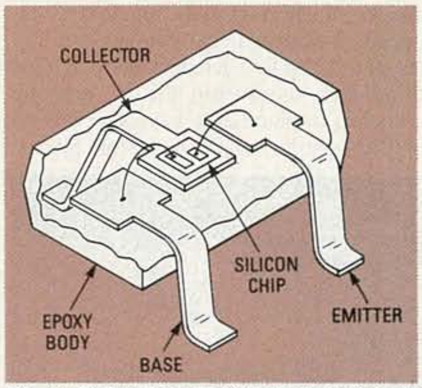


FIG. 6—THE SOT-23 TRANSISTOR package is only about 0.25-inch on a side.

the third in the center of the opposite side. The leads are formed in gull-wing fashion similar to the SOIC. The SOT-23, including leads, is about 1/10-inch on a side—that's about 1/3 the size of an ant!

Other SMT devices

New SMT configurations are introduced often. For example, the SO8 package shown in Fig. 7 is actually about 0.25-inch on a side, but it is functionally equiv-

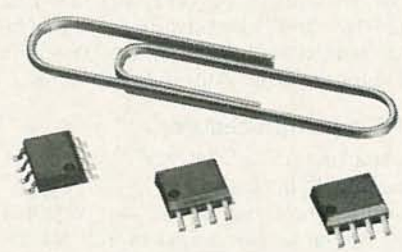


FIG. 7—THE SO8 IC PACKAGE is also about 0.25-inch on a side and it contains the equivalent of a 78L05 regulator.

alent to a 78L05 voltage regulator. In addition, components other than semiconductors are becoming available in SMT configurations. For example, the devices shown in Fig. 8 are surface-mount trimmer resistors manufactured by Noble

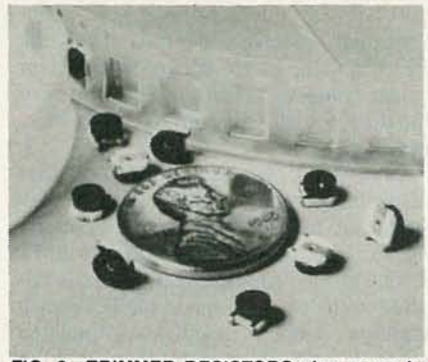


FIG. 8—TRIMMER RESISTORS also come in SMT form; each device is about 4 mm on a side.

U.S.A. (151 Stanley Street, Elk Grove Village, IL 60007). The "chip trimmer" devices can operate at temperatures ranging from −30°C to +100°C, and they can handle 200 mW of power at 20 volts. They measure about 4 mm on a side, and they're about 2 mm thick.

SMT in the real world

To get an idea of how SMT devices may be used, take a look at Fig. 9. Shown there is a 128K × eight-bit static RAM module;

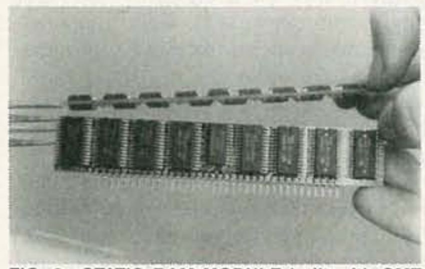


FIG. 9—STATIC RAM MODULE built with SMT devices uses less power than comparable dynamic RAM's.

overall dimensions of the device are less than 1″ × 5″. There are eight 8K × 8-bit static RAM's and a custom decoder IC mounted on one side of the module, and eight more RAM's and four 10 μF bypass capacitors mounted on the other side.

According to the manufacturer (Advanced Electronic Packaging, 2159 Bay Street, Los Angeles, CA 90021), the module uses 500 times less power bit-for-bit than a conventional 256K × one-bit dynamic RAM.

Conclusions

The watchword in electronics these days is SMT, and what SMT stands for is increased utility that uses less power and that occupies less space. For example, one company is marketing 20-megabyte disk drives for the IBM PC. The complete disk controller electronics, *as well as the drive itself,* is mounted on a single standard-sized plug-in expansion card.

The increased utility that SMT brings, however, goes hand-in-hand with new problems in manufacturing and troubleshooting. So new tools and techniques will be needed to keep up with SMT. **R-E**

Making Measurements with IC's

New IC sensors are revolutionizing the way industry gathers information. In this article we learn about the kinds of devices currently available, and what shape future sensors are likely to take.

HARRY L. TRIETLEY

WE ALL KNOW HOW SEMICONDUCTOR technology has revolutionized electronics. In one generation we have gone from hand-wired assemblies using vacuum tubes to entire computers mass-produced on silicon wafers by largely-automated processes. That revolution has transformed industries, and, indeed, the economy of the world. Needless to say, the effects have also been felt in the fields of consumer and hobby electronics.

The electronics industry is now in the early stages of a similar revolution in sensor manufacture. At present, most devices that measure such variables as temperature, pressure, force, and chemical composition are assembled from discrete components, and often require machining, hand assembly, soldering, welding, gluing, epoxying, etc. Now, however, new techniques for the creation of mechanical microstructures and chemically-sensitive devices in silicon are changing all that. Integrated silicon devices measuring temperature, strain, pressure, and video images already are available from several manufacturers. University and laboratory research is progressing on electrochemical and other complex sensing devices. In this article we'll take a look at today's sensor products, the research that is being done in the field, and what form future sensors might take.

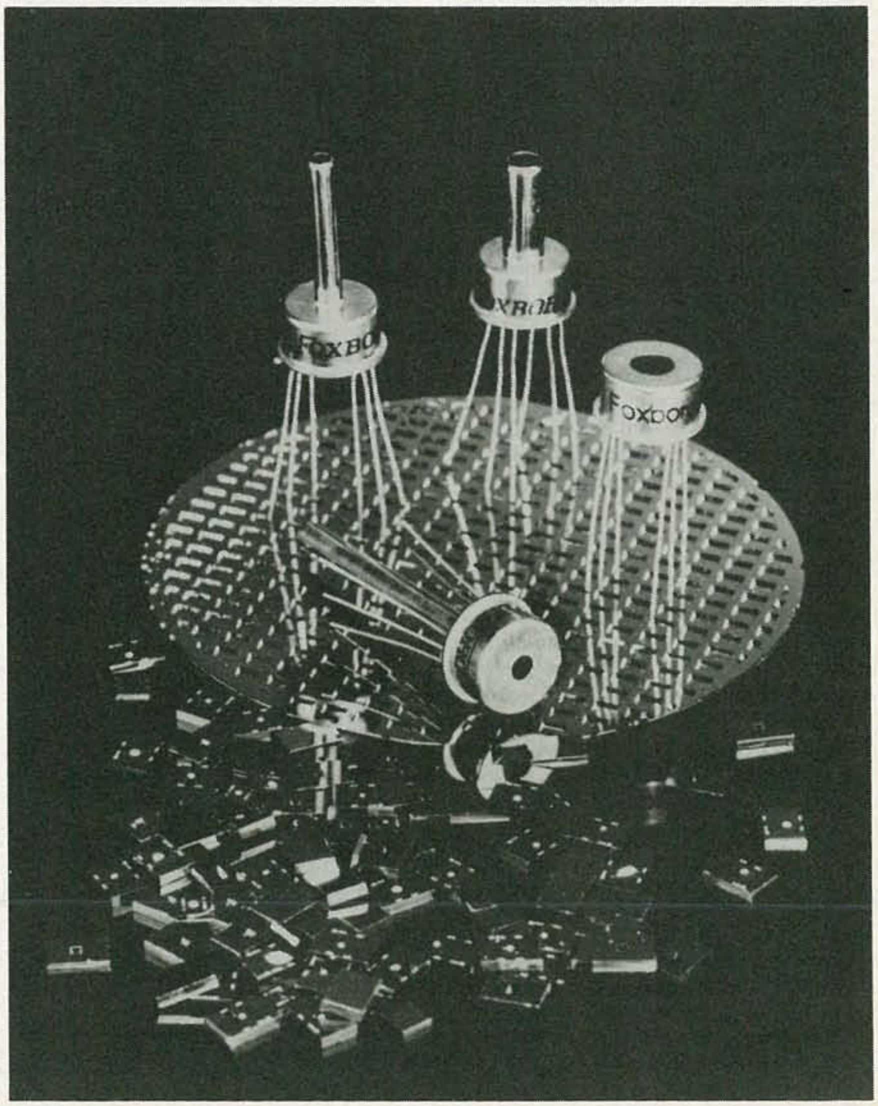
Temperature sensors

The drop across a forward-biased P-N junction (diode or base-emitter junction) is about 0.7 volts at 25°C. As temperature rises, that voltage drop decreases by about −2millivolts/°C. Because of that, diodes and transistors are sometimes used as temperature sensors, especially in compensation applications where absolute accuracy is not important. The exact temperature sensitivity depends on the semiconductor's doping, the junction's geometry and current density, and resistances in series with the junction. Those characteristics vary from device to device. Manufacturers do not normally control or test for exact temperature coefficient.

Temperature sensor IC's having controlled characteristics are available; they are generally housed in conventional transistor or IC packages. Several different families exist, each with its own unique circuitry and output. Fig. 1 shows the schematic of one device, an Analog Devices AD590. In that IC, two identical transistors, Q9 and Q11, are connected so that the ratio between their two collector currents is fixed. For a ratio r, the difference between their base-emitter voltages will be proportional to absolute temperature, T. More specifically, the difference will be (kT/q)(ln r), where k is Boltzman's constant, q is the electron charge and (ln r) is the natural logarithm of the current ratio.

That voltage is converted to a current by R5 and R6, which are low-temperature-coefficient thin-film resistors that are laser-trimmed for proper calibration at 25°C. The collector current of Q10 tracks those of Q9 and Q11. Transistor Q11 supplies all the leakage and substrate current used by the rest of the circuit. That forces the entire current to be proportional to the absolute temperature. The AD590 is a two-terminal device, inserted in series with any DC supply between 4 and 30 volts, regulating the series current to be equal to 1μA/°K, where °K is the Kelvin temperature (1°K equals 1°C plus 273.15.)

The operating range for temperature-sensor IC's is similar to that of other IC's, generally −55 to +150°C. Although lin-



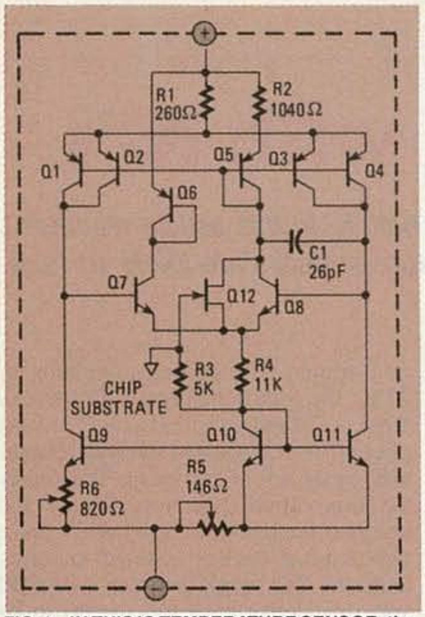


FIG. 1—IN THIS IC TEMPERATURE SENSOR, the AD590, the ratio of the base-emitter voltages of Q9 and Q11 is proportional to the absolute temperature.

ear, their accuracies and stabilities do not yet equal those of other temperature sensors. Remember, however, that those devices have only recently been developed and their performance is likely to improve with continuing research.

Strain gages

Strain gages respond to mechanical stress, changing their resistances as they are stretched or compressed. Bonded to metal or other slightly elastic surfaces, they are often used to measure mechanical force, weight, or tension. Lengths of doped silicon (that is, silicon resistors) undergo noticeable resistance changes when they are stressed, mainly because distortion of their crystal lattice structure changes both the concentration and the mobility of their charge carriers (electrons or holes).

Strain gages increase (p-type) or decrease (n-type) in resistance as they are stretched. Strain gages may typically be stretched or compressed up to 0.5% of their original length, at which point they will undergo resistance changes of between 25% and 100% depending on their doping.

A multiple strain gage, perhaps configured as a strain-gage bridge as shown in Fig. 2-*a*, may be diffused into silicon structures. Two such structures are shown in Fig. 2; Fig. 2-*a* shows a diaphragm while Fig. 2-*b* shows a beam. The diaphragm is used to measure pressure, as we shall see shortly, while the beam is used to measure force.

Unfortunately, silicon resistors are affected by temperature as well as strain. (In fact, they are also sold as positive-temperature-coefficient thermistors.) Without some sort of compensation, normal ambient temperature fluctuations can cause significant measurement errors. Also, even at a constant temperature, their sensitivity and calibration will vary from unit to unit. Those effects can be compensated for by using fixed resistors and connecting the gage or gages as a Wheatstone bridge. The value of those fixed resistors is determined by measuring the bridge's behavior at two or more temperatures. That information is then fed to a computerized circuit model to calculate the fixed bridge-resistor values. The resulting circuit generally looks somewhat like the one shown in Fig. 3. Those measurements and calculations are beyond the capabilities of most experimenters and many production facilities; however, manufacturers of the devices (especially integrated devices such as those in Fig. 2) can supply the calculated values for each individual device.

Pressure sensors

Integrated-circuit pressure sensors are made by etching a thin membrane in silicon. A strain-gage bridge is diffused into the membrane and protected by a grown layer of silicon oxide as shown in Fig. 4. The cavity behind the diaphragm is covered by a Pyrex or silicon backing-plate. Barometers or absolute pressure sensors are created by evacuating and sealing the cavity, while gage-pressure or differential-pressure devices include an opening through the back plate.

Integrated pressure sensors are most often mounted in transistor-type housings. Absolute pressure sensors have a single hole or connection tube; gage- or differential-pressure devices include a second opening. Manufacturers offer assemblies designed for more rugged applications, including industrial assemblies in which the IC is protected from corrosive fluids by stainless-steel diaphragms.

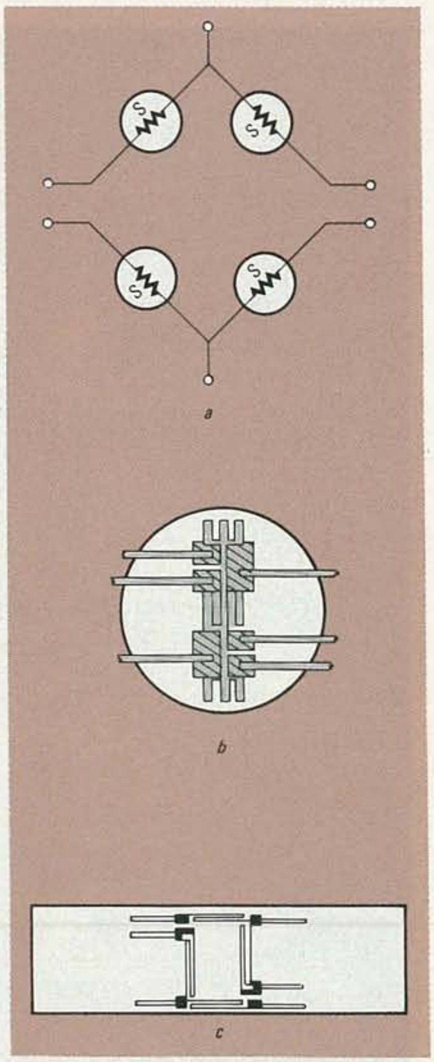


FIG. 2—A STRAIN GAGE BRIDGE (*a*) can be defused into a silicon diaphragm to measure pressure (*b*) or into a beam to measure force (*c*).

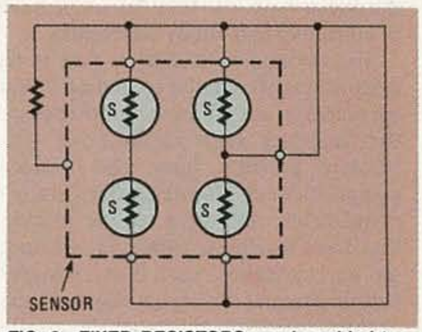


FIG. 3—FIXED RESISTORS can be added to a silicon strain-gage bridge to adjust its sensitivity and minimize its drift with temperature.

Let's look at some typical transducer specifications. Pressure ranges run from 5 to 5,000 psi, with full-scale sensitivities between 50 and 300 mV. Sensitivity tolerances may be ±25 or 50% of nominal, with zero-offset tolerances adding another several percent. It is up to the user to calibrate his readout circuitry to match each particular sensor. With some devices it is also necessary to add temperature-compensating resistors using values computed by the manufacturer as mentioned earlier. Some manufacturers do supply calibrated assemblies including electronics; those, however, are not monolithic ICs.

Acceleration

To simplify things somewhat, acceleration may be measured by attaching a mass to a spring or other elastic device. When the opposite end of the spring is accelerated, the spring stretches or is compressed. The change in length (strain) is proportional to the rate of acceleration.

The basic concept, as applied to an integrated semiconductor-accelerometer, is shown in Fig. 5. A thin cantilever beam is etched into the silicon crystal, using an anisotropic etchant, which dissolves the silicon well in certain direction but poorly in others, to etch a cavity under the beam.

A mass is attached to the unsupported end of the cantilever, either by etching so as to leave a mass of silicon or by adding a heavy electroplated layer of gold. The device is sealed with a protective glass top cover. Typical dimensions of an experimental device reported by Stanford University are 2- × 3- × 0.6-mm. The cantilever itself is 15μm thick.

When the device is accelerated perpendicularly to the cantilever, the beam flexes, its displacement being proportional to the acceleration. Displacement may be measured by diffusing a strain gage into the cantilever or by depositing a piezoelectric material on it.

Note that the device discussed here is experimental; as far as the author is aware, no commercial IC accelerometer devices are available at this time.

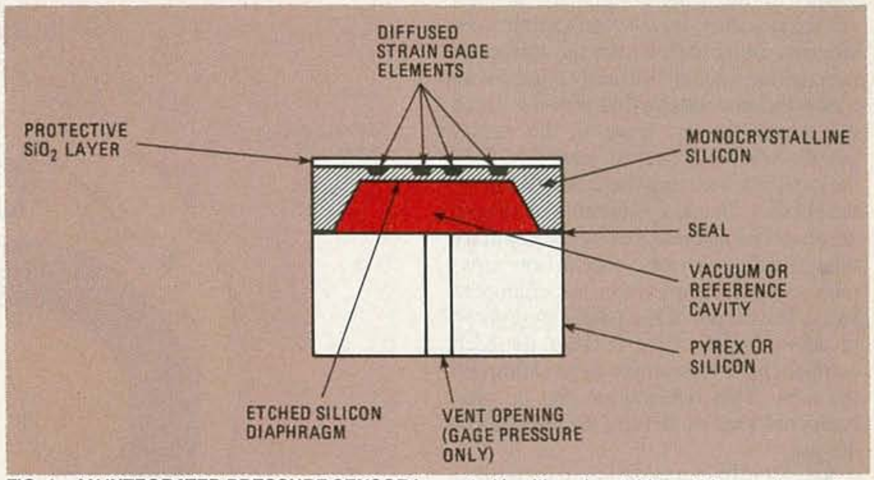


FIG. 4—AN INTEGRATED PRESSURE SENSOR is created in silicon by etching a thin membrane, then diffusing four strain gages in it. The sensor is completed by sealing it with a backing of Pyrex or silicon.

Hall-effect sensors

A Hall-effect device (the Hall effect was first demonstrated by E. F. Hall in 1879) measures magnetic-field strength by deflecting moving electrical charges in a semiconductor. The amount of deflection of that moving charge is proportional to the field's strength.

The concept behind the Hall-effect device is shown in Fig. 6. Electrons flowing in an n-type semiconductor are deflected by the magnetic field at right angles to the direction of the current. That causes them to drift to the right, inducing an electric field between the sides of the semiconductor as shown. The electric field's force opposes the magnetic deflection, producing a balanced condition. As a result, the induced voltage is proportional to both the current and the strength of the magnetic field. A similar effect occurs in p-type semiconductors; however, the induced electric field's polarity is opposite that shown in Fig. 6.

Several companies, including Sprague and Texas Instruments, offer commercial devices based on the Hall effect, usually integrating analog or digital signal-conditioning circuitry with the sensor.

Digital-output devices are used in conjunction with permanent magnets as proximity switches and mechanical limit-sensors, and may replace mechanical microswitches in many applications. They are useful in keyboards (the magnet is in the switch cap) and other control devices, having no contacts to wear or bounce. Other applications are as diverse as pinball detectors and ignition switches.

Analog-output Hall-effect devices are used to measure magnetic flux or to sense movement of a permanent magnet. The latter, of course, allows movement to be translated into an electrical signal. A Hall device also can serve as the secondary of a DC transformer to allow the isolated measurement of DC currents. Let's explain further: A winding on a transformer core produces a field proportional to its current; the Hall effect sensor is used to measure the field directly, and the DC current indirectly. In the case of large currents (say, 30 amps or more) the primary can be a single wire inserted through the center of the core.

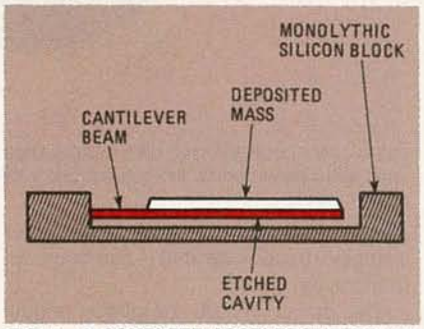


FIG. 5—A COMPLETE ACCELEROMETER can be etched from a single, monolithic crystal of silicon. A strain gage diffused into the cantilever beam detects the flexing of the beam as the device is accelerated or vibrated.

Image detectors

TV and image detectors are large-scale photodiode arrays, integrated with switching and shift register circuitry that scans the diodes and produces a serial output. Array sizes run from single-line devices of 64 to 4,096 diodes, to matrix arrays of up to 256 × 256 (65,536 diodes). Applications include optical character-recognition, single-line arrays used in the wands that scan prices and inventory codes at checkout registers, robotics, and other industrial applications, and TV. Arrays are available that detect infrared, X-rays, and visible light.

Photodiode arrays are usually housed in IC packages with ground and polished glass windows. Two single-line arrays, and their associated circuitry, are shown in Fig. 7. In Fig. 7-*a*, the diode charges are transferred to a charge-coupled device (CCD) analog shift-register (a bucket-brigade device) and then clocked sequentially to the output. The circuit of Fig. 7-*b* clocks a pulse through a digital shift-register to connect one diode at a time to the output line. Matrix arrays, of course, use two-dimensional switching arrays.

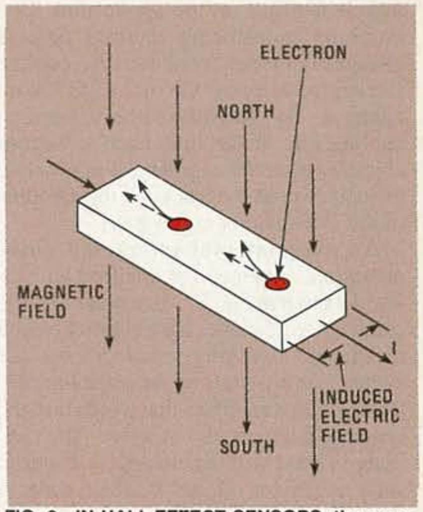


FIG. 6—IN HALL-EFFECT SENSORS, the presence of a magnetic field deflects moving electrical charges, inducing an electrical field and hence a voltage.

The sensing elements are diffused-junction pn diodes, which convert light to an electric charge. The charge builds up (integrates) as long as the diode sees any light; the total charge is dumped when each diode is connected to the CCD or output line. The longer the time between frames the more charge builds up. Thus, there is a tradeoff between speed and sensitivity. Clock frequencies of 1 to 5 MHz are common, and devices with speeds of 10 MHz are available.

Gas chromatograph

Probably the most complex IC sensing device to be designed to date is a gas chromatograph. The gas chromatograph is a device that is used to separate and identify the contents of a sample of a gaseous mixture.

In a gas chromatograph, the sample to be analyzed is injected at the head of a long, thin capillary column. It is then flushed through the column by an inert carrier gas. As it travels, the sample constituents are absorbed onto the surface of the capillary, which is usually coated with a material that aids in that process. Once the sample passes, however, the carrier gas flushes the absorbed materials from the capillary, carrying them out the end of the column. Because different substances are absorbed and released by the capillary tube at different rates, that action separates the gas sample into its component parts. The output of the tube is monitored to determine the time it takes for each component of the sample to pass through the tube. That information can be analyzed and used to identify the contents of the gas.

Several different techniques are used to monitor the tube's output; the method of monitoring is a matter of choice, and largely depends on the application. One common monitoring method detects changes in thermal conductivity (cooling rate) as the composition of the gas stream changes. By measuring the change in cooling rate at the time each substance emerges from the capillary, it is possible to analyze both the types and the amounts of the constituents of the gas.

An experimental integrated chromatograph developed at Stanford University is shown in Fig. 8. Most notable is the capillary, a 1.5-meter long column etched in silicon. Two long spiral grooves are etched side-by-side and joined at the center, creating a capillary that winds into the center and then back out again. The capillary is lined with an absorptive material such as silicon oil and bonded under a plate of glass. The entire device is built on a single silicon wafer that is 5 centimeters in diameter.

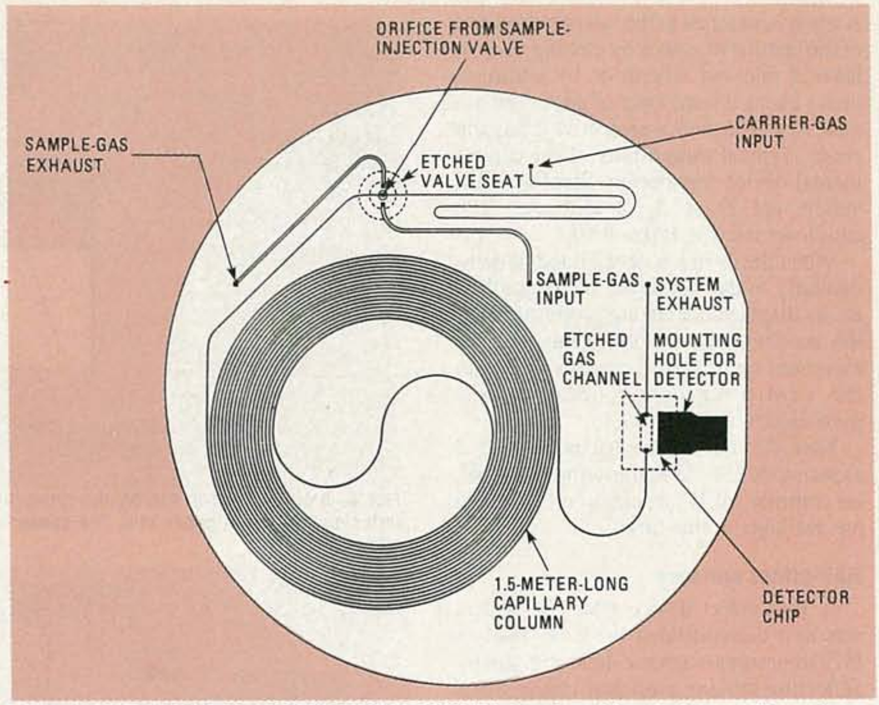


FIG. 8—AN EXPERIMENTAL GAS CHROMATOGRAPH IC integrates a 1.5-meter long capillary column, input and exhaust ports, valve seats, and a thermal gas detector on a single 5-centimeter diameter silicon wafer.

The device is not completely monolithic. The necessary valve seats, inlets, and outlets are etched in the silicon, but the valves themselves are implemented using miniature solenoids, plungers, and diaphragms. The thermal detector is a small thin-film resistor supported on a thermally-isolated Pyrex glass membrane.

Although the Stanford device is not commercially available, Microsensor Technology Inc. (Fremont, CA) has developed a similar silicon mechanism. Their device does not incorporate the capillary column, but it contains most of the Stanford chromatograph's other features. It is not available as a component, but is built into a gas analyzer sold by Microsensor Technology.

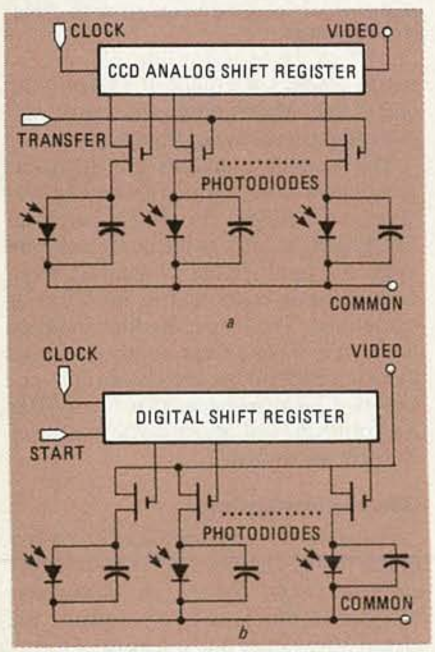


FIG. 7—THE OUTPUTS of an integrated photodiode array can be clocked into an analog CCD shift-register and shifted out (*a*), or scanned sequentially using analog switches and a digital shift register(*b*).

Future possibilities

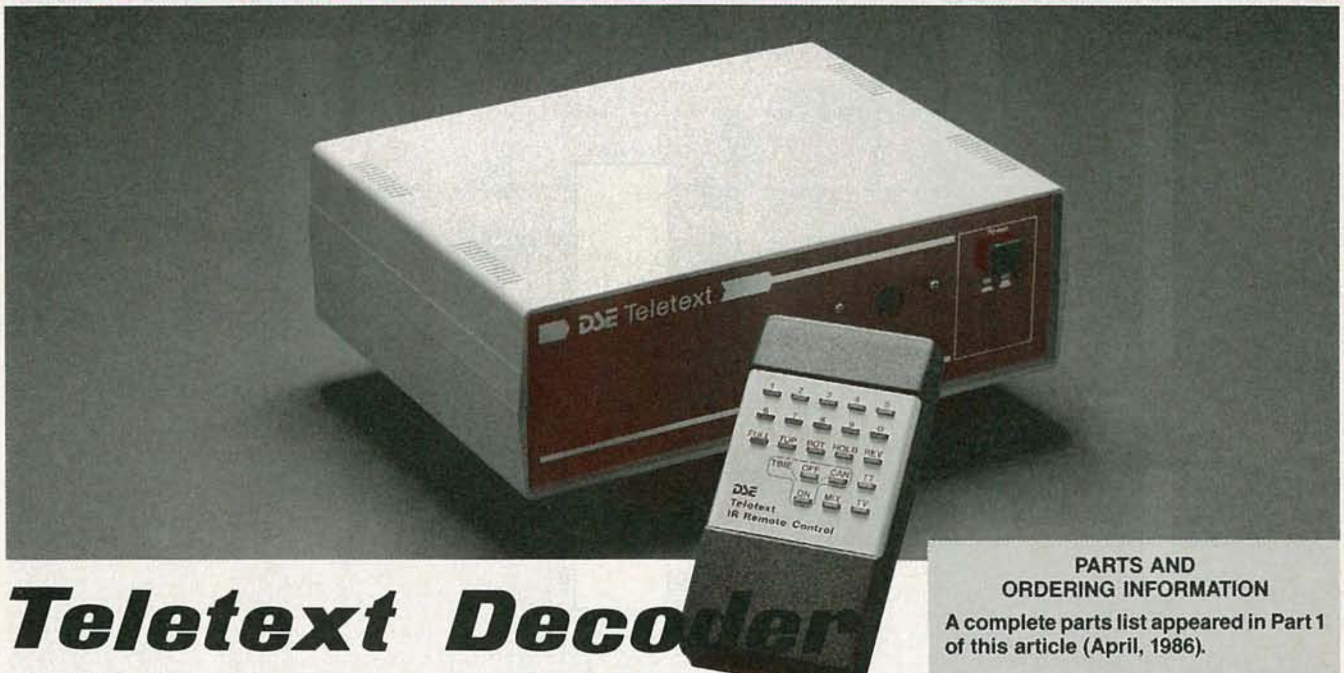
Integrated transducers are in their infancy. Potential advantages include size, reliability, and mechanical ruggedness, but perhaps most important is cost. The cost of measurement electronics has been dropping steadily due to advances in microelectronics and microprocessors, but transducer costs have not kept pace. Researchers are working to develop integrated sensors capable of high-volume automated production. Leading research institutions include Stanford University, Case Western Reserve, the University of Pennsylvania's Moore School of Engineering, Delft University of Technology in the Netherlands, and several Japanese research laboratories.

IC temperature-sensors presently have much looser accuracy specifications than resistance thermometers, precision thermistors, or thermocouples. (Selected precision devices are available, but they are very expensive.) It is reasonable to expect better precision at lower prices in the future.

Experimental pressure and acceleration transducers have been built using variable capacitance to detect motion. The basic diaphragm and cantilever beam designs of those devices are like those described earlier, but the strain gages are eliminated and replaced with metallized surfaces that form the plates of variable capacitors.

Because both the plates and their movements are very small, the capacitance changes generated within such a transducer are small compared to the shunt capacitances of even the shortest external connections. Successful commercial capacitance-type sensors will require measurement circuitry to be integrated on the same chip, something no manufacturer has yet introduced.

It should be expected that, as reliable sensors are developed, active circuitry will be integrated with them. That not only will provide signal conditioning and amplification, but also will allow sensor shortcomings such as nonlinearity and calibration errors to be compensated for by burning the appropriate data into an on-board PROM, making user calibration a thing of the past. Once it becomes practical to integrate sensors with their processing circuitry, the possibilities will be endless. **R-E**



Teletext Decoder

Build this World System Teletext decoder and tune in to a whole new world of information.

J. DANIEL GIFFORD

> **PARTS AND ORDERING INFORMATION**
>
> **A complete parts list appeared in Part 1 of this article (April, 1986).**
>
> **A kit of parts (No. K-6315), including PC board, case, and all parts—except those for the wireless remote control circuit, (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.**

Part 2 LAST MONTH, WE DEscribed what teletext is and how it's broadcast and received. We also described most of the decoder circuit that we're building. But before we get to construction details, we still have a couple of circuit sections to look at: the RGB-to-NTSC encoder and the video switch.

The RGB-to-composite-video decoder is shown in Fig. 10. Although the R, G, B, Y, and blanking outputs of the SAA5050 TROM (of the Mullard teletext module) could be connected directly to an RGB monitor for display, that's not particularly practical because it makes TV/teletext switching impossible. Therefore, the outputs of the module are routed to IC4, a Motorola MC1377 RGB-NTSC encoder IC. That IC combines the module's outputs into a standard NTSC composite-color video signal. The RGB-NTSC encoder is the most complex portion of the circuitry outside the module, but IC4 makes it a good deal simpler than it might otherwise be.

To allow remote switching between TV, teletext, and text-over-TV (mix) modes, the original video signal from the video buffer is sent to a video switch along with the output from the MC1377. That video switch is built around IC5, a 4066 quad analog switch, as shown in Fig. 11. The switch is controlled by the Y and blanking outputs from the TROM, and by the module's PICTURE ON (PON) signal, which is high when the TV picture is to be displayed and low when teletext only is to be displayed. Two of the gates in IC3, a 74HCOO quad NAND gate IC, are used to invert the blanking and PON signals; only the inverted blanking signal ($\overline{BL}$) is used, but both PON and $\overline{PON}$ are used to obtain alternate switching.

The third NAND gate in IC3 is used as the active element in the MC1377's oscillator, and the fourth is not used.

The output of the video switch is sent to the video output buffer, the output of which is available at the VIDEO OUT jack, J3. That signal, along with the output of the audio buffer, is used to drive the Astec UM1285-8 video RF modulator. Switch S2 is used to set the modulator's output on Channel 3 or 4.

The power and channel-select switches are the only controls on the decoder itself. All other functions are controlled by the remote handset. That makes this teletext decoder easy to build.

Building the decoder

Building the decoder is reasonably easy because the decoder itself is a preassembled module. The Mullard VM6780-2 teletext decoder module, as discussed last month, performs almost all of the work of decoding teletext signals. As we've seen, it requires only the addition of a power supply, a remote-control circuit, video and audio input buffers, an RGB-composite-video encoder, and a video switch and output buffer to form a complete set-top decoder. We will build that outlying circuitry on a main board, and connect it to the module using four ribbon cables. We should note here that there is a third board required by the decoder: the remote-control receiver preamp. Of course, we cannot forget the handheld remote control either. However, we will not present construction details for the handheld unit that was shown schematically last month in Fig. 8.

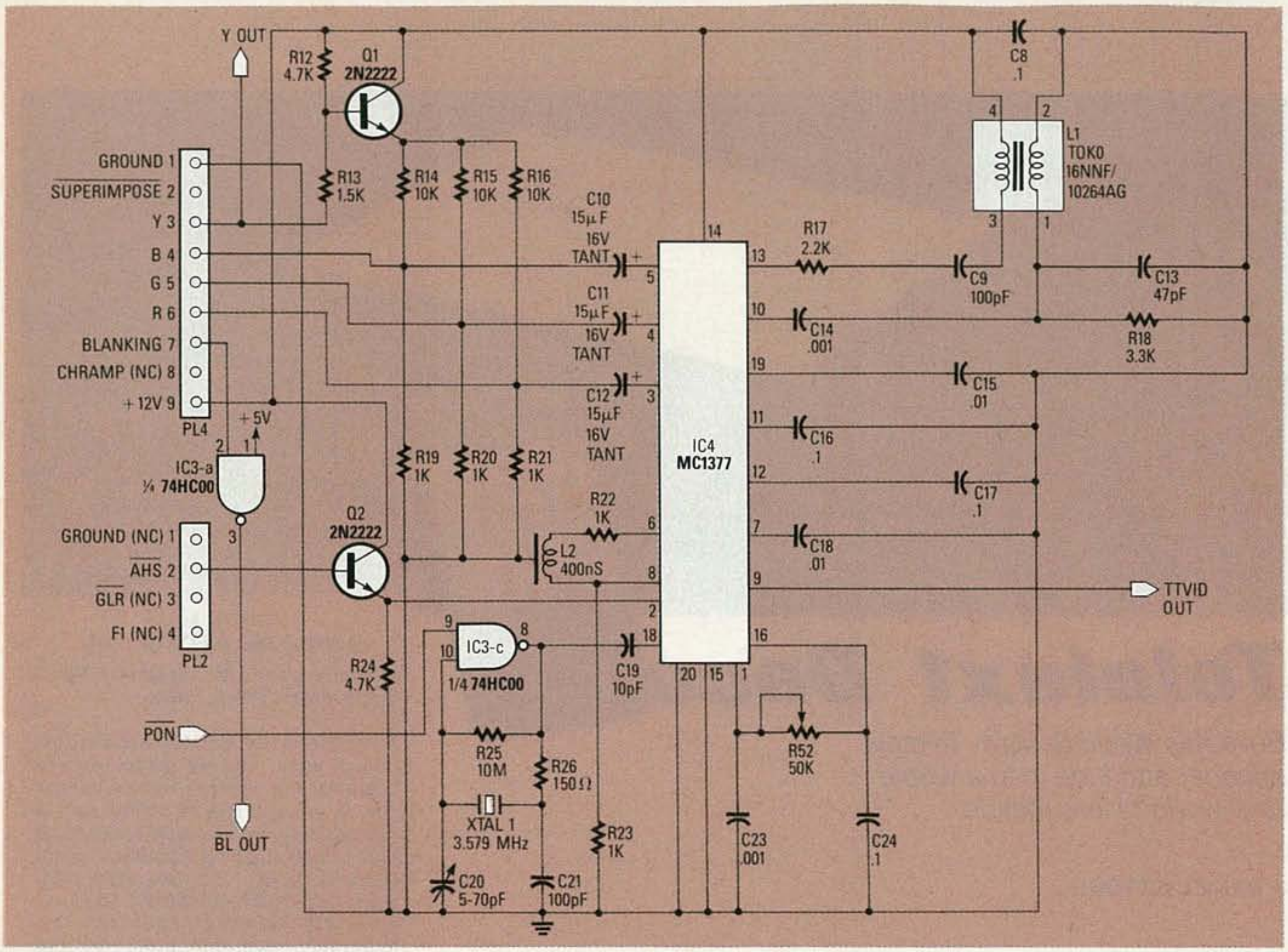


FIG. 10—THE RGB-TO-NTSC composite-video encoder is the most complex circuit outside the Mullard module. IC4 combines the separate R, G, B, and Y signals into a standard composite signal. The *A*fter *H*ours *S*ync (AHS) output from the module allows the decoder to operate even if the television station goes off the air.

The first step in building the decoder is to make or buy printed-circuit boards. The foil patterns for the main board and the remote-control receiver preamp board are shown in "PC Service." A parts-placement diagram for both boards is shown in Fig. 12.

Once you have the boards, you should start by mounting the 22 jumpers on the main board. Use 22-gauge bus wire and keep the jumpers tight and flat against the board. Next, mount all of the resistors, and then all of the capacitors, using care to orient the polarized electrolytic and tantalum types correctly.

Mount the four 1N4001 diodes D1-D4, the 1N4735 zener diode D5, and the eleven transistors, again making certain that the devices are oriented properly. Install the 5 IC sockets (but not the IC's). Finally, solder in the 400-nanosecond delay line L2, the chroma coil L1, and the 3.58 MHz crystal.

Install the RF modulator on the board. It should be a tight fit; if necessary, twist the lugs to hold it in place. Solder all four lugs to the ground plane. Solder the three input leads closest to the edge of the PC board (VIDEO IN, +V, and AUDIO IN) in place, leaving the fourth lead (Channel Select) free for the moment.

Bolt the power supply transformer T1 to the PC board, with the primary lugs toward the edge of the board and a ground lug under the rearmost nut. The three short angled PC traces behind the transformer, with their six pads, are to simplify AC power connections. The three pads along the edge of the board are for the incoming power cord; the other three are for the connections to the transformer and the power switch on the front panel.

Solder a short length of 18-gauge wire from the center of these three pads to the solder lug under the transformer's mounting bolt. Solder another piece from the innermost pad to the closest transformer primary lug. Solder a 6" piece of 18-gauge wire to the other primary lug, and a 10" piece to the last PC pad. These two wires will go to the power switch S1.

The three PC pads behind the four 1N4001 rectifier diodes are for the secondary AC hookup. Connect the innermost of these pads to the 15 volt tap of the transformer, the center pad to the 7.5 volt tap, and the last to the 0 volt tap. Solder two 6" pieces of 22 gauge wire to the 0 and 7.5 volt taps: Those wires will go to S1's internal lamp.

Now it's time to prepare the remote-control preamp board. There are a couple of tricky things about assembling the board. First, you'll have to be sure that the LED and the photodiode will be visible from the front of the decoder. So don't install them until you're sure about how you'll mount the board inside the decoder case. Second, the preamp board needs to be shielded. So after you install the components and the wires that will connect the preamp board to the main board, install four PC terminal posts at the corners of the circuitry. Bend a piece of tin into a U shape and solder it to the posts so that it covers the components on the board. Then mount a flat tin piece to the bottom of the board.

Follow the parts placement diagram (Fig. 12) and wire the CHANNEL SELECT switch, S2, the power cord, the power switch and the input and output jacks. Be sure to use coaxial cable for the jacks.

Finally, prepare the four ribbon cables

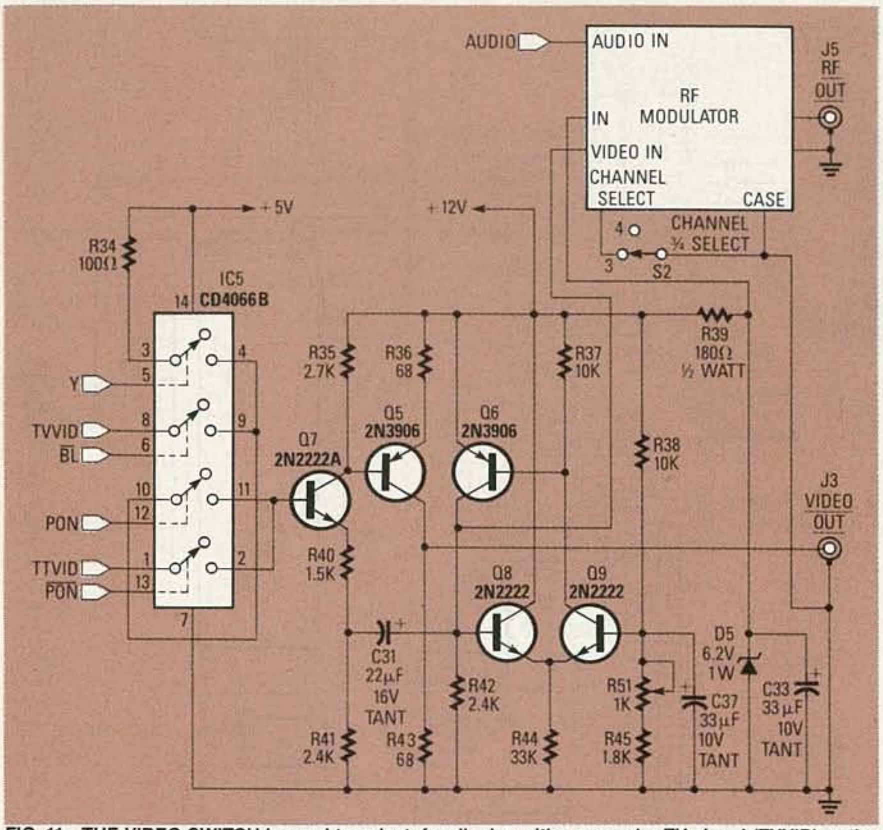


FIG. 11—THE VIDEO SWITCH is used to select, for display, either a regular TV signal (TVVID) or the decoded teletext display (TTVID), or a combination of the two for Mix mode. Note that both RF and composite video outputs are available.

to connect the module to the board by cutting three pieces of 10-conductor ribbon cable and separating them to form one cable each with 4, 6, 9, and 10 conductors. Separate the conductors at one end of each about 1" and strip each conductor 1/4 inch.

Solder the two regulators IC6 and IC7 in place, leaving as much of their leads as possible above the board--only about 1/16 inch should protrude from the bottom, just enough for a secure solder joint. Attach heatsinks and bend the regulators into position, parallel to the PC board.

Put the four 1/2 inch machine screws used to mount the Mullard module in place and secure them with a drop of superglue. Make certain that they remain straight while the glue sets.

The PC board is now complete. After checking all of the solder work for bridges and incomplete joints, the PC board may be installed in the case bottom, along with the rear panel. Secure the AC power cord with a strain relief.

Testing and final assembly

Plug the decoder in and turn it on; the lamp in S1 should light up. Check the power supply voltages at the regulators' outputs: they should be within 5% of 5 and 12 volts. Check the voltage at the power lead of the RF modulator (the only lead without a plastic insulator): it should be within 0.3 volts of 6 volts. Turn the decoder off and discharge the power supply capacitors by shorting the regulators' inputs to ground.

Install the remaining IC's in their sockets, making certain that they are oriented correctly and that their pins seat properly. Be careful when handling the ICs: All but the MC1377 are MOS devices and are subject to static-discharge damage.

Power up the decoder again and check the supply voltages at the IC pins (note that the SAA5010/5012 will not have a 12 volt supply until the Mullard module is connected.) If you have a frequency counter, check the operation of the MC1377's oscillator at pin 18 or at pin 8 of IC3. If all supply voltages are correct and none of the IC's heats up, the Mullard module can now be installed.

WARNING: The decoder module is very expensive and it is subject to static-discharge damage. Leave it in its protective sleeve until it is ready for installation, and handle it only while wearing an anti-static wrist strap. Thoroughly discharge all capacitors on the PC board before connecting the ribbon cables.

The Mullard module is mounted to the main board using three bolts and three ¼-inch spacers. (The mounting holes are not shown on the parts-placement diagram because we chose to show the parts-placement diagram for the remote-control receiver preamp where the module is usually mounted.) Put the module in place on the four bolts and secure it with washers and nuts. Then attach the four cables. Be sure that the wires from PL1 through PL4 are connected correctly—the wire from pin 1 as marked on the parts-placement diagram should go to pin 1 as marked on the module, and so on.

Power up the decoder again. If any of the module's IC's gets more than slightly warm (particularly the two 2114L2's) shut the power off at once, disconnect the module, and trace the problem on the PC board. If everything checks out (it is normal for the two regulator ICs to get quite warm), you're finished building the teletext decoder.

Aligning the decoder

The decoder can be adjusted, for the most part, without a teletext signal. In fact, the preliminary adjustments are easi-

TELETEXT TUNING GUIDE

Service	Station	City
Electra	WKRC, Channel 12	Cincinnati, OH
Infotext	WHA, Channel 21	Madison, WI
	WHLA, Channel 31	La Crosse, WI
	WHRM, Channel 20	Wausau, WI
	WHWC, Channel 28	Menomonie, WI
	WLEF, Channel 36	Park Falls, WI
	WMVS, Channel 10	Milwaukee, WI
	WMVT, Channel 36	Milwaukee, WI
	WPNE, Channel 38	Green Bay, WI
Keyfax	WFLD, Channel 32	Chicago, IL
Metrotext	KTTV, Channel 11	Los Angeles, CA

The following services are available on the Galaxy 1 and Satcom 3 satellites, as well as on any cable-TV system carrying WTBS, SPN, or the Discovery Channel:

Service	Channel/Transponder
Electra	WTBS/Galaxy 1 TR18 (page 100)
	SPN/Satcom 3 TRO
Cabletext	WTBS/Galaxy 1 TR18 (page 201)
	SPN/Satcom 3 TR6
Infotext	TDC/Galaxy 1 TR22 (page 100)

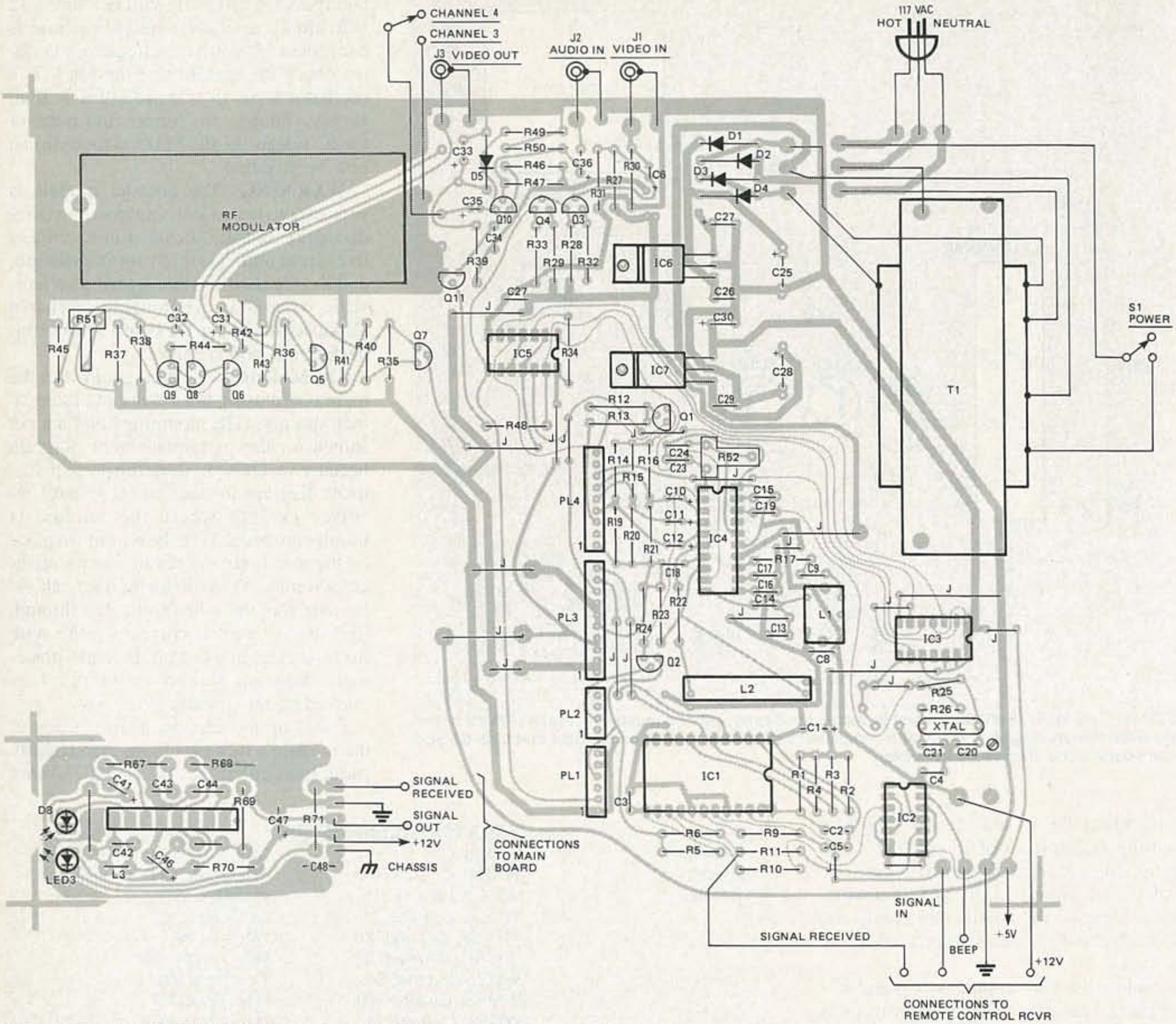


FIG. 12—PARTS PLACEMENT DIAGRAMS for the main board and the remote-control receiver preamp board. Note that the preamp board is shown in the area where the Mullard module is to be mounted. The preamp board is mounted at the front of the case so it can "see" the signals from the handheld remote control and so that you can see LED3.

er with a non-teletext TV broadcast.

Connect the decoder's AUDIO IN and VIDEO IN inputs to the outputs of the tuner, satellite receiver, or VCR, and connect the RF output to the TV's antenna input. (Even if you will normally be using the decoder's composite outputs, connect it via the RF output for adjustment purposes.) Plug in the remote controller and turn the decoder on.

Set the TV to Channel 3 or 4, and set the CHANNEL SELECT switch on the decoder accordingly. Set the tuner to a strong station, preferably one without a teletext signal.

Using a 1/16-inch screwdriver, adjust the tuning slug in the hole closest to the modulator's input leads until the best picture is obtained. Then adjust the modulator bias control R51 (near the modulator) until the image is at its best. Some cross adjustment of those two controls may be necessary to obtain the best picture. Adjust the other tuning slug of the modulator until the best sound is obtained. Slight adjustments of the TV's fine tuning, color, and contrast settings may be needed, but picture and sound should now be perfect.

Press the TT button on the handset. After a brief delay, a blank screen should appear, with "P100" in the upper left corner should. The TV's horizontal hold control may have to be adjusted slightly.

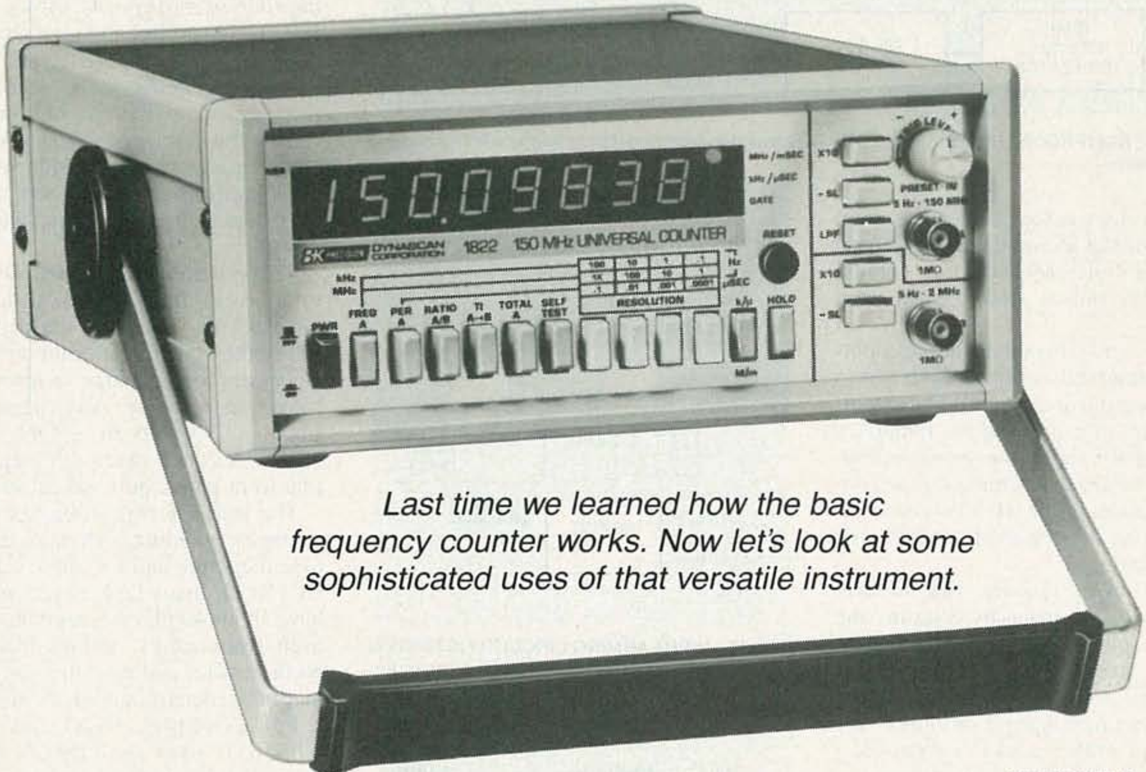
If the characters are sharply defined, no further adjustments of the picture are necessary. If the figures are not sharp, press MIX to get text-over-TV mode and repeat the previous adjustments until both the text and TV image are sharp.

Return to the teletext (TT) mode again, and set the tuner to a teletext-broadcasting station. The "P100" should almost instantly be joined on the top line by a 6-digit clock, the day and date, and other characters. If the top line data does not appear or is scrambled, use a small screwdriver to carefully adjust the tall silver coil on the Mullard module. When the line appears correctly, stop adjusting.

When the top line appears, it should be followed almost immediately by the title page of the teletext service. If you're lucky, the page will appear without any errors. More likely, there will be scrambled lines or random characters scattered through the page. Wait for a minute or so to see if the garbage clears away by itself. If not, adjust the module coil again, a fraction of a turn at a time, until the image clears. Wait for 10-15 seconds between adjustments to give the title page time to come around in the data loop.

continued on page 102

All About FREQUENCY COUNTERS



Last time we learned how the basic frequency counter works. Now let's look at some sophisticated uses of that versatile instrument.

VAUGHN D. MARTIN

Part 2

USING A FREQUENCY counter to measure frequency is simple, but how about using one to measure phase or risetime? This month we'll start out by seeing how those measurements may be made.

Measuring phase

A frequency counter can be used to measure the phase difference between two equal-frequency signals. Actually, we just make a special measurement of *period* (time), and then calculate phase from that time.

Note, in Fig. 15, the values T and $T\phi$; T is simply the period of either signal, and $T\phi$ is the time difference between successive positive-going zero crossings of each signal. You may measure the period of T in the conventional manner. To measure $T\phi$, set the frequency counter up to operate in the STOP/START time-interval mode. The stop and start triggers should be AC-coupled and set for a level of 0-volts DC. The input signals should have the greatest possible amplitude.

When you have values of T and $T\phi$, you can calculate the phase difference (ϕ) between the two signals from this equation:

$$\phi \text{ (degrees)} = (T\phi/T) \times 360$$

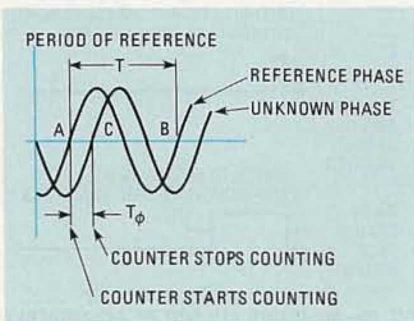


FIG. 15—THE PHASE DIFFERENCE between two equal-frequency signals may be measured with a frequency counter that has adjustable start- and stop-trigger levels.

Measuring risetime

As shown in Fig. 16, you can use a frequency counter (in the period mode again) to measure the risetime (T_R) of a squarewave or other digital signal. Just set the START and STOP trigger-level controls to respond at 10% and 90%, respectively, of the maximum voltage (V_M) of your signal. For example, standard TTL gates have a (nominal) high output voltage of 2.4 volts. Measure the risetime by setting the START control to trigger at 0.24 volts and the STOP control to trigger at 2.16 volts.

Now let's look at some sophisticated frequency counters and accessories.

The reciprocal counter

The reciprocal frequency counter differs from the ordinary frequency counter in that it uses separate registers to accumulate time- and event-counts. The contents of those registers are then processed to provide outputs that represent either period or frequency. A simplified block diagram of a reciprocal frequency counter, Hewlett-Packard's model HP5345A, is shown in Fig 17. It works

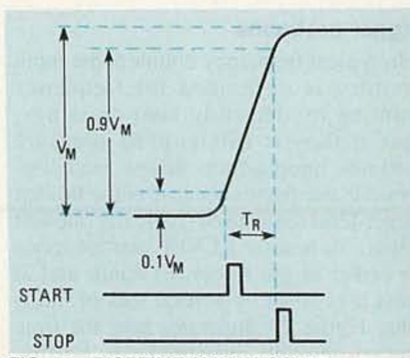


FIG. 16—RISETIME MAY ALSO BE measured with a frequency counter that has adjustable start- and stop-trigger levels.

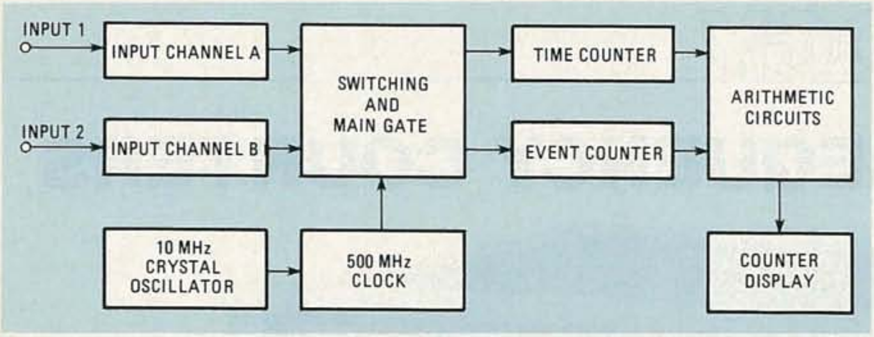


FIG. 17—THE RECIPROCAL FREQUENCY COUNTER provides separate input channels for measuring time and events.

like this: As long as the main gate is open, the event counter accumulates pulses from the external source while the time counter accumulates pulses from the internal clock.

Some reciprocal counters allow counting to be externally armed, as shown in Fig. 18. External arming could be useful, for example, in measuring the frequency of a pulsed-RF signal, as shown in Fig. 19. By setting the measurement-time control to the width of the RF burst, an accurate frequency measurement of the burst could be made.

In a reciprocal counter, time-interval measurements are made by counting the number of pulses between independent START and STOP inputs, as shown in Fig. 20. The resolution is determined by the frequency of the timebase oscillator. For example, a 10-MHz clock could provide a $1/10^7$, or 100-nanosecond, resolution.

Some reciprocal counters use *direct* gating, as shown in Fig. 21-*a*, but direct gating can cause an unacceptable bias by shortening the clock pulses, as shown in Fig. 21-*b*. Note that part of the clock pulse is shortened when the gate is opened, and that part of the clock is also shortened when the gate is closed.

The solution is to use *synchronous* gating, as shown in Fig. 22-*a*. As shown in Fig. 22-*b*, that gating scheme allows the correct number of pulses to pass through the main gate and be counted. With the direct gating circuit above, three pulses would be counted, but here two pulses would be counted.

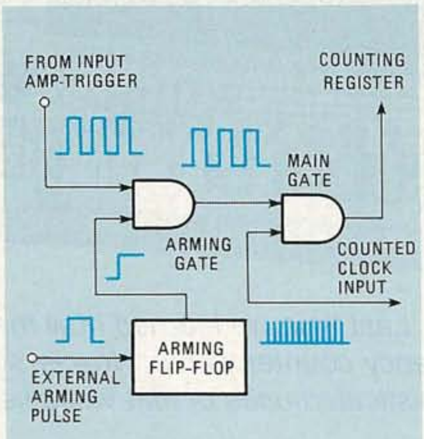


FIG. 18—INPUT-ARMING CIRCUITRY IS USED IN a reciprocal counter for specialized measurements, as shown in Fig. 19.

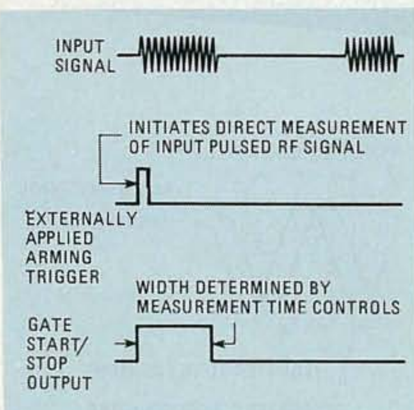


FIG. 19—MEASURE PULSED RF ACCURATELY by using start and stop pulses to limit counting to the width of the burst.

Trigger problems

In typical frequency counters the input circuitry is optimized for frequency counting by detecting zero crossings. That makes it difficult to measure risetimes, propagation delays, and low-periodic-rate pulses because of the limited trigger-level range used (typically one volt or less). At best the LEVEL control varies the center of the hysteresis band, and at worst it is offset by several tens of millivolts. Figure 23 illustrates how the time interval actually measured can be distorted by improper triggering.

Sometimes you can compensate for the ambiguity in the trigger point by using "hysteresis compensation," in which a DC voltage equal to ½ the hysteresis band is added to (in the case of a positive-going signal) or subtracted from (in the case of a negative-going signal) the selected trigger level or reference voltage.

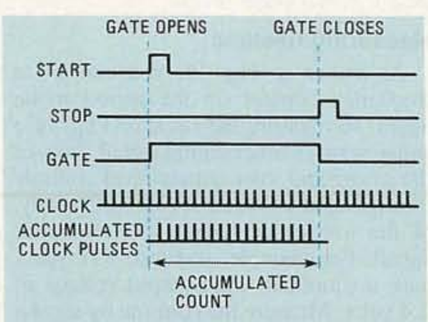


FIG. 20—INDEPENDENT START AND STOP pulses allow a reciprocal frequency counter to measure time interval accurately.

Rather than hysteresis compensation, the *time-interval probe* solves the problem of trigger-level ambiguity by using an automatic calibration scheme. The user grounds the probe to be calibrated and then presses a front panel switch. That causes the reference voltage V_R to decrease in a stair-step fashion in one-mV steps until the device triggers. For negative slope calibration, that voltage increases.

The system then uses that value of V_R to adjust itself so that the actual trigger voltage corresponds to the trigger level selected by the user. Recalibration, when slopes or probes change, assures constant triggering accuracy. Any trigger voltage from −9.99 volts to +9.99 volts may also be selected, in ten-mV steps, by setting front-panel thumbwheel switches.

The time-interval probe has other advantages including high input impedance (one megohm) and low input capacitance (10 pF). Ordinary high-impedance probes have about 40 pF of capacitance, and, at high frequencies, delays through the probe, cable, and circuitry can cause an inaccurate determination of time interval.

For example, Hewlett-Packard's HP5363B uses two DAC's (*D*igital-to-*A*nalog *C*onverters) for setting trigger level, and for self calibration. The main DAC, controlled by a thumbwheel switch, supplies the +9.99 to −9.99V trigger level voltages. The offset DAC, used to compensate for residual offset voltages in the two probes, is initially offset from the main DAC by +75 mV, and it may vary from +75 mV to −75 mV in one-millivolt steps.

When calibrating for a positive slope, the LEVEL CALIBRATE switch clears both DAC's, then internal calibration circuits sweep the offset DAC's voltage output from +75 mV downward in one-millivolt steps until the input channel just switches. That voltage is stored digitally and then it is added to the thumbwheel-controlled DAC to give the true trigger voltage used for subsequent measurements. When calibrating for a negative slope, the process is similar except that the offset DAC starts from −75 mV and scans upward.

Visual trigger indication

A scope marker gives us a visual indication of the actual voltage at which a frequency counter triggers. We will examine three types of markers: dot, gate, and squarewave markers.

The dot marker is a 100-ns pulse initiated by an input channel's triggering. For example, the dots on the waveform shown

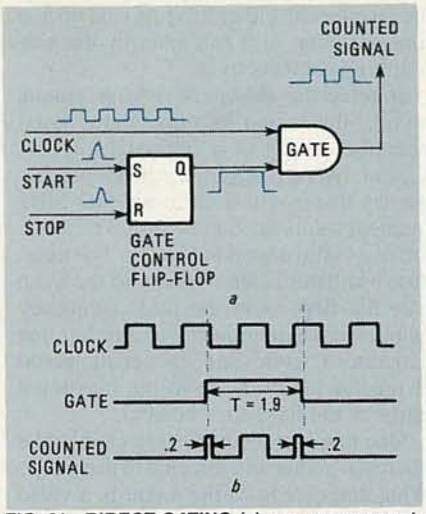


FIG. 21—DIRECT GATING (*a*) can cause counting errors (*b*).

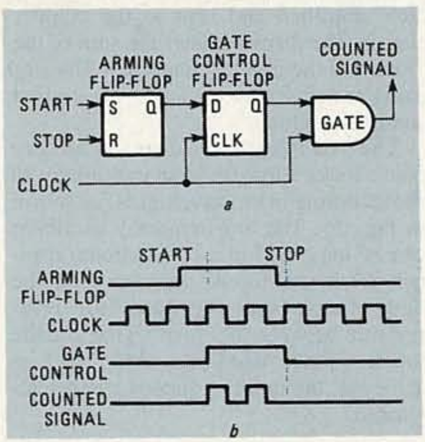


FIG. 22—SYNCHRONOUS GATING (*a*) eliminates counting errors (*b*) suffered by direct gating (see Fig. 21).

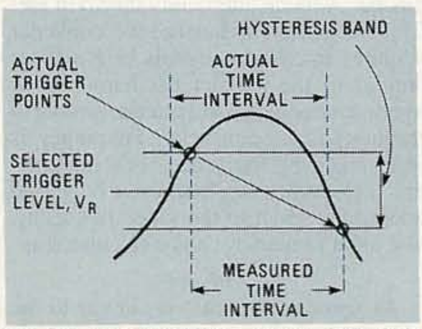


FIG. 23—TIME-INTERVAL MEASUREMENTS can be distorted by improper triggering.

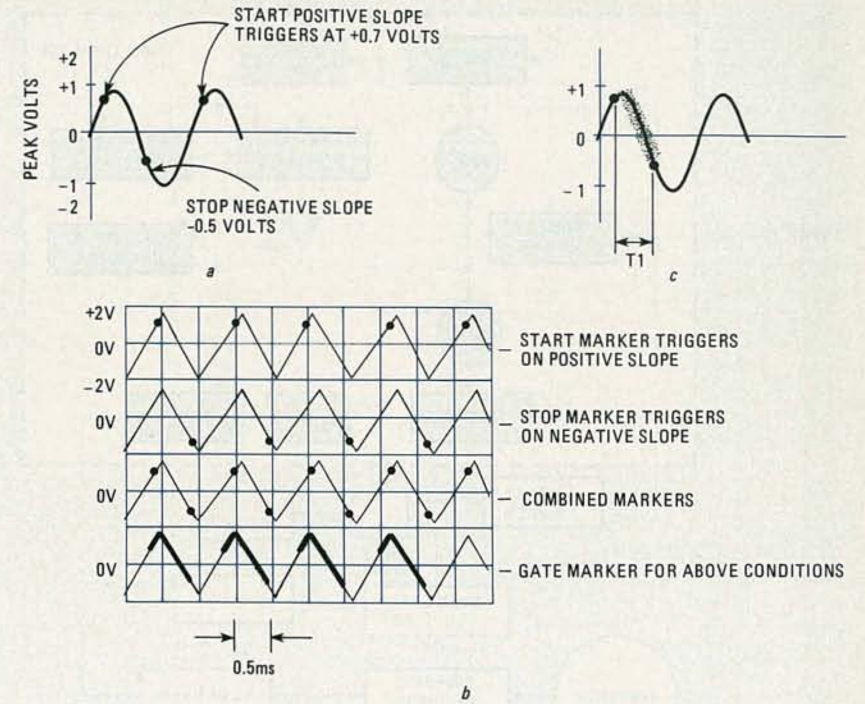


FIG. 24—DOT- AND GATE-MARKERS provide visual indication of trigger level. At *a* are shown the trigger levels that produce the dot-marker outputs shown in the upper four traces at *b*. At *c* is shown the trigger range that is displayed in the gate-marker trace at the bottom of *b*.

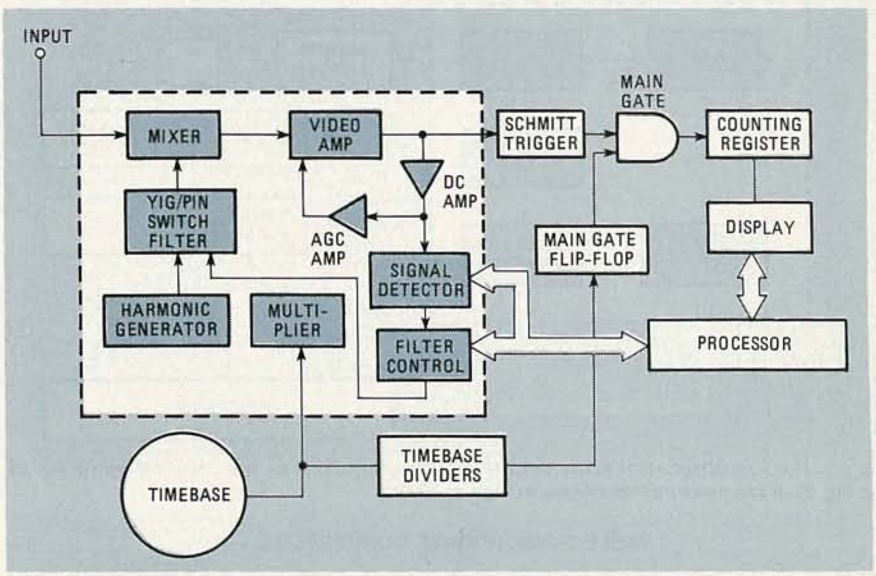


FIG. 25—THE HETERODYNE DOWN-CONVERTER is one way of measuring the frequency of microwave signals as high as 20 GHz.

in Fig. 24-*a* indicate the stop- and start-trigger levels. That pulse is used to intensity-modulate a scope, so it appears as a bright dot on the screen of the scope, as shown in the upper trace of Fig. 24-*b*.

The gate marker is similar to the dot marker, but it provides continuous output between the START and STOP trigger pulses. The fuzzy portion of the waveform in Fig. 24-*c* indicates that the same input-voltage range will trigger the gate marker as triggered the dot marker in Fig. 24-*a*. Its appearance on the scope would resemble the lower trace in Fig. 24-*b*.

The squarewave marker usually appears as an inverted replica of the Schmitt-trigger output of the frequency counter. It may be viewed on a multi-trace scope along with the input signal to verify that the input circuitry is triggering properly.

Microwave frequency counters

To understand how microwave frequency counters work, recall that a frequency counter has a gate that regulates the flow of counting pulses. The switching speed of common gates is limited to signals far short of the microwave region (for our purposes, about 3 Ghz). So how can we measure 10-GHz signals? Basically, there are four methods of measuring the frequency of a microwave signal: 1) Prescaling, which is effective to about 1.5 GHz; 2) Heterodyne down-conversion, good to 20 GHz; 3) Transfer-oscillator techniques, good to 23 GHz; 4) Harmonic-heterodyne converters, which seem to yield reliable results as high as 40 GHz.

Prescaling, as we discussed earlier in this article, is accomplished by inserting a divider ahead of the frequency counter's input. To compensate for a division by *n*,

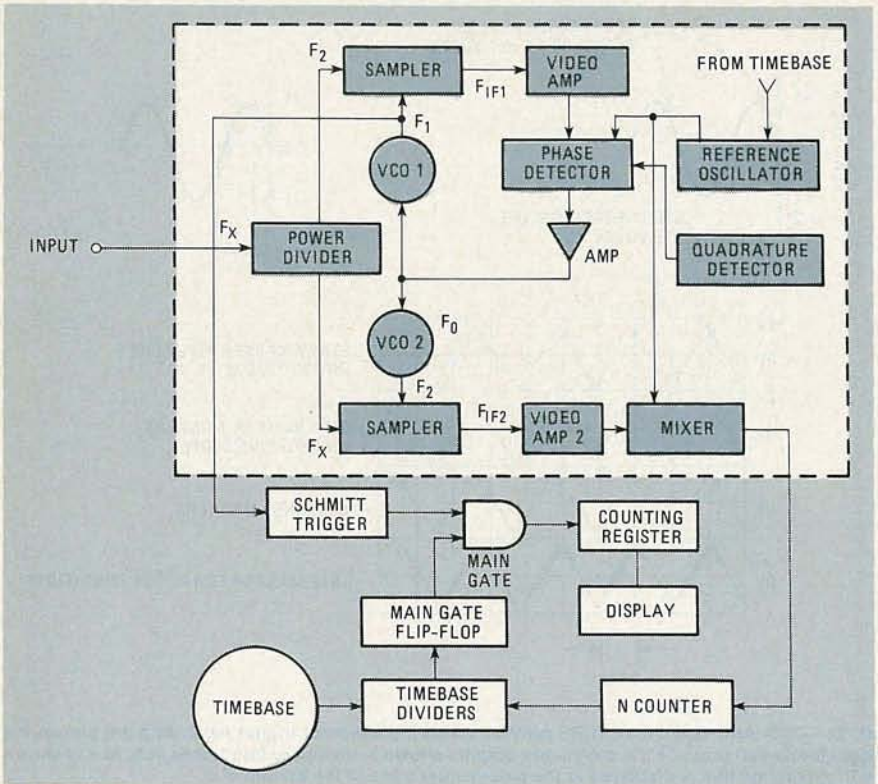


FIG. 26—THE TRANSFER OSCILLATOR can measure microwave signals as high as 23 GHz.

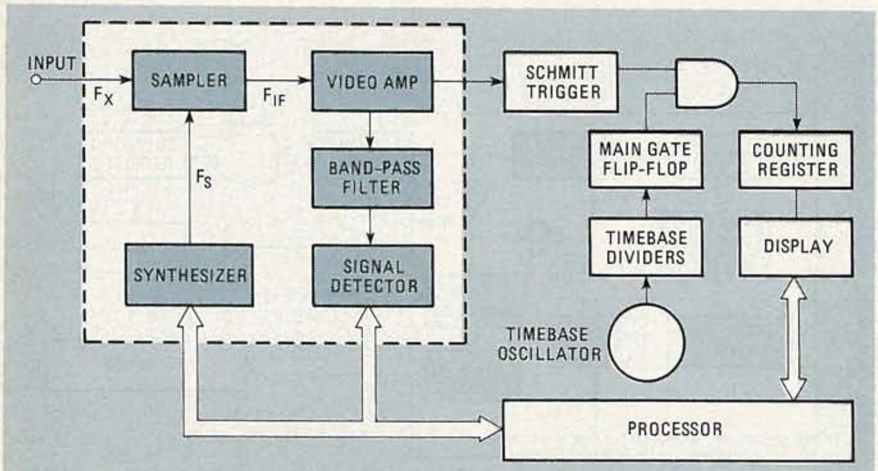


FIG. 27—THE HARMONIC-HETERODYNE CONVERTER is a hybrid of the two circuits shown in Fig. 26 and Fig. 27. It can measure frequencies as high as 40 GHz.

TABLE 3—MICROWAVE CONVERTERS

Characteristic	Heterodyne converter	Transfer oscillator	Harmonic heterodyne converter
Frequency Range	20 GHz	23 GHz	40 GHz
Measurement Speed	150 ms acquisition 1/R gate	150 ms acquisition N/R gate	350 ms acquisition 1/R gate
Accuracy	Timebase limited	Timebase limited	Timebase limited
Sensitivity/ Dynamic Range	−30 dBm/35–50 dB	−35 dBm/40 dB	−30 dBm/35–50 dB
Signal-to-Noise Ratio	40 dB	20 dB	20 dB
FM Tolerance	30–40 MHz peak-peak	1–10 MHz peak-peak	10–50 MHz peak-peak
AM Tolerance	Less than 50%	Greater than 90%	Greater than 90%
Amplitude Discrimination	4–30 dB	2–10 dB	2–10 dB

the counter can either leave its gate open *n* times as long, or it can multiply the gate register's contents by *n*.

Heterodyne down-conversion entails mixing the incoming microwave signal with the output of a high-stability oscillator. Doing that yields a difference frequency that is within the usual 500-MHz frequency-counter bandwidth. The basic process is illustrated in Fig. 25. The time-base oscillator is fed not only to the main gate flip-flop, as in the basic frequency counter, but to a frequency-multiplier that generates a "comb line" of signals spaced at regular intervals out to the maximum range of the frequency counter.

One line of the comb is selected by the microwave filter and directed to the mixer. What emerges from the mixer is a video signal that is equal to the difference between the two input signals. That signal is then amplified and sent to the counter circuit. The display shows the sum of the video and the input frequencies. The signal detector serves to detect the correct comb-line value.

The *transfer-oscillator technique* phase-locks a low-frequency oscillator to the incoming microwave signal, as shown in Fig. 26. The low-frequency oscillator can be measured in a conventional manner, so the microwave frequency can be determined from the harmonic relationship between the input signal and the low-frequency oscillator. After lock is achieved, the input frequency can be calculated:

$$F_X = nF_1 - F_{IF1}$$

The harmonic-heterodyne converter is a hybrid of the two techniques just discussed. A block diagram is shown in Fig. 27. The harmonic-heterodyne converter acquires microwave signals in a manner similar to the transfer oscillator, but it measures frequency in a manner similar to the heterodyne converter. Frequency is determined by the processor's multiplying the synthesizer frequency by *n* and adding the result to the video frequency. The input frequency can be calculated as:

$$F_X = nF_S + F_{IF}$$

As you can see, that is similar to the way the heterodyne converter works, in that the *n*th harmonic of a stable oscillator is mixed with the input to produce a video difference frequency.

Most microwave frequency counters can measure frequency-modulated signals, but the heterodyne converter and harmonic-heterodyne frequency counters have a distinct advantage in making that measurement, as shown in Table 3. Also shown in that table is the fact that the heterodyne converter has a limited tolerance to AM due to its AGC circuitry. The transfer oscillator and harmonic-heterodyne converters do not suffer that limitation, and they can measure a carrier at −10 dBm with 95% modulation. **R-E**

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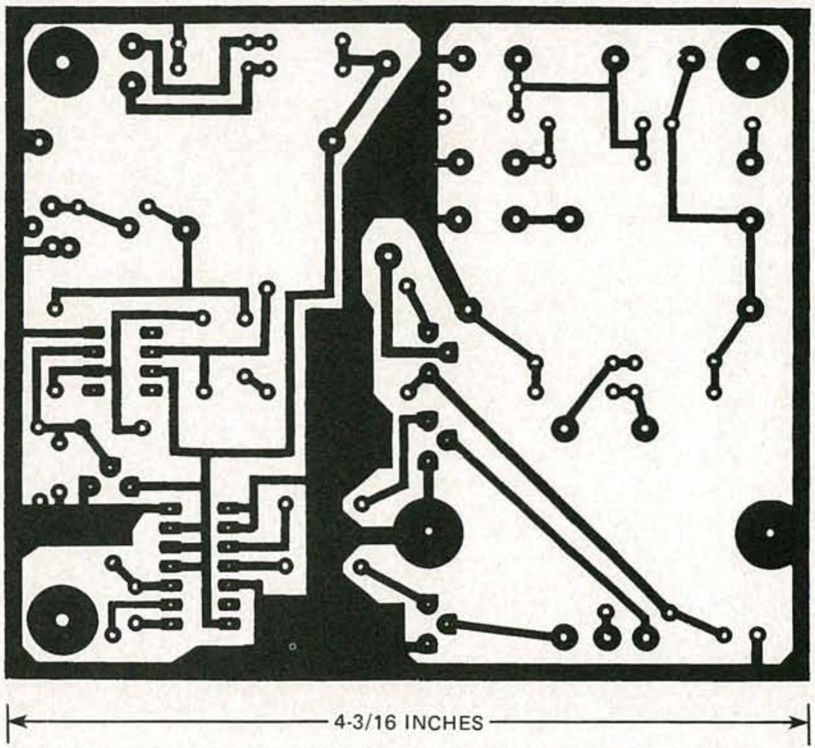
Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a



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PC SERVICE

bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are probably used to.

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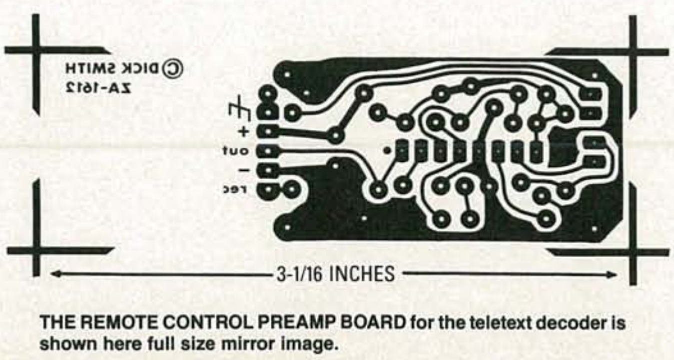

THE REMOTE CONTROL PREAMP BOARD for the teletext decoder is shown here full size mirror image.

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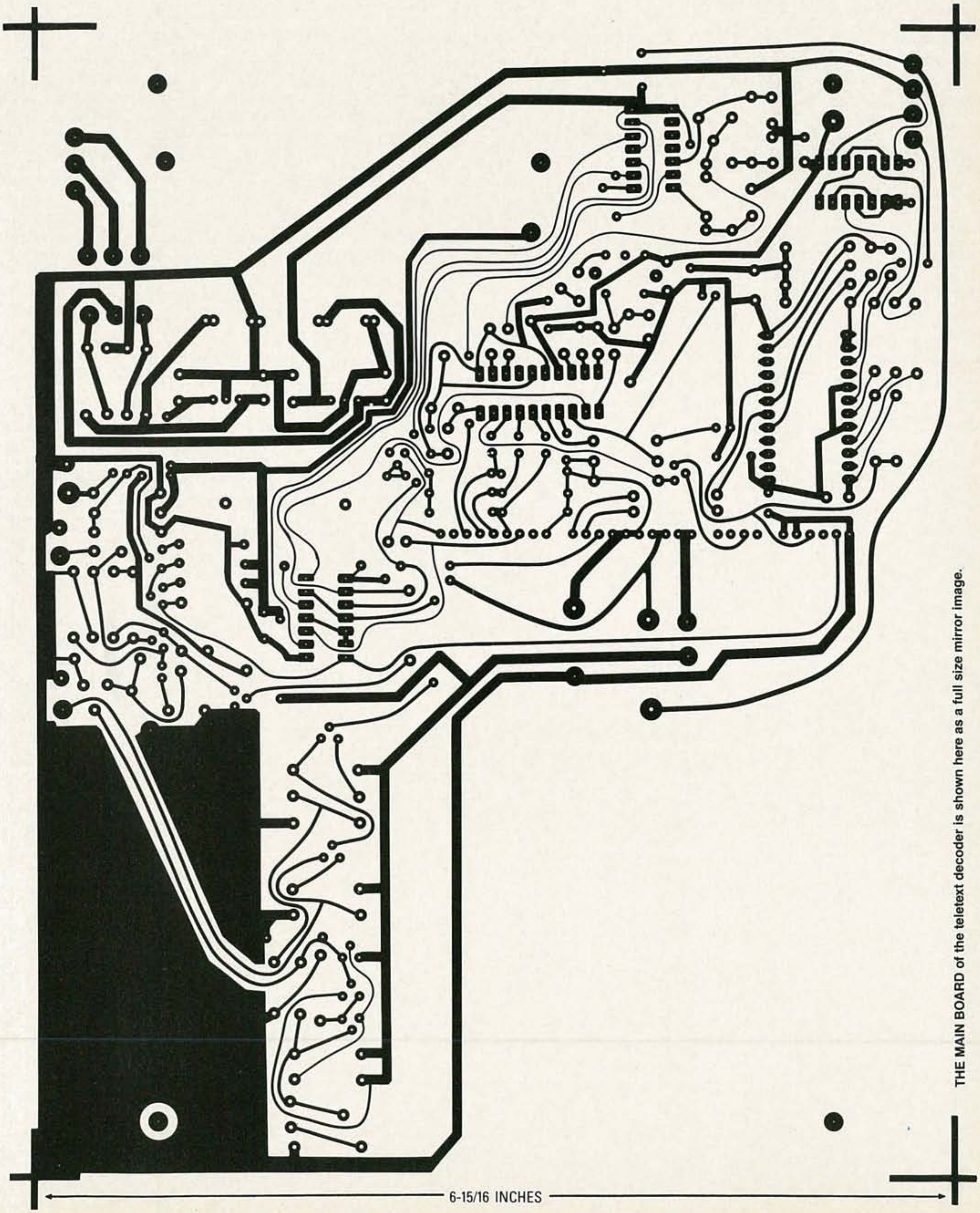

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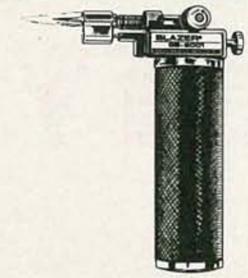

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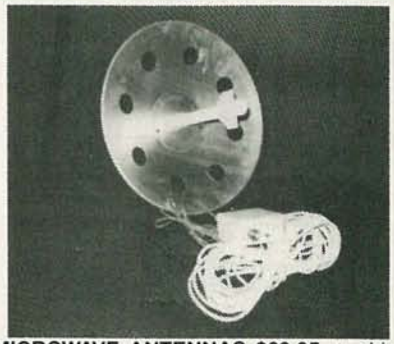

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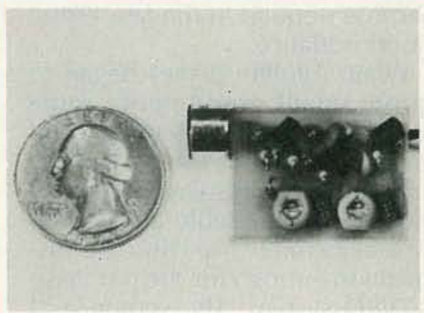

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SATELLITE TV

BOB COOPER, JR.*
SATELLITE TV EDITOR

Scrambling update

IT FINALLY HAPPENED. ALL SIGNALS transmitted by HBO and sister service Cinemax after midnight, January 15th will be scrambled. Gone forever is the free programming enjoyed by more than 1.5 million satellite-dish owners since TVRO became popular in the late 1970's. Good riddance.

When satellite dishes began to sprout up all over America some seven years ago, you could count on HBO to provide the best uncut, un-interrupted display of late-run movies of all the cable services. So the ability to receive HBO was justification enough for the purchase a TVRO system. The sentence "I have a dish" was almost always followed by "And I get HBO."

In theory, anyone who wishes to continue receiving HBO can do so by adding a descrambler to his or her present system. The descrambler is shown in Fig. 1; it is called *Videocipher,* and it was designed by the Linkabit division of M/A-Com. During 1985, HBO provided, free of charge, more than 10,000 Videocipher descramblers to authorized affiliates. And for home viewers, several less-complicated versions of Videocipher have been introduced.

The devices are available in two models: the *VC2000E* and the *VC2000E/B*. You can purchase a descrambler for under $400, and, for an extra charge, sign up for HBO, Cinemax or both. You can sign up by calling (800) 845-2748 and giving the operator your Videocipher serial number and a VISA or MasterCard number. Or you may contact a local distributor.

If you sign up for descrambling

FIG. 1

directly from HBO, it will cost you $12.95 per month for either HBO or Cinemax, or $19.95 per month for both. However, it seems that you can get the same service from a local distributor for as little as $12.95 per month for both services.

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.

You may obtain your *TVRO Dealer Starter Kit* free of charge by writing on company letterhead, or by enclosing a business card with your request. Address your inquiries to: *TVRO STARTER KIT, P.O. Box 100858, Fort Lauderdale, FL 33310.* That kit *not* available to individuals not involved in some form of electronics sales and service.

How they work

The *VC2000E* descrambler accepts a 70-MHz signal from a TVRO receiver (which must have a straight-through 70-MHz connection). The descrambler demodulates the 70-MHz signal and then recovers the descrambling codes from the baseband video. The digitally-encrypted audio signal is also recovered from the baseband video. The descrambler can properly decode fairly "sloppy" input signals.

The *VC2000E/B* is not so forgiving. That unit performs the same decoding, but it uses the baseband video signal rather than the 70-MHz IF signal. The *VC2000E/B* requires a relatively pure baseband signal. The signal must have little phase shift and group delay; other video parameters are equally tight. The problem is that few currently-available receivers can readily supply signals of that sort.

There is no difference in price between the two units, even though the *VC2000E* is more complex, uses more parts, and costs more to build than the *VC2000E/B*. Unfortunately, the *VC2000E* was not made available at the same time as the *VC2000E/B*, and the marketplace is confused about why only some receivers work with the descramblers initially made available.

Problems

HBO had promised that, when full-time scrambling began, suppliers would have an adequate supply of descramblers in the distribution pipeline. Unfortunately, they didn't.

In fact, fewer than 1,000 de-

* Editor-in-chief, Coop's Satellite Digest

scramblers (all *VC2000E/B's*) were actually in distributor's hands on January 15th. In addition, those descramblers worked with few receivers. HBO blamed its supplier, M/A-Com, for the snafu, and M/A-Com refused to answer desperate queries from either users or suppliers. All things considered, scrambling did not get off to a very good start.

In fact, M/A-Com has provided no hard information on the descrambler product for over a year. Meanwhile, HBO was advertising their scrambling plans for months, and they advised TVRO owners to contact their local M/A-Com distributors for additional information and to order descramblers. HBO's failure to provide distributors and dealers with any information has left luckless TVRO owners with nothing. And HBO had originally promised that things would get off to a smoother start.

So the TVRO industry is incensed by the lack of concern shown by both HBO and M/A-Com about the scrambling switch-over. Congressional hearings requested by SPACE (the *S*ociety for *P*rivate *A*nd *C*ommercial *E*arth stations, the industry trade association) are scheduled to occur around the time you read this report. At stake here is the way consumers (i.e. TVRO owners) are to be treated by cable programmers. Those programmers, to date, have shown considerable reluctance to deal with TVRO owners at all.

Bootleg descramblers

The truth is that bootleg descramblers are already on the market. However, the ones I have seen so far recover only the video portion of the transmission. That's no great trick, since the Videocipher system merely inverts the polarity of the baseband video signals and retards the sync signal. That's similar to the way that many of the terrestrial (subscription TV) systems scramble their signals. That system does not pose much of a obstacle to someone determined to unscramble a transmission. So far so good.

Audio recovery, however, is another matter. It's difficult for the following reasons. Audio is sent digitally. That fact alone prevents use of a simple demodulator. Next, the digital pulse sequence is varied using a key that is transmitted with the digital audio. The key itself is also encrypted; it's part of a master key that is burned in a custom set of IC's inside each Videocipher. The balance of the master key is transmitted with the signal. The key/master-key information is changed several times per minute, so unlocking the key sequence at any point in time only provides the user with momentary audio recovery. Hence it seems unlikely that a simple method of recovering Videocipher audio will be developed soon.

Another point is that if M/A-Com has its way, eventually all cable-TV transmissions will use the same scrambling technique. In that scheme, every descrambler is addressable by the program supplier who can lock and unlock individual decoder boxes on command. Ideally—for the cable operator—

all channels delivered to a home would be equipped with a combination converter/decoder with cable-operator control over which homes receive which services. That addressable system is the pay-TV delivery system of the future, and it's operating now in the satellite portion of the pay-TV distribution system.

Other problems

When HBO began scrambling there were some bugs. Early home subscribers discovered several things:

- It was impossible to subscribe to just HBO; consumers received Cinemax whether they wanted it or not. However, if a subscriber had not ordered Cinemax, HBO decided not to charge for that service in that situation.
- The HBO descrambler also decoded test transmissions from it's competitor, Showtime, as well as a new scrambled Pay-Per-View first-run movie service carried on satellite.

Those unintentional freebies were caused by a malfunctioning addressing computer in HBO's master control system.

And you might find it interesting to know that there are fail-safe routines built into the M/A-Com system in the event of a major equipment failure. For example, suppose the whole addressing portion failed at the satellite uplink. All descramblers in the system—there could be millions of them—turn off, so only scrambled audio and video would be received. HBO could then reactivate all decoders in the system *en masse* using a special "open" command. Then, as the addressing computer was repaired, individual descramblers could be re-addressed and the appropriate services enabled or disabled.

In sum, 1986 is going to be a shake-down year for an exciting new technology. There have been glitches in the system already, but none appear to be sufficiently serious to cause the system to be abandoned at this late date. Showtime and The Movie Channel are scheduled to begin scrambling in late spring or early summer. We'll keep you up to date about what happens. **R-E**

ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Heath's new Hero

THE HEATH COMPANY (BENTON HARbor, MI 49022) has finally released the latest member of its family of *Hero* robots. The new addition, *Hero 2000,* is shown in Fig. 1; he differs significantly from his predecessors. For one thing, *Hero 2000* is 32.4 inches tall and weighs about 78 pounds—considerably greater than *Hero 1.* The additional size and weight makes *Hero 2000* much more powerful than *Hero 1;* let's get an idea of what that power consists of.

Mechanical features

Hero 2000's ability to move is provided by a two-wheel drive system that uses several casters for balance. Each drive motor is coupled via optical feedback into a closed-loop system that provides precise control. It's interesting to note that, if the robot is moved from a rest position, it immediately attempts to return to the point of origin.

Heath can supply an optional arm for *Hero 2000,* and it's simply exquisite. Forget you ever laid eyes on *Hero 1's* arm. The new one is as precise as anything currently available. It's driven by the same closed-loop system that is used in all the robot's joints. The driving mechanism is a combination of chains and cables. Although the arm can lift only one pound, it can do so even with the arm fully extended. The weight limitation is due more to safety factors than technical ones; Heath has restricted *Hero 2000's* weight-lifting ability in order to reduce the possibility of accident. For example, if the arm were too strong, a child's (or adult's!) finger could be severed in the robot's elbow joint if it were accidentally inserted there. Heath should be commended for showing such a responsible engineering decision.

FIG. 1

The gripper is composed of two parallel jaws. However, removable finger pieces are provided, and that allows custom grips to be inserted. Heath intends to provide a variety of fingers in their training courses. In addition, there is a unique touch/force-sensing mechanism built into the gripper. In fact, it's so special, that Heath has patented it.

Hero 2000's head does not rotate (unlike *Hero 1's* head). Instead, the entire torso, from the waist up, rotates. That gives the arm another degree of freedom. A hex keypad is mounted in the head for manual entry of data or commands; also, you can move the robot by pressing direction keys in the head. There is a "status indicator" area of the head that has eight user-definable LED's. They can be used to show the progress of your program, to add "personality" to your robot, etc.

The internal gel-cell battery can be recharged using a clever charger that *Hero 2000* can find on its own. The recharging hardware is provided with the basic robot, but the software will be sold separately.

Inside the torso rests the heart of the system. As shown in Fig. 2, there is a twelve-slot S100-like motherboard. It is through that bus that all the electronics of the robot communicate. Even the CPU card is plugged in the bus, so it is conceivable that you could use a different microprocessor to control your *Hero 2000* than the one supplied. In the basic system only three of those slots are used, and that leaves nine to play with!

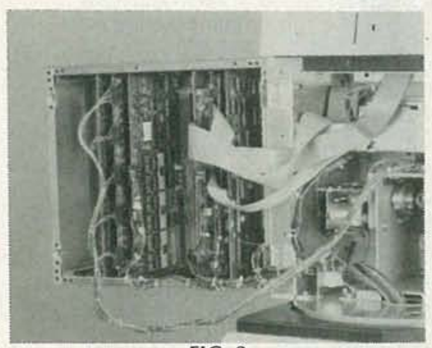

FIG. 2

Robot brains

The main microprocessor is an 8088—the same as in the IBM PC. Is the *Hero 2000* IBM compatible? Heath officials are reluctant to answer that question, but I got a glimpse of a *Hero 2000* running a system that printed out "MS-

continued on page 84

DOS." That brings up another thing. *Hero 2000* will be offered with an optional disk drive. The controller will support four drives, but only two can fit in the torso.

Helping out the 8088 are 11—that's right, 11—8042 eight-bit slave microprocessors. They perform the tasks of servo control and sensor management. Most auxiliary tasks are distributed among those processors, and that gives the 8088 time to do the really complex tasks like those involved in artificial intelligence. In addition, the *Hero 2000's* built-in 24K of battery-backed-up CMOS RAM can be expanded to as much as 576K!

The sensor compliment is as follows. There are two Polaroid-like ultrasonic rangers on board. (See the "Robotics" columns in the November and December 1985 issues of **Radio-Electronics** for a discussion of ultrasonic rangers.) They're "intelligent" through use of the 8042's. The main ranger is located on the robot's head. It is connected to a stepper motor that can rotate it 360°. The second sensor is located on the front of the base.

Integrally mounted with the ultrasonic sensor on the *Hero 2000's* head is a light sensor. It too can measure light levels in a 360° area. A sound-level detector can measure ambient sound within the range of normal human hearing. A temperature sensor can measure temperatures from 60°F to 90°F.

Voice communication is vastly improved in the new *Hero*. The new voice synthesizer is absolutely amazing. They have a demo that makes the robot appear to breathe! You've got to hear it to believe it!

You can communicate with the robot in two different ways. There is a built-in bi-directional RF link, and an RS-232C port on the CPU card. A portable console that includes a full QWERTY keyboard and a two-line 40-character LCD display is used to talk with *Hero 2000* via the RF link. You can use that remote terminal to program the robot just as if you were typing at a directly-connected terminal. There is also an RS-232C port on the console so that a different computer can communicate with the *Hero 2000* via the RF link.

Programming *Hero 2000* is a dream. The robot comes with a full-featured implementation of BASIC that includes statements and functions that allow easy control of the robot's motion and sensors. One nice feature of *Hero* BASIC is that it allows interrupt control. In addition, you can call machine-language subroutines for those times when BASIC is just not fast enough.

Conclusions

Now that you're all excited, here's the bad news. A kit that includes everything mentioned above except a disk drive goes for just under $3000. I hope that didn't spoil your enthusiasm. Actually, several kits are offered starting as low as $1999.95. To find out whether the *Hero 2000* is really worth it, I suggest that you visit your nearest Heath store and ask for a demonstration. I'm sure you'll be impressed. **R-E**

ANTIQUE RADIOS

RICHARD D. FITCH
CONTRIBUTING EDITOR

Contributions by hams and SWL's

COLLECTING ANTIQUE RADIOS IS A FASCINATING hobby for everyone. Younger collectors, to whom an "antique" radio is a set from the 1950's, can learn much about the history of radio, and more senior collectors can appreciate the amount of change the radio industry has gone through in less than a century. So, for the benefit of our younger readers, we'll discuss equipment from their era occasionally. Today, for example, our antique of the month is an interesting set from the 1950's; after discussing it we'll go on to talk about how ham operators and SWL's influenced the development of radio.

The antique of the month

The Belmont Model 5-D-128 Series A, shown in Fig. 1, is our (to-be-restored) antique of the month. As you can see, the case style of that radio is considerably different than that of the radios we usually display here. But its variable tuning control and five pushbuttons for automatic station selection make the Belmont an interesting relic of its period.

FIG. 1

Hams and SWL's

We can't discuss antique radio without mentioning amateur radio and shortwave listening. Senior readers of this column are well aware of the importance of the connections between the developing radio industry and hams and SWL's. Hams were communicating via the airwaves well before the 1920's; they used spark-gap transmitters for that communication. The U. S. Navy had to exercise considerable control over those devices.

During the war (WWI), all amateur radio transmitting and experimenting had to be suspended. But after the war ended, radio returned to its pre-war status. And that's when things really began to mushroom. Again, during WWII radio experimenting was forbidden, but afterwards a new surge of growth brought things to a higher level than ever before.

In the early period, there was some discussion about whether listening devices should be licensed. Finally licensing requirements were dropped after it was decided that receiving antennas didn't interfere with other radio signals. That turned out to be a good decision; otherwise there would have been few listeners for KDKA's famous broadcasts—or for anything else.

While everyone is familiar with the way hams help out in a time of emergency, their contributions to the advancement of radio are often overlooked. The number of amateur radio operators continued increasing through the 1940's when their ranks grew to some 50,000. That number includes only the licensed operators; you might multiply that number several times to include all those who just listened to shortwave signals. The reason is that, while amateur radio was suspended during WWII, shortwave listening became even more popular.

By the 40's, most commercially-sold receivers had shortwave bands. Many of us recall picking up heart-rending messages from foreign countries on our home radios during the war years. An operator would beg for help in broken English, and then his signal would fade as enemy troops overran his area.

Amateur radio resumed, more popular than ever, when hostilities ceased. However, shortwave listening didn't fare so well; the listening public soon found other interests including Hi-Fi and stereo, FM radio, CB, and television, of course.

Returning to the early 1920's, interest in receiving shortwave also faded after the end of the first World War. There were enough regular broadcast stations on the air to keep the listener occupied, although the shortwave bands were still busy for those inclined to listen. By the late 1920's, few new receivers (most of which had elaborate, artistic cabinets) could receive a shortwave band without some sort of adapter. Aesthetic considerations were put to good use later on in the 30's, when intricate turning dials marked the shortwave (and other) bands. Those dials were surely a selling point for the radio salesmen of the thirties.

However, after six or seven years of listening to regularly-scheduled broadcasts, people's interest in shortwave began to revive. Alert manufacturers then began to offer shortwave adapters, sometimes in kit form, that allowed shortwave signals to be received on broadcast-band radios. At first, band selection was accomplished by plugging in different coils, rather than by rotating a switch.

Early radio enthusiasts usually made whatever parts they could, and that included winding their own coils. Perhaps they bought the coil form and the wire, but a pre-wound coil was seldom purchased. Some built coils out of old tube bases and sockets. Or the cardboard cover from a flashlight battery could be used as a coil form.

Sometimes it wasn't clear which coil you needed. Frequency assignments were varied often. In the early days, the Department of Commerce assigned those bands. Later it was the duty of the Federal Radio Commission, which came to life in 1927.

Band scrambling

At the end of 1921, entertainment programs (music shows, for example) were consigned to 360 meters, and public service reports to 485 meters. A year later, "high-powered" stations (over 500 watts) were assigned to one band, and a year later, they were re-assigned to 375–545 meters. Low-powered stations were placed on the 230–300 meter band.

Later, because of overcrowding, a problem developed at the low end of the dial. Broadcast stations there had to monitor nearby frequencies for emergency messages from ships and planes. If anything was detected, the station had to stop transmitting until that frequency was clear. By 1925 the broadcast band was extended to 200 meters. That gave it a total range of 200–545 meters.

Since most receivers sold in the late 20's could receive the broadcast band only, adapter kits and plans were plentiful. However, many of those adapters didn't meet expectations. Some simply didn't bring in the desired signals, and others worked, but only with certain radios. Disappointment in those adapters surely led to loss of interest in shortwave listening.

A manufactured set (or even a suitable kit) that covered both the broadcast band and various shortwave bands was needed. A radio made by National Co., of Malden, Massachesetts, was one which met that need.

The *Thrill Box*

National's receiver tuned the entire 15–550 meter range, which included the most often listened to shortwave bands, as well as the broadcast band. Complete battery operation was recommended for that early (about 1929) four-tube receiver. The tubes include a 222, a 200A, a 240, and a 171A.

Working backwards from the output stage, first comes the 171A, a power tube. The loudspeaker is connected directly to the plate cir-

VOL. 3 NO. 5 May 1986

COMPUTER DIGEST

A NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

REMOTE POWER CONTROLLER
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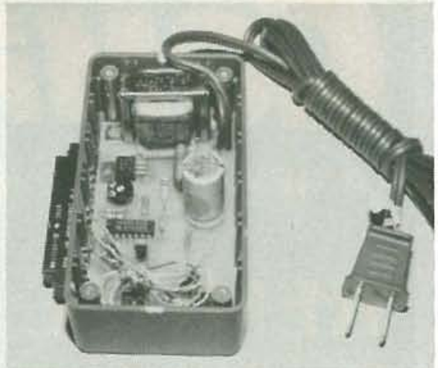

Vol. 3 No. 5 May 1986

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FULL WAVE BRIDGE
CAPACITOR INPUT FILTER

TRANSFORMER' VOLTAGE (RMS)	DC VOLTS	DIODE PIV	CAPACITOR VOLTAGE
5	6	12	7
6	8	16	10
7	9	18	11
8	10	20	13
9	12	24	15
10	13	26	16
11	14	28	18
12	16	32	20
13	17	34	22
14	18	36	23
15	20	40	26
16	21	42	27
17	22	44	28
18	24	48	31
19	25	50	32
20	26	52	33
21	28	56	36
22	29	58	37
23	30	60	39
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25	33	66	42
26	34	68	44
27	36	72	46
28	37	74	48
29	38	76	49

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ON THE COVER

Here's the completed Remote Controller to automate your home. We imposed on the author to get his photographed and he couldn't wait to get it installed once again! For additional information, see page 11.

COMING NEXT MONTH

It's "alphabet soup" time, with a story on GPIB, the General Purpose Interface Buss, and then we've got a story on LAN, Local Area Networking. To round out the issue, you'll be reading a most-interesting piece on what can happen when lightning strikes, as far as your computer equipment is concerned. It happened to one of our authors! Of course, you'll also enjoy all of the regular departments, including our Editorial, the Letters Column, and the latest in Computer Products.

EDITORIAL

Who are you fooling?

■There are some basic, fundamental tenets in engineering that we are forced to live with. The first of these, is that you "don't get something for nothing." Whatever you gain must be paid for with a sacrifice elsewhere. In computer design, for example, if you want the miniaturization offered by a liquid crystal display, you can't at the same time, have the easy readibility of a cathode ray tube. And if you want low cost you'll usually give up several nice little options that you might also like to have. After all, these things *do* cost money, and somebody has to pay the piper.

A friend of mine called last night to tell me that his new hard disk system was now installed and working. From his enthusiasm, as he read the display, there was no question that he was delighted with the seemingly unlimited workspace he had attained. And the numbers were indeed impressive. Even with his operating systems on the disk, there was still more than ample room left for at least a year's worth of work, and I *know* this guy really cranks it out. Frankly, it left me feeling a trifle envious. It also made me think. The more convenience you build into your system, the less effort you have to exert. Unfortunately, our own "Murphy's Law" that you don't get something for nothing, was working here too. Hard disk systems cost. There are other things we'd like to add to our own system. Things have to be prioritized.

Frankly, I'm as much a sucker for a bargain as anybody else. Offer me a "deal," and you've probably got me hooked. But in retrospect, there are few deals that are worthwhile, and these come far between. You want to buy the most for your money, the seller wants to give as little as possible to improve his own profit picture. Nobody is in business on an altruistic basis. You know how much you've got to spend; the seller knows what he has to offer. He may show you something with fewer of the "extras" that will save you some bucks, and you probably figured to add the extras later on.

That's why we figured out a new version of the Law... "Buy the best you can afford and make your first expense your last."

Byron G. Wels

Byron G. Wels
Editor

ComputerDigest is published monthly as an insert in Radio-Electronics magazine by Gernsback Publications, Inc., 500-B Bi-County Blvd., Farmingdale, N.Y. 11735. Second-Class Postage Paid at New York, N.Y. and additional mailing offices.

COMPUTER DIGEST

Computer Digest
Gernsback Publications, Inc.
Executive offices
500-B Bi-County Blvd.,
Farmingdale, NY 11735
516-293-3000
President: Larry Steckler
Vice President: Cathy Steckler

LETTERS

More Plus 4

I just acquired a Commodore Plus 4 and can't seem to get any information at all on the unit. Can anybody out there help me?
—F.K., Rowayton, CT.

F.K., we've gotten a lot of mail on this. It seems that somebody's pushing these units at a low price on TV. We've done a bit of digging around, and suggest that you write to ETT Book Club, Department CD, P.O. Box 240, Massapequa Park, N.Y. 11762. Send 'em $6.50 plus $1.00 shipping and handling, and they'll send you a book on programming the Plus 4 and C-16.

Valuable tool

I just wanted to write and say that I count **ComputerDigest Magazine** as one of my more valuable tools. I save every issue and refer to them constantly. Thanks for the good job!—T. J., Oklahoma City, OK.

Thank YOU T.J. We appreciate the kind words.

Moving

I see from your last issue that you've moved or are moving. Will this have any effect on my subscription?—S. L., Taos, N.M.

No, S. L. By the time you read these words, the move will have been accomplished. Since it's the nature of a magazine to work ahead, we're well backed-up with ready-to-go material, so your issues will continue as though nothing happened.

Dilletante?

It seems that interest in electronics comes in waves. First it was hi-fi, then stereo, followed by the CB craze. After that it was computers, and as suddenly, interest shifted to satellite. Magazines suddenly burst out to cater to those interests, the electronic shops stock up for them, and as suddenly, they die out. From where you sit, can you tell me what's coming next?
—P.T., Princeton, NJ.

Wish I could, P.T. I'd be laying out a new magazine right now! But I don't have a crystal ball either. Incidently, you can eliminate computers from your list of "drop-outs." Because the computer has such enormous practical value to so many, it isn't just a passing fad. We're here to stay!

Help?

Can anybody help with a service manual or schematic for a Commodore SX-64? (Not a C-64). I'll pay any reasonable fee for this information. It's not available from Commodore or Sams.—P. S., Boynton Beach, FL.

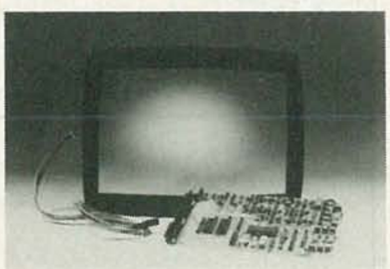
If you can help, write to Paul Schultz, 9535 Listow Terrace, Boynton Beach, FL 33437.

COMPUTER PRODUCTS

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

TOUCH SCREEN, is a 19-inch capacitive touch screen, designed for OEM's and systems integrators, The *MicroTouch Screen* comes fabricated in the standard spherical shape to fit most 19-inch monitors, or in cylindrical form to fit the line of 19-inch Sony monitors. It more than doubles the display area of the 13-inch screen, providing better visibility, greater visual impact, and more touch area to manipulative data.

The *MicroTouch Screen* allows users to interact with the computer intuitively by simply touching images on the CRT screen. The screen operates by automatically sensing the location of a capacitive coupling when it is touched by a finger or conductive stylus. Constructed of solid glass with a resistive coating bonded to its surface, the screen is virtually impervious to damage under normal conditions, and will not distort the display image.

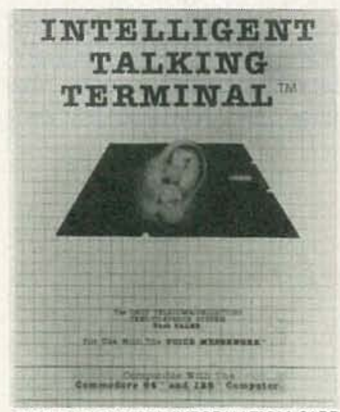


CIRCLE 11 ON FREE INFORMATION CARD

The *MicroTouch Screen* is priced at $1395.00 for single units.—**Microtouch Systems, Inc.,** 400 West Cummings Park, Woburn, MA 01801.

TALKING MODEM, the *Intelligent Talking Terminal,* lets the user receive modem-transmitted data verbally, just as if he or she were listening to a telegram on the phone. The user can also receive information the ordinary way: text-on-screen or printed. The *Intelligent Talking Terminal* enunciates data transmitted over phone lines—even if transmitted at high baud rates—and talks in clear, understandable speech.

With a talking modem, one can now read and hear stock market quotes or the latest business news. It can also be tapped into a wide range of other library data bases for educational, research, and reference materials, financial information, or news updates.



CIRCLE 12 ON FREE INFORMATION CARD

The *Intelligent Talking Terminal* has a suggested retail price of $29.95.—**Welwyn Currah,** 104 W. Fourth Street, Royal Oak, MI 48067.

SOFTWARE REVIEW

WORD FINDER—An Electronic Thesaurus.

■Depending on how it's used, a word can be dull or exciting, or even take on a different meaning. And the repeated use of words can turn even the most-exciting thoughts into eyelid-closers.

Because of this, one of the most-important tools a writer has, is a "thesaurus" which is a collection of words arranged according to the ideas they are meant to express. The author looks up the word he is considering and the thesaurus suggests synonyms. For example, if you want to avoid using the word "impair" four times in a short sentence, a thesaurus will suggest such words as "damage," "hurt," "harm," "injure," "mar," "prejudice," "tarnish," and perhaps a handful of others if the thesaurus is sufficiently large.

Writers find it difficult to create text at lightning speed on a word processor and then have to stop and go through the pages of a thesaurus to locate a suitable synonym. To meet the pace of the electronic age, the *electronic thesaurus* was created which allows the user to call up synonyms from the word processing program. One of the best we've seen, and the easiest to use, is WORD FINDER, designed for use with WordStar, WordStar 2000, Multimate, Word Perfect, pfs:WRITE, Microsoft Word, and Easy Writer 2. We tested the WordStar version because WordStar remains the most-popular word processor.

WORD FINDER consists of a 30K control program which is loaded into RAM prior to the word processor and a 90,000 word dictionary that requires 157K of disk storage. In a two-drive system, the thesaurus' dictionary must be on the same disk as the word processor. If you're using WordStar either MailMerge or the spelling checker can't be on the same disk. If you want direct access of the thesaurus, a spelling checker and MailMerge, the best arrangement is a hard disk or a RAMdisk for the thesaurus' dictionary.

The program responds to 9000 keywords which can call up an average of ten synonyms each: It means you may get anywhere from one to 50 synonyms for each keyword.

WORD FINDER works at "lightning" speed whether running from a hard disk, a floppy or a RAMdisk. To use the thesaurus while composing a document, you mark a word by placing the cursor on *any* character and press a control key (which you can pre-program). WORD FINDER creates a window on the screen with a list of synonyms. If a suitable synonym is displayed, you move the cursor in the window to the synonym, press RETURN: The synonym substitutes for the marked word, the window vanishes and the word processing display is restored to full size. If there is no direct synonym the window displays the alphabetically-closest spelling of 30 words and the selection process is repeated, only this time it's for the words in the window. You can call up the synonyms for any of the 30 words, and pressing the RETURN key installs the selected synonym into the word processing text. Even if the window doesn't show the desired word or a close synonym there's a good chance that something in the window will suggest precisely what's needed. In this instance, you simply type it into the word processing text.

Obviously, a 90,000 word thesaurus is not equal to a printed version, but WORD FINDER is done well: We had few omissions for commonly-used words. While you might have to refer to a printed version, there is no question that WORD FINDER is a major enhancement for a personal computer's word processor.

Although WORD FINDER can be installed only once—for your particular word processor—the working program isn't protected and you can make as many copies as you like; you simply cannot reinstall the program for another word processor. WORD FINDER automatically determines whether your monitor is color or monochrome from the computer's monitor adapter bit and sets itself accordingly. However, if you are driving a monochrome monitor from a color adapter's composite video output the program will assume you're using a color monitor and key on the color adapter, and the display will appear as garbage. If this happens, run the DOS's MODE BW80 before you load WORD FINDER.

WORD FINDER is priced at $129.95 for both PC/MS-DOS and CP/M computers. It is available direct from Writing Consultants, 11 Creek Bend Drive, Fairport, NY 14450. If you have any questions, phone them at 1(716) 377-0130.

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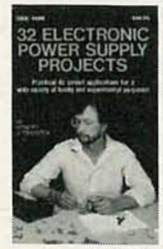

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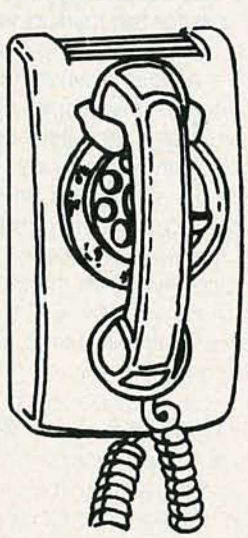

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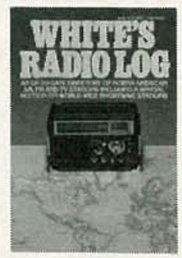

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USING A Ti-99 KEYBOARD ON A SINCLAIR ZX-81

You push the middle key down, and the signals go round and round, whoa-ho-ho-ho, ho-ho.

Robert Grosblatt

■The Sinclair ZX-80 and ZX-81 got more people hooked on computers than any machine ever made. For under a hundred bucks you could connect it to a TV, power it up, and find out what computers were about. If you were interested you moved to a bigger machine. If not, it was worth it to satisfy your curiosity.

Even though technology has increased, prices have decreased, and the lowly Sinclair is no more, the fact remains that it's still a powerful machine. Now that it's available on the surplus market for under twenty bucks, what was a good deal has become a bargain.

The biggest drawback to the Sinclair is the membrane keyboard. Not only is it a pain to use but, unless you're gentle with it, it breaks. Replacing the keyboard is a good idea but it seems ridiculous to spend some $50 on a keyboard for a twenty dollar computer. Well, things are looking better.

When Texas Instruments dropped the TI-99/4A, a huge inventory of keyboards were dumped on the surplus market. Modifying them for use on the Sinclair is easy...easier, in fact, than adapting some of the more expensive keyboards. In order to understand what has to be done, let's take a look at the Sinclair.

The Sinclair

Both the Sinclair and the TI use a simple matrix-type keyboard. This means that each key returns a unique row and column code every time the computer looks at the keyboard to find out which key was pressed. Unfortunately, these keyboard codes have nothing to do with standard ASCII. However, TI's oddball keycodes are so close to Sinclair's oddball codes that it only requires minor keyboard surgery to make them the same.

Sinclair Keyboard Horizontal Grouping Showing Connector Numbers

#8	1	2	3	4	5	6	7	8	9	0	#6
#7	Q	W	E	R	T	Y	U	I	O	P	#4
#5	A	S	D	F	G	H	J	K	L	ENT	#2
#3	SHFT	Z	X	C	V	B	N	M	.	SPC	#1

Sinclair Keyboard Vertical Grouping Showing Connector Numbers

#9	#10	#11	#12	#13	#13	#12	#11	#10	#9
1	2	3	4	5	6	7	8	9	0
Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	ENT
SHFT	Z	X	C	V	B	N	M	.	SPC

TI Keyboard Horizontal Grouping Showing Connector Numbers

#9	LCK	FCTN	1	2	3	4	5	6	7	8	9	0		#14
#6		CNRL	Q	W	E	R	T	Y	U	I	O	P	ENT	#15
#13		SHFT	A	S	D	F	G	H	J	K	L	;	SPC	#12
#5			Z	X	C	V	B	N	M	,	.	/	=	#11

TI Keyboard Vertical Grouping Showing Connector Numbers

#10	#4	#8	#3	#2	#1	#7	#7	#1	#2	#3	#8	#4
LCK	FCTN	1	2	3	4	5	6	7	8	9	0	
	CTRL	Q	W	E	R	T	Y	U	I	O	P	ENT
	SHFT	A	S	D	F	G	H	J	K	L	;	SPC
		Z	X	C	V	B	N	M	,	.	/	=

FIG. 1—COMPARING THE LAYOUTS of the two keyboards. Both have eight horizontal sections but the TI has two extra vertical sections.

In Figure 1 you can compare the layout of the two keyboards. The first thing you should notice is that while both keyboards have eight horizontal sections, the TI has two extra vertical sections. One of them, #10, is for "Alpha Lock" and the other, #4, contains most of the operator keys. Figure 2 shows you how these section numbers relate to the connectors going from the keyboard to the computer's motherboard.

There are a couple of ways to go about adapting the TI keyboard to the Sinclair. The most elegant is to design some circuitry that converts TI code to Sinclair code. Put the translation tables in an EPROM and the circuit does everything for you. This lets you add goodies like auto repeat, macros, and function keys. After all, the TI keyboard has seven extra keys to play around with. The disadvantage is that you have to design circuitry, build a board, and burn EPROMs.

The easiest way is to do a bit of cutting and pasting to the TI board to make it put out the codes the Sinclair expects to see. Most of the extra keys will go to waste but it's less work. Especially since the two keyboards have really similiar arrangements to start with. Figure 3 is a list of the changes that have to be made to the TI keyboard. There are fourteen keys that have to be moved. The "Alpha Lock" key, a push on - push off switch, can be isolated and put in parallel with the "Shift" key to give a quick and dirty Shift lock.

Unfortunately, the rest of the TI's extra keys won't do anything at all. They can't be used for extra characters because the ZX-81 won't recognize any additional keycodes. All you can do is put them in parallel with other keys to make the keyboard more convenient to use. Once you've made these changes to the TI keyboard all that's left is making the connections to the ZX-81 motherboard.

Turn the ZX-81 upside down and locate the five screws that hold the case together. Three of them are located under the rubber feet as shown in Figure 4. Once the case is open, lift out the mother board by removing the two retaining screws, pull the two keyboard connectors from their sockets and tape them out of the way on the underside of the case. Solder 12-

Sinclair Keyboard Connectors Viewed from the Back of the Keyboard

1 2 3 4 5 6 7 8 — 9 10 11 12 13

Vertical Connectors — Horizontal Connectors

TI Keyboard Connectors Viewed from the Back of the Keyboard

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Horizontal Connectors = 5, 6, 9, 11, 12, 13, 14, 15

Vertical Connectors = 1, 2, 3, 4, 7, 8, 10

FIG. 2—HOW THE SECTION NUMBERS relate to the connectors from the keyboard to the computer's motherboard.

Cut and Paste Guide for Adapting the TI Keyboard at the Sinclair

Key	Original Location	New Location
B	Horizontal #15	Horizontal #11
SPC	Horizontal #12	Horizontal #11
SHFT	Horizontal #13	Horizontal #5
ENT	Horizontal #15	Horizontal #12
LOCK	Horizontal #9	Horizontal #11
Z	Vertical #8	Vertical #3
X	Vertical #3	Vertical #2
C	Vertical #2	Vertical #1
V	Vertical #1	Vertical #7
N	Vertical #7	Vertical #1
M	Vertical #1	Vertical #2
ENT	Vertical #4	Vertical #8
SPC	Vertical #4	Vertical #8
SHFT	Vertical #4	Vertical #8
LOCK	Vertical #10	Vertical #8

TI Keyboard to ZX-81 Motherboard Connection Guide

T1 Keyboard	ZX-81 Motherboard
1	12
2	11
3	10
4	NOT USED
5	3
6	7
7	13
8	9
9	8
10	NOT USED
11	1
12	2
13	5
14	6
15	4

FIG. 3—A LIST OF CHANGES to be made in the TI keyboard. A total of fourteen keys have to be moved.

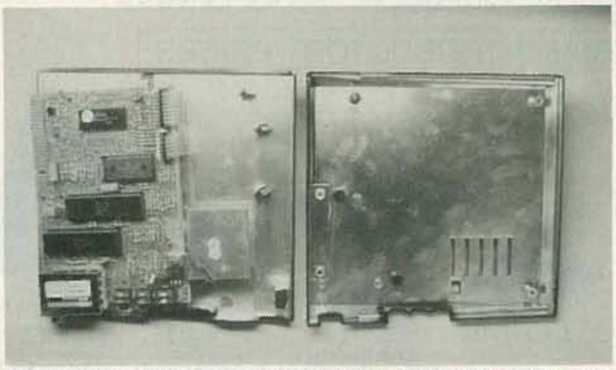

FIG. 4—TURN THE ZX-81 upside-down and you'll see the five screws that hold the case together.

inch lengths of hookup wire to each of the thirteen keyboard connectors on the bottom of the motherboard. You can remove the original keyboard connectors but it's easier to lap solder directly to the motherboard. The same is true of the TI keyboard.

As you can see from Figure 5, I used male and female DB-25 connectors to connect the TI keyboard to the Sinclair motherboard but you can connect them directly together. Since the ZX-81 motherboard is smaller than the keyboard, you can get rid of the case and put the whole thing together in a small utility case. If so, use an aluminum case and connect the case to the housing around the RF modulator. The Sinclair has a problem with RF and you'll have trouble with the video if you use a plastic box.

I can't show you exactly how to do the surgery on the keyboard. TI used several manufacturers to make the boards and though all the keyboards are functionally the same, the traces are different from manufacturer to manufacturer. As long as you identify the switches on the printed circuit board you should have no trouble altering it to use on the Sinclair.

When you finish, don't throw away the old Sinclair keyboard. You can cut out the key tops with a hobby knife and glue them to the tops of the keys on the TI keyboard. A new keyboard is nicer if the keys are properly labeled.

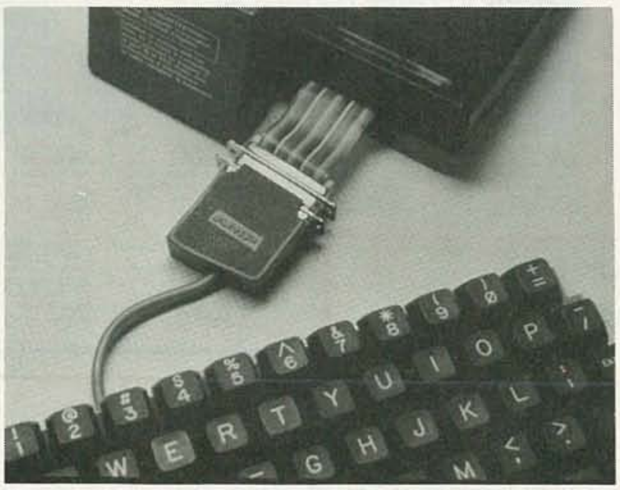

FIG. 5—MALE AND FEMALE DB-25 connectors connect the TI keyboard to the Sinclair motherboard.

Sinclair Keyboard Keycodes

Key Location Pressed	Keycode	Register
None	FF	L
Horizontal #1	7F	L
Horizontal #2	BF	L
Horizontal #3	FE	L
Horizontal #4	DF	L
Horizontal #5	FD	L
Horizontal #6	EF	L
Horizontal #7	FB	L
Horizontal #8	F7	L
None	FF	H
Vertical #9	FD	H
Vertical #10	FB	H
Vertical #11	F7	H
Vertical #12	H	
Vertical #13	DF	H

If the SHIFT key is pressed with another key bit 0 is reset to 0 in the H register so that FF = FE, FD = FC, F7 = F6, etc.

FIG. 6—HERE ARE THE CODES put out by the Sinclair keyboard. This will be of great help if you're building translation circuitry.

Translation circuitry

If you're set on building translation circuitry you'll find Figure 6 helpful. I've listed the codes put out by the Sinclair keyboard. The keyboard scanning routine in the Sinclair ROM (located at 022B hex) returns with the keycode in the Z-80's HL register. The key's row (horizontal) location is stored in L and the column (vertical) location is stored in H. Once the computer has the complete keycode, it uses a routine located at 07BD hex to translate the code into the character it represents. The lookup table is stored from 007E to 00CB hex.

Building circuitry to do the job means bringing power and ground out from the motherboard. Since the data bus has to be 13 bits wide, you'll have to think about the 8 bit limitation of the EPROM. There are two ways of handling the problem. You can use two locations in the EPROM to store each keycode and let your circuit clock the data out in order or use two EPROMs to widen the bus to 16 bits. This last approach is easier and even though it means burning two EPROMs it will cut the circuitry needed down to a much more managable size.

The Sinclair is a great first computer and a good choice for a dedicated controller. Once you get your software straight, you can burn the program into an EPROM and replace the ZX-81's 2k RAM chip with the EPROM. Although I've been skimpy on the details of designing the EPROM circuitry needed to do a nifty keyboard adaptation, if there's enough interest I can deal with it much more thoroughly in a separate article.

REMOTE POWER CONTROLLER FOR YOUR COMMODORE-64

Couple a wireless remote and your computer. Instant automation!

Chandler Sowden

■One of the useful things a home computer can do is control things around the house. Unfortunately, this usually involves stringing control wires from the computer to the device being controlled.

Enter the home wireless remote control system, as manufactured and sold by BSR and Radio Shack. With this system, lights and appliances can be controlled (manually) from a central location without wires.

How it works

The wireless remote modules respond to a pulse coded 125KHz signal placed on the AC power line. The pulses occur in groups of three and are synchronized to the power line. As shown in Figure 1, the device consists of a 60 Hz wave shaping circuit, an

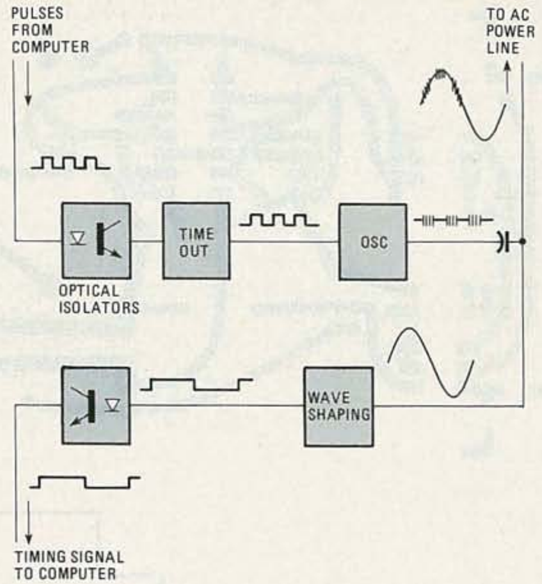

FIG. 1—BLOCK DIAGRAM reveals simplicity of the circuit. Opto-isolators keep AC out of the computer.

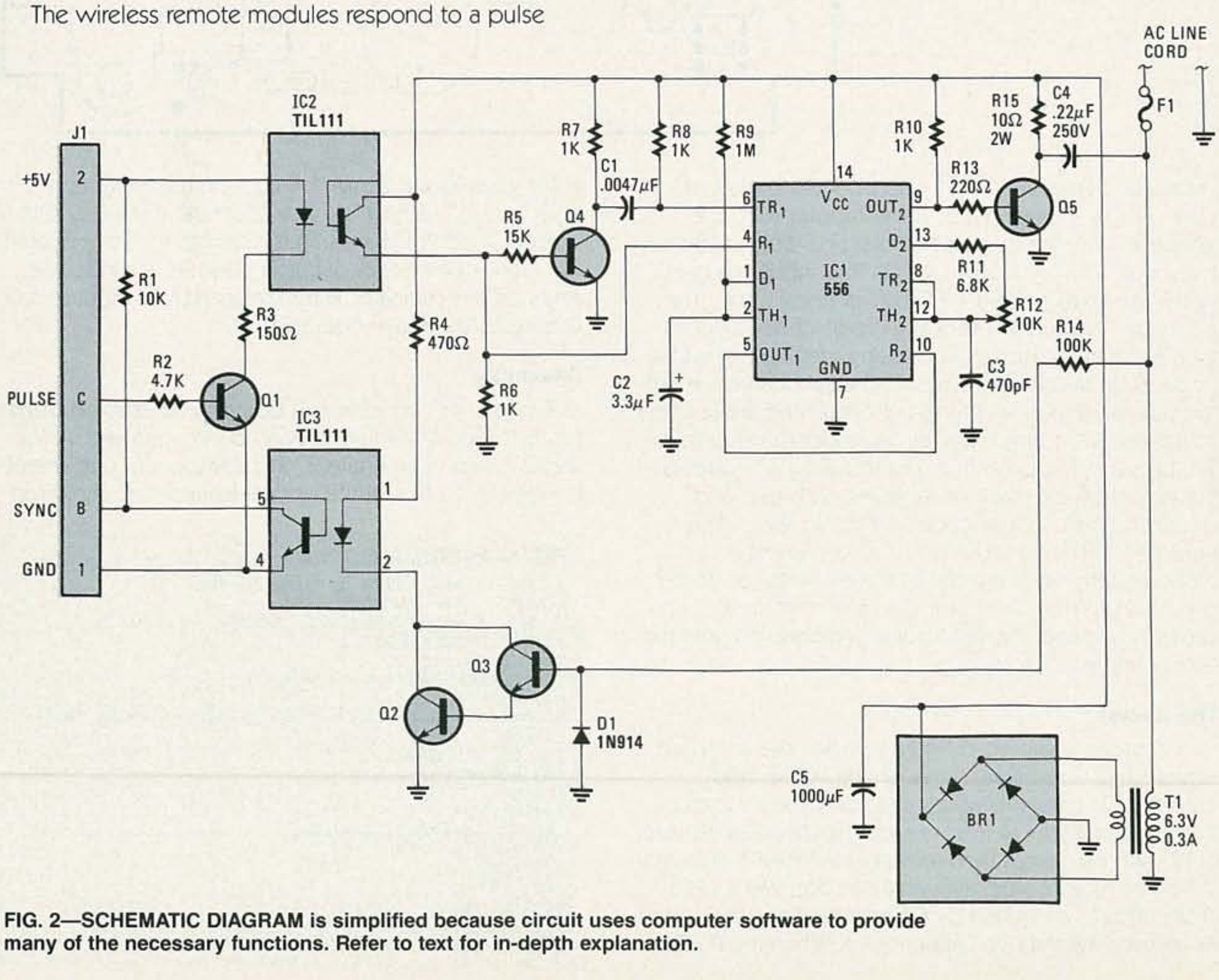

FIG. 2—SCHEMATIC DIAGRAM is simplified because circuit uses computer software to provide many of the necessary functions. Refer to text for in-depth explanation.

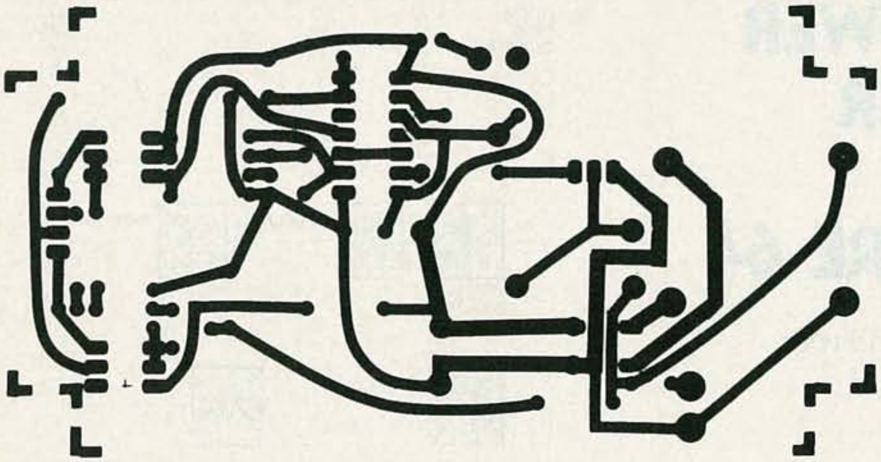

FIG. 3—HERE'S THE FOIL PATTERN for those of our readers who desire to do their own circuit-board etching.

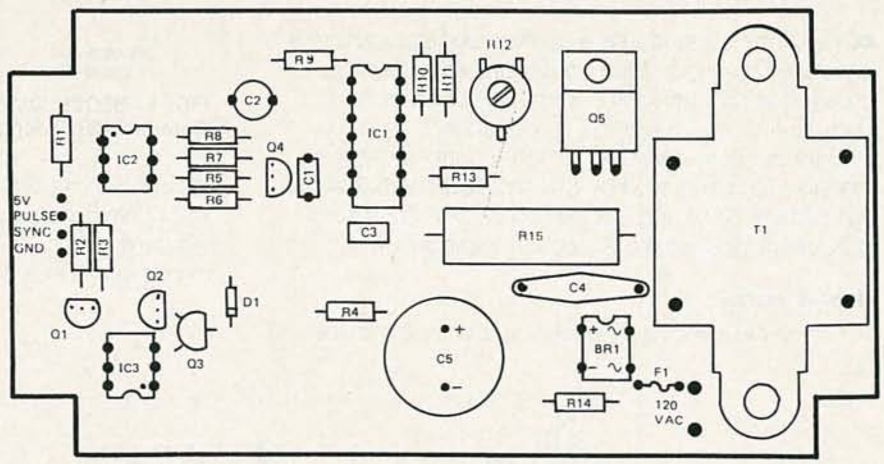

FIG. 4—...AND WHEN YOU'VE GOT THE BOARD etched, here's where all the parts go.

oscillator, a time-out circuit, and optical isolators to keep AC line power out of the computer. Machine language software in the computer first looks at the 60 Hz square wave from the device. This input changes at each zero crossing of the AC power line voltage. The computer then either outputs a group of three pulses or waits until the next zero crossing, depending on the code to be transmitted. These pulse groups go through the optical isolator and time-out circuit and are applied to the oscillator, which places corresponding bursts of 125 KHz on the power line. The grouping of pulses is controlled by the machine language software, and depends on the house code, unit code, etc., to be transmitted. The time-out circuit is to prevent a software hang-up from leaving the oscillator on. If the pulse output from the computer stays high for 2 seconds or more, the oscillator is switched off until the output returns to zero.

The circuit

The circuit is shown in Figure 2. When the computer sends a high logic level signal on the PULSE input, transistor Q1 turns on, which turns on optical isolator IC2 and transistor Q4. This triggers the monostable side of IC1, whose output then releases the RESET input (pin 10) of the astable side, allowing it to oscillate. Its 125 KHz output is amplified by Q5 and then applied to the AC power line through capacitor C4. When the PULSE input goes low, IC2 turns off and the monostable is reset through resistor R6, thus shutting off the 125 KHz output. If the PULSE input remains high for some reason, the monostable times out after about 2 seconds and shuts off the oscillator. Returning the PULSE input to low then restores normal operation.

Assembly

The power controller can be easily assembled using point-to-point wiring or a printed circuit board. A foil layout is shown in Figure 3, and component placement in Figure 4. Note that the optical isolators are mounted

FIG. 7—PROGRAM LISTING.

```
1 REM     BSR POWER CONTROLLER PROGRAM
2 REM     FOR COMMODORE 64
3 REM     WRITTEN BY G.C. SOWDEN 6/14/85
10 LET P=PEEK(56577)
20 FOR I=1 TO 20
30 IF PEEK(56577)<>P THEN GO TO 100
40 NEXT I
50 PRINT "POWER CONTROLLER IS NOT PLUGGED IN"
60 END
100 POKE 56579,1
102 GOSUB 109
104 GO TO 600
109 RESTORE
110 FOR A=49152 TO 49336
120 READ D
130 POKE A,D
140 NEXT A
142 RETURN
145 REM BSR
150 DATA 169,2,141,42,192
```

```
160 DATA 32,47,192,173,43,192
170 DATA 141,44,192,32,68,192
180 DATA 173,45,192,208,3,32,94,192
190 DATA 173,46,192,141,44,192,32,68
200 DATA 192,206,42,192,208,222,96,0,0
210 DATA 0,105,0,0,171
220 REM SC
230 DATA 32,94,192,169,3
240 DATA 141,67,192,32,120,192
250 DATA 206,67,192,208,248,32,94,192
260 DATA 96,0
270 REM BITS
280 DATA 169,8,141,93,192,14,44,192
290 DATA 144,6,32,120,192,76,87,192
300 DATA 32,94,192,206,93,192,208,237
310 DATA 96,0
320 REM TZ
330 DATA 169,0,141,119,192,206,119,192
340 DATA 208,251
350 DATA 173,1,221,141,119,192
360 DATA 173,1,221,205,119,192,240,248
370 DATA 96,0
380 REM T1
390 DATA 169,3,141,160,192,173,161,192
400 DATA 9,1,141,1,221,162,186,202
410 DATA 208,253,173,161,192,141,1,221
420 DATA 169,183,141,162,192
430 DATA 206,162,192,208,251
440 DATA 206,160,192,208,222,96,0,0,0
450 REM UNIT CODES
460 DATA 105,169,89,153,86,150,102,166
470 DATA 106,170,90,154,85,149,101,165
480 DATA 179,181,173,171,205,203
600 LET N=100
610 DIM T(N),U(N),F(N),S$(16)
620 FOR I=1 TO N
630 READ T(I),U(I),F(I)
635 IF T(I)>2359 THEN GO TO 1000
640 NEXT I
650 DATA 1201,1,1
651 DATA 1202,1,2
999 DATA 9999,0,0
1000 LET C$="A"
1010 PRINT "TIME(HHMM)"
1020 INPUT T$
1030 LET TI$=T$+"00"
1040 LET T$=LEFT$(TI$,4)
1060 LET H$=LEFT$(T$,2)
1070 LET M$=RIGHT$(T$,2)
1090 LET T1=VAL(T$)
1100 FOR I=1 TO N
1105 IF T(I)>2359 THEN GO TO 1160
1110 IF T(I)<>T1 THEN GO TO 1150
1120 LET U1=U(I)
1130 LET F1=F(I)
1140 GOSUB 8000
1150 NEXT I
1160 GOSUB 7000
1170 LET TO$=LEFT$(TI$,4)   .
1180 IF PEEK(197)<>64 THEN GO TO 1220
1190 IF T$=TO$ THEN GO TO 1170
1200 LET T$=TO$
1210 GO TO 1060
1220 IF PEEK(197)<>64 THEN GO TO 1220
1230 INPUT D$
1240 INPUT "TYPE DEVICE NUMBER:";U1
1250 IF U1=0 THEN END
1260 INPUT "FUNCTION?(TYPE 1 FOR ON, 2 FOR OFF)";F1
1270 GOSUB 8000
1280 GO TO 1160
7000 PRINT "{CLR}"
7010 PRINT H$;":";M$
7020 PRINT
7030 PRINT "DEVICE NUMBER AND STATUS:"
7040 PRINT
7050 FOR K=1 TO 16
7060 PRINT S$(K),
7065 NEXT K
7070 PRINT
7080 PRINT "PRESS RETURN FOR MANUAL CONTROL"
7090 RETURN
8000 LET S1$=" OFF"
8030 IF F1=1 THEN LET S1$=" ON "
8040 LET S$(U1)=STR$(U1)+S1$
8050 GOSUB 9000
8060 RETURN
9000 GOSUB 109
9002 POKE 49195,PEEK(49250+ASC(C$))
9008 POKE 49198,PEEK(49314+U1)
9010 POKE 49197,1
9020 SYS 49152
9030 FOR J=1 TO 10
9031 NEXT J
9032 IF F1<5 THEN GO TO 9050
9034 LET F2=2*(F1-100*INT(F1/100))
9036 LET F1=INT(F1/100)
9040 POKE 49153,F2
9050 POKE 49198,PEEK(49330+F1)
9060 POKE 49197,0
9070 SYS 49152
9075 POKE 49153,2
9080 PRINT U1,F1
9082 FOR J=1 TO 200
9084 NEXT J
9090 RETURN
```

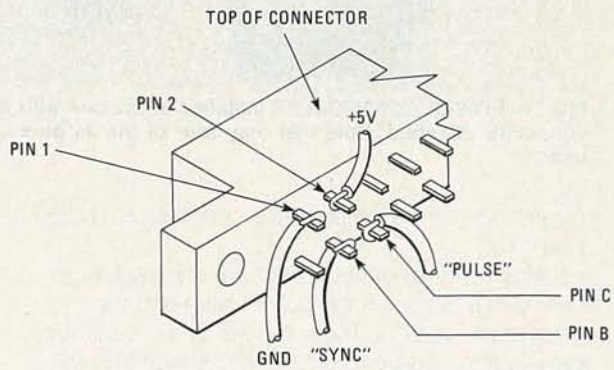

FIG. 5—WIRING FOR THE CONNECTOR is shown above. Provide good mechanical connections for all leads and then carefully solder.

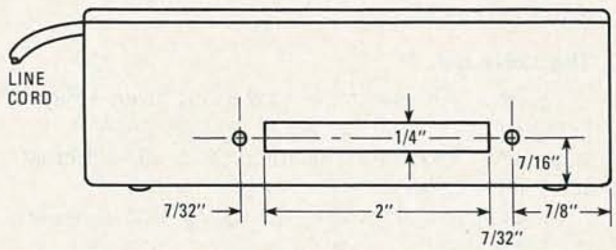

FIG. 6—DIMENSIONS ARE PROVIDED here for openings in the connector. See text for additional explanation.

facing opposite directions. You'll have to cut openings for the AC cord and the computer card-edge connector. The connector mounts on the side of the box, and it than plugs into the Commodore User Port.

After the components are in place, install the power cord. Solder hookup wire to the card-edge connector, as shown in figure 5. Cut a rectangular opening in the

FIG. 8—THE CIRCUIT BOARD completely wired, ready for installation in the box.

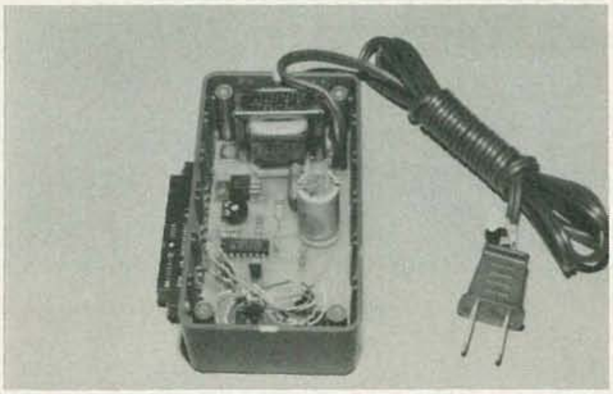

FIG. 9—POWER CONTROLLER installed in the box with the connector attached. Note that only four of the 24 pins are used.

plastic box for the card-edge connector, as shown in Figure 6.

Using a volt-ohmmeter, measure the resistance between a blade on the power plug and the connector contacts. There should be no continuity between the power plug and any contact on the connector. Next, plug the unit into a wall outlet and CAREFULLY measure the DC voltage at the output of the bridge rectifier. It should be about 8 volts. Be careful, because most of the components have power line voltage on them.

The software

Type the software in from the listing given in Figure 7. Double check the listing, especially the DATA statements. Save the program on tape or disk before you run the program.

The program is designed as a clock-time controller, but it also allows manual control of the remote modules from the computer keyboard. The program allows up to 100 on or off operations in a day, but this could be changed by changing line 600. The desired on/off times are in DATA statements is: (line number) DATA time, unit, code where "code" is a 1 for on, 2 for off. In the program, line 650 means "At 12:01 (24 hour time), turn unit 1, ON (code 1)," while line 651 says "At 12:02, turn unit 1, OFF (code 2)."

The "house code" for the power controller is set at line 1000. Sixteen different house codes are provided,

FIG. 10—POWER CONTROLLER plugs into the user port at the rear of the cabinet.

FIG. 11—THIS ILLUSTRATES the power controller connected to the computer. Be sure the connector location is such that the box does not cover the opening for the cassette interface.

in case your neighbor uses a similar system.

Take a remote module, set it to House Code "A" and unit code "1." Plug it in and plug a lamp into it. Run the program. It will then ask for the time. Type in the time in 4-digit, 24-hour format, then return. The program will clear the screen, print a heading, then a line which asks you to "press return for manual control." Press RETURN. It will say "type device number;" type 1 (and return); it will ask "Function? (Type 1 for on, 2 for off)." Type 1 (and return). The lamp should turn on. If it doesn't, try checking the house and unit codes, then check the program for typos. If that doesn't help, then try tweaking potentiometer R12.

PARTS LIST

Semiconductors
BR1—1 ampere, 50V. bridge rectifier
IC1—LM556 dual timer
IC2, IC3—TIL111 (or similar) optical isolator
Q1-Q4—2N3904 or similar transistor
Q5—TIP31 transistor

Resistors
(All resistors ¼watt unless otherwise indicated)
R1—10,000-ohm
R2—4700-ohm
R3—150-ohm
R4—470-ohm
R5—15,000-ohm
R6-R8, R10—1000-ohm
R9—1-megohm
R11—6800-ohm
R12—10,000-ohm ⅛ watt potentiometer
R13—220-ohm
R14—100,000-ohm
R15—10-ohm, 2 watts

Capacitors
(All capacitors at least 16V.)
C1—.0047µF.
C2—3.3µF. C3—470pF
C4—.22µF.
C5—1000µF.

Miscellaneous parts and equipment
F1—¼ a. fuse (see text)
J1—Card-edge connector, Texas Instruments No. H411121-12 (available from Digi-Key Corp., P. O. Box 577, Thief River Falls, MN 56701-9988)
T1—6.3V 300mA transformer
Line cord, box, etc.

COMPUTERIZED POWER SUPPLY COMPONENT SELECTION

Let your computer choose your power-supply components.

Jack Cunkelman

■As critical as a power supply may be, it seems to be the last thing to be considered. Only after a project is working, using the bench supply, do we think about the power supply and how we are going to fit it into the enclosure. This is where this program comes into play. It will make component selection faster and easier.

A power supply can consist of a battery or a transformer/rectifier assembly to power it from 120 volt AC sources. The linear type of power supply seems to be the most popular transformer/rectifier combination and that is what we will deal with here.

There are only a few ways to obtain DC power from AC sources using linear power supplys. One of the following three circuits are used by most experimenters: full wave bridge, full wave-center tapped, and full wave bridge -center tapped. We will limit ourselves to these three circuits.

Once the program is running there are two options available, output to the screen or output to a printer. The printer output will generate a list of component rating values for various power supply voltages and configurations.

The screen option treats the transformer as the variable element. Plugging in the values from those transformers in your "junk box" will enable you to quickly determine if they can be used or not. The screen display also deals with current ratings. A 0 entry, when a question is asked will return you to the menu. A 0 entry on the menu will stop the program.

All ratings are conservative for cool running, reliable operation. If you cannot find components with the exact rating, always step up to the next highest rated component available.

FULL WAVE BRIDGE
CAPACITOR INPUT FILTER

TRANSFORMER VOLTAGE (RMS)	DC VOLTS	DIODE PIV	CAPACITOR VOLTAGE
5	6	12	7
6	8	16	10
7	9	18	11
8	10	20	13
9	12	24	15
10	13	26	16
11	14	28	18
12	16	32	20
13	17	34	22
14	18	36	23
15	20	40	26
16	21	42	27
17	22	44	28
18	24	48	31
19	25	50	32
20	26	52	33
21	28	56	36
22	29	58	37
23	30	60	39
24	32	64	41
25	33	66	42
26	34	68	44
27	36	72	46
28	37	74	48
29	38	76	49
30	40	80	52
31	41	82	53
32	43	86	55
33	44	88	57
34	45	90	58
35	47	94	61
36	48	96	62
37	49	98	63
38	51	102	66
39	52	104	67
40	53	106	68
41	55	110	71
42	56	112	72
43	57	114	74
44	59	118	76
45	60	120	78
46	61	122	79
47	63	126	81
48	64	128	83
49	65	130	84
50	67	134	87
51	68	136	88
52	69	138	89
53	71	142	92
54	72	144	93
55	73	146	94

```
10 CLS
20 REM POWER SUPPLY SPECIFICATION PR
OGRAM
30 REM BY JACK CUNKELMAN
40 REM JUNE 1985
50 INPUT "DO YOU WANT SCREEN DISPLAY
 (S) OR PRINTER OUTPUT (P)";D$
60 IF D$="S" THEN 80
70 IF D$="P" THEN 500
75 PRINT "INPUT ERROR" : GOTO 50
80 CLS
85 PRINT"POWER SUPPLY TYPE"
90 PRINT"    FULL WAVE BRIDGE (1)"
100 PRINT"    FULL WAVE CENTER TAP (
2)"
110 PRINT"    FULL WAVE BRIDGE CENTE
R TAP (3)"
120 PRINT" ALL USING CAPACITOR INPUT
 FILTERING"
130 INPUT" SELECT TYPE 1 , 2 , 3 OR
0 TO QUIT";T
135 IF T=0 THEN END
140 ON T GOTO 1000,2000,3000
150 GOTO 80
500 CLS
510 PRINT "THE PRINTER OPTION PRINTS
```

```
 A TABLE OF VALUES FOR VARIOUS
       TRANSFORMERS"
520 PRINT "TYPE OF CIRCUIT:"
530 PRINT"     FULL WAVE BRIDGE (1)"
540 PRINT"    FULL WAVE CENTER TAP (
2)"
550 PRINT"     FULL WAVE BRIDGE CENTE
R TAP (3)"
560 PRINT" ALL USING CAPACITOR INPUT
 FILTERING"
570 INPUT" SELECT TYPE 1 , 2 , 3  OR
 0 TO QUIT";T
580 IF T=0 THEN END
590 ON T GOTO 1500,2500,3500
1000 CLS
1010 PRINT"FULL WAVE BRIDGE , CAPACI
TOR INPUT FILTER"
1020 INPUT"TRANSFORMER RMS VOLTAGE";
V
1025 IF V=0 THEN 80
1030 INPUT"TRANSFORMER CURRENT RATIN
G (AMPS)";C
1040 RV=INT((V*.95*1.414)+.04)
1050 DV=INT(2*RV)
1060 CV=INT(1.3*RV)
1070 OC = INT(C/1.8*10)
1080 GOSUB 5000
1090 PRINT V;TAB(21)RV;TAB(31)DV;TAB
(41)CV;TAB(52)OC/10
1100 GOTO 1010
1500 CLS
1510 INPUT"MINIMUM TRANSFORMER VOLTA
GE";M
1522 T$="FULL WAVE BRIDGE"
1524 GOSUB 6000
1530 FOR V = M TO M+50
1540 RV=INT((V*.95*1.414)+.04)
1550 DV=INT(2*RV)
1560 CV=INT(1.3*RV)
1580 LPRINT TAB(8)V;TAB(20)RV;TAB(31
)DV;TAB(41)CV
1590 NEXT V
1600 GOTO 500
2000 CLS
2010 PRINT"FULL WAVE CENTER TAPPED ,
 CAPACITOR INPUT FILTER"
2020 INPUT"TRANSFORMER RMS VOLTAGE (
ENTIRE SECONDARY)";V
2025 IF V=0 THEN 80
2030 INPUT"TRANSFORMER CURRENT RATIN
G (AMPS)";C
2040 RV=INT((V*.95*1.414)+.04)/2
2050 DV=INT(4*RV)
2060 CV=INT(1.3*RV)
2070 DV=INT(4*RV)
2075 OC=INT(C/1.2*10)
2080 GOSUB 5000
2090 PRINT V;TAB(21)RV;TAB(31)DV;TAB
(41)CV;TAB(52)OC/10
2110 GOTO 2010
2500 CLS
2510 INPUT"MINIMUN TRANSFORMER VOLTA
GE (ENTIRE SECONDARY)";M
2520 T$="FULL WAVE CENTER TAP"
2524 GOSUB 6000
2530 FOR V = M TO M+50
2540 RV=INT((V*.95*1.414)+.04)/2
2550 DV=INT(4*RV)
2560 CV=INT(1.3*RV)
2580 LPRINT TAB(8)V;TAB(20)RV;TAB(31
)DV;TAB(41)CV
2590 NEXT V
2600 GOTO 500
3000 CLS
3010 PRINT "FULL WAVE BRIDGE CENTER
TAP,CAPACITOR INPUT FILTER"
3020 INPUT"TRANSFORMER RMS VOLTAGE (
ENTIRE SECONDARY)";V
3025 IF V=0 THEN 80
3030 INPUT "TRANSFORMER CURRENT RATI
NG (AMPS)";C
3040 RV =INT((V*.95*1.414)+.04)/2
3050 DV = INT(4*RV)
3060 CV =INT(1.3*RV)
3070 OC =INT((C/1.8)/2*10)
3080 GOSUB 5000
3090 PRINTV;TAB(18)"+/-"RV;TAB(31)DV
;TAB(41)CV;TAB(49)"+/-"OC/10
3100 GOTO 3010
3500 CLS
3510 INPUT"MINIMUM TRANSFORMER VOLTA
GE (ENTIRE SECONDARY)";M
3520 T$="FULL WAVE BRIDGE CENTER TAP
"
3525 GOSUB 6000
3530 FOR V = M TO M+50
3540 RV = INT((V*.95*1.414)+.04)/2
3550 DV = INT(4*RV)
3560 CV = INT(1.3*RV)
3580 LPRINT TAB(8)V;TAB(19)"+/-"RV;T
AB(31)DV;TAB(41)CV
3590 NEXT V
3600 GOTO 500
5000 PRINT"TRANSFORMER";TAB(20)" DC
";TAB(30)"DIODE";TAB(40)"CAPACITOR";
TAB(52)  "  DC  "
5010 PRINT"VOLTAGE(RMS)";TAB(20)"VOL
TS";TAB(30)" PIV ";TAB(40)"VOLTAGE";
TAB(51)  "CURRENT(AMPS)"
5020 RETURN
6000 LPRINT:LPRINT:LPRINT
6005 LPRINT TAB(20) T$
6010  LPRINT TAB(20)"CAPACITOR INPUT
 FILTER"
6015 LPRINT
6020  LPRINTTAB(5)"TRANSFORMER";TAB(
20)" DC ";TAB(30)"DIODE"TAB(40)"CAPA
CITOR"
6030  LPRINTTAB(5)"VOLTAGE(RMS)";TAB
(20)"VOLTS";TAB(30)" PIV ";TAB(40)"V
OLTAGE"
6035 LPRINT
6040 RETURN
```

The biggest variable seems to be the transformer and how it is rated. I have always been within 10% of the desired output value using the transformer's published ratings.

cuit of that tube. A dynamic speaker probably gave the best audio output.

Next comes the 240, a high-mu (high-amplification) tube functioning as the first audio stage. The 200A is a sensitive detector, and the 222 is a screen-grid RF amplifier. The tuning coil is connected directly to the grid cap of that tube, and the plate circuit has a special tuned circuit to increase efficiency. There was also a dial lamp across the filament circuit, and a small switch on the tuning capacitor to cut out the larger section when tuning a high-frequency (shortwave) signal.

That's one of the early *Thrill Boxes,* but there were half a dozen variations sold in different configurations. If a *Thrill Box* was purchased pre-assembled, it included a certificate guaranteeing that it would bring in foreign stations. Unassembled, it cost about $30, and that included a metal cabinet. Of course, early kits seldom included tubes or an output device (headphones or speaker), so the inclusion of the metal cabinet was a plus. By following the enclosed instructions, the hobbyist of that era could have the receiver assembled and operating in about two hours.

As the 1930's wore on, interest in shortwave listening increased. Around 1940, most home radios had shortwave listening bands, and band-switching had most replaced plug-in coils. What were people listening to on all those radios?

Besides the hams, anyone who needed instantaneous communications was on the shortwave bands: ship captains, airplane pilots, and police, to name a few. Even the regular broadcast stations transmitted on the shortwave bands. One well-known broadcast (by KDKA) was received by the Byrd Expedition in 1929. It was sent via shortwaves a distance greater than 20,000 miles to Little America, Antarctica. It was even possible to pick up the audio portion of some early TV transmissions. An announcer would interrupt occasionally to explain what was going on for those who were receiving only the audio portion of the broadcast.

Many governments started transmitting on the shortwave bands. The U. S. led the way with over a dozen stations. And, unlike many foreign countries, the U. S. continually encouraged the growth of Amateur Radio.

One thing that fascinated many SWL's was the reception of Morse code. Code could be received on all bands, including the regular broadcast band. Many broadcasts were worthwhile copying for anyone who was able to, and many listeners who never became hams were nevertheless expert at receiving code. Learning code was itself a hobby. A code practice oscillator (CPO) could be built from plans or kits; pre-assembled units could also be purchased.

Winding up

That's about all for now; next month we'll discuss the Grunow table model *Type 5* with the teledial, an automatic tuner that resembles a telephone dial.

I hope to present the much improved and expanded tube substitution chart soon. Thanks to all who sent information. **R-E**

DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT
CIRCUITS EDITOR

Schmitt triggers

ONE OF THE MAIN ADVANTAGES DIGITAL has over analog electronics is the ease with which signals can be processed. After you've captured a signal, you can do just about anything you want with it. But it's often a problem in digital (and in analog) circuits to capture the signal in the first place.

The nice, logical circuit elements on the PC board want nice, clean input signals. And a clean input signal can be hard to come by. Often a signal from the "real world" must be conditioned before it can be handled by the electronics on your board. If the signal is dirty, it's a safe bet that even the world's best-designed circuit will take one look, turn up its electronic nose, and refuse to deal with it.

Probably the best, and simplest, way to condition a signal is to use a Schmitt trigger. All logic families (TTL, LSTTL, CMOS, HCMOS, etc.) have a collection of Schmitt trigger IC's in several different gate configurations. In Table 1 we list several popular, off-the-shelf devices. They're very easy to use, but sometimes you don't have room for another IC on a PC board, or cost considerations prevent you from adding another IC, and so on. So what you can do is build your own Schmitt trigger using an unused gate (and there's almost always one of those on a board).

TABLE 1—SCHMITT TRIGGERS

IC	Type	Description
4093	CMOS	Quad 2-Input NAND Gate
4584	CMOS	Hex Inverter
40106	CMOS	Hex Inverter
74C14	CMOS	Hex Inverter
7413	TTL	Quad 2-Input NAND Gate
7414	TTL	Hex Inverter

Rolling your own

The circuit shown in Fig. 1 illustrates one way of converting a standard non-inverting gate into a Schmitt trigger. To understand how it works, assume that we're working with a CMOS gate, and that its input (and its output) are both low. What happens when we bring the input high? If R1 weren't connected to the input, the gate would change state at ½ V_{CC}, the normal CMOS trip point.

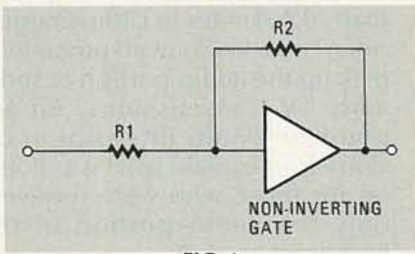

FIG. 1

However, with the resistors connected, as the input begins to go positive, the output of the gate remains low. The resistors function as a voltage divider that keeps the voltage at the gate's input lower than the actual input voltage. The inverter will only change state when the voltage at its input is equal to half the supply voltage. The two resistors make that trip voltage greater than half the supply voltage.

When the gate finally changes state, its output goes high, and that output voltage will be higher than the gate's input voltage. When that happens, the voltage divider helps pull the gate's input high. So, if you think for a moment, you'll realize that what we've just described are the two basic characteristics of a Schmitt trigger—hysteresis and snap action.

The same sort of dynamics occur when the circuit goes the other way. The circuit's trip point will be less than ½ V_{CC} by the amount of hysteresis generated by the resistors.

One advantage of designing your own Schmitt trigger is that you can play around with the values of the resistors and thereby create a Schmitt trigger with just as much hysteresis as you want. The range of hysteresis, H, you get is controlled by the supply voltage as well as by the values of the resistors:

$$H = (R1/R2)V_{CC}$$

There are limits to the values the resistors can have. You'll get no Schmitt-trigger action at all if R1's value is very small compared with R2's value, or if the resistors are inadvertently switched. A sensible limit for the values of the resistors is about 200K for R2, and a maximum R1:R2 ratio of 5:1.

Since the circuit is so easy to rig up, the best approach to finding the right resistor values for a particular application is probably the empirical one. Breadboard the circuit and then experiment with values for the two resistors. Just keep those values within the limits just mentioned. You could also create a chart of the amount of hysteresis produced by different combinations of resistors. Keep it handy so you can use it to build a custom Schmitt trigger whenever the need arises. **R-E**

STATE OF SOLID STATE

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

New op-amps

THE OP-AMP IS STILL ONE OF THE MOST widely used linear IC's. The OP-41 op-amp from PMI (Precision Monolithics, Inc., P.O. Box 58020, Santa Clara, CA 95052) is a new device that features a cascode FET-input stage that has a CMRR (*C*om-mon-*M*ode *R*ejection *R*atio) of greater than 100 dB. The OP-41 also has improved linearity, and stabilized bias current with changing common-mode voltage.

The OP-41 consumes only 750 μA and it has a power-supply rejection ratio of 25 μV/V. Those factors make the OP-41 ideal for use in battery-powered systems. Slew rate is symmetrical, and, despite the device's low current drain, is a respectable 1.3 V/μs. Offset voltage has been reduced to less than 500 μV so external nulling is unnecessary in many applications.

Other features include a maximum bias current of five pA, and a guaranteed gain of 1 million into a 2K load. Linearity is good in both high- and low-gain configurations. As a voltage follower, the CMRR effects dominate linearity, and, in high-gain service, open-loop gain dominates linearity.

Further, the OP-41 recovers rapidly from signal overload. Following saturation at the positive supply, the output recovers in only 6 μs, and recovery from a negative overdrive takes only 100 ns.

The superior performance characteristics of the OP-41 make it an excellent output amplifier for a CMOS DAC (*D*igital-to-*A*nalog *C*onverter). The OP-41's low, stable bias current would make it an excellent choice as a photodiode amplifier in medical applications. At unity gain, the output can drive 250 pF without oscillating.

The OP-41's superior characteristics and a pin-out that is identical to the industry-standard 741 make it simple for the designer to up-grade an existing low-power bipolar/JFET design.

An 11-page data sheet contains performance curves for various characteristics including bias current *vs.* temperature, bias current *vs.* common-mode voltage, supply current *vs.* supply voltage, and power-supply rejection *vs.* frequency. Also included in the data sheet are circuits for testing and measuring performance characteristics.

In addition, several applications diagrams, including a high-Q notch filter, a current-to-voltage converter, and an amplifier for piezoelectric transducers, are included. But perhaps the most interesting and useful application is the low-current ammeter shown here in Fig. 1. The circuit can measure current as low as a few pA and as high as 100 μA in six switch ranges.

Unlike many low-current ammeters, the one shown here does not require high-value precision resistors. As you can see, the desired range is selected from a tap on a voltage divider made up of six 1% (or better) 511-ohm resistors. The ammeter's accuracy is 1% or better over most of its range; accuracy depends on the decade resistors (R6–R11) and on the OP-41's input bias current.

Any good ammeter should cause very little voltage drop across its input terminals. The voltage drop across the input of the OP-41 is less than 500 μV, so that makes it effective as a low-current metering device.

The circuit works as follows.

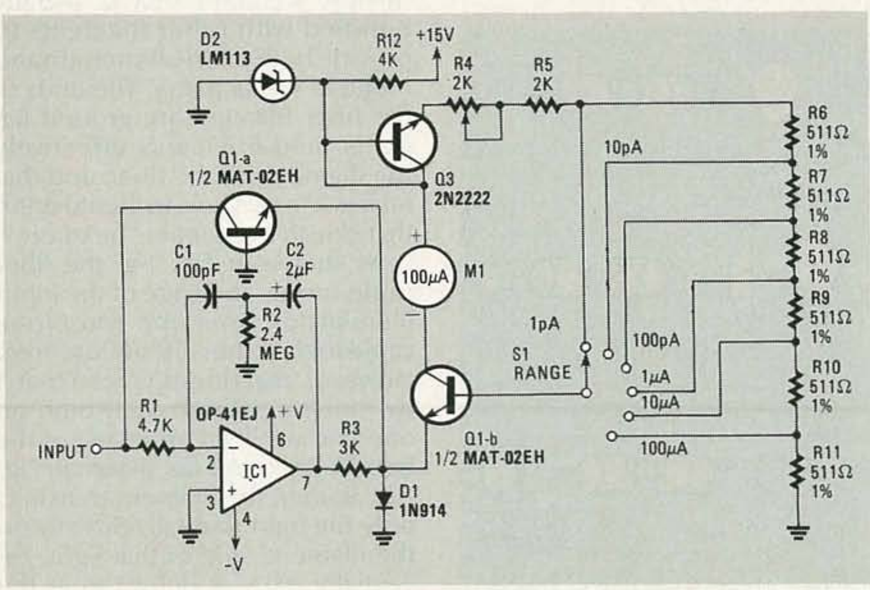

FIG. 1

COMMUNICATIONS CORNER

Fiber-optic communications

HERB FRIEDMAN
COMMUNICATIONS EDITOR

IT'S HARD TO STAY ON TOP OF THINGS in consumer communications because we often find out that tomorrow came yesterday. In other words, we discover that technology we thought would take several years to become economically competitive has actually been available in ordinary consumer appliances for years.

Fiber optics is just such a technology. It's been around for some time in high-technology hardware, and many news magazines and newspapers have discussed how it is used for interstate telephone circuits buried in railroad rights-of-way, in computerized telephone-switching equipment, and in *Teleport,* the super-duper satellite-communications center being built in New York City.

But those are very sophisticated applications, so I assumed that I could delay getting involved in yet another new technology until it became available in common, everyday hardware. Unfortunately, fiber optics came in the basement window while I was watching the front door.

I discovered that my pocket camera, my flashlight, and even my home photocopier all use fiber optics as a low-cost way to move information from one point to another. The key fact is that, while fiber-optic technology is expensive for mega-buck industrial uses, it often turns out to be an inexpensive way to do things in consumer hardware. To illustrate the savings made possible by fiber optics, think about those home copiers. For a few hundred dollars you can get a copier that turns out copies equal to those produced by units costing well over $1000 only a few years ago.

Naturally I was interested to see how that feat was achieved. I found that, instead of an expensive camera and lens mechanism, the copier uses fiber-optic filaments to move the image from the original to the copy. In a way, the only difference between the copier and fancy telecommunications gear is that the signal ends up on paper rather than in an electronic circuit.

So I thought that, if the technology was now low-cost enough to be used in a home copier, it must also be available in conventional communication equipment. Sure enough, seek and ye shall find. Buried in the week's mail—under the copier's manuals—were computer-supply catalogs listing moderately-priced fiber-optic modem for personal computers. A fiber-optic modem can couple a PC into a fiber-optic communications cable; they transmit data by light beam rather than by electric current.

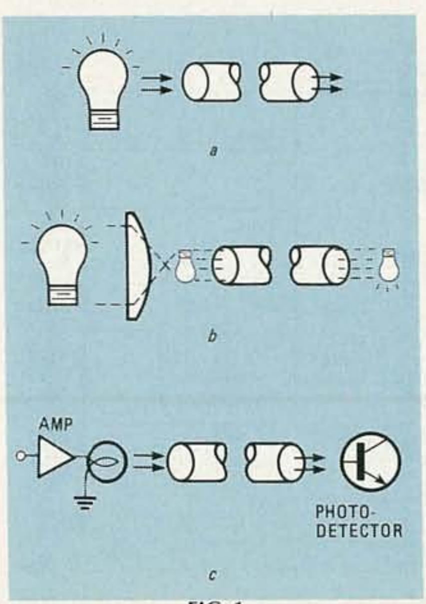

FIG. 1

The reason why fiber optics can serve equally well in desk-copier and desk-computer applications is that the fiber cable is really just a means of conveying a signal from one point to another. But unlike wire, fiber-optic cable is wideband, essentially lossless, and 100% free of induced ground-loop current. In addition, fiber-optic cable causes no interference to adjacent circuits. Here's an example of the power of fiber optics: a single fiber thread about the thickness of a human hair can simultaneously carry as many as 8000 multiplexed telephone conversations.

How it's done

In actual use the fiber is a thin, flexible filament that is usually bundled with other filaments to provide both physical strength and multiple signal paths. The ends of the fiber filament are ground flat so its field-of-view is effectively the diameter of the fiber, and that makes it insensitive to illumination that doesn't originate "head on."

As shown in Fig. 1-*a*, the fiber cable carries an image of the input illumination from one end of the cable to the other almost loss-free. However, that doesn't mean that if we shine a 100-watt light bulb on one end we'll get an image of the bulb at the other (as shown in Fig. 1-*b*). Rather, the filament transmits only the light that falls directly on the filament; and of that light, essentially 100% is delivered at the output. The reason for that high efficiency is that there is no internal loss due to heat, nor external loss caused by spill outside of the filament. All the light is contained within the filament, and that permits two adjacent filaments to carry independent signals without interfering with each other.

A big problem in many electrically-wired communications circuits is that of ground loops, which are caused by circuit grounds that are not true "earth" grounds. In general, circuit grounds are rarely true earth grounds; hence there is a potential difference between grounds at different points in a circuit, and that can cause current to flow in conventional cable-shields that are grounded on both ends. The current flowing between those grounds often induces "hum" and "hash" in the internal signal wires. The fiber-optic filament is not subject to ground loops because fiber-optic circuits use no shields or ground wires: It's all done with light.

A basic fiber-optic communications circuit is shown in Fig. 1-c. The input signal is coupled into the fiber filament by a light source driven by an amplifier. At the receiving end, the fiber filament points at a photo detector whose output current (or voltage) is proportional to the illumination from the filament.

When the signal is analog—continuously variable across a range of voltage—both the transmitter and the detector must have a linear response. Otherwise, the input signal could be digitized so that the fiber-optic system would handle only two states: on and off.

For example, in a fiber-optic modem the computer drives a small lamp that shines on the end of a fiber filament. At the receiver the filament shines directly on a phototransistor, thereby coupling the digital signal directly into the receiving computer without the need for a lot of complex analog hardware.

Fiber-optic communications hardware is still relatively esoteric and expensive. But since it can be used in home copiers, pocket cameras, and flashlights, it won't be long before we'll all be communicating by beams of light. **R-E**

STATE OF SOLID STATE

continued from page 89

Transistor Q1-a is in the op-amp's feedback loop. That causes the transistor's collector current to equal the input current. Hence its base-emitter voltage is proportional to the log of the input current. That logarithmic output drives the emitter of Q1-b; that transistor performs an antilog function to provide linear output for meter M1. The output of Q1-b is scaled according to the position of RANGE switch S1.

The voltage across the divider string (R6–R11) is stabilized by an LM113 voltage reference diode. That voltage is fed to the voltage divider through a 2N2222 transistor configured as a diode, then through CALIBRATION potentiometer R4, and R5. The output of the LM113 varies with absolute temperature; that provides temperature compensation.

To calibrate the circuit, potentiometer R4 is adjusted for full-scale deflection of the meter when a 1 μA current is applied to the circuit. That provides maximum accuracy over all six ranges.

Micropower voltage regulator

The LP2950 micropower voltage regulator is a recent addition to National Semiconductor's line of low-dropout regulators. The LP2950 features a quiescent current of only 75 μA and a dropout voltage that is as low as 40 mv under a light load. One advantage of the LP2950 regulator is that its quiescent current increases very little under most conditions, and it even stays low when battery voltage drops.

The LP2950 is available in 3-pin and 8-pin versions. The former is a 5-volt, 100-mA regulator with a temperature coefficient of 50 ppm/°C. Load and line regulation are typically within 0.05%.

The output voltage of the 8-pin version can be programmed from 1.24 to 29 volts with the addition of an external pair of resistors. And, by shorting pins 1 and 2, the LP2950 becomes a 5-volt regulator. The 8-pin version has several other interesting features including an ERROR output to warn of low output voltage and a SHUTDOWN input that permits the user to switch the regulator on and off using logic-level drivers (a TTL gate, for example).

Both versions feature short-circuit protection and thermal shutdown, and both require a 1-μF capacitor on the output pin for stability. The LP2950 costs $1.08 in lots of 100 or more.—**National Semiconductor,** 2900 Semiconductor Drive, Santa Clara, CA 95051.

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The Sil800 from Siliconix is a hybrid array of eight N-Channel, high-speed JFET switches in a hermetically-sealed package. It is designed for 64K core-memory circuits as a sense/drive switch for military and industrial applications.

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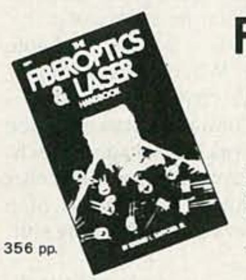

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KIRLIAN

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posure using S2. As a guideline, start with an exposure time of about 10–15 seconds, but it is likely that you will have to do a lot of trial-and-error experimentation with both exposure time and oscillator frequency, which is adjusted using R1, before you will obtain results that you are satisfied with.

The author has had good success with two types of film: Kodak 6118 Ektachrome

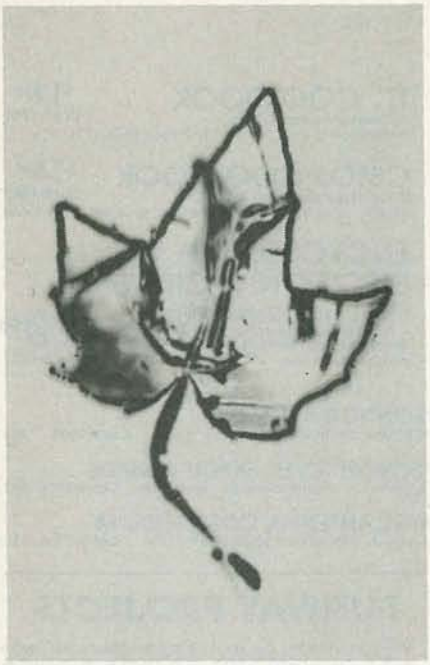

FIG. 6—ALTHOUGH THE RESULTS are not visually striking, Kodalith film is easy to work with. Here is a Kirlian aura captured on that film.

and Kodalith 2556 or the film, type 3.

The Ektachrome film will give you spectacular color transparencies, such as the ones that accompany this article. However, it can be difficult to work with (a dark room is absolutely required) and to develop. Unless you have a photographic darkroom and are equipped for developing that type of film, you will probably want to take it to a professional.

Kodalith 2556 ortho film, type 3 is a high-contrast, black-and-white graphic arts film that may be familiar to those who use the photographic method to make their own PC-board masks. The results are less spectacular, as shown in Fig. 6, but that film's light requirements are less exacting (a photographic safelight can be left on when handling the unexposed film or making exposures) and the processing procedure is much simpler, requiring just three basic chemicals. The author has had success finding the right exposure time and frequency using the Kodalith, and then turning to the Ektachrome for the final exposure. **R-E**

LEAKAGE TESTER

continued from page 58

it only for the test purposes intended, and discharge tested capacitors with a screwdriver when finished. In addition, use of this project is recommended by technically qualified personnel only.

Now that that's out of the way, the unit is a cinch to use. Let's look at some typical applications for the project:

Testing capacitors is easy. If applicable, remove the suspect unit from the circuit first, as any external leakage can cause a good capacitor to test leaky. Set S1 to the DISCHARGE position. Then set S2 to the working voltage of the capacitor. If the voltage is greater than the project can provide, use the 100-volt position.

Then use insulated clips to connect the capacitor to the project.

Flip S1 to the CHECK position. The meter needle will "kick" upscale and drop to zero for a good capacitor. If desired, press S3 for more sensitivity; that will give you 0-1 mA readings instead of the nominal 0-10 mA readings.

Note that the meter needle may kick upscale many times before settling down. That indicates that the capacitor has excessive leakage at the test voltage and requires "forming." That is a common situation with capacitors that are used at a voltage far lower than the working voltage, like, say, a 50-volt part in a 12 volt circuit. That is not a fault of the project. However, if the meter doesn't stop kicking after several minutes, the capacitor isn't forming and should be replaced.

When the testing is finished, return S1 to the DISCHARGE position. The meter will read negative, indicating discharge. When the needle returns to zero, remove the capacitor.

So how much leakage should a good capacitor have? There is no simple answer, as it depends upon the capacitor type and circuit requirements. However, here are a few rules of thumb you can use.

Paper, mica, polyester, and tantalum capacitors should display no leakage. Electrolytic capacitors up to 50 μF should show less than 25 μA of leakage current. Electrolytic capacitors from 51 μF to 500 μF should show less than 50 μA leakage. Electrolytic capacitors from 501 μF to 1,000 μF should show less than 100 μA leakage. Electrolytic capacitors from 1,001 μF to 20,000 μF should show less than 500 μA leakage.

Another use for the project is forming new capacitors. Understand that electrolytic capacitors chemically deteriorate when they sit unused. The capacitor's electrolytic film, essential to capacitor operation, deteriorates, causing very high leakage currents. If you apply a voltage to the capacitor, the film can reform. But if that voltage is too high, that is, close to the device's rating, the film may not be able to form fast enough. So the capacitor will consume power, get hot, and possibly explode. Here's how to solve that problem:

Set S1 to the DISCHARGE position and S2 to the 3-VOLT position. Then use insulated clips to connect the capacitor.

Flip S1 to the CHECK position and note the meter reading. When the meter reads minimum current, change S2 to the 6-VOLT position. Continue increasing the voltage until the working voltage is reached. Discard any capacitor that takes over five minutes to form, or still has high leakage when checked at its working voltage.

Appliance safety is easy to check. Here's how: Set S1 to DISCHARGE and S2 to 100-VOLTS. Assuming the device to be tested uses a three-wire power cord, use an insulated clip lead to connect the "hot" side of the power cord to the positive binding post. After that, connect the ground lead of the power cord to the negative binding post. The return or common side of the power cord is unconnected. If the appliance does not use a three-wire power cord, connect the negative binding post to any exposed case screws or other metal surfaces on the unit to be tested.

To test, flip S1 to the CHECK position. Press S3 for more meter sensitivity. The meter must read under 50 μA. For higher readings repairs are indicated.

Cables may be easily checked for leakage problems. Simply perform the checks the same way you did for appliance leakage. Remember to always connect the positive binding post to the center conductor and the negative binding post to the shield; that prevents a shock hazard.

If you need more sensitivity when performing leakage testing, try using your DMM if it has a 200-μA DC range. Simply set it to the 200-μA range and connect it in series with the positive binding post and the cable under test. That technique works great for other applications, except testing high-value capacitors. With those, when you switch to DISCHARGE, the current from the capacitor passes through the DMM, overloading it.

Another use for the project is quickly checking those special high voltage diodes used in TV sets and microwave ovens. Usually a DMM can't check those components because it can't supply enough voltage to turn on the device.

To test the diode, set S1 to DISCHARGE and S2 to 100-VOLTS. Then remove the diode from the circuit and connect it to the project's binding posts. Flip S1 to CHECK and note the reading. Then return S1 to DISCHARGE and reverse the diode. Flip S1 to CHECK again and note the reading. With most silicon diodes we expect a full-scale reading when the diode is connected one way and zero when it is reversed. With selinium diodes, the difference should be at least 100 to 1. **R-E**

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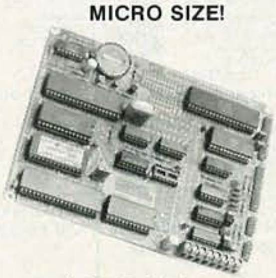

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TELETEXT DECODER

continued from page 70

Once the page appears correctly, alternate between TV and teletext modes several times, making certain that the page comes up properly each time.

If you have trouble getting a clear image and you have a static-and snow-free TV image, adjust the module's oscillator so that it will lock onto the incoming data. This is done by adjusting the trimmer capacitor near the crystal on the module. The module coil and that trimmer may have to be adjusted in concert to get a clear teletext image; go slowly, and allow the page time to clear between adjustments.

When you have a stable teletext image, adjust the trimmer capacitor C38 on the PC board until the color appears in the teletext page. Don't worry about color values; adjust for clear, even colors across the display. Then adjust the chroma balance control R52, near IC4 (MC1377), until the colors are acceptable. Again, some cross adjustment of C38 and R52 may be necessary to obtain the best color.

Using the decoder

Using the DSE Teletext is as easy as turning it on—even a child can use it without more than brief instruction. How you connect it into your video system depends on whether you want to be able to bypass the decoder; if it cannot be bypassed, it will have to be on whenever you watch TV.

The decoder can be used in three modes: teletext, mix, and newsflash. If you simply want to scan through the pages of a teletext service, press TT to enter teletext mode and select the page you want to see by simply entering its number. If you want to view the pages and monitor the TV image at the same time (during a commercial, for example, or while checking sports scores in the middle of a game), press MIX and the text will appear in white over the TV image. Finally, if you just want to watch TV, but want to be alert for news, you can set the decoder to a teletext service's newsflash page in mix mode.

The newsflash page is normally held blank, so that the TV image will remain undisturbed in the mix mode. If a news story breaks, the service inserts one or two lines of text at the bottom of the page, usually a brief headline and the page to see for details.

When the decoder is switched from TV to teletext mode, it will always come up on page 100, which has been chosen as the universal index page for World System Teletext. From that page you can go to any other, be it an index or a feature page, simply by entering that page number. When the page comes around in the loop, the decoder will store it in RAM and display it on the screen.

If you want to go to another magazine broadcast within the same VBI, simply enter a page that is within that magazine's loop. On WTBS and SPN, *Electra*'s title page will always come up on page 100, and any page between 100 and 199 is within *Electra*'s loop. If you want *Cabletext*, enter any page number between 201 and 212, and the decoder will enter *Cabletext*'s loop and present the selected page from that magazine.

When you select a new page, the previous page remains in RAM and on the screen until the new one appears—there is no blank screen time. The wait for a new page can be 15 to 20 seconds, but is about 4 seconds on the average. If you don't want to wait, or if you want to check the TV image without disturbing the teletext's operation, press CANCEL. That will return the display to regular TV, without interrupting the decoder's operation. At your convenience, you can return to teletext or mix mode, right where you left off. All of the remaining decoder commands are summarized in Table 1.

Now, get started and enjoy your decoder! **R-E**

TABLE 1—REMOTE CONTROL FUNCTIONS

Key	Function
0–9	Enters desired page number
TT	Switches decoder to teletext mode
TV	Switches decoder to regular TV display mode and clears teletext settings
MIX	Superimposes teletext display over regular TV image
CANCEL	Returns display to regular TV image without interrupting teletext operation
TOP	Expands top 12 lines of teletext display to fill screen
BOT	Expands bottom 12 lines of teletext display to fill screen
FULL	Restores teletext display to full 24 lines
REVEAL	Causes hidden portion of display to appear
HOLD	Causes page in RAM to be held despite changes in broadcast signal.
TIME ON/TIME OFF	For timed-page and rolling-page systems only.

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HM6116-3	2048x8	(150ns)(CMOS)	1.49
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LP=Low power

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74LS12	.22	74LS195	.69
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74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
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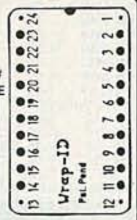

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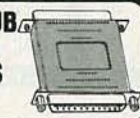

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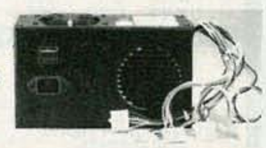

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10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
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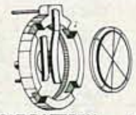

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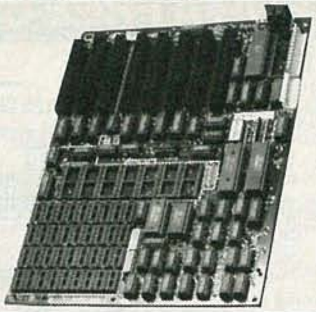

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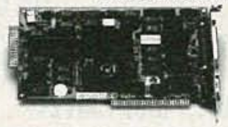

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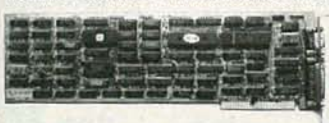

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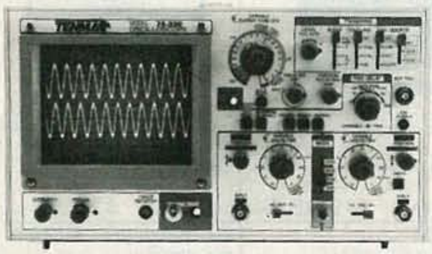

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- Two high quality 10:1 probes included
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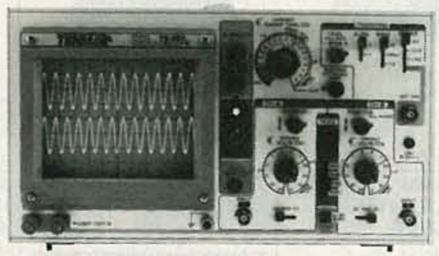

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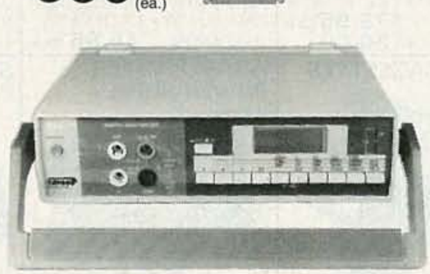

TENMA Bench Top DMM

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- Eight function DCV, ACV, DCA (up to 20A), ACA (up to 20A), Resistance (up to 20Mohm), Audible continuity test, diode test, capacitance test (up to 20μF)

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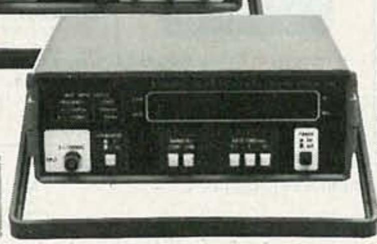

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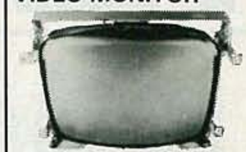

Green phosphor; 40/80 column, 1000-line resolution. 18MHz bandwidth. Compatible with IBM, Apple, Commodore, and more. Includes external transformer for operation on 115 VAC & video cable. Mfr – Elston Elec. #DM30
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(ASCII 75-Key)

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12V @ 450 ma
Contains 10 AA cells. Recharge rate: 45 ma. 16–18 hours. Case with tab output connections.
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Mfr — GE 123233 or equiv.
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13.2V @ 1.65 AH
Contains 11 C cells.
For model boats, toys, etc.
Mfr — GE #41B035BB00101
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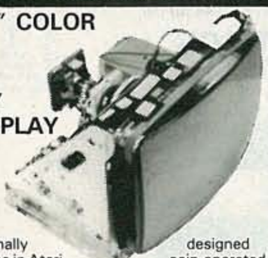

Originally designed for use in Atari coin-operated games. Contains 3-gun color tube, focus and brightness controls. Requires external X-Y inputs, 250-0-24V transformer for power. May be used for oscilloscopes, reprogrammed for game use, or modified with the use of external vertical and horizontal oscillators to a rastor scan display or TV monitor for computer use. (IBM compatible.) Transformer supplied.
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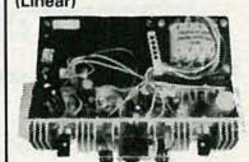

DC Output: −5V @ 200 ma.
+5V @ 3 amps
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+18V (inductive) @ 1 amp
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Chassis Dim: 11"W x 4"H x 8"D
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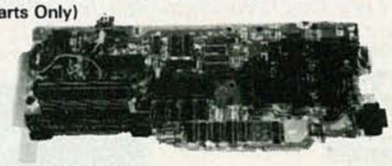

♥ of the 'ADAM'
Logic board for the Adam computer. Includes the following components: 8 ea. 4164-4s, 74LS157, 74LS541, LS273N; 2 ea. LM339s, plus microprocessors with ROMs.
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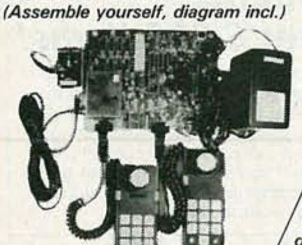

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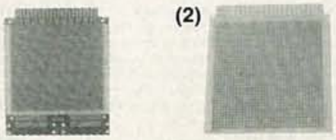

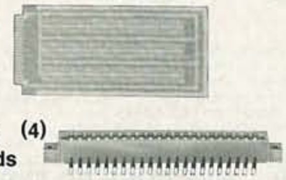

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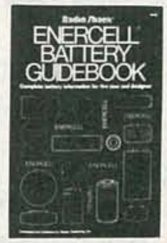

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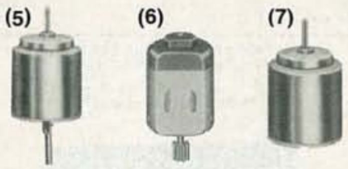

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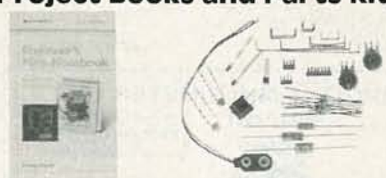

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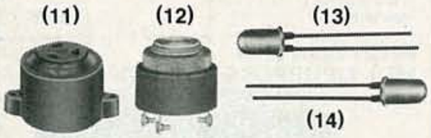
Values in Sight and Sound

(11) (12) (13) (14)



(11) Two-Tone Piezo Buzzer. Super-loud 100 dB sound level. 8-16 VDC. #273-070 .... **8.95**
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Description	Type	Cat. No.	Each
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Hex Inverter	7404	276-1802	.99
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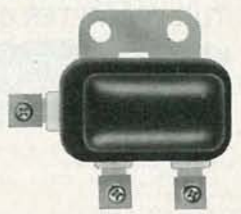
Heavy-Duty Automotive Relay

Only **4⁹⁹**



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2. Read out: twelve hours system display for hour, minute, second (by colon flash), AM & PM.
3. Display: three display modes of time, alarm time & date.
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7. Language available: English,

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YAMATO 4001

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The YAMATO 4001 is a 3½ DIGIT COMPACT DIGITAL MULTIMETER, it employs FE type LCD, with large figures. Its ADVANTAGES: High accuracy in measuring. High impedance assures min. measuring error. One rotary switch allows fast & convenient operation. 26 measurement range enable wider application. Over-input indication & low battery life appears on display. LSI-circuit use provides high reliability and durability. Measurement possible even under strong magnetic field.
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LCD THERMOMETER CLOCK

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Features:
0.34" DIGITAL thermometer with Hi & Low temperature alarm function and 12 hours clock combination.
Measuring range: 0°F to 160°F or −20°C to +70°C.
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100W DYNAMIC CLASS "A" MAIN POWER AMPLIFIER

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This powerful dynamic bias class "A" circuit makes this unit unique in its class. Crystal clear 100W R.M.S. POWER output will satisfy the mose picky HI - FI fans. This is a single channel amplifier. If you need a stereo effect you can buy two to make a total of 200W DYNAMIC POWER!
Over 3000 KITS ARE SOLD IN THE STATE!
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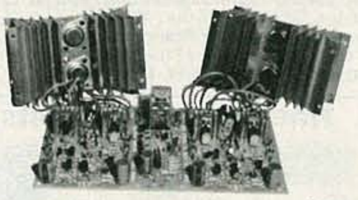
80W + 80W PURE DC STEREO POWER AMPLIFIER

TA-802



Kit **$39.95**

NF-CR BI-FET PRE-AMP

TA–2800

The heart of this Pre-amplifier is TL-984 IC which contains 4 BI-FIT operational amplifier and has very good transient response and low distortion.
High precision NF–CR MM cartridge amplifier has a superior distortion characteristic (less than 0.005%) and RIAA equalization (0.2dB). It reproduces melodical sound.
It has 40 steps volume céntrol, seperate high, middle and low tone control, tone compensation and tone defeat system.
It is compatible with any power amplifiers which are made by our company such as TA–1000A, TA–477, TA–802.
Kit **$44.50**

STEREO SIMULATOR

TA–3000

SPECIAL KITS OFFER!

KIT ONLY $25.00

You can own a stereo TV from today! This simulator is a special design of using the most advanceable monoploised L.S.I. It produced a superior analog stereo effect since the L.S.I. Is equalled 60 pcs. of LOW NOISE FET & TRANSISTOR. The simulator can even help you to promote your television from a normal one to a special one with a Hi-Fi STEREO function. Our simulator is also applicable to any other 'mono sources' in covering it to ANALOG STEREO. Undoubtedly, it is the most advanced equipment for every family, while it should contribute to your listening pleasure.
Ass. with tested **$30.00**

10W AC/DC SHOULDER AMPLIFIER

TA-008

TA-008 employs the most advanced I.C. of TOSHIBA, as a main device, the sound is powerful, it can be supplied by only 4 pieces of 'UM-1' 1.5V battery or AC to DC 6-9V adaptor. It is simple to operate, just 'press-to-talk', and with ON-OFF power switch on the mike. Besides, while it is well-packaged and with light weight, so it is convenient to bring along in both indoor and outdoor activities. Please Read our catalog for details.
Assembled with tested **$48.00**

COLOR LIGHT CONTROLLER

TY–23B

As a result of the advanced technology, this unit can control various colorful light bulbs, the visual effect of which is most suitable in places like party, disco, electronic game centre and also in lightings for advertisement. Total output power is 3000W (1000W/Ch.) which means that it can control 30 pieces of 100W or 600 pieces of 5W color light which is enough for most usages.
Kit **$65.00**
Ass. with tested **$75.00**

TA–2400A ELECTRONIC ECHO AND REVERBERATION AMPLIFIER

REMIX records yourself!

This unit combines the most advanced computer V.L.S.I. technique with high quality Japan Made component, so it has the following FEATURES:
It can generate various reflection and reverberation effect such as that in valley and music hall. It has a 3 section effect control which includes reverberation control, delay control and depth control. Special effect can be made in your record tapes by using this model. All kinds of infield sound effect can be obtained by skilful use of this control. It has LED display to show reflection and reverberation.
Ass. with tested **$99.85**

HIGH QUALITY MULTIPURPOSE PRE-AMPLIFIER

TA–2500

This specially designed pre-amplifier includes a professional GRAPH EQUALIZER TONE control system and has a gain to 12dB. Frequency response extends from 5Hz to 20KHz, so even in bad listening condition it can improve well. It can accept input from variouoos magnetic cartridge, record deck and tuner, its output can be connected to all kinds of power amplifier! The following combinations are good examples.
Assembled with tested **$90.00**

Model No.	Description	Kit/Assembled	Unit Price
TA–001	1W Mini Amplifier	Kit	$3.90
TA–006	6W Mini Amplifier	Kit	$4.92
TA–007	12W Stereo Power Booster	Kit	$8.00
TA–008	AC/DC SHOULDER AMPLIFIER	Ass	$48.00
TA–10	STEREO PRE-AMPLIFIER WITH MAGNETIC MIC AMP	Kit	$6.00
TA–50 A, B	MULTI-PURPOSE MELODY GENERATOR	Kit	$10.76
TA–120	PURE CLASS "A" MAIN POWER AMPLIFIER	Kit	$25.00
TA–202	20W AC/DC STEREO AMPLIFIER	Ass	$60.00
TA–300	30W Multi-Purpose Single Channel Amp.	Kit	$11.07
TA–302	60W Stereo Power Booster	Kit	$50.00
		Ass	$60.00
TA–323A	High Quality 30W+30W Stereo Amplifier	Kit	$24.60
TA–322i	60W IC Stereo Pre-Amplifier & Power Amplifier	Kit	$29.50
TA–400	40W TRANSISTORIZED MONO-AMPLIFIER	Kit	$13.84
TA–477	120W MOSFET POWER AMPLIFIER	Kit	$61.28
TA–800	80W+80W DC LOW TIM PRE-AMPLIFIER & POWER AMP.	Kit	$55.38
TA–802	80W+80W PURE DC STEREO POWER AMP. (W/SPEAKER)	Kit	$39.95
TA–820A	60W+60W OCL DC PRE-MAIN & STEREO AMPLIFIER	Kit	$43.00
TA–1000A	100W DYNAMIC CLASS "A" MAIN POWER AMP (MONO)	Kit	$51.95
TA–1500	100Wx2 NEW CLASS "A" DC STEREO PRE-MAIN AMP	Kit	$67.00
TA–2400A	ELECTRONIC ECHO AND REVERBERATION AMP	Ass	$99.85
TA–2500	HIGH QUALITY MULTI-PURPOSE PRE-AMPLIFIER	Ass	$90.00
TA–2200	DC FET SUPER CLASS "A" PRE-AMPLIFIER	Kit	$38.00
TA–2800	NF-CR BI-FET PRE-AMP (WITH 3WAY TONE CONTROL)	Kit	$44.50
TA–3000	STEREO SIMULATOR	Ass	$30.00
		Kit	$25.00
SM–43	3 1/2 MULTI-FUNCTIONAL LED D.P.M.	Kit	$29.23
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SM–48	4 1/2 HI-PRECISION D.P.M.	Kit	$38.00
		Ass	$43.00
SM–100	150MC UNIVERSAL DIGITAL FREQUENCY COUNTER	Ass	$99.00
TY–43	3 1/2 DIGITAL PANEL METER	Kit	$28.00

Model No.	Description	Kit/Assembled	Unit Price
TR–355 A, B	3-5A REGULATED DC POWER SUPPLY	Kit	$8.90
TR–503	0-15V/3A POWER SUPPLY WITH SHORT CIRCUIT BREAK & OVERLOAD PROTECTOR	Kit	$10.25
TR–100	0-15V 2A REGULATED DC POWER SUPPLY	Ass	$69.50
		Kit	$59.50
TY–1A MK4	BATTERY FLUOPESCENT LIGHT	Kit	$3.99
TY–7	ELECTRONIC TOUCH SWITCH	Kit	$5.50
TY–11A	MULTI-FUNCTIONAL CONTROL RELAY	Kit	$3.99
TY–12A	DIGITAL CLOCK WITH TWO TIMER	Kit	$13.86
TY–13	COLOR LED VU METER	Kit	$17.50
TY–14	ELECTRONIC SHOCK	Kit	$3.00
TY–18	HIGH PRECISION SOUND CONTROL SWITCH	Kit	$7.68
TY–20	SUPER SENSITIVE COLOR POWER LEVEL INDICATOR	Kit	$19.50
TY–23B	COLOR LIGHT CONTROLLER	Kit	$65.00
		Ass	$75.00
TY–25	SPEAKER PROTECTOR	Kit	$9.50
TY–35	FM WIRELESS MICROPHONE	Kit	$7.68
TY–36	AC/DC QUARTZ DIGITAL CLOCK	Kit	$16.92
TY–38	SOUND OR TOUCH CONTROL SWITCH	Kit	$10.00
TY–41 MKIII	INFRARED REMOTE CONTROL UNIT	Kit	$25.00
		Ass	$30.00
TY–42	BAR/DOT LEVEL METER	Kit	$21.00
TY–45	BAR/D@T AUDIO LEVEL DISPLAY	Kit	$34.95
TY–47	SUPERIOR ELECTRONIC ROULETTE	Kit	$16.92
YAMATO 4001	3½ DIGITAL MULTIMETER	@ SET	$33.80
T1	LCD THERMOMETER CLOCK W/IN/OUT DOOR SENSOR	@ SET	$20.00
T2	LCD THERMOMETER CLOCK W/F°/C° MEASURING	@ SET	$18.00
8504	TALKING CLOCK MYNAH	@ SET	$25.00
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Ass=Assembled form, it is fully checked and tested.

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The ProModem™ is a Bell 212A (1200/300) intelligent stand-alone modem · Hayes command set compatible plus an additional extended command set · Shown with alphanumeric display option. **RS-232 Stand-Alone Unit:**

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ProCom Communications Software. Please specify Operating System – Apple: ProDOS or CP/M – IBM: PC DOS or MS DOS

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512K Memory for PM-OP512K

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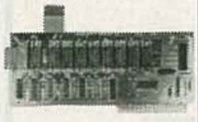
16K RAM CARD (Language Card)
For Apple II and II+*



Expand from 48K-64K. Runs AppleSoft, DOS, CP/M and Pascal. **(ARC-16K/MEM-1)**

JE860 . . $39.95**

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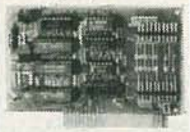
For Apple II, II+ and *IIe**



Capable of handling up to two drives. Recommended drives: ADD-514 or ADD-12. **(ACC-1)**

JE875 . . . . $49.95

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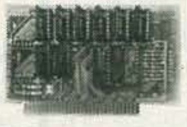
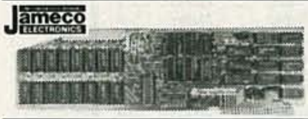
For Apple *IIe**



JE864 is an extended 80-column/64K RAM Card. Ultra-high resolution capability.

JE864 . . . . $69.95



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For Apple II, II+ and *IIe**

Four key software programs are included: Utilities, Diagnostics, Demos, and RAM Disk Emulators for DOS 3.3, CP/M and Apple Pascal. **Expand-A-RAM:**

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PREVENTS CRASHES!

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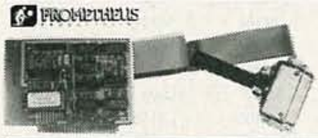
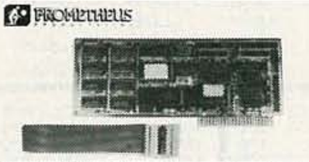


PARALLEL PRINTER CARD
For Apple II, II+ and *IIe**

Fully compatible with Apple CP/M, Apple Pascal (or FORTRAN), and most other operating systems and software packages. Available for Apple II, II+ and *IIe**. **PRT-1:**

JE880. . . . . $59.95



PARALLEL/SERIAL 64K BUFFER CARD
For Apple II, II+ and *IIe**

Using the parallel jumper cable supplied, the JE883 will attach to the JE880 (above). Parallel Card needed for operation. The JE883 includes a standard parallel input with both parallel and serial (RS232) buffered outputs. **P/S Buffer:**

JE883. . . . . $79.95

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**When using CP/M, the JE860 and JE868 will only function with Version 2.20 or earlier: PASCAL (JE868) Version 1.1 or earlier.

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Key: a=Apple II or II+ b=Apple *IIe*

APF-1	Cooling Fan with Surge Protection · Key: (a,b).	$ 39.95
KHP4007	Switching Power Supply · Key: (a,b).	$ 39.95
JE614	Numeric/Aux. Keypad - 11 accessible functions · Key: (b).	$ 49.95
AMON	12" Green Monitor with Swivel Stand · Key: (a, b and *IIc*).	$ 99.95
KB-EA1	Apple Keyboard and Case · Key: (a).	$ 99.95
JE520AP	Voice Synthesizer – Plug-In, User Ready · Key: (a,b).	$119.95
ADD-12	5¼" Half-Height Disk Drive · Key: (a,b).	$129.95
ADD-IIc	5¼" Half-Height Disk Drive · Key: (*IIc*).	$129.95
ADD-514	5¼" Full Height Disk Drive · Key: (a,b).	$139.95
PM1200A	Prometheus Internal Modem – 2 Cards · Key: (a,b).	$299.95
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4-CHANNEL SWITCHING POWER SUPPLY

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· Identical layout as original IBM PC Keyboard · Highly desirable case with palm rest · Complete with cable and data · *JUST PLUG IN!*

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FD55B	Teac 5¼" DS ½-Height.	$119.95
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TM100-2	Tandon 5¼" DS Full-Height.	$119.95

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Complete with power supply, switch, power cord, fuseholder and connectors.

DDE-1FH. $69.95
Houses 1 Full-Height 5¼" Floppy Drive

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7486	7475	7489	7493	7493	*LS02	LS03	*LS04	LS05	*LS08	*LS10	LS107
LS112	*LS138	LS139	*LS14	*LS14	LS153	LS155	LS156	LS157	LS158	LS161	LS163
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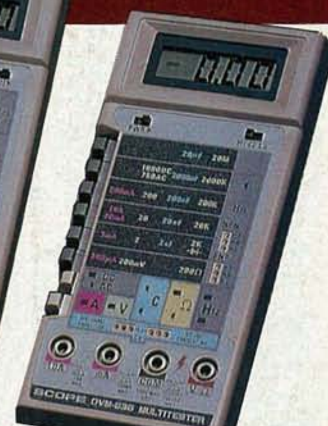

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