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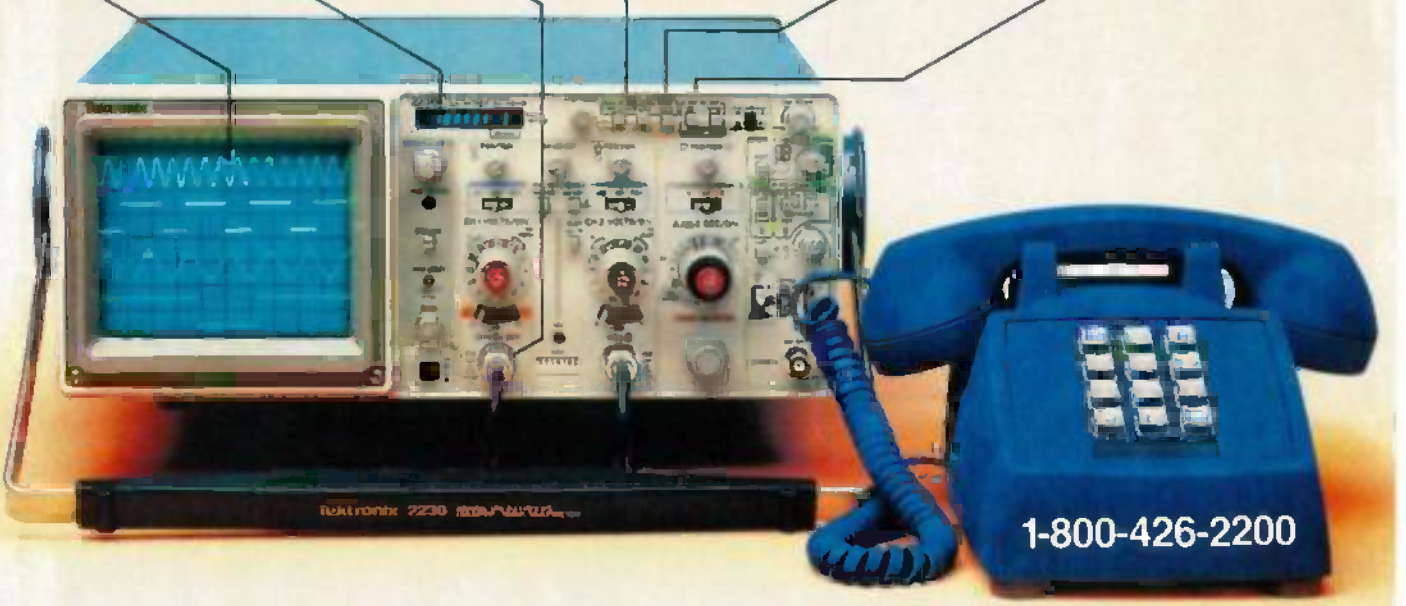

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JANUARY '86

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Vol. 57 No. 1

BUILD THIS

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COVER 1

What's new in satellite TV for 1986? A receiver for $100! What a way to kick off the new year! The receiver shown on the cover is a prototype of a satellite receiver that is available in kit form from Dick Smith Electronics. The receiver performs as well—or better than—many commercially available satellite receivers. Its low price makes it an ideal way to begin assembling your own TVRO system. Of course, for a complete system, you must add a downconverter, an LNA, and a dish, like the Uniden UST 110 shown in the background.

If you already have a system, can you think of a better way of adding a second receiver? The receiver we'll show you is easy to build. We even provide the foil pattern for the board! The hard-to-get parts are available separately, and a complete kit is also available. For more on this price/performance breakthrough, turn to page 45.

NEXT MONTH

THE FEBRUARY ISSUE IS ON SALE DECEMBER 31

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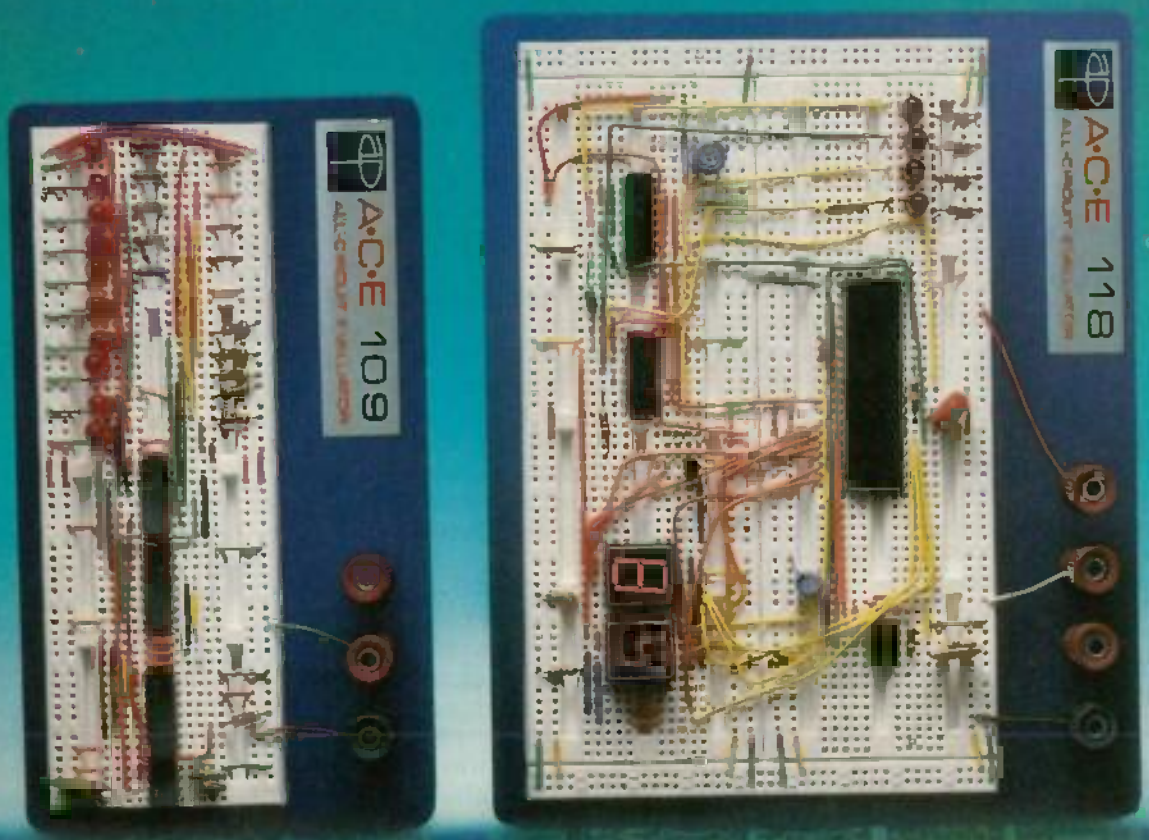

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WHAT'S NEWS

New Still Video System prints from live scenes

A prototype of a still video system consisting of camera, player, and printer was demonstrated at the past Summer Consumer Electronics Show by Konica, Inc., of Englewood Cliffs, NJ. It can make still images of live scenes and play them back on the Konica still video player, or make hard-copy prints in black-and-white or color.

THE KONICA SV-C20 STILL VIDEO CAMERA.

The camera uses 2-inch floppy disks to store the still images of what is being displayed in the viewfinder. The still video player plays back what is recorded on the floppy disk and will display other information, such as the date and time the image was recorded. The printer, besides making hard-copy prints from the camera, can produce a hard-copy print (on color paper) from any video source, including a videocassette recorder. That will permit owners of home-video equipment to make still prints from their home-video movies.

It is hoped, Konica officials stated, that the first of the still video system's components will be on the market sometime within the next 15 months.

New stabilized laser device for fiber optics and space work

A laser device just announced by RCA is expected to have important applications in space communications and fiber optics.

The recent explosion in fiber optics has created a strong demand for lasers that operate at a single stabilized wavelength. Lasers with stable wavelengths will also be required in the future for space communications, optical computing, and data storage.

The wavelength of solid-state lasers changes because of changes in temperature, power level, and the strength of the pulsating driving currents required to put information on the light beam. Many companies are eagerly searching for a solution to that stability problem.

RCA's approach is a laser with an external waveguide structure; that waveguide contains a reflective grating and is made of a different material than the laser itself. The new device, called an External Bragg Reflecting Laser, provides greater reliability and improved performance over previous lasers of the same type.

The new approach avoids complicating the actual process of growing the crystal, thus simplifying manufacture. It has an additional advantage of allowing off-the-shelf diode lasers to be combined with off-the-shelf waveguide units to achieve stabilization at a desired wavelength. The external waveguides may also be used to shape the output light beam and to assist in coupling the light into optical fibers.

New software program ends cut-and-try mold making

General Electric has demonstrated what it calls a major advance in factory automation—computer software that can assist in analyzing complex parts and then automatically generate instructions for machining the molds in which they are made. Known as TRUCE (*T*ridimensional *R*ational *U*nified *C*ubic *E*ngine) it greatly amplifies the capabilities of solid modelling. With it, realistic images can be displayed on a computer terminal and manipulated just like objects held in the hand. They can be rotated to show all sides, cross-sectioned to reveal the interior, or peeled away a layer at a time.

The mold for a plastic backpack frame is the first production-oriented item projected by the G.E. researchers. The project started out with a conceptual sketch. The engineers then went directly to the computer to create a preliminary solid model embodying the features they wanted in a backpack frame, and to refine its various features. (In the structural performance tests alone, stress analysis made it possible to optimize the material's thickness to produce a backpack frame stronger than an existing metal one, but with only three-quarters of the weight.

Using a computer controlled milling machine, the researchers then cut a solid cavity block from high-density foam to verify the computer-generated tool paths. The GE researchers then machined the mold's actual core out of aluminum. No engineering drawings, blueprints, or physical models of either the part or the mold were required for any stage of the manufacturing process. **R-E**

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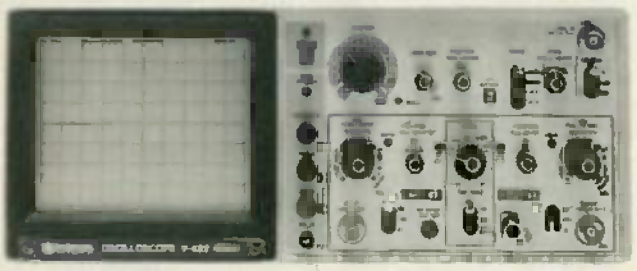

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Digital-effects VCR.** A VHS recorder using a computer memory to produce special effects is now being marketed in Japan by Toshiba; it is expected on the American market next spring. Unlike other video recorders with "clean" special effects, the new Toshiba uses only two heads, yet it provides the best slow-motion and freeze-frame we have seen on a consumer machine. The pictures were clear and sharp, with no trace of noise bars in the picture.

The VCR contains four 256K and two 64K dynamic RAM's, a memory-control IC, and analog-to-digital and digital-to-analog converters. For slow motion, the tape runs at a constant one-quarter speed, while the digital circuit sequentially selects and stores images in memory. In addition to freezing a frame of a videotape, the circuit can freeze any frame being displayed on the TV, provided the VCR's tuner is being used. The VCR sells for about $700 in Japan, but should cost somewhat more here.

• **More digital TV's.** To be introduced both here and in Japan early in 1986 is a new 26-inch digital-TV set by Sharp that can divide the screen into nine segments and show a series of still pictures of what is available on each of nine local channels. A similar system has been demonstrated by Mitsubishi, but it has no marketing date. The Sharp set can also convert any incoming signal to a sequence of still pictures—showing, for example, a sequence of still pictures of a baseball being hit by a bat. ITT Semiconductors, still the only source of IC's for a complete digital-TV set, says it has sold enough IC's to produce 200,000 digital sets. ITT's own TV-manufacturing facility in Germany has used about half of those. In addition to ITT and Sharp, digital sets are being produced by Panasonic, Sony, Toshiba, and Italy's Sinudyne. ITT says that 10 other brands will go into production within the next few months.

• **Camcorder news.** Camcorders, or combination camera-recorders, remain the hottest items in the portable-video field. Kodak is introducing a camcorder outfit consisting of an 8-mm tape deck and a separate camera, each weighing about 2 pounds. The camera and recorder can be used as separate items, connected by a cable, or they can be plugged together to form a camcorder. Kyocera, parent of the Contax and Yashica camera companies, will sell an 8-mm camcorder in the United States under its own name. Meanwhile, Sharp has joined those manufacturers offering camcorders that take full-size VHS cassettes.

• **TV station "sets" VCR.** It could never happen in this land of commercial TV, where TV stations don't encourage home videotaping, but in Germany, some stations actually are correcting programmable VCR's when their schedules slip. Unlike their American counterparts, German TV programs' listed starting times are often only approximate, and schedules frequently are upset when special programs are inserted unannounced. What happens when you set your VCR to tape a program scheduled for 8 p.m., but that actually doesn't start until 9:17? Your tape comes out fine if the station is using VPS.

VPS stands for Video Program System. It involves a special code-signal transmitted on line 16 of the vertical interval along with the program. A VCR equipped with VPS circuitry (or a VPS adaptor) starts to search for the VPS code 10 minutes before the scheduled starting time and continues to search for up to four hours afterwards. Recording starts only when the proper VPS code is found.

• **Star-spangled Sony.** Sony was the first Japanese manufacturer to set up an American TV-set plant (back in 1972), but it doesn't talk about it much, on the theory that Americans seem to prefer Japanese-made TV sets. Sony's U.S. plant in San Diego will produce 850,000 color sets this year, and in the next few months it is scheduled to increase its capacity to as many as 1,500,000 annually. Sony's newest color-TV model is a 27-inch set, and the company plans to produce 600,000 of them a year in San Diego. The company manufactures picture tubes as well as TV receivers at the plant. **R-E**

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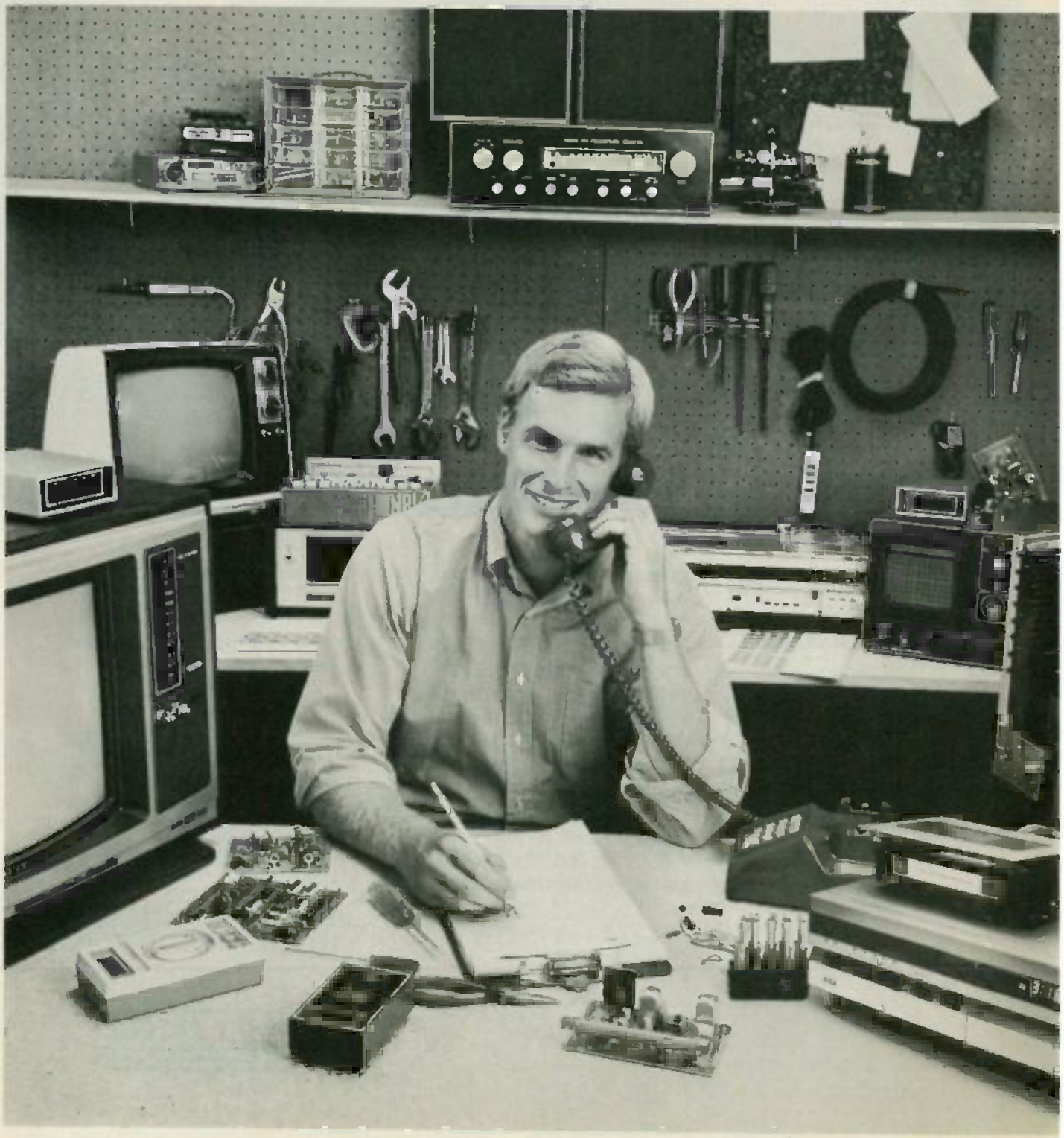

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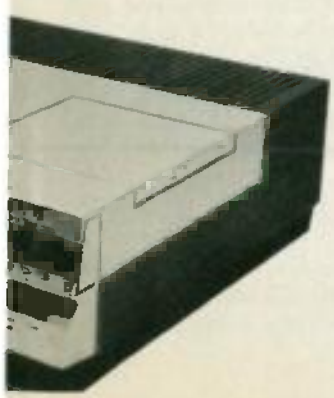

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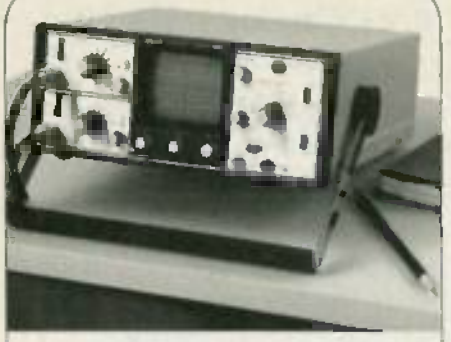

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TOUCHSCREEN TECHNOLOGY

My purpose in writing this critical letter is to alert you to the poor quality of Mr. Stern's article entitled, "Touchscreen Technology," in the September, 1985 issue.

It is hard to see how your writer could have spent much effort investigating this technology and market, and still have so grossly misunderstood how such an important product works, much less appreciate the advantages and limitations of the technology. You will note that the design does not involve three layers. The dots are inactive spacers that play no role in determining the resolution. Resolution of 4,000 × 4,000 has been standard with resistive touch screens for several years. Only one coordinate pair is generated each time the screen is touched. And sampling rates of up to 150 coordinate pairs per second are routine.

There are many other value statements in the article with which I would take exception. Elographics is the major supplier of touch screens and has a reputation for providing products that are highly reliable. One would hardly get that impression about resistive-membrane touch screens from the article.

While writers can be forgiven for making some misstatements when writing on areas of technology that are foreign to them, I do not recall reading an article as replete with error, and as poorly organized, as this one. Since the only supplier mentioned was Microtouch, I assume that someone from that company provided much of the information included in the article. That they may have given Mr. Stern incorrect information does not absolve him from the responsibility of double-checking his source prior to publication.

I might add that Microtouch has yet to deliver their product in quantity, or to prove that it will be a reliable product with long term use.

I hope that you will institute improved procedures to protect against such misinformation as that article presents.

ROBERT R. HIGHFILL
V.P. Marketing, Elographics, Inc.

While it's true that resistive-membrane touch screens are theoretically capable of 4,000 by 4,000 resolution, that is rarely ever achieved because of the nature of this touchscreen. Made of a plastic laminate, a relatively wide area of the membrane is, in fact, depressed when it is touched. Therefore, a resolution of 256 by 200 is far more realistic. Likewise, a 150 pair-per-second sampling rate is also claimed in product literature, but, since many coordinate pairs are actually depressed when the screen is touched, that sampling rate is effectively much lower, on the order of one-quarter or so of the claimed figure. Therefore, the figures quoted are typical of real-world findings, and that is why they were used in the article. As for clarity and long-term reliability, it can't be denied that a touchscreen, no matter how clear, will still impact the overall clarity of a CRT screen; and because the typical unit is a plastic laminate, it won't stand up to sharp instruments for long.—Marc Stern

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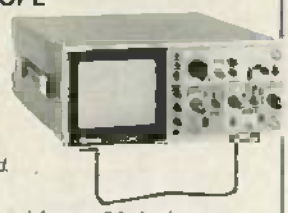

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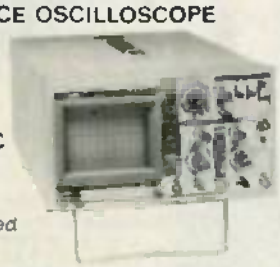

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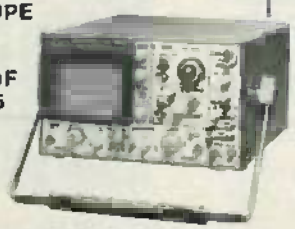

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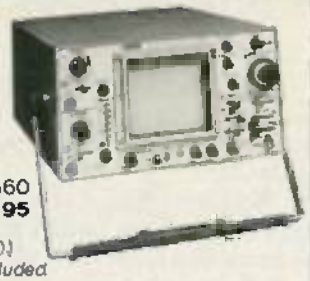

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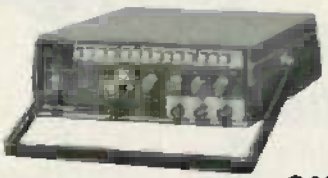

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ters and two A/B switches, as detailed in, "Hooking Up Your VCR" (**Radio-Electronics**, August 1985, page 56, Fig. 12). Use a UHF block converter to move your pay channel up to a UHF channel. That setup has no switches, gives the VCR and TV access to everything, and gives the VCR full programmability.

SCOTT MALAN
Alpine, Ca.

ANTI-LOCK BRAKE SYSTEM

The description of our ABS anti-lock brake system in the September issue ("Electronics Under the Hood") was incorrect.

The system does not employ a brake-pedal pressure sensor, nor does it use an electronic module to engage the brakes, as was stated. Instead it reads wheel speeds from three sensors (one on each front wheel and one on the pinion gear of the rear axle differential). Those data are fed to an electronic control unit that establishes a vehicle reference speed and a basis of comparison for each wheel. When the brake pedal is pushed and, because of specific road-surface adhesion, at least one wheel approaches the point of locking, the system redirects the brake fluid from the involved wheel(s) back to the master cylinder. As wheel speed stabilizes and than begins to build again, braking is resumed. Effectively, the system precisely pumps the individual wheel brakes as needed, at a rate of up to 10 times per second.

It all happens automatically. The driver need only step on the brake pedal and steer.

A.B. SHUMAN
Manager, Public Relations,
Mercedes Benz of North America

PROPAGATION VELOCITY

In the August issue I was drawn to the "See-In-The-Dark Viewer"—and to the error in the box on page 51.

The propagation velocity of the electromagnetic radiation in space is equal to the product of the wavelength and frequency; in all other media it is less. One can't determine if the K employed here is intended to account for that. Of course, we may have a printing error, but I can't presume to deprive Mr. Grossblatt; he is such a deserving fellow! Keep up the good work!

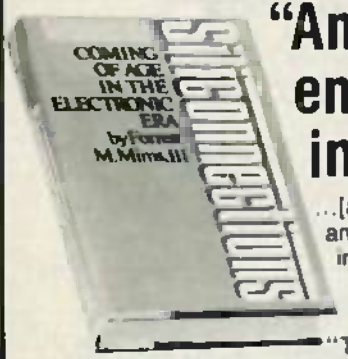
L.D. SMITHEY

Pacific Palisades, CA.
You're absolutely right. The speed of light is, of course, $c = f\lambda K$, where K is the dielectric constant of the medium through which the light is travelling.

CHALLENGE TO THE VCR AND CABLE-TV INDUSTRY

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 selec-



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tion. 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 already exists, since most VCR's and many cable decoders use digital channel selection. If a simple LSTTL logic interface could be agreed upon, one common cable subscribers' complaint 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, audio) signals, process the data and feed it to the output devices. Thus the TV receiver is easily updated (with ROM perhaps) to encounter 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 described. 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.

GENE SIMMONS
Riyadh, Saudi Arabia

NEW IDEAS: APRIL FOOL?

I looked for an April Fool article, in the April 1985 issue of R-E, and finally decided that it had to be the "New Ideas" page, "Making Electronic Music—Automatically!" I can do the same thing it purports to do using only three IC's and one transistor, and I get nine notes instead of eight.

If I am wrong, my apologies to Mr. Artur Manhica.

SID BUCK
Key Largo, Fl.

I think you're missing the point of our "New Ideas" column. Its purpose is to bring new circuits designed by our readers to the attention of other readers. They're ideas, not finished products. If you can use a circuit that we present as a starting point for a more elegant design, then you're benefitting from it. If you're looking to "New Ideas" for tried-and-true solutions to problems, you've got the wrong idea.—Editor **R-E**

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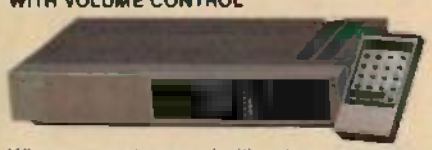

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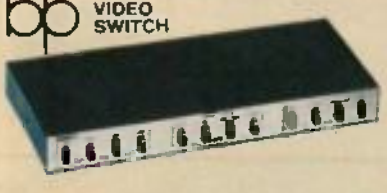

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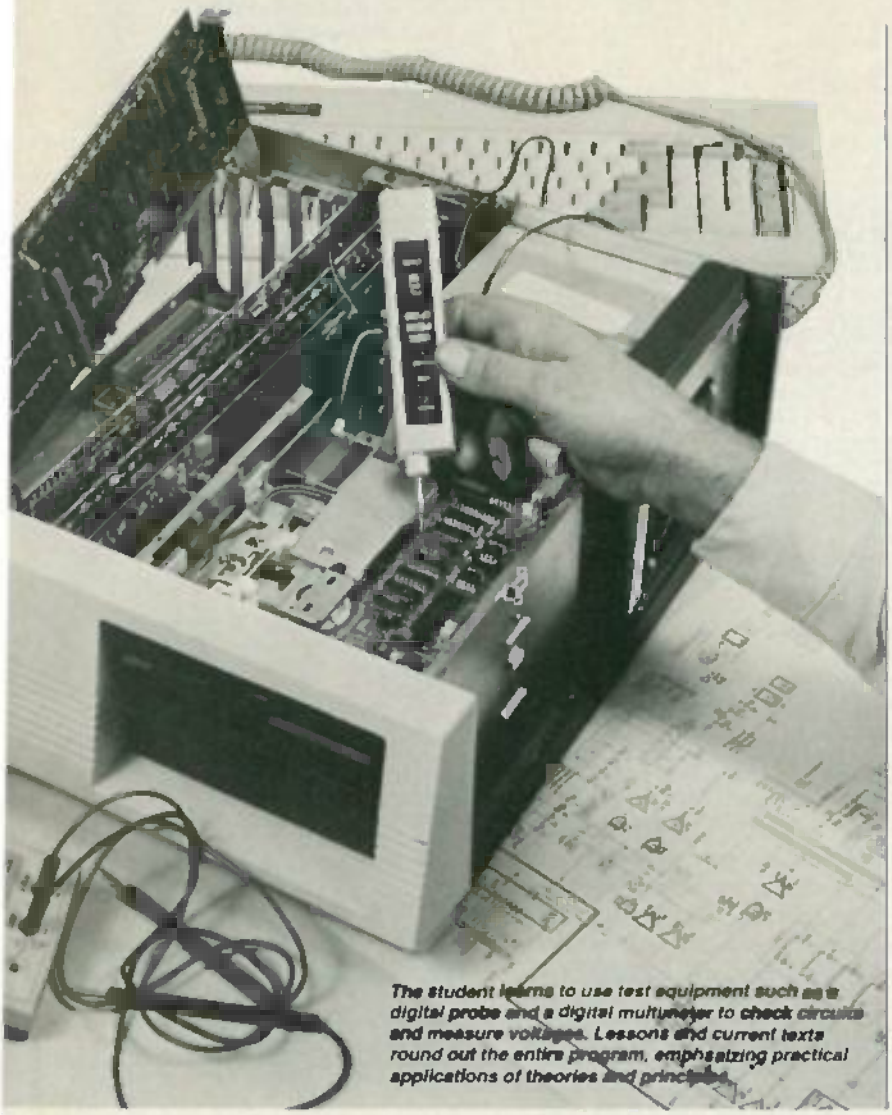

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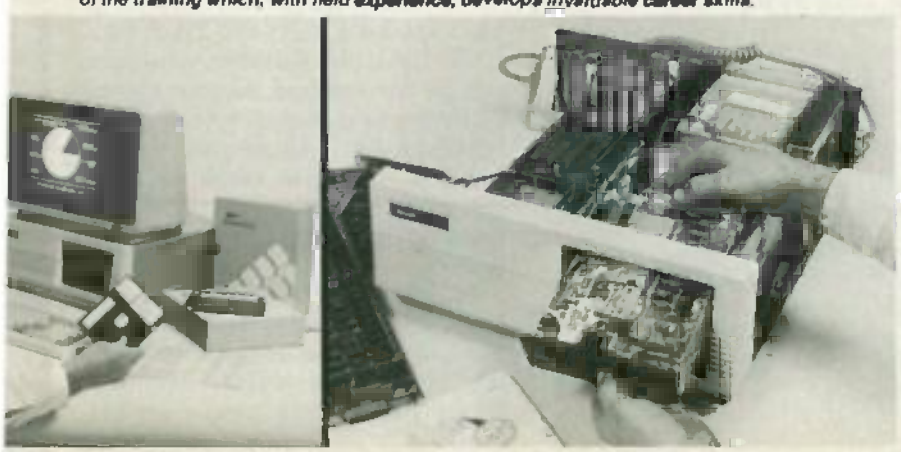

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ASK R-E

WRITE TO:

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Radio-Electronics
200 Park Ave South
New York, NY 10003

RESISTOR DECADE BOX

I want to build a resistance decade box that has six decades ranging from one ohm to one megohm. The problem is that using ten precision resistors per decade will be expensive. I understand that there are tricks for creating ten discrete values using only four resistors. Please show me how.—J. A., Cobleskill, NY.

Resistance decade boxes evolved from the British "Post Office Bridge," shown in its basic form in Fig. 1. (The British Post Office functions like both our FCC and our National Bureau of Standards.) The resistors are precision wire-wound types. The desired value, as shown in Table 1, is selected by opening and closing the correct combination of switches.

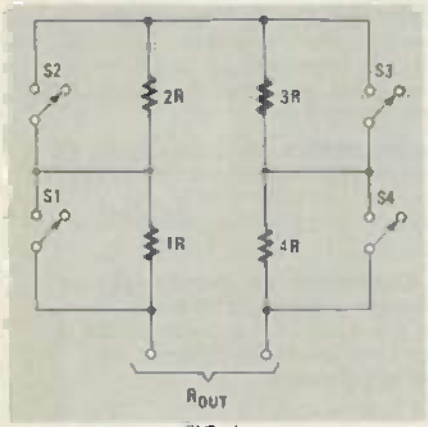

FIG. 1

TABLE 1—RESISTANCE VS. SWITCH POSITIONS

Value	Closed	Opened
1R	S2, S3, S4	S1
2R	S1, S3, S4	S2
3R	S1, S2,S4	S3
4R	S1, S2, S3	S4
5R	S2, S3	S1, S4
6R	S1, S3	S2, S4
7R	S1, S2	S3, S4
8R	S2	S1, S3, S4
9R	S1	S2, S3, S4
10R	—	S1, S2, S3, S4

Here, and in Figs. 2–4, note that the values of the resistors have not been specified exactly. To build a decade box using one of those circuits, just make sure that the resistors maintain the indicated proportions relative to each other. In Fig. 1, for example, values of 1 ohm, 2 ohms, 3 ohms, and 4 ohms will be suitable for a 1- to 10-ohm decade box. To build a 100- to 1000-ohm decade box you would use resistors of 100, 200, 300 and 400 ohms.

There are several ways to wire a 2-gang, 10-position rotary switch to obtain resistance values in discrete steps from 1 to 10. They use resistor combinations such as 1-2-2-5, 1-2-4-5, 1-2-3-5, 2-2-3-5, etc. Unfortunately, suitable switches can be hard to find, or expensive. In case you'd like to give it a try, however, Fig. 2 shows one example that is easy to hook up. The resistors should be wired directly between contacts on the switch wafer.

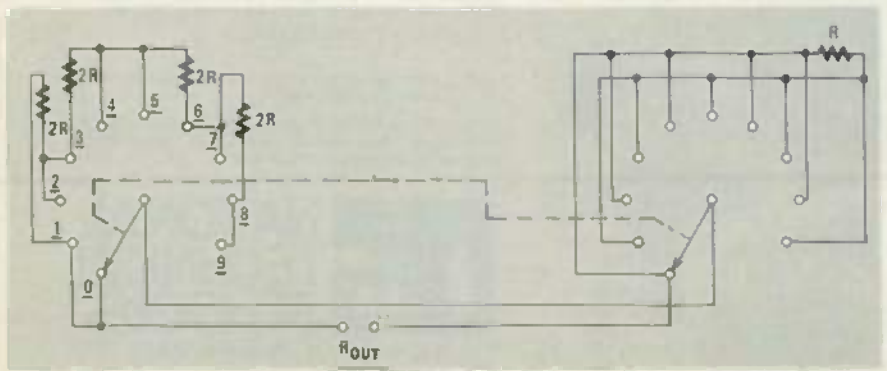

FIG. 2

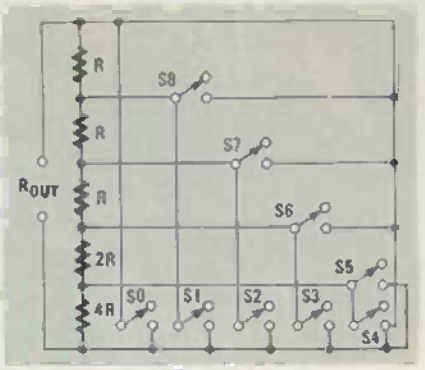

FIG. 3

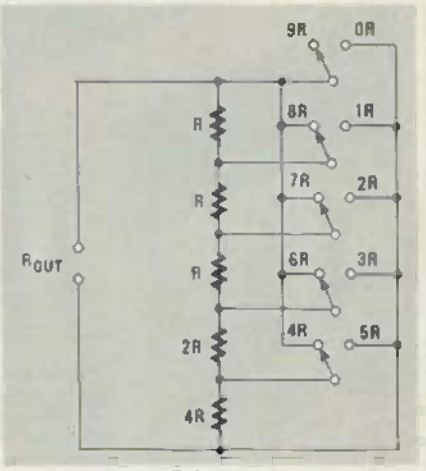

FIG. 4

Toggle and slide switches are less expensive and more readily available than rotary switches. Figure 3 shows how you can use nine single-pole, single-throw (SPST)

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  - Video De-emphasis: CCIR 525 lines
  - Video Output Level: 1 volt (peak to peak)

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  - Audio Output Level: –dB Nominal

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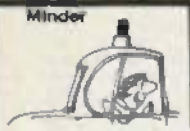

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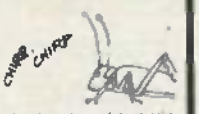

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Z-3527	.20	.15	.10	Zener diode 5V6 1 Watt IN4734
Z-3529	.20	.15	.10	Zener diode 6V2 1 Watt IN4735
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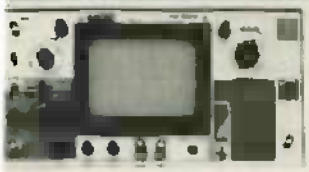

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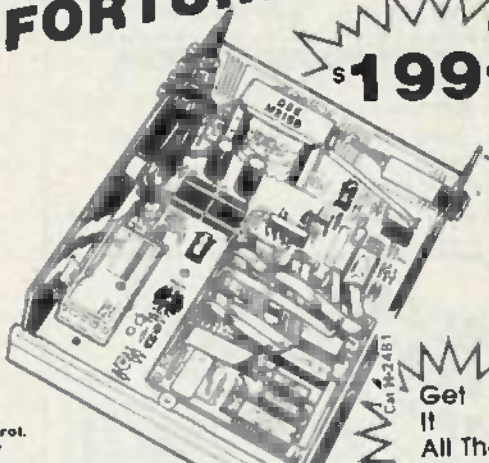

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The largest national commercial teletext service is called Electra. It is produced by Tele-Broadcasting of Cincinnati, Ohio, and is available there on WKRC Channel 12, in ⊕ also linked to the VBI of Superstation WTBS Atlanta, and is thus available to some 9,000 cable-TV systems with 37 million homes. It is also available to airplane with a TVRO dish on the Galaxy 1 satellite, transponder 18, and on the SPN channel of Satcom 3, transponder 9.

Along with Electra, the company that feeds WKRC with WTBS also produces a business "magazine" called Calstream, which is 11 pages of 18-minute delayed NYSE, AMEX and OTC stock prices, along with a long "selling page" of stock information and business headlines. (Calstream is available simultaneously with Electra). Factory starts on page 100. Calstream on page 201.

Electra is a 100-page magazine with fast-breaking news, "talk news", business headlines and subpages, sports scores, headlines, and resources, and features such as weather, travel pages, and a daily sports quiz. Over 50 different program screens of the genre of a Bulletin (REVISAL).

Another very large teletext service is the NPM university-oriented INFOTEXT service produced by the University of Wisconsin and available on television systems throughout the world. INFOTEXT provides global news, detailed weather information, reports and BRIDGE, and general market information.

Two other services are KTTV — Los Angeles Manager and WLTV — Chicago Teledyne.

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switches and a 1-1-1-2-4 string of resistors to obtain a workable decade box. With that circuit, closing just one switch gives the desired resistance. A variation of that circuit is shown in Fig. 4, which uses five single-pole double-throw (SPDT) switches. The catch is that each switch must have a center-off position or the circuit won't function properly.

REPORTING SHORTWAVE RECEPTION

I've recently become an avid shortwave listener, and now I want to start collecting QSL cards. I understand that foreign stations want SINPO reports. What's SINPO?—R. N. H., Brentwood, NY.

A well-prepared reception report can be very helpful to a station's engineers and program managers. They'll send a QSL (verification) card if you send them enough information to prove that you actually heard their broadcast. List the station's call letters (if any) and frequency, the time (in GMT or Greenwich Mean Time) you heard the broadcast, and something about the contents of the program, such as "Announcements in English, then French, followed by a piano and flute duet." Follow this with the SINPO code, in a format something like this: S5–I5–N3–P3–O3. The complete SINPO code is shown in Table 2.

TABLE 2—SINPO CODE

	S	I	N	P	O
	Signal Strength	Interference	Noise, Static	Propagation Disturbance	Overall Merit
5	Excellent	None	None	None	Excellent
4	Good	Slight	Slight	Slight	Good
3	Fair	Moderate	Moderate	Moderate	Fair
2	Poor	Severe	Severe	Severe	Poor
1	Barely Audible	Extreme	Extreme	Extreme	Unusable

WIRING EXTENSION SPEAKERS

I stopped in a hi-fi store to purchase wire for extension speakers that I'm adding to my stereo. The young clerk really got on my case. He asked me all kinds of things about speaker size, how far away my speakers would be located, and lots of other fool questions. I walked out and purchased a spool of speaker wire at a supermarket. Later, I thought about that clerk's questions, and I wondered whether he was really trying to be helpful.—E. O. C., Port Chester, NY.

Oh, if we only had more clerks like the one that tried to help you! He wasn't being nosey; he really was trying to be helpful. When he asked about the "size" of your speakers, he most likely meant their *impedance*, not their diameter (6 inches, 12 inches, etc.) A loudspeaker is an AC-circuit device that has capacitance, inductance, and resistance, and all of those resist, or impede, the flow of electricity. The combination of all three is called impedance, which is specified in ohms.

TABLE 3—WIRE SIZE VS. MAXIMUM LENGTH FOR 15% POWER LOSS

B&S Gauge	4 ohms	8 ohms	16 ohms
24	11	23	47
20	30	60	118
18	47	95	190
16	75	150	300
14	120	240	475

Whenever a speaker is connected to an amplifier, there will be some power loss in the speaker cable. The longer the cable, and the smaller its diameter, the greater will be the power loss.

When the cable size is too small, that is, when its impedance approaches that of the speaker itself, there can be a reduction in speaker volume, as well as a decrease in the speaker's low-frequency response. Table 3 shows the maximum wire length that can be used between the amp and the speakers so that line losses do not exceed 15% of the power being delivered by the amplifier. R-E

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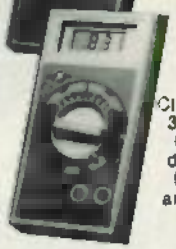

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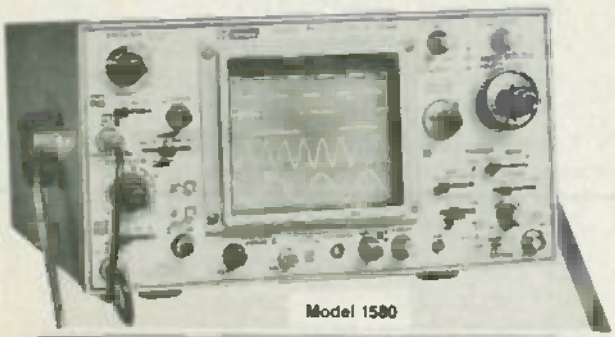

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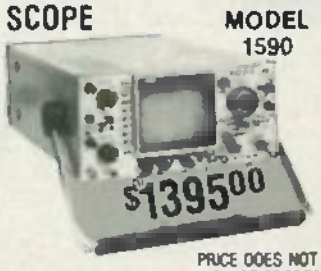

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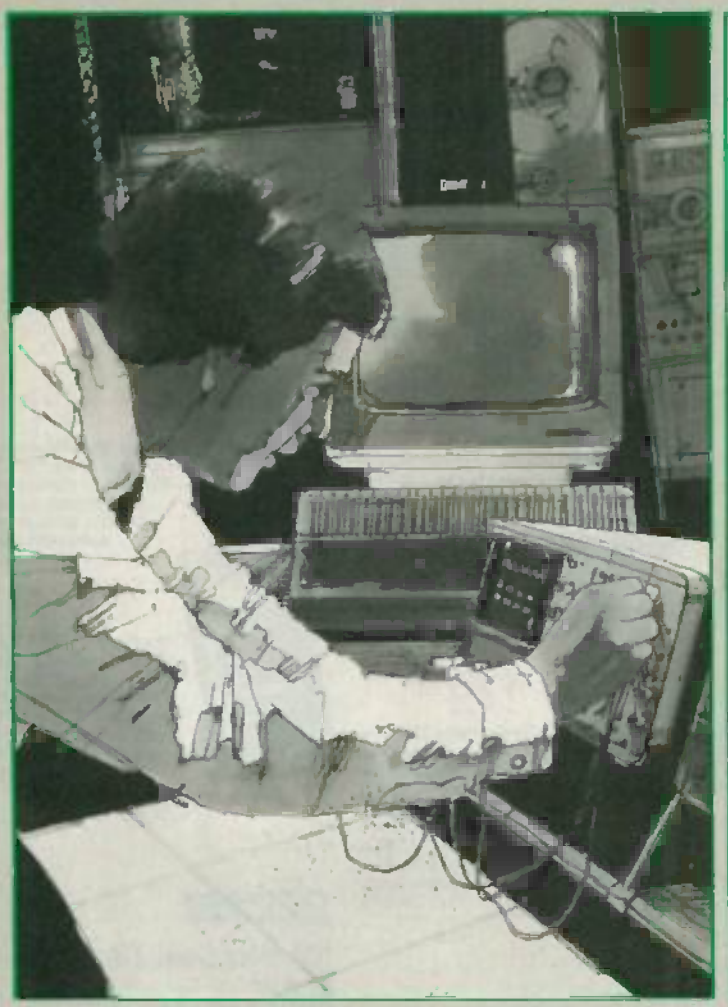

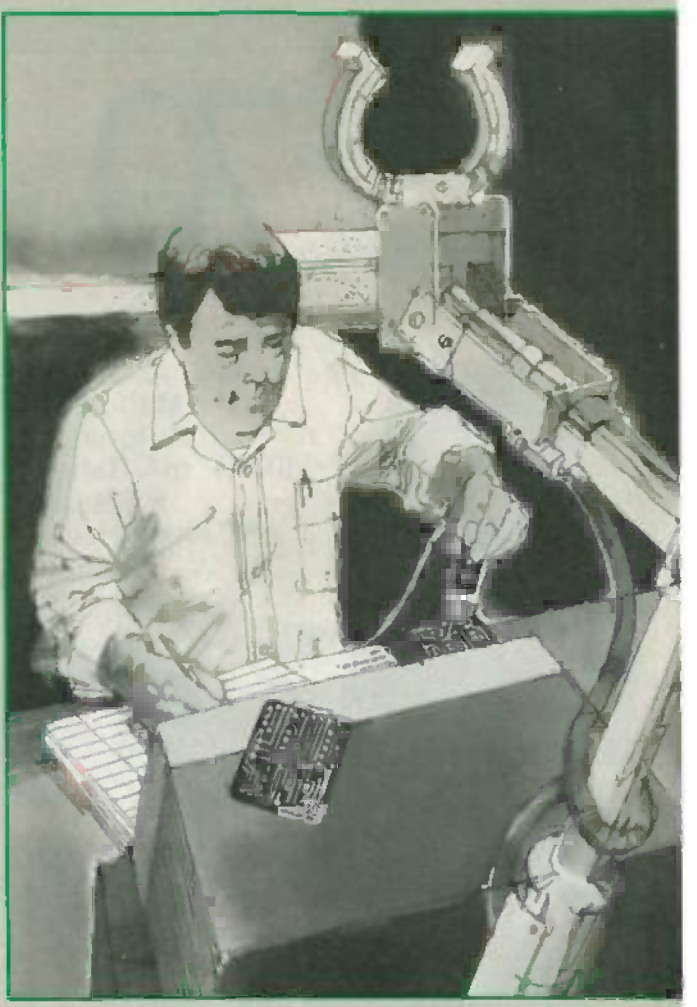

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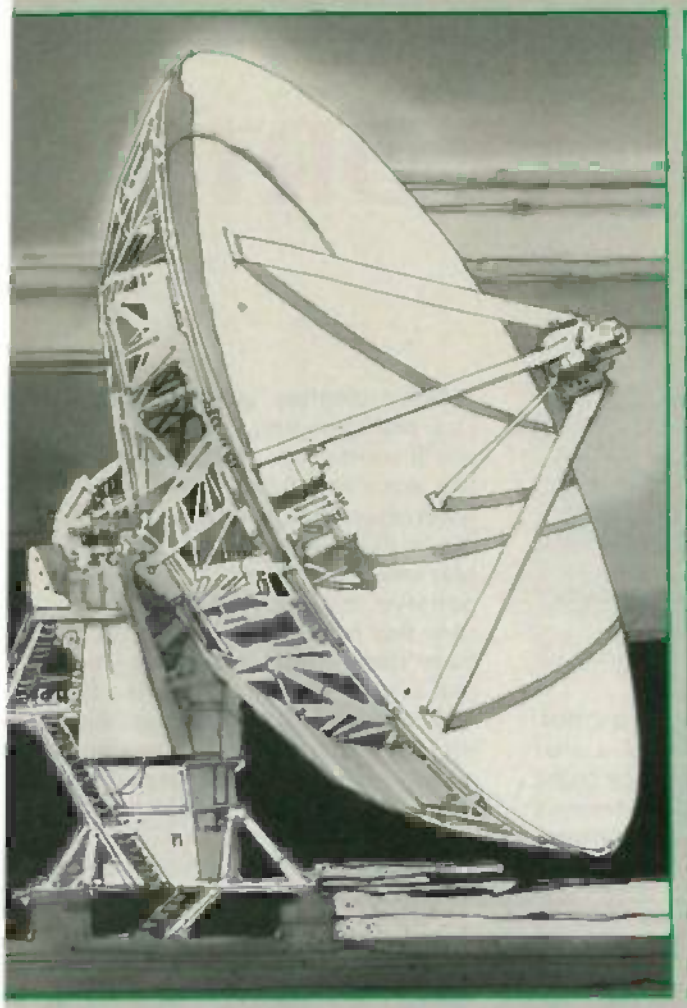

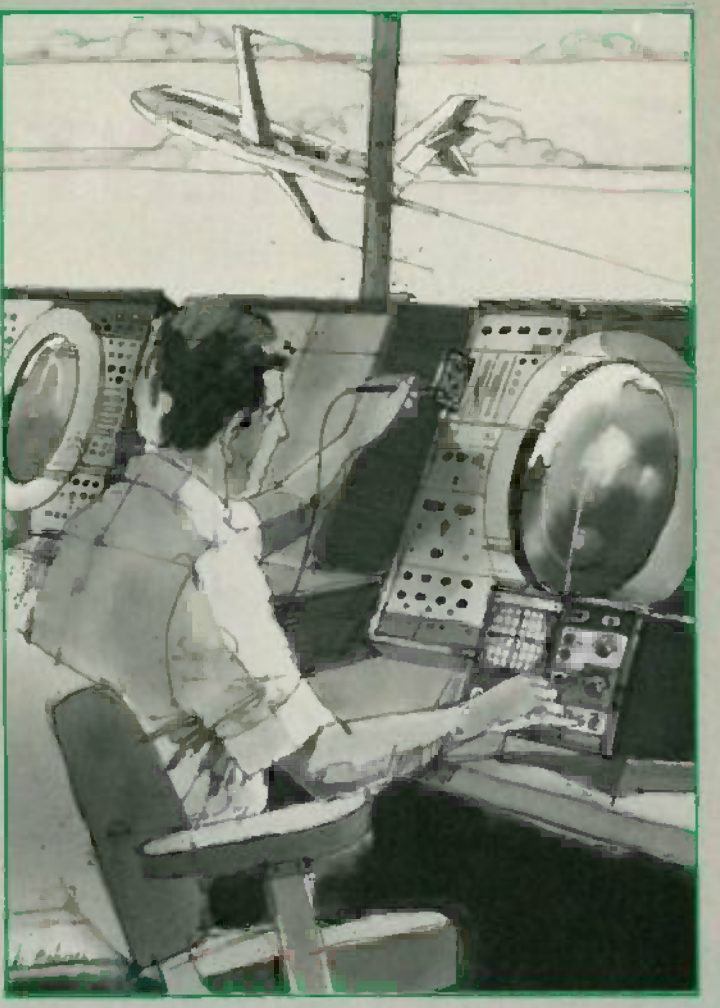

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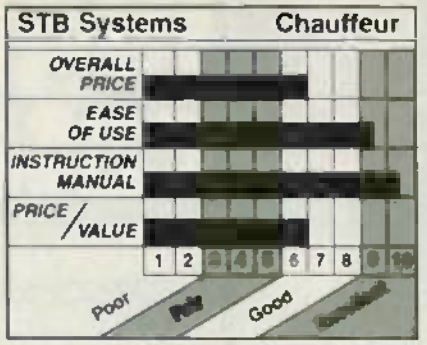
make that decision easier: the *Chauffeur* video board from STB Systems, Inc. (601 North Glenville, Richardson, TX 75081). That add-on board takes the place of IBM's display adapter and acts as both a monochrome and a color adapter. Color displays are converted into a format that is compatible with a monochrome monitor. It's a good compromise.

The chauffeur is software-compatible with the IBM color/graphics adapter, and it is hardware-and-software-compatible with the IBM monochrome/printer adapter. In its text mode, it allows an 80-character × 25-line display, and provides underline, blink, reverse-video, hidden, and dual-intensity character attributes. Its video memory is 16K in text mode.

In its color mode, the *Chauffeur* converts a color display into a 16-level gray scale, and supports the IBM standard resolutions of 640 × 200 × 2 colors (shades) and 320 × 200 × 4 colors (shades). Its video memory in the graphics mode is 32K.



Setting up the *Chauffeur*

Installing the *Chauffeur* is similar to installing any other add-on card to a PC or compatible. The well-organized and well-written manual helps to make the process as easy as possible. Before the board is physically installed, all that's required is setting a few switches. First, a switch on the PC's motherboard must be set to indicate that a color/graphics display adapter is installed. Then, some jumpers and switches must be set on the *Chauffeur* itself. Two DIP switches are used to set the address of the parallel port, and the other two are set according to the type of monitor you have. (If your monitor isn't listed in the manual, you may have to adjust those switches after the board is installed.) A jumper lets you choose between displaying color screens as 16 shades of gray and displaying colors in only two shades (full intensity and black).

Can the *Chauffeur* and a monochrome monitor really replace a color/graphics card and color monitor? No. The *Chauffeur* has some disadvantages. For example, although colors are displayed in sixteen shades of gray, not all monitors can display all the shades. We found that much color software was hard to use because many of the colors ran together. We suggest that you see the *Chauffeur* in action—running the software you're interested in—*before* you buy.

The shading selection is chosen with a jumper on the *Chauffeur* board. Some color software looks better in 16 shades, some doesn't. Unfortunately, you have to open

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*Patent issued November 8, 1983. U.S. Patent No. 4,414,260

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up the PC to get to the video board to change the jumper. We wish that STB Systems found some way to make the shading mode switch-selectable from the rear panel.

Many software packages are designed to run on both monochrome and color monitors. Such software checks the computer's configuration switches or jumpers to determine which monitor is attached. Of course, when you use the *Chauffeur*, the software thinks that you have a color-display adapter installed. That can be a disadvantage because the standard monochrome display often looks better than the *Chauffeur*'s converted color display.

The *Chauffeur* package comes with *PC Accelerator* software that offers print-spooling, RAM-disk emulation, and some keyboard-enhancement features. We did not test that software.

So, you still haven't made up your mind—monochrome, color, or the *Chauffeur*? Well, at $395, the *Chauffeur* isn't cheap. But then neither are RGB monitors. We found the *Chauffeur* to work amazingly well with some software packages, but not so well with others. How do you really make up your mind? Have a dealer demonstrate the *Chauffeur* with the software that you will use the most; it's the only way to tell if the *Chauffeur* is right for you. R-E

Scope DVM-638 Multimeter

A full-featured meter at a budget price.

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ASK A HOBBYIST OR TECHNICIAN about the features that they would like to see in a DMM, and you would get a "wish list" that's a yard long. Ask the same person what a meter with just a few of those desirable features would cost, and the response is likely to be just a wistful look, or a roll of the eyes.

But a decent meter, one with some of the "bells-and-whistles" that can help make a troubleshooting job, or any other kind of job, a lot easier need not cost an arm and a leg. Consider, for instance, the *DVM-638* from Scope, which is available through Fordham Electronics (260 Motor Parkway, Hauppauge, NY 11788); its impressive array of features, and its budget price, make for an exciting combination.

The *DVM-638*

Just in terms of the number of features, the *DVM-638*, offers far more than the typical DMM. But all the "bells-and-whistles" in the world can't turn a poor meter into a good one. They can, however, turn a good meter into a great one.

The *DVM-638* starts out as a good meter. It performs all of the basic functions one would expect of a digital multimeter, and does them well. DC voltage is measured over 5 ranges, from 200-mV to 1000-volts full scale; on the 200-mV range, levels as low as 100 μV can be measured. DC accuracy on all ranges is specified as ±5% of reading + 1 digit. The unit is overload-protected to 1000-volts DC or peak AC on all ranges.

AC voltage (rms) is also measured over 5 ranges, with the top range being 750 volts. Basic accuracy is specified as ±1% of reading + 4 digits, except for the top range (750 volts), where it is ±2% of reading + 4 digits. The unit is overload-protected to 750-volts rms on all ranges except the lowest (200 mV), where the overload protection is specified as 300-mV rms for a maximum of 15 seconds.

The unit can measure AC and DC current. AC current is measured over 4 ranges, from 2 mA to 10 amps full-scale; on the 2-mA range, currents as low as 1 μA can be measured. Accuracy is ±1% of reading + 4 digits on all ranges except the 10-amp range, where it

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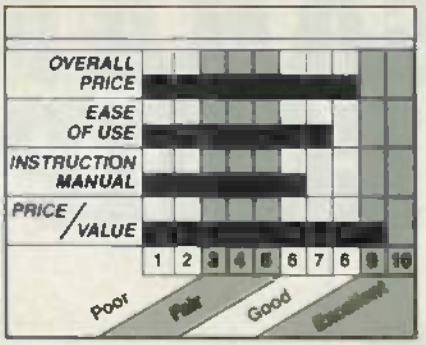
is specified as ±1.5% of reading + 4 digits. The 10-amp range is not fused; all other ranges are protected by a 250-volt, 0.8-amp fast-blow fuse.

DC current is also measured over 4 ranges, from 2 mA to 10 amps full-scale. Accuracy is specified as ±0.8% of reading + 1 digit, except for the 10-amp range where it is specified as ±1.5% of reading + 1 digit. Overload protection for the DC-current function is similar to that of the AC-current function.

Resistance is measured over 6 ranges, from 200 kilohms to 20 megohms full-scale; on the 200-kilohm range, resistances as low as 0.1 ohm can be measured. On the 200-kilohm range, the specified accuracy is ±0.8% of reading + 3 digits; on the 20-megohm range, the accuracy is specified as ±1.5% of reading + 1 digit. On all other ranges, the accuracy is specified as ±0.5% of reading + 1 digit. The unit is protected against overloads to 250 volts DC or rms. In addition, there is a low-voltage resistance function. When that function is se-



lected, via a front-panel switch, the unit will output less than 0.25 volts when making resistance measurements. That voltage level will not turn on silicon junctions, thus allowing in-circuit resistance measurements to be made.

Bells and whistles

Now we get to the "good stuff." Those are functions and features normally found only on the most sophisticated (and expensive) meters.

The *DVM-638* has a built-in capacitance meter. It is capable of measuring capacitance over 5 ranges, from 2 nF to 20 µF full-scale. On the 2-nF range, capacitance as small as 1 pF can be measured. Accuracy is affected somewhat by the dissipation characteristics of the capacitor itself; overall, it is specified as ±1% of reading + 4 digits.

While all meters measure resistance, a function that is gaining popularity on high-end units is conductance. (Conductance is the reciprocal of resistance and is measured in Siemans; the Sieman was formerly known as the mho.) That's because that function provides an easy way to test for leakage. The *DVM-638* offers a 200-nS conductance range. That effectively increases the unit's resistance-measuring ability to 10,000 megohms, although the user will have to perform the conversion from conductance to resistance himself; that task is made easier by the inclusion of an nS-to-megohms conversion chart in the manual.

The unit also provides a transistor- (H_{FE}) test function. When

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testing a transistor, the device is plugged into the appropriate socket (NPN or PNP) on the meter. The transistor's gain (H_{FE}) is then displayed on the readout.

You can, of course, test continuity with any meter, but the job becomes easier if an audible indicator is provided. Such tones are becoming standard on most better DMM's, and this unit is no exception. The tone is switch-selectable. In addition, up-arrow and down-arrow annunciators on the display are used to give a quick visual indication of continuity.

Finally, the unit has a level-detector function that can be used to sense high and low logic levels. In that function, the input is compared to an internal 0.8-volt reference. The result of that comparison is displayed on the read out via the up-arrow (logic low) annunciators. The audio tone, if selected, sounds on inputs that are below the reference.

The unit is supplied with manual, vinyl carrying case, set of test leads, battery, and spare fuse. The manual is small, but fairly complete. It includes just about everything you might expect, except perhaps for some information on the unit's theory of operation. Also, while the location of the calibration adjustments in the unit are indicated, further details on calibration were not provided. A detailed schematic is included, as well as a parts-placement diagram.

Our only real complaint with the *DVM-638* is in the area of mechanical construction. We subjected the unit to "field conditions;" in other words, we dropped it to see how it would hold up. The result was that the range and function selector switches, located down the side of the unit, ceased to work properly. Evidently, the impact (the unit was dropped onto the floor from bench level) caused the case to bind the switches. The problem was fixed by opening the case to relieve the situation; once everything was buttoned up, the unit worked perfectly. The unit's high-impact plastic case was unmarred by the test.

The bottom line on the *DVM-638* is value. At its price of $79.95, you will have a tough time finding a unit that is its equal. R-E

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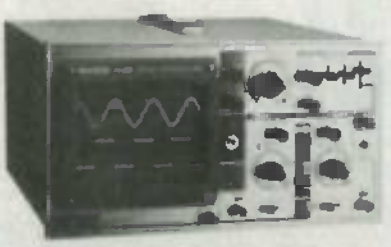

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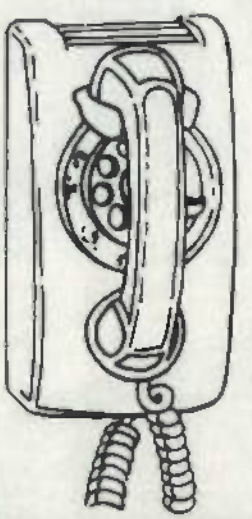

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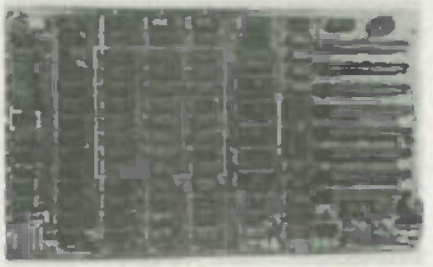

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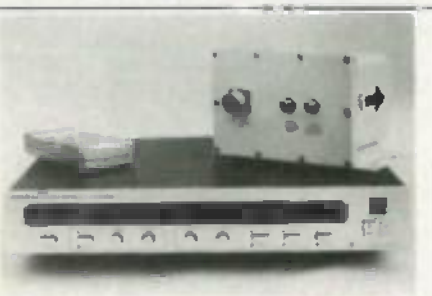

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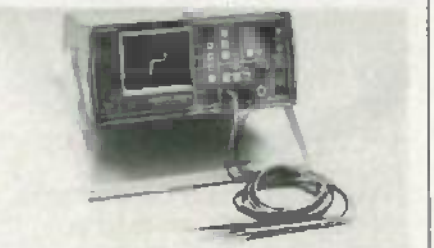

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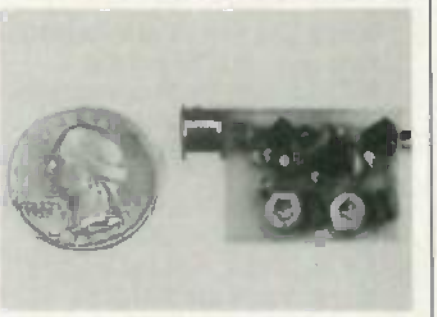

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Introducing two all new Regency scanners. First, there's the MX7000, a 20 channel, no-crystal unit that receives continuously from 25 to 550 MHz and 800 MHz to 1.2 GHz. That's right! Continuous coverage that includes VHF and UHF television audio, FM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

Practical Performance

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

At Home Or On The Road

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

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$99 Satellite-TV Receiver

RICHARD MADDOX

OK, TVRO fans, here's your chance to build a high-performance satellite receiver—for peanuts!

THE IDEA OF RECEIVING TV SIGNALS FROM satellites became popular almost instantaneously when the first home TVRO was built in 1979. However, due to the tremendous costs involved, the *practice* of receiving TV signals from satellites was nowhere near as popular. Only recently have prices dropped to the point where satellite-TV can be enjoyed by a large number of people.

Receiver kits helped make satellite TV affordable to electronics hobbyists (to whom TVRO was escecially appealing.) But the kits that were available were difficult to build, and they required a lab's worth of expensive test gear to align. But now—thanks to advances in electronics and state-of-the-art circuit design—we can show you how to build a satellite receiver for less than one hundred dollars! It's very easy to build, and requires only your eyes, a TV set, and a voltmeter to align. And that's not all: The receiver performs as well as—if not better than—commercial units costing several times as much.

If you already own a satellite-TV system, this is an ideal opportunity for you to add a second receiver to your system at a very low cost. All that is required is an isolated two-way power divider, a downconverter, and the associated cabling. If you have an older satellite system, and your picture, sound, or both aren't up-to-snuff, then this receiver may be just what you need to improve reception. It accepts a standard 70-MHz input, and features continuous transponder-tuning, tunable audio subcarrier with switchable bandwidth, a polarization control circuit, defeatable AFC, and an integral crystal-controlled RF modulator for output on TV Channel 3 or 4.

Of course, the receiver can't pick up satellite-TV signals all by itself—several other components are necessary. We'll briefly describe what's needed for a complete system. But if you're very unfamiliar with satellite TV, we suggest you check the special sections that appeared on the subject in the June 1984, October 1984, June 1985 and July 1985 issues of **Radio-Electronics**.

Main system components

There are several components, in addition to the receiver, that are needed to complete a TVRO system: the dish, the feedhorn, the LNA (low-noise amplifier), the downconverter, and the cable. We'll examine each of those in turn.

The dish is parabolic in shape, and it is built from metal. The strength of the signal received by the antenna probe in the feedhorn is proportional to the diameter of the dish. Luckily, satellite power levels have increased the past few years to the point that a small dish (four to six feet in diameter) provides adequate reception throughout much of the midwest and south. Throughout the rest of the country, an eight- to ten-foot dish will probably be necessary for good reception, although newer satellites may allow the use of a four- to six-foot dish. Whatever sized dish you use, though, it must be aimed precisely at the desired satellite. Signals from the satellite then hit the dish and are reflected to a point, the focal point of the dish, where the *feedhorn* is located.

The feedhorn has several purposes. It collects the microwaves that have been reflected by the dish, directs them to the LNA, and selects the desired polarity.

To understand why polarity is important, you must understand that TV satellites can broadcast on 24 different

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channels, numbered 1 through 24. The trick is that the odd-numbered channels are broadcast in a different spatial orientation than the even-numbered channels. That is done because the frequencies of the odd and even signals actually overlap one another. But because they're polarized differently, we can receive one set without interference from the opposite set. We'll discuss more about how that works in the "theory-of-operation" section below.

The *LNA* (low-noise amplifier) is similar to the antenna pre-amp found on fringe-area TV antennas. Its purpose is to boost the satellite signals to a level that can drive the downconverter. The LNA is mounted behind the feedhorn.

The two most important specifications of an LNA are the noise temperature and the gain. Noise temperature is rated in degrees Kelvin: the lower the number, the less noise the amplifier adds to the signal as it is amplified. Gain is measured in dB, and typically ranges between 30 and 55 dB. An average LNA today might have 100°K noise temperature and 50 dB gain, although some high-performance models are rated at 85°K.

Roughly speaking, the noise temperature of the LNA can be correlated to the size of the dish. For example, a ten-foot dish and a 100-degree LNA will give results similar to an eight-foot dish and an 80-degree LNA, or to a six-foot dish and a 60-degree LNA.

The *downconverter* is what actually tunes in the desired channel. It is mounted directly to the LNA or behind the dish on the mount. Downconverters usually have three electrical connections: the input, which comes from the LNA, the 70-MHz output, which goes to the receiver, and an additional voltage that is used to tune in the desired transponder channel. That voltage is set by the user at the receiver. Most common downconverters use a tuning voltage that ranges from two to sixteen volts. Receivers usually supply that tuning voltage to the LNA through the same cable and connector that the 70-MHz signal travels through.

Some downconverters are designed to be mounted directly to an LNA, and must be used with a 30- to 35-dB gain LNA. If a 50-dB LNA is used, it is recommended that the downconverter be mounted behind the dish and connected to the LNA via RG213 cable, unless the dish is smaller than about seven feet, or unless the downconverter is specifically designed to be used with a high-gain LNA.

There are two types of coaxial cable used in typical satellite systems: RG213 and RG59. The standard 75-ohm cable used to hook up TV antennas is RG59, and RG213 is special 50-ohm cable designed for high-frequency use. The LNA is connected to the downconverter with RG213 cable, and two RG59 cables connect the receiver and the downconverter. An additional RG59 cable connects the receiver to the TV set. Finally, the feedhorn is connected to the receiver via a two-conductor shielded cable. One conductor carries the supply voltage from the receiver, and the other provides the polarizing pulses that we'll discuss in a moment. But let's begin at the beginning. Refer to the block diagram in Fig. 1 and the complete schematic diagram in Fig. 2 while following this discussion.

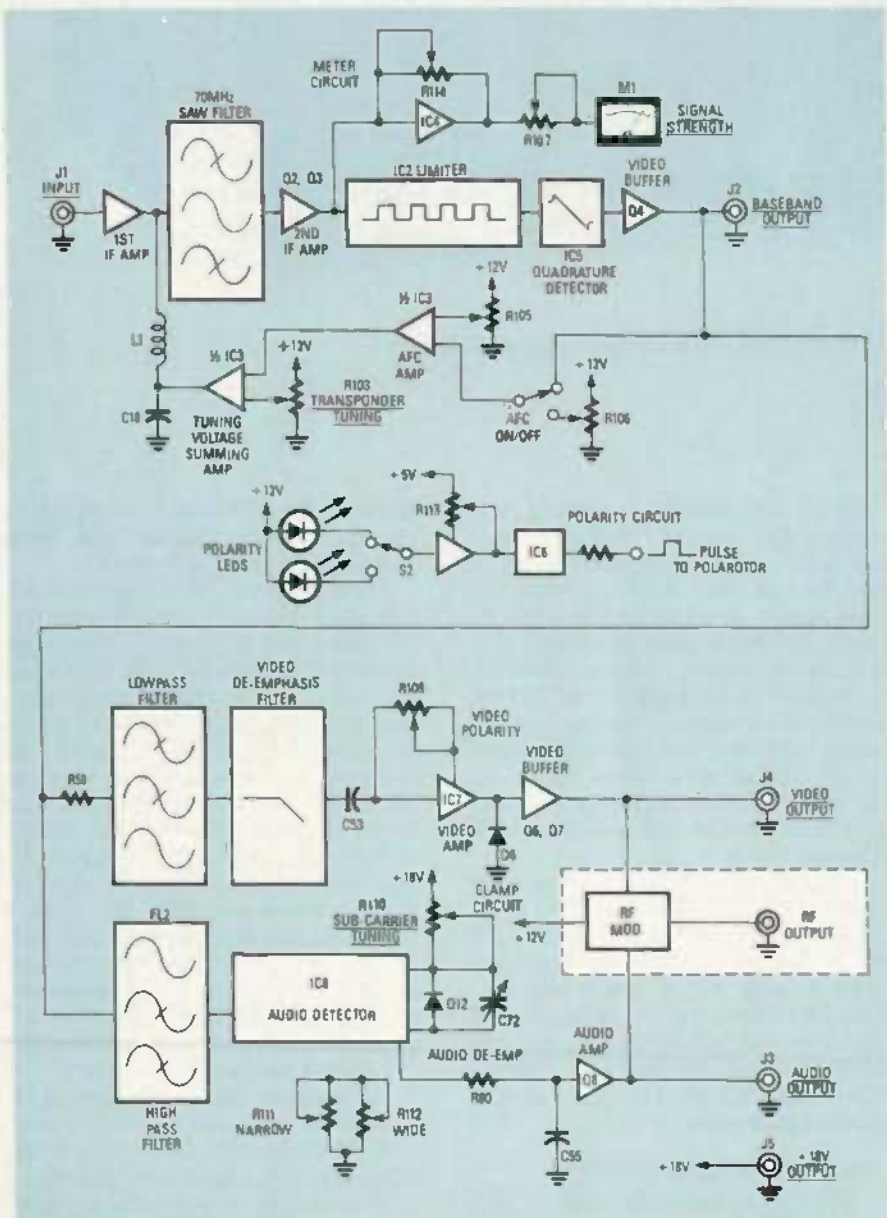

FIG. 1—SATELLITE RECEIVER BLOCK DIAGRAM. When analyzed in segments, the receiver isn't really as complicated as it looks.

Theory of operation

The receiver accepts a 70-MHz signal from the downconverter at jack J1; that jack also supplies the variable tuning voltage to the downconverter. The input signal is isolated from the tuning voltage by inductor L1 and capacitor C18. Front panel potentiometer R103 (TRANSPONDER TUNING) is used to tune in the desired transponder. Trimmer potentiometers R102 and R104 set the maximum and minimum voltages, respectively, presented to the downconverter.

An AFC (Automatic Frequency Control) voltage is derived from the received signal and summed with the tuning voltage by IC3. AFC can be defeated by front-panel switch S1 if terrestrial interference is encountered (or if a synthesized downconverter is used). When AFC is defeated, R106 supplies a compensation voltage for proper tuning.

The 70-MHz input signal is capacitively coupled to IC1, which provides a gain of about 25 dB. Filter FL1 is a SAW (Surface Acoustic Wave) filter with a bandwidth of 27 MHz. Its purpose is to strip off noise and interference occurring on either side of the selected channel.

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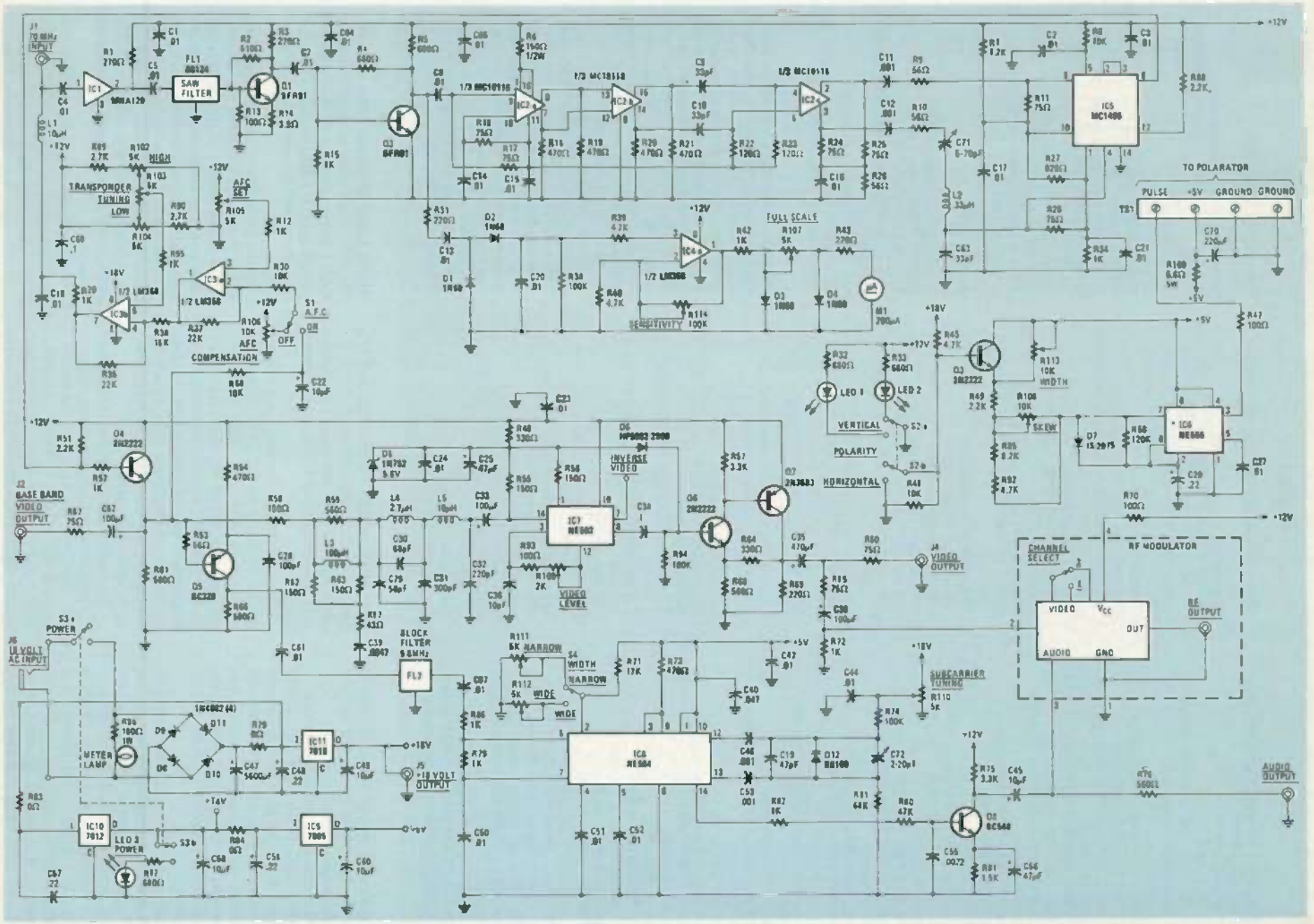

FIG. 2—THE COMPLETE SCHEMATIC of the receiver shows the tuning circuit, the IF section, the video and audio circuits, polarization-control curcuit, RF modulator, and power supply. A complete kit is available, and hard-to-find components, including the PC board, are available separately.

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PARTS LIST

All resistors 1/4-watt, 5% unless otherwise specified.
R1, R3—270 ohms
R2—510 ohms
R4, R5, R32, R33, R77—680 ohms
R6—150 ohms, ½-watt
R7—1200 ohms
R8, R30, R44, R46—10,000 ohms
R9, R10, R26, R53—56 ohms
R11, R16, R17, R24, R25, R28, R60, R65, R87—75 ohms
R12, R15, R29, R34, R42, R52, R72, R79, R82, R86, R95—1000 ohms
R13, R47, R70, R93, R96—100 ohms
R14—3.9 ohms
R18–R21, R54, R73—470 ohms
R22, R23—120 ohms
R27—820 ohms
R31, R43, R69—220 ohms
R35, R37—22,000 ohms
R36—18,000 ohms
R38, R74, R94—100,000 ohms
R39, R40, R45, R92—4700 ohms
R41—unused
R48, R64—330 ohms
R49, R51, R88—2200 ohms
R50—120,000 ohms
R55, R56, R58, R62, R63—150 ohms, ½-watt
R57, R75—3300 ohms
R59, R61, R66, R68, R76—560 ohms
R67—43 ohms
R71—12,000 ohms
R78, R83, R84—0 ohms (jumper)
R80—47,000 ohms
R81—1500 ohms
R85—8200 ohms
R89, R90—2700 ohms
R91—68,000 ohms
R96—180 ohms, 1 watt
R97–R99, R101—unused
R100—5.6 ohms, 5 watts
R102, R104, R105, R107, R111, R112—5000 ohm trimmer potentiometer
R103—5000 ohm linear potentiometer
R106, R113—10,000 ohm trimmer potentiometer
R108—10,000 ohm linear potentiometer
R109—2000 ohm trimmer potentiometer
R110—5000 ohm linear potentiometer
R114—100,000 ohm trimmer potentiometer

Capacitors
C1–C5, C7, C8, C13–C18, C20, C21, C23, C24, C27, C42, C44, C50–C52, C61, C64, C65, C67—0.01 µF, ceramic disk
C6, C37, C41, C43, C54, C59, C66—unused
C9, C10, C63—33 pF, ceramic disk
C11, C12, C46, C53—0.001 µF, ceramic disk
C19—47 pF, silver mica
C22, C45, C49, C58, C60—10 µF, 25 volts, tantalum
C25, C56—47 µF, 16 volts, tantalum
C26, C48, C57, C59—0.22 µF, 30 volts, tantalum
C28—100 pF, ceramic disk
C29—56 pF, ceramic disk
C30—68 pF, ceramic disk
C31—300 pF, ceramic disk
C32—220 pF, ceramic disk
C33, C38, C62—100 µF, 16 volts, electrolytic
C34, C68—0.1 µF, ceramic disk
C35—470 µF, 16 volts, electrolytic
C36—10 pF, ceramic disk
C39—0.0047 µF, ceramic disk
C40—0.047 µF, ceramic disk
C47—5600 µF, 40 volts, electrolytic
C55—0.0022 µF, ceramic disk
C70—220 µF, 25 volts, electrolytic
C71—5–70 pF, variable
C72—2–20 pF, variable

Semiconductors
IC1—MWA120, hybrid small-signal amplifier
IC2—MC10116, triple differential line receiver
IC3, IC4—LM358, dual op-amp
IC5—MC1496, video detector
IC6—NE555, timer
IC7—NE592, video amplifier
IC8—NE564, phase-lock loop
IC9—7805, 5-volt regulator
IC10—7812, 12-volt regulator
IC11—7818, 18-volt regulator
Q1, Q2—BFR91
Q3, Q4, Q6—2N2222
Q5, Q7—BC328 or 2N3683
Q8—BC548 or ECG548
D1–D4—1N60
D5—1N752, 5.6-volt zener diode
D6—HP 5082-2800 or 1N6263 Schottky diode
D7—1S2075
D8–D11—1N4002
D12—BB119 tuning diode
LED1—standard green LED
LED2, LED3—standard red LED's

Other components
J1, J5—"F" connector
J2, J3, J4—RCA phono jack
J6—coaxial power input jack
TS1—4-position screw-terminal strip
L1, L5—10 µH
L2—0.33 µH, six turns on a ¼-inch form.
L3—100 µH
L4—2.7 µH
S1, S4—SPDT, toggle switch
S2, S3—DPDT, toggle switch
FL1—BO124 SAW filter
FL2—5–8 MHz block filter (Dick Smith L-1600)
M1—200 µA edge-reading meter
RF modulator
T1—18-volt AC power transformer

Note: the following are available from Dick Smith Electronics, Inc., P.O. Box 8021, Redwood City, CA, 94063: Complete kit of parts including case but no power transformer, #K-6316, $99.95 plus $4 shipping; SAW filter, #L-1620, $29.95; Case, #H-2507, $12.95; PC board, #H-7000, $29.95; 18-volt transformer, #M6672, $7.95; BFR91 transistor, #Z-1691, $1.19; BB119 diode, #Z-3070, $0.20; MWA120 RF amplifier, #Z-6095, $12.50; MC10116 ECL IC, #Z-6000, $0.79; HP5082-2800 Schottky Diode, #Z-3230, $2.00; 5–8—MHz filter, #L-1600, $3.95. Other individual parts, and complete satellite systems, are also available from Dick Smith. California residents please add 6.5% sales tax. Orders outside U.S. must include U.S. funds and add 15% of merchandise total for shipping.

Transistors Q1 and Q2 boost the filtered signal to drive both the limiter and the signal-strength meter circuit.

The signal-strength meter provides a relative indication of transponder strength. It can be used to fine-tune the position of the dish and the feedhorn for maximum signal strength. Trimmer potentiometer R107 sets the meter's full-scale deflection, and R114 sets the meter's sensitivity.

Amplitude limiting is provided by IC2, an MC10116 balanced ECL (*E*mitter *C*oupled *L*ogic) transceiver. That limiting removes amplitude-modulated components—impulse noise—from the 70-MHz signal. Two limited FM signals are provided by IC2's final stage at pins 2 and 3; those signals are 180 degrees out of phase with each other. Another 90 degrees of phase shift are provided by C71 and L2 before the signal from pin 3 of IC2 enters pin 4 of IC5. The signal from pin 2 of IC2 enters pin 8 of IC5 without further delay.

The 70-MHz carrier frequency is removed by IC5, an MC1496 balanced modulator-demodulator. That IC mixes the signals from pins 8 and 10 with those from pins 4 and 1 and removes the carrier frequency. The remaining signal, output on pin 6, is the baseband video signal. It contains all the video information as well as the audio sub-carrier.

The baseband video signal is buffered by Q4 to provide a low-impedance output. The inductors, resistors, and capacitors between R58 and C33 form a lowpass filter and a video de-emphasis filter. The filtered video is then amplified by IC7, an NE592 balanced-output video amplifier. The video level is set by R109, while the video polarity is set by a PC-board jumper connecting C34 either to pin 7 or pin 8 of IC7. For a normal video signal, connect C34 to pin 8.

Diode D6 is the clamp that traps out the 30-Hz dispersion waveform that is added to the video signal during uplinking. (That *dithering* technique helps to eliminate interference to terrestrial microwave communications.) Transistors Q6 and Q7 buffer the signal to provide a 75-ohm output with a one-volt p-p video level. The output of Q7 is also used to drive the RF modulator.

The baseband signal from Q4 is also amplified by Q5, and feeds a 5- to 8-MHz filter. The filtered signals are then routed

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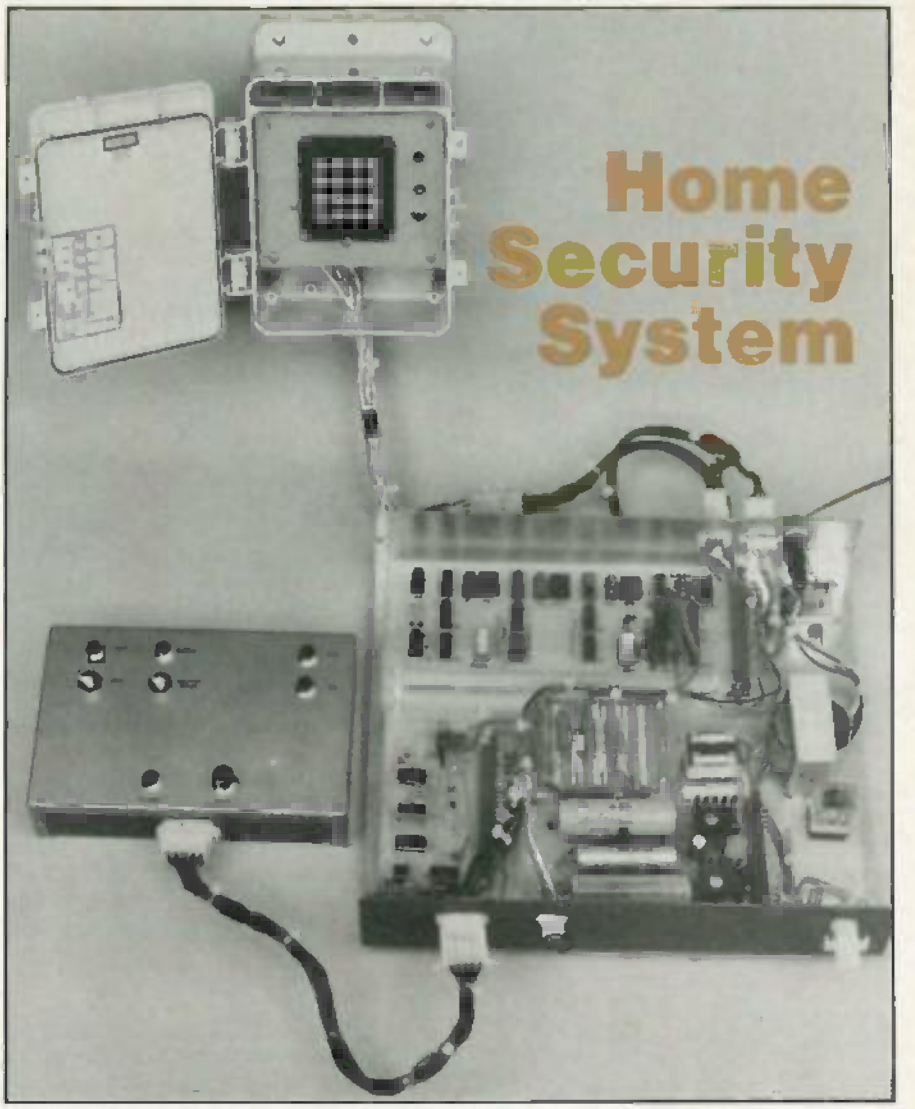
Home Security System

This low-cost home alarm system features a digital combination lock, optional display circuitry, simple installation; and it's not limited to home use.

ANTHONY J. LaMARTINA



Part 2 LAST TIME, WE BEGAN to look at the display board. Let's finish that discussion now. (See Fig. 4 in last month's **Radio-Electronics**.)

After a key has been pressed, its binary code, according to its position in the matrix, appears on IC15's output pins 16–19, and the DAV (DATA AVAILABLE) output is sent high at pin 13. That pin goes high whenever a key is pressed, and it goes low whenever the key is released. After a suitable debounce period, DAV will go high again if it senses that another key has been pressed. The 74C923's four-bit outputs are connected to the inputs of IC14, whose outputs are connected to the inputs of IC13, whose outputs are connected to the inputs of IC12. Each time the DAV line goes high, the outputs of each stage are shifted into the following stage.

We should mention that the row (X) and column (Y) inputs of the keyboard encoder IC are not wired to the corresponding rows and columns of the keyboard matrix. That was done to confuse anyone trying to defeat the alarm. For example, pressing the "1" key causes a value of "2" to be output. Similarly, pressing the "9" key causes a "C" to be output.

Anyway, the output of each stage feeds a 74LS85 4-bit comparator and a 9368 seven-segment display decoder/driver/latch. Each of the latter drives a FND500 seven-segment display: any common-cathode display may be used, however. There are seven resistors connected between the outputs of the 9368 and the displays; we used 14-pin resistor networks, rather than discrete resistors, in our prototype.

The 9368 IC's, current-limiting resistors and displays may be omitted from the design without affecting the function of the circuit. They were included to help debug the initial prototype; they also provide visual indication that the keyboard scanning circuitry is working properly.

Each 74LS85 compares four bits of information from DIP switch S1 or S2 to four bits of information from IC12, IC13, IC14 or IC15. The DIP switches are connected to the "A" inputs of the comparator, and the latches are connected to the "B" inputs. Looking at S1, switch *a* is the MSB (*M*ost *S*ignificant *B*it) of the leftmost digit. Switches *b*, *c* and *d* are the remaining bits of digit 1. Switch *e* is the MSB of the second digit, and switches *f*, *g* and *h* are the remaining bits of that digit. The individual switches in S2 similarly correspond to the third and fourth digits.

Counting in this circuit is done in binary. For example, in order to use "5" as the first digit of our four-digit code, switches S1-a–S1-d would be set up as 0101. A "1" or high logic level represents an open switch and a "0" or low logic level represents a closed switch.

Sixteen distinct values can be represented by each digit: the digits zero through nine and the letters A through F. Unlike some IC's, the workhorse 7447 for example, the 9368 seven-segment display decoder/driver/latch we have specified will accept binary inputs above the value of nine and display the correct hexadecimal digit. For example, a binary input of 1111 equals hex "F," and will be so displayed.

We use a 16-key keyboard to punch in the digital combination code. Ten of those keys could be labeled with the numerals 0-9. The six additional keys might be labeled CLEAR, ENTER, FUNC A, and so on, to help confuse someone trying to break in the protected area.

Each 74LS85 has three outputs, indicating whether the "A" inputs are greater than, equal to or less than the "B" inputs. Those outputs are cascaded from IC11 to IC10, from IC10 to IC9, and from IC9 to IC8. The outputs of the latter indicate the overall relationship between the values programmed in S1 and S2, and the last four keyboard entries. When the values programmed in the DIP switches are less than the (last four) values punched in at

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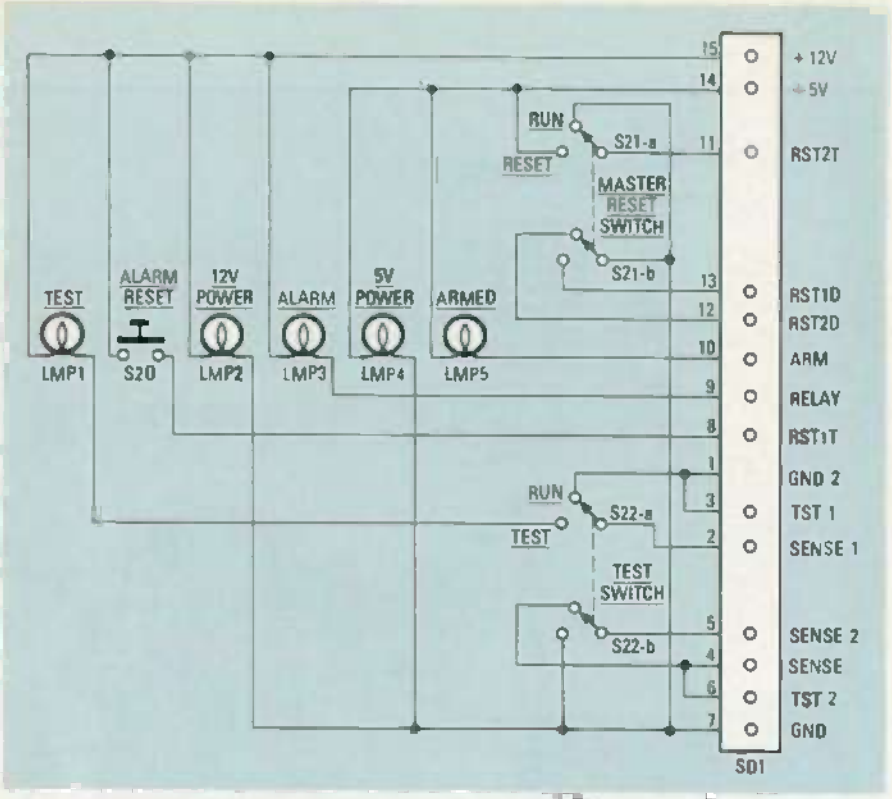

FIG. 6—SCHEMATIC DIAGRAM OF THE CONTROL PANEL. All five lamps should be low-current devices to conserve power.

the keyboard, LED6 illuminates. Likewise, LED8 lights up to indicate the greater than condition, and LED7 indicates the equality condition. On the keyboard panel, OK LED10 also lights up to indicate the equality condition.

The A=B signal from IC8 is also fed to one input of AND gate IC6-a. The other input comes from ENTER switch S19 on the keyboard panel (Fig. 5). After the code sequence has been punched in at the keyboard, the A=B output goes high, and LED10 lights up, indicating that ENTER switch S19 should be pressed. After that is done, pin 6 of IC6 goes high and clocks a "1" into "D" flip-flop IC7-a, whose Q output goes high and energizes relay RY4. Then the relay's contacts close and short out the sense loop terminals, and that allows the actual sense loop to be broken.

In addition, once the flip-flop has been set, additional keyboard entries, which might cause A=B to go low, will not reenable the alarm circuit; MASTER RESET SWITCH S21 must be toggled for that to occur. In fact, both the timer board and the display board are reset by that switch. When it is pressed, several things happen. Four-bit latches IC12–IC14 are reset, so "Ø's" appear at their outputs, on the displays, and at the inputs to the comparators.

At the same time, one side of RY3's coil is grounded, which energizes the relay, and causes its contacts to close across the X0 and Y1 inputs of the keyboard encoder IC. The relay's closing simulates pressing the 0 key, and is done because IC15 has no RESET pin. In that way, all four digits are reset to values of zero. For that reason, "ØØØØ" should not be used as the entry code, as system reset would disarm the alarm. In addition, "D" flip-flop IC7 is reset when MASTER RESET SWITCH S21 is toggled; that de-energizes RY4 and allows the sense loop to function properly.

Control panel

As shown in Fig. 6, housed in the control panel are the TEST, ALARM RESET and

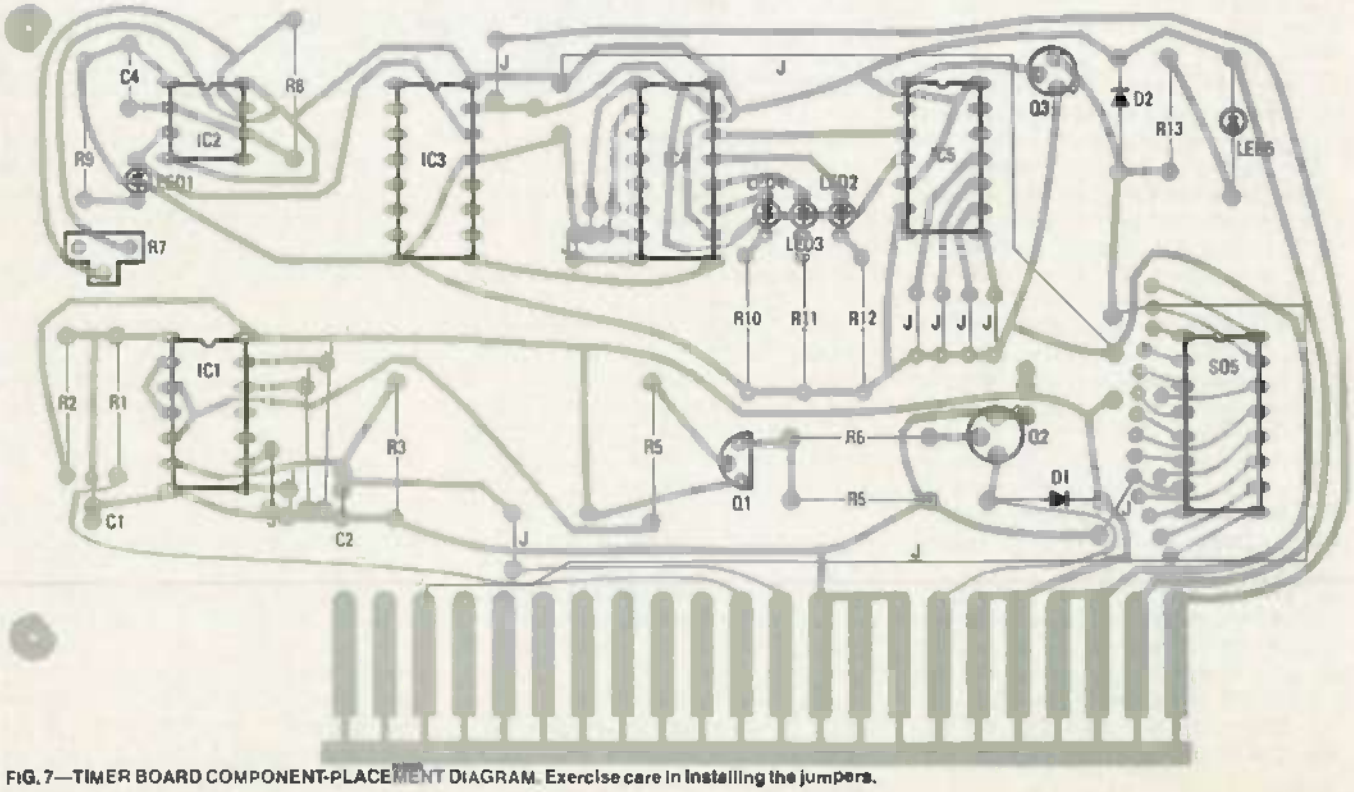

FIG. 7—TIMER BOARD COMPONENT-PLACEMENT DIAGRAM. Exercise care in installing the jumpers.

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PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1, R3—100,000 ohms
R2—4.7 megohm
R4, R5—10,000 ohms
R6—100 ohms
R7—100,000 ohm potentiometer
R8—3,300 ohms
R9, R10, R11, R12, R13—150 ohms
R14, R15, R16—220 ohms
R17–R46—330 ohms
R47—25 ohms, 1 watt
R48—10,000 ohms, 1/2-watt

Capacitors
C1, C5, C9, C12—0.1 µF, 35 volts, tantalum
C2—100 pF
C3—0.47 µF
4—10 µF, 10 volts, electrolytic
C6, C8, C11—1 µF, 10 volts, electrolytic
C7—4000 µF, 25 volts, electrolytic
C10—2000 µF, 25 volts, electrolytic

Semiconductors
IC1—4001 quad NOR gate
IC2—555 timer
IC3—4017 decade counter
IC4—4518 dual BCD up counter
IC5, IC7—4013 dual "D" flip-flop
IC6—4081 quad AND gate
IC8–IC11—74LS85 4-bit comparator
IC12–IC14—74C173 4-bit latch
IC15—73C923 20-key encoder
IC16–IC19—9368 hexadecimal display decoder/driver
IC20—LM340T-5 5 volt regulator
IC21—LM340T-12 12 volt regulator
IC22—H11C5 or MOC3001 opto-isolator
BR1, BR2—BR31 1-amp bridge rectifier
D1, D2—1N4001
DSP1–DSP4—FND500 common cathode, 7-segment display
LED1–LED10—standard LED's
Q1—2N4403
Q2, Q3—2N4401
Q4—2N2222
TR1—BT136-600 or similar triac

Other Components
F1—6/10 Amp, 250 volts
F2, F3—1 Amp, 250 volts
LMP1–LMP3—12 volt lamp
LMP4, LMP5—5 volt lamp
RY1—12 volts DC, DPDT relay
RY2–RY4—SPST 5-volt reed relay
S1, S2—8-position DIP switch
S2–S18—16-position keyboard matrix
S19—SPST momentary
S20—SPST momentary
S21, S22—DPDT momentary
S23—SPST key-operated switch (optional)
T1—117-volt AC Primary, 8 and 13 volt secondaries (Northlake F3-214)

Connectors
EC1, EC2—22-position edge connector
P1, P2—15 position Molex
P3–P5—16 position DIP header
P6—9 position Molex
P7—4 position Molex
P8—12 position Molex
P9—2 position Molex
SO1, SO2—15 position Molex
SO3—2 position Molex
SO4—6 position Molex
SO5–SO7—16 position DIP socket
SO8—8 position Molex
SO9—4 position Molex
SO10—12 position Molex

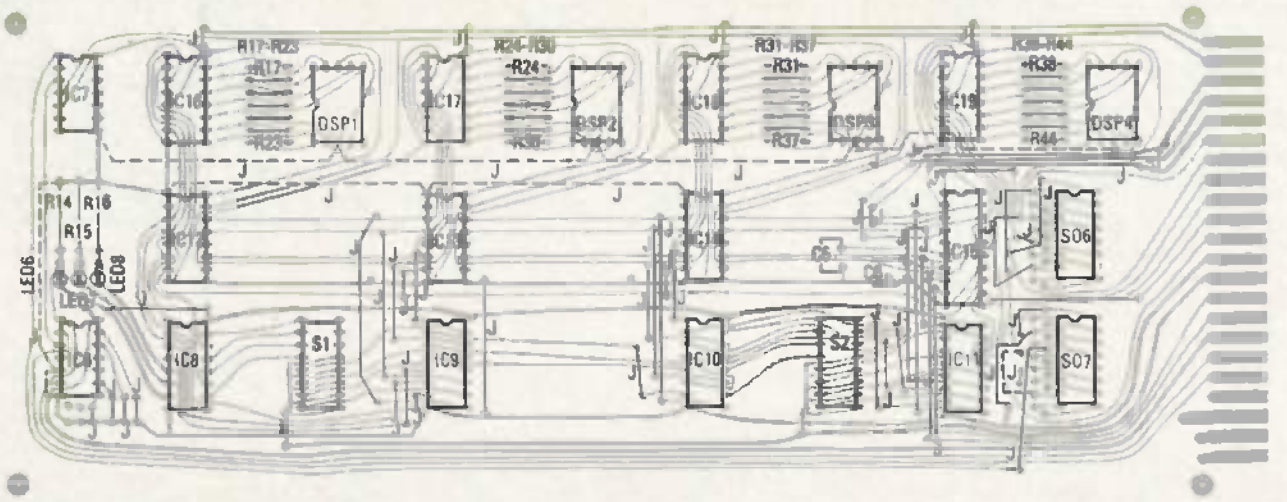

FIG. 8—DISPLAY BOARD COMPONENT-PLACEMENT DIAGRAM. Jumpers must be wired on both sides of this board. The solid lines represent jumpers mounted on the component side of the board; the dashed lines represent jumpers mounted on the foil side.

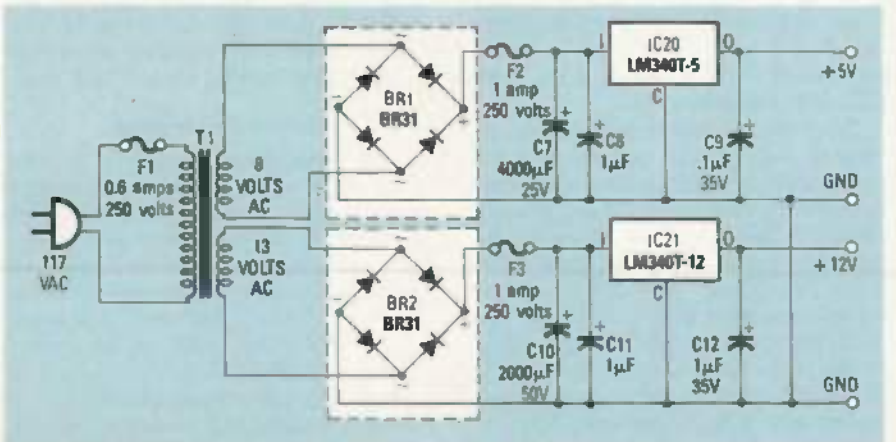

FIG. 9—POWER SUPPLY FOR THE ALARM. This circuit may be built on a piece of spare perf-board.

MASTER RESET switches. In addition, lamps LMP2 and LMP4 indicate the presence of twelve and five-volt power, respectively. LMP5 illuminates when the alarm is armed, and LMP1 illuminates when the TEST switch is toggled, but only if the sense loop is intact. Finally, LMP3 illuminates when the alarm is armed and the sense loop is broken.

Construction

A project like this is best built subassembly by sub-assembly. Build each board and panel as if it were a separate project. If you'll be using PC boards, make the boards first using the patterns shown in the "PC Service" section of this magazine. After etching, carefully inspect each board for un-etched copper between adjacent pads and traces.

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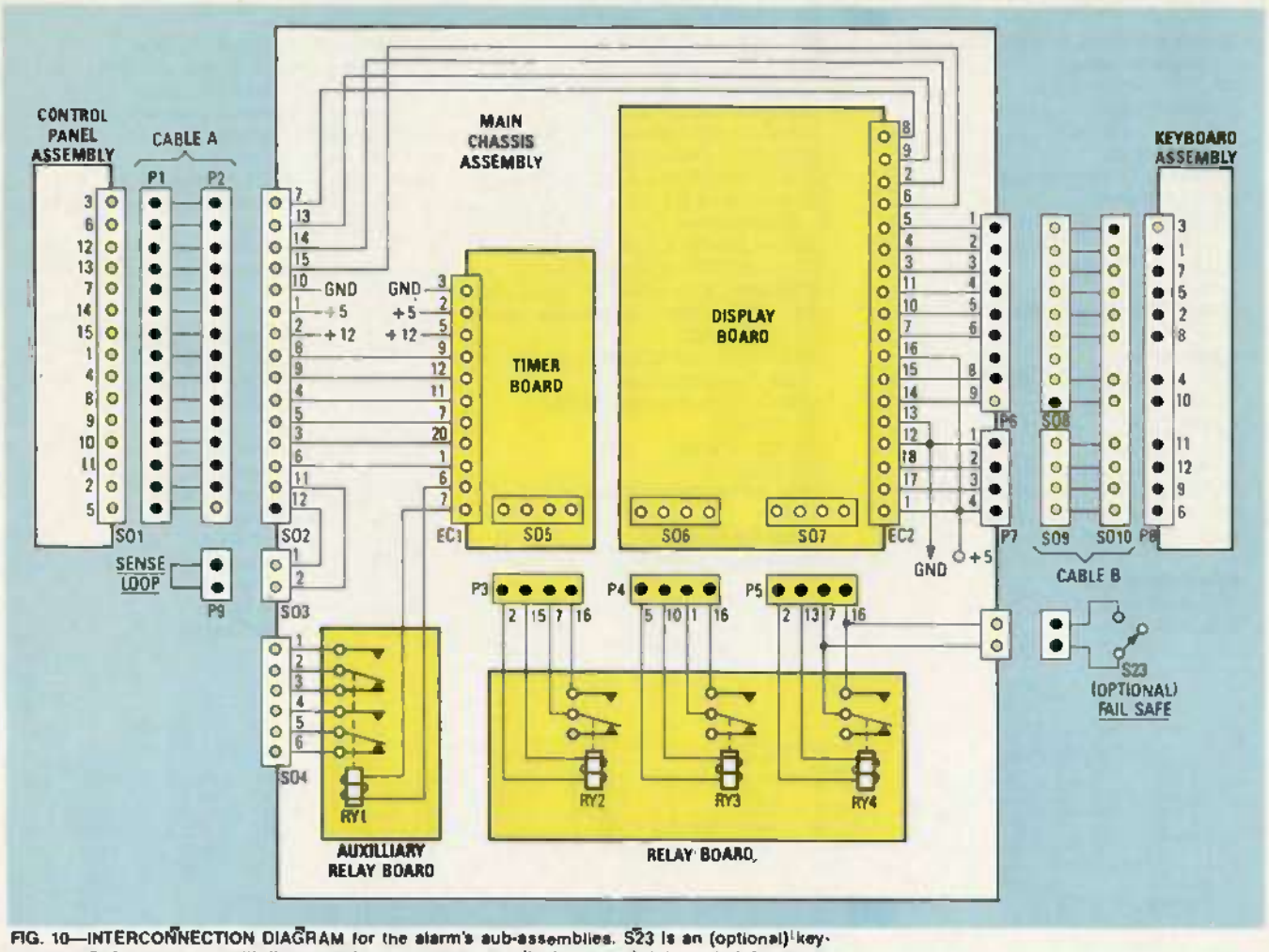

FIG. 10—INTERCONNECTION DIAGRAM for the alarm's sub-assemblies. S23 is an (optional) key-operated SPST switch that will allow entry in case power to the display board is interrupted. Be sure to use reliable connectors, especially for Cable A and Cable B.

After the boards have been cleaned up, stuff them. Use the component-placement diagram provided in Fig. 7 for the timer board and in Fig. 8 for the display board. First insert the lowest profile components, the diodes and resistors. Hold a piece of stiff cardboard against them so they won't fall out. Now turn the board over so the copper side faces up. Solder all leads, and then clip them. Next do the IC sockets, then the transistors and LED's, and finally the capacitors, trimmer resistors, and all other components.

Our PC artwork has a number of extra pads near IC4–IC7. They are used to ground the inputs of unused gates and flip-flops that might pick up stray signals and cause other gates in the same package to act erratically. Providing separate pads on the PC board allows for future expansion or modification of the circuit. To use those gates you would simply remove the jumpers grounding them and hook up the circuit you need. In any case, wire all the jumpers in accordance with the component-placement diagrams in Fig. 7 and Fig. 8. Note that the timer board has jumpers on *both* sides of the board.

After the boards have been completely stuffed, carefully inspect them again and make sure there are no solder bridges between adjacent pads or traces. It's also a good idea to verify that the five- and twelve-volt power lines are not shorted to ground. The power supply used in our prototype is a surplus unit, but an equivalent circuit is shown in Fig. 9.

The relays in our prototype are mounted on pieces of perf-board. Relay RY1 is socketed because it switches fairly heavy loads, and may need to be replaced. Relays RY2–RY4 are hard-wired to 16-pin DIP plugs P3–P5, which mate with SO5–SO7, respectively.

After all the boards are stuffed, inspected, and approved, mount them to the main chassis assembly using snap-in plastic standoffs. Wire up the 115-volt primary circuit, T1 and fuses F1–F3. Connect the secondary leads of T1 to the inputs of the power supply, and verify that the correct voltages appear at its outputs before connnecting those outputs to the other boards. To facilitate insertion and removal of the circuit boards, the edge-card connectors are not rigidly mounted. The wiring that connects all sub-assemblies together is shown in Fig. 10; all wiring is point-to-point and bundled.

The control panel components are mounted in an aluminum chassis about 6 × 8 × 2 inches. Internal wiring is point-to-point. Molex connectors were used to connect the control panel to the main chassis; again you may wish to use "D" connectors.

The keyboard panel components were mounted in a waterproof "bell" box. The keyboard itself, the LED's, and the ENTER switch were all mounted on perf-board; the entire assembly was then attached to standoffs pre-molded in the "bell" box.

Final assembly and testing

Before permanently mounting the three chassis assemblies and wiring up the area to be protected, make two short test cables for Cable A and Cable B (shown in Fig. 10). Connect the control and keyboard panels to the main chassis with those cables. Apply power, and verify that power lamps LMP2 and LMP4 in the control panel, and LED9 in the keyboard panel all light up. The LED connected to the 555 on the timer board (LED1) should be flashing about once per second. That rate should

continued on page 112

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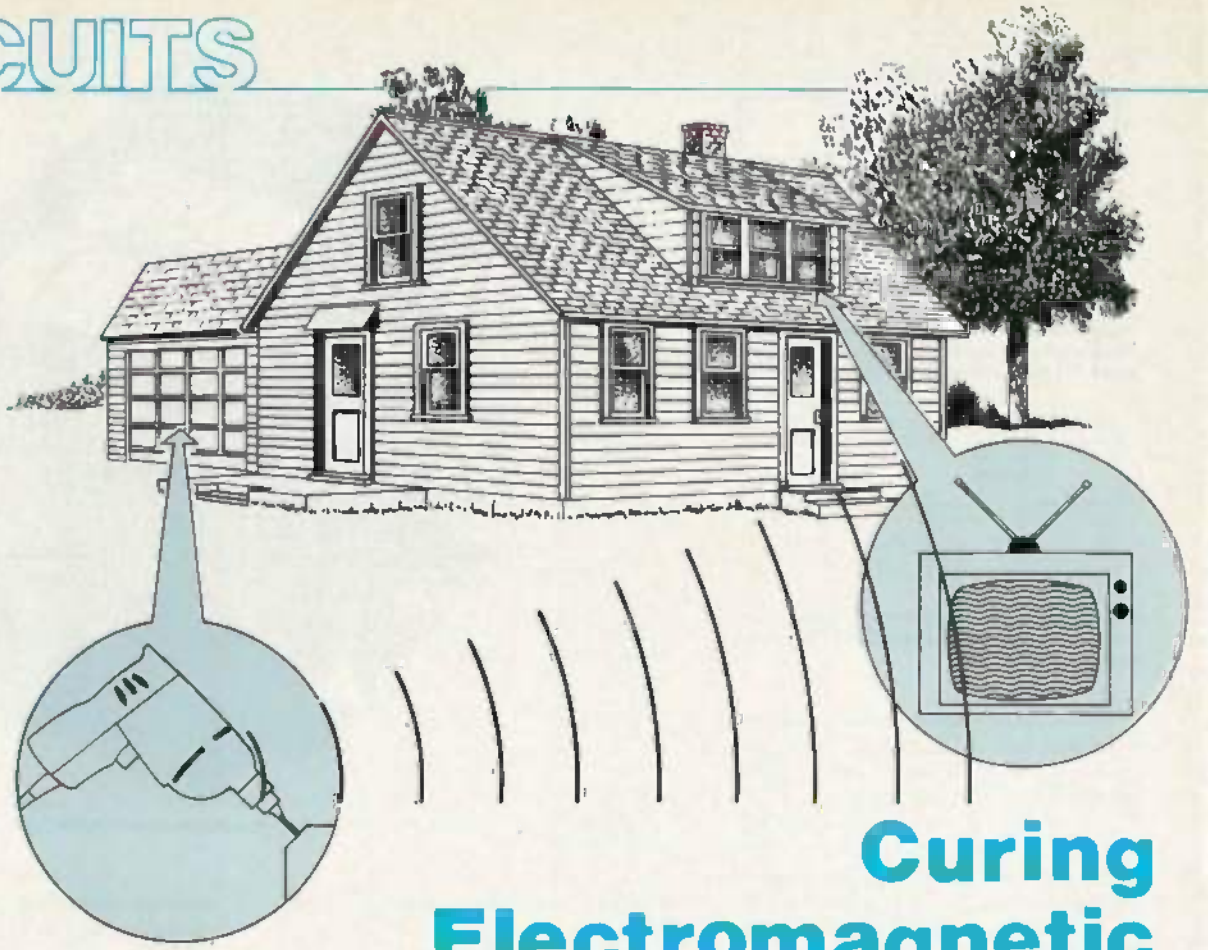

Curing Electromagnetic Interference

MICHAEL F. VIOLETTE

Shields and grounds play an important role in minimizing the effects of EMI. In this article we learn how they work, and how to design an effective shield or ground system.

Part 2 LAST TIME, WE TALKED about the general nature of *E*lectro*M*agnetic *I*nterference (EMI). Among other things, we looked at its sources, what it affects (its victims), and how the interference gets from the source to the victim (the coupling path). We also looked at the two different types of EMI; common-mode and differential-mode interference.

This month we will delve more deeply into the ways EMI can be eliminated and *E*lectro*M*agnetic *C*ompatability (EMC) can be achieved. Specifically, we will be looking at grounds and shields, and how they can be used to eliminate the effects of EMI.

Grounds

Consider the grounding scheme shown in Fig. 1. In it, a long ground wire connects circuits 1 and 2, and circuit 3 is tied to the ground wire of circuit 2. The system ground or ground reference is shown at the left. Ideally, conductors have no impedance; if that were actually the case, the grounding scheme shown would work fine. However, real wires do have an impedance associated with them. Consider, for instance, Fig. 2. That figure is the equivalent circuit for the grounding system shown in Fig. 1. As shown in Fig. 2, ground currents I_{G1}, I_{G2}, I_{G3}, flow in the ground leads. Because of the impedances in the leads, noise voltages are generated, and they can be large enough to cause problems for the circuits connected to them.

Also, as is shown in Fig. 2, the design of the ground system is such that ground loops exist. A ground loop can be created when a circuit is physically connected to a ground lead or bus at more than one place. Because the nature of the connections between circuits 1 and 2, and circuits 2 and 3 is, at this point, unknown, it is entirely possible that the circuit shown could have two ground loops. Ground loops are un-

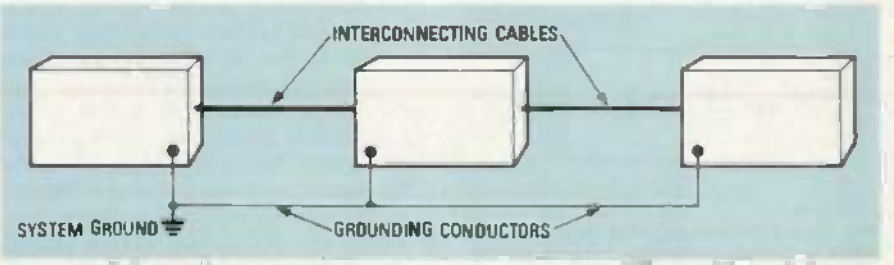

FIG. 1—A POOR GROUNDING SYSTEM. Because of the impedances associated with the ground leads, this system is susceptible to EMI.

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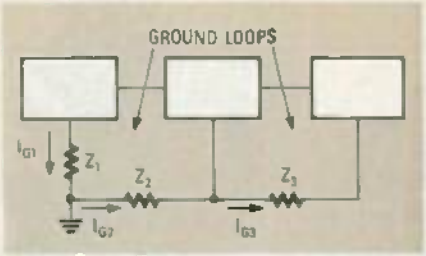


FIG. 2—EQUIVALENT CIRCUIT for the grounding system shown in Fig. 1. The ground currents flowing through the impedances of the ground leads will generate noise voltages.

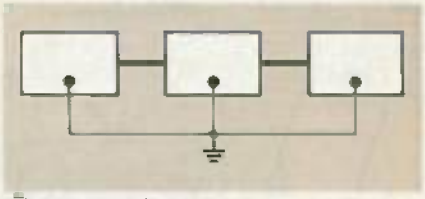


FIG. 3—A STAR GROUND. In this grounding system, all of the circuits are tied directly to a single system ground.

desirable because the common-mode currents that flow in them can couple into circuitry and cause interference (called common-mode interference).

A better arrangement is shown in Fig. 3. The grounding system shown there is called a star ground. Notice that each circuit is connected to a common ground point or system ground (sometimes called the star point) through a dedicated connection. To keep impedances as low as possible, those connections should be kept as short as possible. Star-ground systems are used in many electronic devices, including computers and TV's.

Breaking ground loops

There still may be ground loops in the system of Fig. 3 and they still must be eliminated. Several techniques are used to break ground loops. One technique is to "float" one or more of the interconnected circuits (disconnect the circuit from the system ground). That is not always possible, and it is unsafe in high-voltage circuits.

A better approach is to physically isolate the various circuits. That can be done with a opto-isolator. As shown in Fig. 4, that device consists of an LED and a phototransistor. Such devices are readily

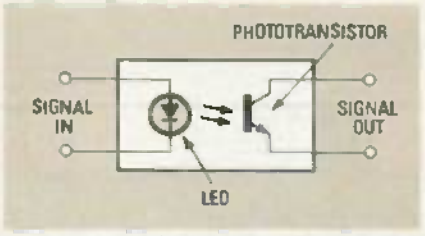
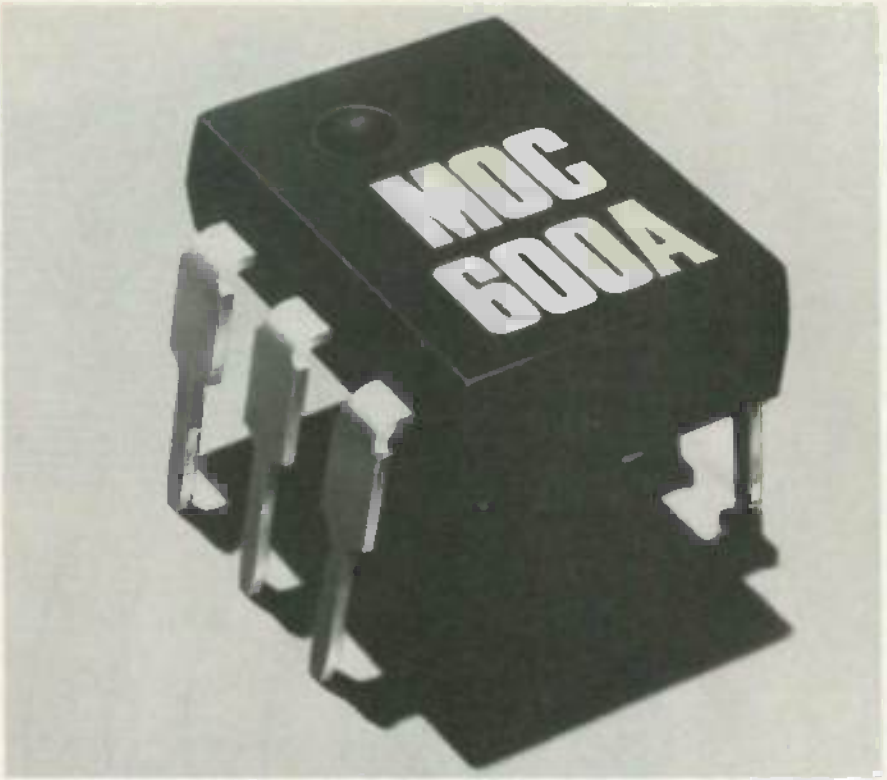


FIG. 4—AN OPTO-ISOLATOR. Since it eliminates electrical connections between two circuits, this device can be used to break up ground loops.



OPTO-ISOLATORS, such as the members of the Motorola MOC600A family, are inexpensive and readily available.

available in IC form and are fairly inexpensive.

The operation of an opto-isolator is as follows: With no input signal the LED is off; but when an input signal is present, the LED turns on, and the light from the LED turns the phototransistor on. Current flows through the phototransistor, which results in a signal at the output of the opto-isolator. There is no hard-wire connection between the input and output of the opto-isolator, and therefore, no ground-loop currents flow.

The opto-isolator is also effective against common-mode currents. By definition, common-mode currents flow on both input lines of the device, but they are unable to flow across the opto-isolator because of the absence of connection between the input and the output of the device. One limitation of the opto-isolator is a parasitic (unintentional) capacitance that exists between the input and output of the device. At higher frequencies, that capacitance results in a degradation of the isolation between the input and the output. Depending on the device, and its application (signal isolation or power switching), that capacitance is somewhere between 1 pF and 180 pF.

Isolation transformers can also be used to eliminate ground loops. An isolation transformer has a turns ratio of 1:1, so that the signal levels are identical in the primary and secondary. An isolation transformer can be effective against ground-loop currents and common-mode signals because there is no hard-wire connection between the primary and the secondary of the isolation transformer. Again, the limitation to the isolation transformer is the primary to secondary parasitic capacitance, which can be significant (up to 1000 nF).

That parasitic capacitance can be reduced or eliminated by inserting an electrostatic (foil) shield between the primary and the secondary. That metal shield is made of a nonmagnetic material (nonferrous) and does not interrupt the normal flow of magnetic flux around the transformer; thus the magnetic circuit of the transformer is affected very little. At high frequencies, more than one shield may be required.

Figure 5-*a* shows an unshielded isolation transformer and the primary-to-secondary (input-to-output) capacitance, C_{IO}. Figure 5-*b* shows a single-shielded isolation transformer; such a transformer is usually effective at frequencies up to 100 kHz. The shield effectively reduces the primary-to-secondary capacitance by dividing C_{IO} into a primary-to-shield (input-to-shield) capacitance, C_{IS}, and a shield-to-secondary (shield-to-output) capacitance C_{SO}. The series combination of C_{IO} and C_{SO} is less than C_{IO}. Note that the shield in Figure 5-*b* is connected to the common-mode reference (ground) by a low impedance connection. As shown, a portion of the common-mode currents flow from the transformer primary through C_{IS} and return to ground, reducing the common-mode current on the secondary side of the transformer. Thus, the

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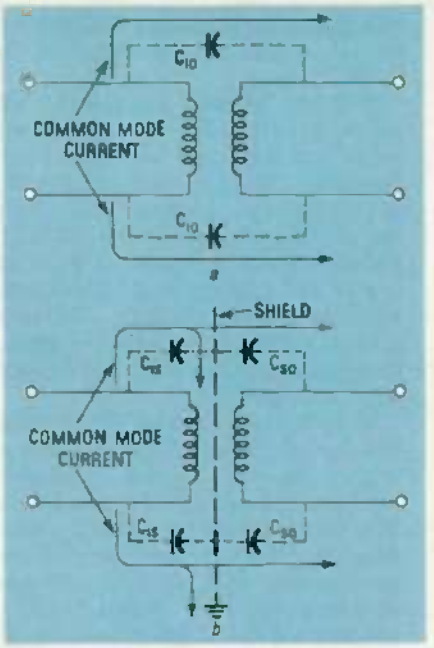

FIG. 5—ONE DRAWBACK in using an isolation transformer to break up ground loops is the high parasitic capacitance between the windings (a). One solution to that problem is to place a shield between the windings (b).

action here is that of a current divider, and the net effect is a decrease in common-mode currents on the secondary side.

Ground planes

Examine the PC board used for a high-speed digital circuit and you will likely see that the majority of the copper is unetched; the only copper removed is that needed to avoid shorting traces. The remainder of the copper, surrounding the circuit, is used as a ground plane. A ground plane is a flat metal plate or surface to which ground connections are made.

Ground planes offer several advantages. For one, their use helps eliminate the possibility of ground loops on the PC board. Also, at high frequencies, their large surface area (when compared with a PC trace) results in a low impedance.

Safety considerations

It is possible that a design intended to minimize EMI may be unsafe. For example, floating a circuit to break a ground loop may not be advisable because of the impact on the safety design of the system. If the circuit is a high-voltage one, a connection to the system ground must be provided in the event of a short. When dealing with AC-powered equipment, especially equipment housed in a metal cabinet or case, a safety ground (usually via a 3-line power cord) should be provided. Otherwise, should a breakdown occur and the "hot" side of the AC supply be applied directly to the case, there will be no path to ground. That is, until someone touches the case, perhaps with disastrous results.

Shielding against EMI

Shielding is used to reduce unwanted radiated energy from coupling to and from a system. Radiated energy is generated by many sources. In some cases, that is indeed the intended function of the source; those include RF transmitters of all types. Other times, the radiated energy is an unintended side effect. Many different types of equipment can be unintentional sources of radiated energy. Among the most common of those are computers and power lines. Radiated energy can also be generated by natural sources, such as lightning.

Electromagnetic radiation

An antenna is used to transmit and/or receive electromagnetic radiation energy. That energy is in the form of n electromagnetic wave that travels through space at the speed of light. Associated with that wave is a wavelength, λ, and a frequency, f, which are related through the equation $\lambda = C/f$, where C is the speed of light (3×10^8 meters/second), λ is measured in meters, and f is measured in hertz. Note that wavelength and frequency are inversely proportional; that is, as the frequency of radiation increases, the wavelength decreases. When the length of a wire is equal to about a quarter wavelength at some frequency (or some integral multiple of a quarter wavelength), the wire becomes an efficient antenna at that frequency. That means that it is capable of easily receiving or transmitting electromagnetic radiation.

While an efficient antenna is desirable when you are dealing with radio communications, if one of the conductors in your project becomes an "efficient antenna," it is a nuisance. That conductor becomes a means for electromagnetic energy to couple into the circuit. If the coupled energy is higher than the sensitivity (for analog circuits) or noise margin (for digital circuits) of the circuit, that energy can cause the circuit to malfunction. In addition, if the circuit is a high-frequency one, it is possible for it to become a source of electromagnetic radiation itself, affecting the operation of nearby equipment.

In either case, the way to cure the problem is to place a shield around the project. A shield is designed either to keep the EMI out or to keep it from escaping.

How does a shield work? A good EMI shield absorbs part of the electromagnetic wave and reflects part of the wave away. The theory behind shielding is quite complex. It is based upon aspects of Maxwell's electromagnetic radiation equations and it is beyond the scope of this article. But we can describe what goes on qualitatively, so that you can gain some understanding of how the process works.

The shielding mechanism

First, there are three different types of electromagnetic fields. All electromagnetic fields are composed of an electric field and a magnetic field. The relationship between the electric and the magnetic field is similar to the relationship between voltage and current. That relationship is given by Ohm's law, which states $V = IR$.

In electromagnetic field theory, there is a similar equation that relates the electric and magnetic fields. That equation is $Z = E/H$, where E is the intensity of the electric field and H is the intensity of the magnetic field. The variable Z is the impedance of the field; the three different types of electromagnetic fields are defined in terms of that impedance. Those are high-impedance, low-impedance, and free-space fields.

A high-impedance field is created by a source (antenna) that has a high impedance. For instance, a dipole antenna has a very high impedance because the antenna elements are not connected together (except through the capacitance in the air between the elements). It is difficult to shove current into the dipole because of that high impedance. The radiated wave that comes off of the antenna is also high impedance; it is called an electric field because E is large relative to H, which creates a large value of Z.

A low-impedance field is created by a source that has a low impedance. One type of low-impedance source is a loop antenna. A loop antenna has its ends shorted together and therefore has a low impedance at its terminals so current can easily flow through the loop. That creates a low impedance, or magnetic, field. An example of a source of magnetic fields is a power line in which relatively large current flows; such lines are the cause of many EMI problems.

High and low impedance fields exist when you are close to the source or the antenna; that region is called the *near field*. As you move away from the antenna, you approach what is called the *plane-wave* or *free-space* region. In the free-space region, the impedance of an electromagnetic wave is very simply equal to 120π (or approximately 377 ohms).

For proper design of the shield, it is important to know the impedance of the electromagnetic field. For that reason, it is also important to know where the near-field region ends and the free-space region begins. That distance, known as the transition distance (R), is defined as $R = \lambda/(2\pi)$.

Shield design

As stated, the purpose of a shield is either to reflect or to absorb electromagnetic radiation. A shield around a circuit acts as a barrier to electromagnetic energy by reducing the field strength on the other side of the barrier. The *shielding effectiveness* (SE) of a shield is a comparison

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between the amplitude of the field on one side of the shield (incident field) compared to the amplitude on the other side (the resultant field). If the SE of a shield is high, then the "problem" wave is reduced in amplitude.

A simplified model of how a shield works is shown in Fig. 6. An electromagnetic wave is incident from the left of the shield (although the wave can be generated from the inside of equipment). Part of the wave is reflected away and part of the wave penetrates into the shield material. When the wave penetrates to the other side of the shield, another reflection takes place at the interface between air and metal. The energy that is reflected travels back through the material and exits on the left side. Much of the energy that is not reflected is absorbed by the shield material. The remainder of the energy exits the right side of the shield as the resultant field.

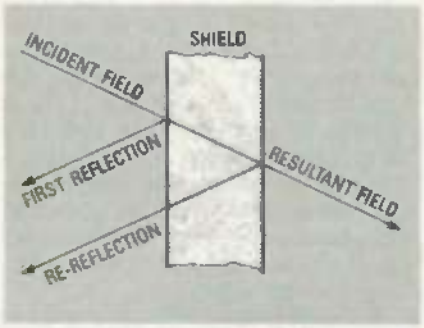

FIG. 6—HOW A SHIELD WORKS. Note that the electromagnetic energy is reflected at both shield/air interfaces. In addition, some of the energy is absorbed by the shield material.

Most shields are designed to attain an SE between 20 and 80 dB (10 to 10,000-fold reduction) and some "super shields" are designed for SE's between 100 and 120 dB (100,000- to 1,000,000-fold reduction). In general, any shield with an SE of less than 20 dB is not very effective.

Let's look at an example. Consider an incident electric field, E_I, with a strength of 1 volt per meter (V/m) that is causing an electronic system to malfunction. If a shield with an SE of 60 dB is installed, what is the resultant field on the inside of the shield? First, convert the electric field to dB: $E_{IdB} = 20\log_{10}(1) = 0$ dB

To find the resultant field strength, E_R, subtract the shielding effectiveness from the incident field strength. Thus, the resultant field is 0 dB – 60 dB = –60 dB. Or, in volts-per-meter:

$$E_R = 10^{(E_{RdB}/20)} = 10^{(-60/20)} = 10^{-3}$$
$$= .001 \text{ volts-per-meter}$$

That is a reduction of 1000.

To design a good shield, it is important to consider the type of field you are dealing with. The following "rules of thumb" should be followed to select the correct shield material:

To shield against electric waves, reflection is important. Use a high conductivity metal (such as copper or aluminum) for the shield. The high conductivity (which results in a low impedance) of the material essentially short circuits the electric field just as a piece of wire short circuits a voltage source in a hard-wired circuit. The field is reflected away by the short circuit. Reflection of the wave results in a reduction of the field on the opposite side of the barrier.

Likewise, copper and aluminum are suitable shielding materials when dealing with free-space electromagnetic waves. The shielding mechanism is a combination of reflection and absorption.

To effectively reduce magnetic fields, however, the shield material must have magnetic properties. For instance, the operation of a transformer depends on the material in the transformer core. Transformer cores are constructed of magnetic (ferrous) materials, such as silicon steel. The current in the primary of a transformer creates a magnetic field that pushes a magnetic flux around the core of the transformer. Very little flux exists in the air around the transformer because air is non-magnetic. The concentrated flux in the core is said to "link" the primary and secondary windings in a transformer. The result is that a time-changing signal in the primary will induce a similar signal in the secondary.

To reduce magnetic fields, then, the shield must be able to concentrate the magnetic flux from the source of the magnetic field. That creates a shield against the magnetic field. Magnetic field shielding is relatively difficult because of the weight and expense of the materials involved (such as steel).

Shielded-box design

An important aspect of shielding design is how the shield material is assembled. A perfect shield is a totally enclosed box, made of the proper shield materials, in which the circuit is placed. However, switches, knobs, power cords, signal cables, and ventilation holes are necessary if the circuit is to be useful. Pretty soon, there are a lot of holes in our perfect shield; those allow radiated energy to "leak" into the box. A compromise between the perfect and the practical must be made. There are methods available to accommodate the holes and still have a pretty good shielded box design. Let's look at some of those methods.

An important consideration in shielded-box design is the size of the hole in the shield. At low frequencies, the wavelength of the EMI is large compared to the size of the hole. As the frequency increases, the wavelength decreases and the energy can leak through the hole and pass through the shielded box. That phenomenon can be observed the next time you ride in a car and pass under a metal truss bridge that has a number of openings formed by the metal members of the bridge.

With the car radio tuned to an AM station, around 1 MHz (λ = 300 meters), notice how the signal fades out or even disappears. The bridge structure is acting as a shield to the AM radio signal. Switch the radio to an FM station (88–108 MHz) where the wavelength is a fraction of the size of the openings in the bridge; the signal should be unaffected. The high-frequency FM signals pass unimpeded through the openings in the metal framework of the bridge.

Thus, to design a good EMI shielded box, keep the openings in the box as small as possible. For instance, ventilation holes can be covered with a screen mesh. Box seams should be soldered closed. Also, there should be good electrical contact across the seam, so remove the paint or non-conductive finish (such as anodization on aluminum) from the edges. The idea is to have, as much as possible, a continuously conductive surface.

In addition, there are numerous products available that can be used to maintain the integrity of the shielding. Those include conductive gaskets, which are fitted to seams and covers of shielded boxes to provide electrical continuity across the seam; shielded windows, which are made of glass or plastic panels in which tiny screen mesh is placed; conductive paints, which are sprayed on plastic enclosures for shielding purposes (many popular computers use conductive paints and coatings on their cabinets), and special shielded switches.

Thus far we have seen how proper grounding and shielding can greatly reduce the affects of electromagnetic interference. While those techniques are useful in eliminating problems that might appear, they are most useful if considered in the design stages of a project. By EMI-"proofing" your design in the first place, you will greatly reduce the chance that any unforseen problems will crop up later on.

Now that we have some idea of how to eliminate or reduce the affects of radiated electromagnetic interference, how do we do the same for conducted EMI? Obviously the methods and products mentioned thus far in this article are effective in fighting radiated EMI, but they will do nothing to eliminate the affects of conducted EMI (interference that enters the circuits via a power line or signal cable). To eliminate the problems caused by conducted EMI, other techniques are required. Among those is the use of filters designed to trap out the interfering signal. In the next part of this article we will look at those filters and how they work. We will also look at still more techniques for reducing the effects of EMI. R-E

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BUILD THIS

VIDEO TITLER

Now that we know how the circuit works, it's time to build and align the unit.

JACK FLACK

Part 3 THIS MONTH, WE'LL finish up our description of the video titler's circuit; we'll see how to build the titler; and then we'll take a look at its operation. As we'll be referring to illustrations that have appeared in the previous two installments (November and December 1985), you might want to have those on hand as we continue.

The microcomputer

The microcomputer section is the most important for human interaction with the titler. Its schematic is shown in Fig. 14. Most of the techniques used are straightforward. The 6809 microprocessor (IC23) was chosen because it offers a number of advanced software features such as 16-bit operations and long-branch instructions for relocatable code.

It is important to recognize the timing requirements of the VDP data and control signals as well as the timing of other devices attached to the 6809 address and data bus. Several timing problems were overcome by using the positive cycle of the E clock (IC23, pin 34) which, along with IC15-c, enables the main system memory decoder, IC18-a, a 74LS139 2- to 4-line decoder/multiplexer.

The titler's interface bus was designed to allow a home computer to access the VDP and ROM. The 6809 three-states its data, address and R/W lines when its HALT line (pin 40) is pulled low. On the titler, pulling that line low also disables the main system memory decoder (IC18-a) by forcing a continuous high output on IC15-c. I/O-select capability is accomplished by R42 and D6, which allow either the main system memory decoder (IC18-a) or an external home computer to select the I/O decoder (IC18-b). ROM SELECT is also provided by R41 and D5.

A full-travel keyboard was included in the design to provide fast and easy creation of titles. Almost any unencoded keyboard—including many available on the surplus market—can be substituted. Of course, you'll need to change the surplus keyboard's wiring by cutting traces and adding jumpers. You could also design a new PC board for the keyswitches.

Figure 15 shows the memory mapping used by the titler. Note how the I/O is mapped. Address line A0 is used by the VDP internally to determine what type of data is on the bus: VDP address/register setup or video memory/register data. Address line A1 is used by the I/O decoder (IC18-b) to choose between the VDP and I/O ports.

That I/O decoder selects the input or output port based on whether a read or write operation is occurring. Therefore, reading from or writing to the port address (8002H) automatically chooses the proper port.

An 8K low-power CMOS static RAM was chosen to provide 30 pages of titles and battery-backup capability. The 8K RAM's have 2 select lines ($\overline{CS1}$ and CS2). The active-high select can be tied to the 5-volt supply. If V_{CC} on the CMOS RAM remains above 2 volts at the same time that the 5-volt supply drops below 0.8 volts (as when the titler is turned off), the RAM will go into standby mode, and data will be retained.

Building the video titler

You don't have to be a pro to build the video titler; but you shouldn't be a rank beginner, either. Testing and adjustments can be performed without an oscilloscope, but they may be more difficult and time-consuming.

While you can build the titler using wire-wrapping techniques, using a PC-board is preferable. You can either make

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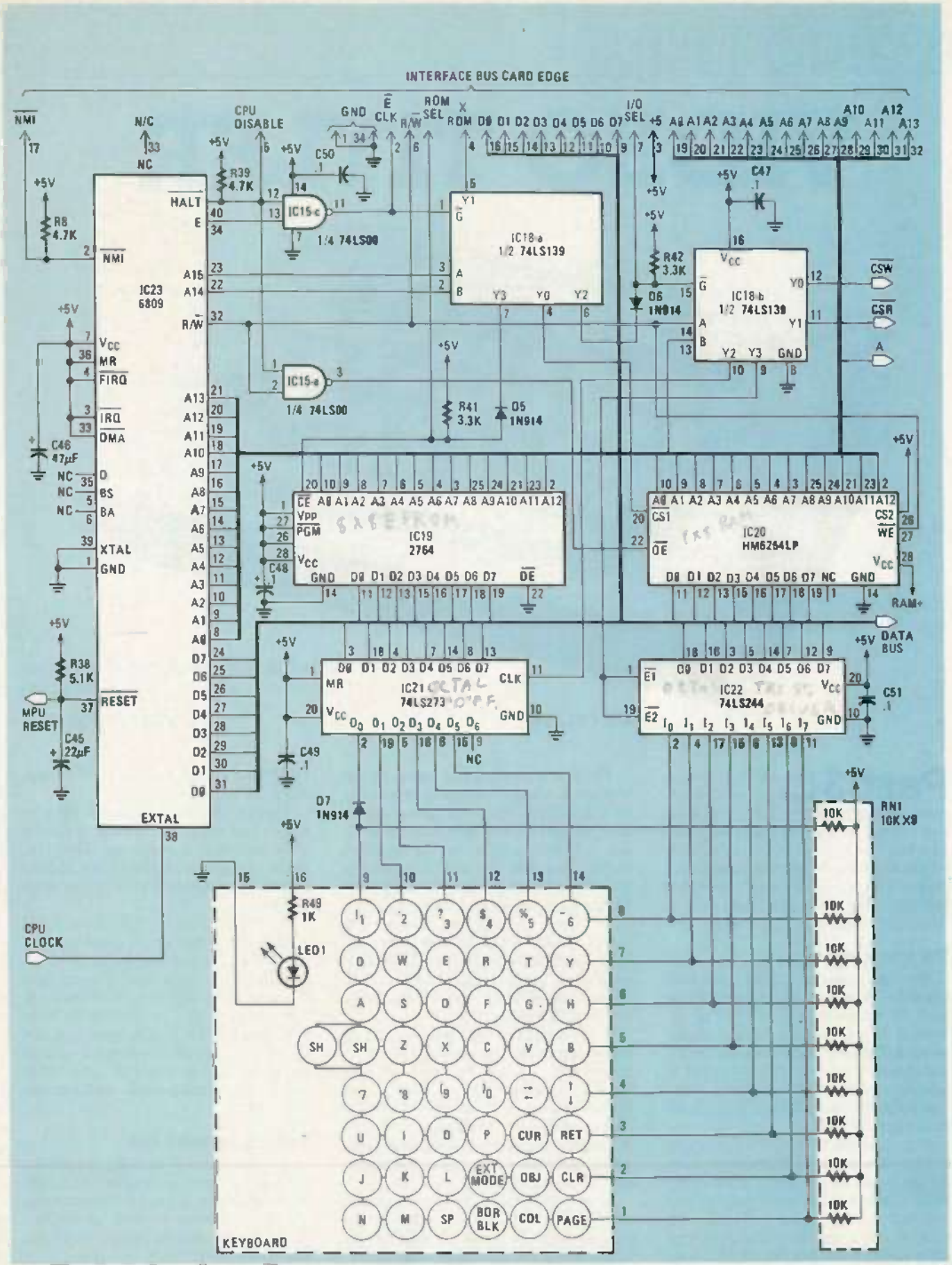

FIG. 14—THE MICROCOMPUTER SECTION has a 6809 microprocessor (IC23) and a programmed 8K EPROM (IC19) as its heart. The interface bus allows a home computer to access the VDP, ROM and external-mode select. We'll get to the details on that in a future issue.

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your own (see the "PC Service" section of this magazine), or you can buy one from the source mentioned in the Parts List. A parts-placement diagram is shown in Fig. 16, and Fig. 17 is a photo of the author's prototype.

Regardless whether you use a PC board, be certain to use sockets for the IC's. If you choose to wirewrap, you'll need to use DIP headers or some other technique for mounting the discrete components.

As you wrap or solder the wires, check off each connection on the schematic. Be sure to use the decoupling capacitors specified in the schematic, and mount them as close to the IC's as possible. For easier troubleshooting, use different-colored wire for power, ground, and other (data-, address-, and control-line) connections.

Remember that several of the IC's are CMOS types and require special handling. Also, use a twisted pair of wires for the video inputs and outputs to minimize RF interference.

If you're not using a PC board, special care should be taken in locating the two oscillator circuits. The PLL (IC4 and IC5) should be as far as possible from the 3.58-MHz chroma clock circuit (IC14 and IC15) and the video inputs and output. The chroma processor (IC14) calls for separation of the oscillator portion (components associated with IC14 pins 6 and 7) and the input (pin 1).

Mount the +5- and +12-volt regulators directly on the enclosure to help dissipate heat. Also, be extremely careful when hooking up the 10-pin video jack

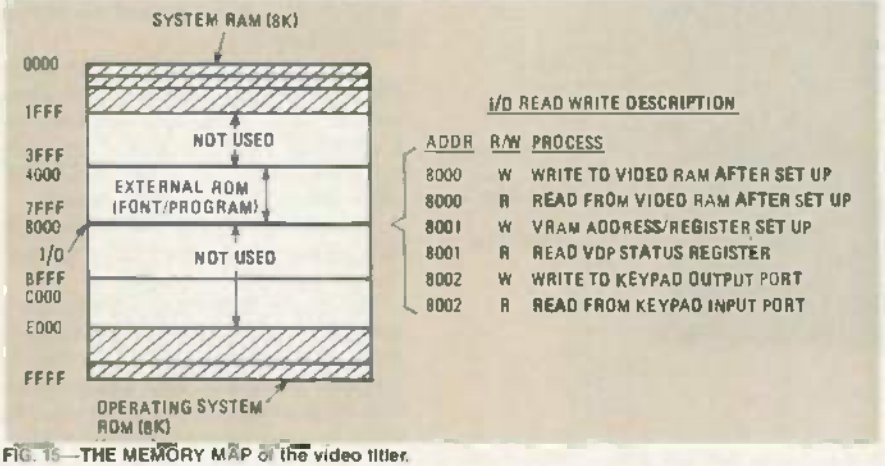

FIG. 15—THE MEMORY MAP of the video titler.

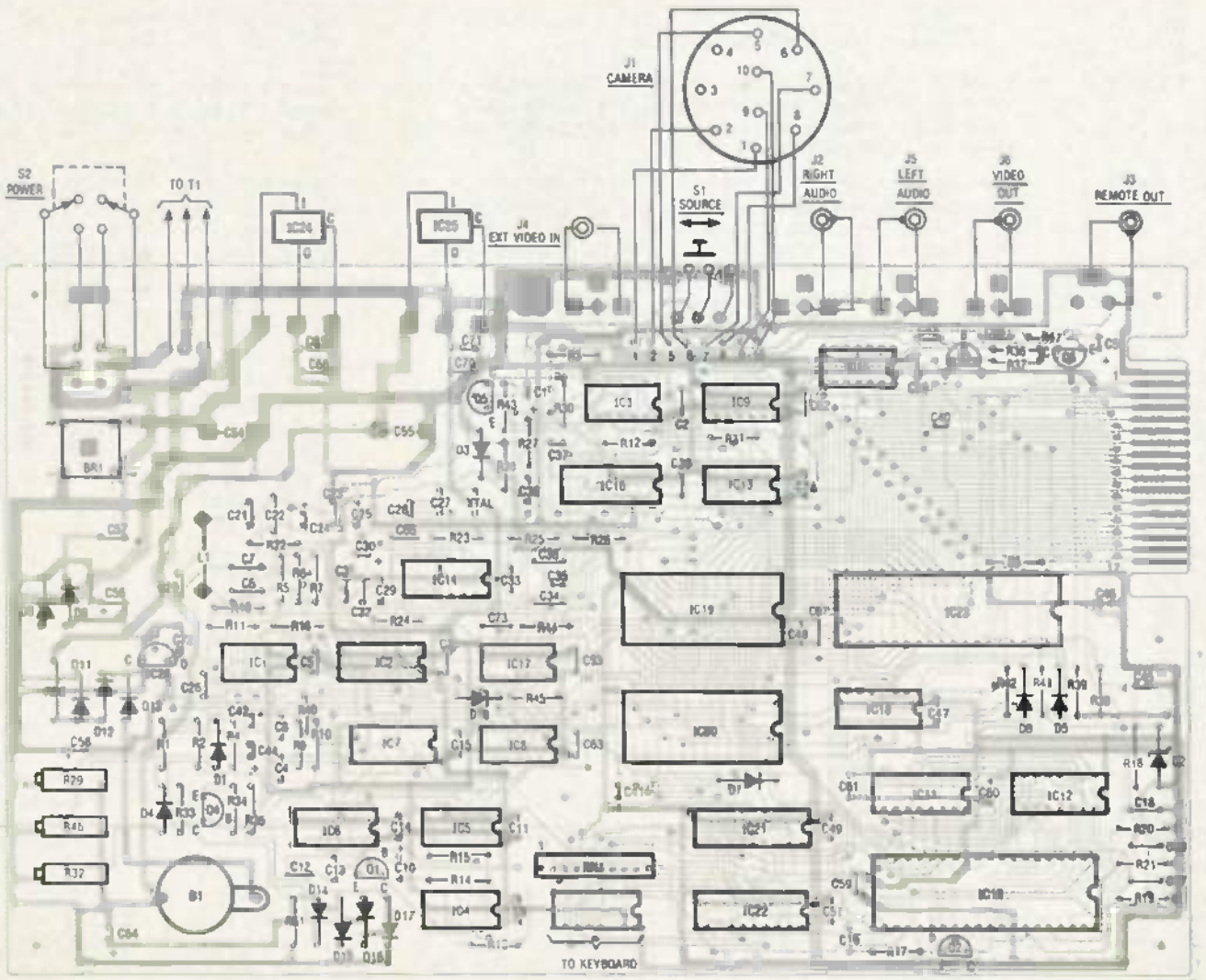

FIG. 16—THE PARTS PLACEMENT DIAGRAM FOR THE VIDEO TITLER. Foil patterns for the titler are shown on pages 77 and 79.

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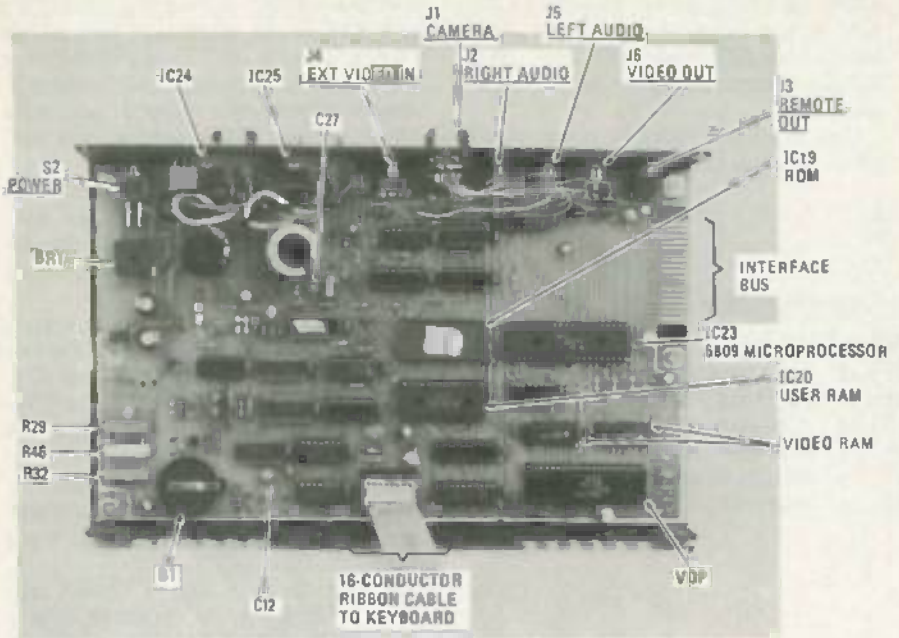

FIG. 17—THE AUTHOR'S PROTOTYPE and some of the main components and adjustments.

TABLE 1—TITLER ADJUSTMENTS

• C12	Changes clock frequency and locking range. When in internal mode, adjust C12 until a black screen with cursor is seen. Fine tuning will be required in the external mode. If a picture still is not present, try the next adjustment.
• R46	Changes level where external video is selected over VDP video. Initially, set voltage at pins 1 and 11 of IC17 (also the wiper of R46) to zero or near zero. Then, in the internal mode, adjust so that the VDP image is clean. In external mode, find the point where the VDP and external video are the cleanest.
• R32	Changes the bias on the VDP video signal. The effect is seen as a VDP image that is darker or lighter relative to the external image. Use black characters for this adjustment, and adjust so that the characters are as black as possible without the picture tearing.
• C27	Adjusts the VDP colors and the locking range of the chroma processor. Color may not be present until this adjustment is made. Adjust in external mode. Try small adjustments and remove screwdriver to check effect.
• R29	Changes the color of the VDP only in the external mode. Display black characters, and adjust so that the least amount of color is visible.

(J1). One mistake could damage your camera.

Initial testing

Before you insert IC's into their sockets, and before turning on the power, use an ohmmeter on a low-resistance setting (1 ohm) to check for shorts in the power-supply connections. You will likely read some resistance (50 to 80 ohms) due to the discrete components, but you should not read zero. That's a short (probably caused by bent wirewrap pins or solder bridges). Examine your board closely. Don't assume that you'll catch your mistakes when you power up—it may be too late.

Once you've determined that the power connections are OK, power up the titler. Look, listen, feel, and *smell!* Transistors and resistors can get hot quickly when something is wrong. Some transformers sound funny when they are beginning to melt. Smoke does not necessarily mean fire, but we're not building a cigarette lighter. If you see something unusual, turn off the unit quickly! (But wait a few seconds before you start touching components. You'll still be able to find the culprit, but waiting could spare you a burn.)

If all is well, leave the unit on and check the main power supply outputs with a voltmeter. The power supply is shown in Fig. 6.) They should be very close to the desired voltages. However, the +3-, +1.5-, and +0.7-volt supplies may vary 10 to 15 percent. And with no IC's installed, the output of the +5-volt supply may be closer to 6 volts because of R50. If any readings are zero or especially low, you probably have a short somewhere. Three-terminal voltage regulators (78XX and 79XX) have protection against short circuits which usually result in voltage drops. If that occurs, turn off the unit and start hunting.

If the main power-supply outputs are OK, check each IC socket for the proper voltage. Most of the logic IC's have standard power supply pins, but the microprocessor (IC23), VDP (IC10), DRAM's (IC's 11 and 12), and others *do not!*

When all checks out, you can insert the IC's. However, you can't really go much farther without the EPROM.

The description of the software that is contained in the EPROM requires an entire article in itself. We'll defer that description until next time and go ahead with the final adjustments and assume that you have a pre-programmed EPROM.

Final adjustments and testing

Once you have all the IC's (including the EPROM) inserted, you're ready for the final adjustments. Connect the titler's video output to the video input of a VCR or video monitor. If you're using a VCR, be sure that the RF connections are correct and that any switches are appropriately set.

Power up the titler. There are a number of possible pictures that could be present. What you want to see is a black screen with a medium green cursor in the upper left corner.

If only garbage is present, don't worry. The clock frequency can vary enough to allow the sync pulses to be outside the specifications of the TV set. Follow Table 1, and try the first two adjustments. Because those two adjustments tamper with the master clock, you'll want to reset the microprocessor and VDP by turning the titler off and then back on before further testing.

The adjustments can be performed without an oscilloscope if you're patient. Remember that at any point in the adjusting process you may have to readjust a previous step. You may also have to power down to reset the microprocessor.

When you complete the initial adjustments and a medium green cursor is present, congratulations! If you're still having problems, an oscilloscope may be necessary. But before you go hunting for one, use an ohmmeter and recheck the power-connections on the VDP (Fig. 7) and other IC's. Also check the RESET/SYNC input on the VDP (IC10, pin 34). It should be at a 4- to 5-volt level. If you get a reading of less than 2 volts or greater than 7 volts, check the connections on pin 34, Q2, R18, and D3. You may need to verify that the correct components were installed at

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PARTS LIST

All resistors 1/4-watt, 5% unless otherwise noted.
RN1—10,000 ohms × 9 resistor network
R1—10,000 ohms
R2—6800 ohms
R3—75 ohms
R4,R48—51,000 ohms
R5, R11, R12, R15, R25–R27, R35, R43, R49—1000 ohms
R6, R8, R30, R31, R39—4700 ohms
R7—3900 ohms
R9, R38—5100 ohms
R10—4300 ohms,
R13, R16, R18, R22, R24, R28, R40—2200 ohms
R14, R23—680 ohms
R17, R36—120,000 ohms
R19, R20, R21—470 ohms
R29, R32—1000 ohms, PC-mount trimmer potentiometer
R33, R37—1500 ohms
R34, R47—220 ohms
R41, R42—3300 ohms
R44, R45—820 ohms
R46—10,000 ohms, PC-mount trimmer potentiometer
R50—33 ohms
R51—68 ohms
Capacitors
C1, C40–C42, C44, C64—10 µF, 25 volts, electrolytic
C2, C3, C5, C9, C11, C14, C15, C16, C26, C33, C38, C39, C43, C47, C48, C49, C50, C51, C53, C60, C61, C62, C63, C68, C70, C72–C74—0.1 µF ceramic disc
C4, C22, C23, C25, C29, C31, C32, C34, C36—0.01 ceramic disc
C6—0.0022 µF mylar
C7—.0047 µF mylar
C8—0.001 µF mylar
C10—0.47 µF, 25 volts, electrolytic
C12, C27—5–30 pF PC-mount trimmer
C13, C28—12 pF, ceramic disc
C17–C19, C66—220 pF, ceramic disc
C20—150pF ceramic disc
C21—390 pF ceramic disc
C24, C30, C58—1 µF, 25 volts, electrolytic
C35, C37—47 pF ceramic disc
C45—22 µF, 10 volts, electrolytic
C46, CS2, C59, C67, C69, C71—47µF, 16 volts, electrolytic
C54—2200 µF, 25 volts, electrolytic
C55—4700 µF, 16 volts, electrolytic
C56, C57—100 µF, 25 volts, electrolytic
C65—33 pF, ceramic disc
Semiconductors
IC1—LM339 quad comparator
IC2—74LS221 dual non-retriggerable one-shot
IC3—74LS05 hex inverter
IC4—MC4044 phase-frequency detector
IC5—MC4024 dual voltage-controlled multivibrator
IC6, IC7—74LS191 up/down binary counter
IC8, IC9, IC13—4066 quad analog switch
IC10—TMS9128 video display processor (Texas Instruments)
IC11, IC12—4416 16K × 4 dynamic RAM, 200 ns
IC14—CA3126 chroma processor (RCA)
IC15—74LS00 quad nand gate
IC16—LM1889 TV video modulator (National)
IC17—SN75108 Dual in-line receiver
IC18—74LS139 dual 1-of-4 decoder
IC19—2764 8K × 8 EPROM
IC20—HM6264 LP 8K × 8 static RAM
IC21—74LS273 octal D-type flip-flop
IC22—74LS244 octal 3-state driver
IC23—MC6809 microprocessor
IC24—7812K regulator, +12-volts
IC25—7805K regulator, +5-volts
IC26—79L05 regulator, −5-volts
D1, D3, D4, D5–D7, D11–D18—1N914
D2—1N751 Zener, 5.1 volts
D8, D9—1N4001 rectifier, 50 PIV
D10—not used
BR1—full-wave bridge rectifier, 6 amps
LED1—standard red LED
Q1, Q6—2N2222
Q2, Q3—2N3906
Q4, Q5—2N3904
Other components
XTAL1—3.579545 MHz
L1—56 µH
T1—14-volt secondary, center-tapped
J1—10-pin video camera jack
J2, J4–J6—PC-mount phono jack
J3—3/32 inch phone jack
S1—SPST PC-mount slide switch
S2—DPDT rocker switch, vertical PC mount
Miscellaneous: Lithium-battery holder and battery, 49-key keyboard, 16-conductor ribbon cable, enclosure, etc.

The following are available from Micro-Video-Technology, P.O. Box 76, Chattanooga, TN 37343: main PC board (silk screened, with gold fingers), $40; Programmed EPROM, $25; Custom keyboard, $80; Custom enclosure, $40; All switches, jacks, and connectors, $30; 14 VCT wall transformer, $30; TMS9128 VDP, $30; partial kit (includes all the above), $250. All orders add $5 ($13 outside U.S.) for shipping and handling.
The following are available from JDR Microdevices, 1224 South Bascom Ave., San Jose, CA 95128 (800) 538-5000: All components—*except those available from Micro-Video-Technology*—$69.95 + $2.50 for shipping.
The following is available from MFJ Enterprises, Inc., 921 Louisville Road, Starkville, MS 39759: Complete titler, assembled and tested with 1 year unconditional guarantee, $599.95 plus $6 shipping. (Return if not satisfied within 30 days for refund, less shipping.) Orders only (outside Mississippi) 1-800-647-1800. Information and Mississippi orders 601-323-5869. MasterCard and Visa accepted.

those locations. Remember that if you see, feel, smell or hear something unusual, you probably have a problem. Power down immediately and check it out.

If all else fails, then an oscilloscope will be required. First make sure that the titler is generating a stable composite-video signal. If it's not, the VDP (IC10) is probably not operating properly. Check the master clock (pin 6) for a 10.7-MHz signal. You should also have a 3.58-MHz clock at pin 37. There should be a black-and-white composite-video signal at pin 36. If no signals are coming from IC10, check the power-supply connections again. If the video signal is present, use the schematic and check the signal at all points until you reach Q6 (in Fig. 13).

Once the hardware is working, the next step is to make sure that your software is functioning properly. Type in several characters and try out all the functions (except external mode).

Once the software is running, you're ready to test the external mode. Before plugging in a camera, make sure that you have 12 volts on pin 10 of the camera connector (J1 in Fig. 7), and that 12 volts is not present on any other pins. Always turn off the titler before plugging in the camera.

Set switch S1 to the camera input or the external input, whichever is appropriate, and turn on the titler. If you're using a camera, you should see all the various camera LED's come on. Since the titler powers up in the internal mode, you should see the same black picture on the screen with a green cursor.

Press the EXT MODE key. That will likely cause more garbage on the screen. Go back to internal mode just to make sure that nothing has happened. If all is well in internal mode, go back to Table 1 and perform the remaining adjustments starting with number 2.

If you are unable to get a clean picture with the adjustments, you have a hardware problem. Disconnect the power, camera, etc. and check for bad solder joints, shorts, bent IC pins, and other possible problems. Don't get too discouraged. Many problems can exist without permanently damaging the components.

Operating features

We've gone through a lot of theory and construction details, but we haven't talked much about what the titler can do and how you can use it. Now that we've finished the testing, it's time to see what we can expect the titler to do.

When the titler is first powered up, it is in its internal mode—the background and

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TABLE 2—KEYBOARD MODES AND KEY RESPONSES

Key	Unshifted	Shifted	Blanked	Unblanked	Cursor on	Cursor off	Object on	Object off
26 Alphabetic	lower case	upper case	NR	—	—	NR	NR	—
10 Numeric Punctuation	Numeric Character	Punctuation Character	NR	—	—	NR	NR	—
Left right arrow	Left	Right	NR	—	If object is off, cursor moves	Checks object	Objects moves	—
Down up arrow	Down	Up	NR	—				
Cursor	—	—	NR	—	Turns off cursor	Turns on cursor	—	—
Return	—	—	NR	—	—	NR	NR	—
Clear	—	—	NR	—	—	NR	—	—
External mode	—	—	—	—	—	—	—	—
Object	Turns on off object	Changes object (in object mode)	NR	—	—	—	Turns off object	Turns on object
Blank border color	Blanks unblanks screen	Changes border color	Unblanks screen	Blanks screen	—	—	—	—
Color	Changes character color	Changes background color	NR	—	If object is off, character color changes	Checks object	Changes object color	—
Page forward back	Pages forward	Pages back	—	—	—	—	—	—

NR = No response
— = Status of mode does not effect key function

border are black, and an external video signal is ignored. The cursor is at the top left corner of the screen and is medium green.

The titler has a character set that is made up of 25 alphabetic characters (capital only), 10 numeric characters, 10 punctuation characters and a "space" character for a total of 47 characters in all. You'll notice 11 other keys on the keyboard; those are used for a variety of functions, such as moving the cursor and changing mode.

The titler can hold 30 pages of characters. Each page can contain eight 16-character lines, and each character can have a different color (background and character color). Sixteen different colors are available, including a transparent color that allows the external video picture to show through (when the titler is in its external video mode).

Once you have your titles or subtitles ready, the cursor can be removed from the screen by pressing the CURSOR key. Then, you might go back to your first page of titles, blank the screen by pressing the BLANK key, and go into the external mode. Blanking the screen does not clear memory or otherwise destroy anything you've entered. It merely causes only the border to appear on the screen. If the border is transparent (as it is after the unit is first powered-up), the external video image appears on the screen.

If no external video signal is present when you enter the external mode, the picture will tear apart and be completely useless. That doesn't affect the data you've entered. You can recover a stable image by going back to the internal mode or by connecting an external video signal to the unit's input.

The action of most of the keys on the titler's keyboard is straightforward. However, there are several aspects that need more explanation. Some keys perform differently when certain modes have been evoked. Table 2 is a summary of the titler's responses to various keys in various modes. For example, as shown in Table 1, in order to place characters in the current page of memory, you need the cursor on, the screen UNBLANKED, and the object mode off.

An *object* (such as an arrow) can be displayed on the screen when the screen is UNBLANKED (with or without the cursor on). Just remember that as long as you see a cursor on the screen and not an object, you can write characters on the current page. You can display, change, and move an object on the screen as long as the screen has not been BLANKED.

Hitting the CLEAR key clears the current page.

The COLOR key initiates three functions. When an object is present, it changes the object color. When the cursor is on and no object is present, it changes the cursor color. (The cursor color designates the color of future characters; existing character colors don't change until they've been retyped using a new cursor color.) Unshifted, the COLOR key changes the character color. When the key is shifted, the background color of the character is changed.

The OBJECT key, when unshifted, alternatively displays and removes the object. While in the object mode (that is, when an object is present on the screen), character inputs are ignored. The two arrow keys move the object instead of the cursor and the COLOR key changes the object color.

When the titler is in its object mode, the shifted OBJECT key changes the *type* of object that can be displayed. Four objects are available: an oval frame, an "X," a rectangular frame, and an arrow. After you leave the object mode, the specific object, pattern, color, and location is retained and used when the object is subsequently displayed.

Unfortunately, that's all we have room for this month. When we continue next time, we'll take an in-depth look at the titler's software and then we'll see how the interface bus can be used. **R-E**

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"Heat-Proofing" your Projects

Do your projects suffer from overheating? We'll show you how to keep them cool.

VAUGHN D. MARTIN and
BILLY W. DAVIS

HEAT CAN DEVASTATE SEMICONDUCTOR components and can make your projects unreliable or short-lived. Fortunately, there are ways to protect your projects from excess heat. We'll show you how it's done. In this article (the first of two parts), we will discuss how electronics designers deal with the flow of heat on a quantitative basis, and how heat may be controlled by using heatsinks and forced-air cooling systems. We will also discuss how thermoelectric devices are used to control heat, and some modern methods of sensing temperature.

In the second part of this article we will examine optical means of sensing and measuring temperature, thermo probes, and Vortex tubes (devices that can produce very low temperatures almost instantaneously without complex drive machinery).

Heat flow

Physicists often talk about three different kinds of heat transfer or heat flow: conduction, radiation and convection. Molecular motion is the cause of *conduction*. Molecules at a higher temperature have higher kinetic energy than do their nearby neighbors, and some of that energy is transferred by those molecules' impinging on one another. Even at the junction of a heatsink's surface and air, energy is transferred via conduction from molecules in the heatsink to molecules in the air.

Heat flow due to *radiation* is caused, not by particle motion, but by the emanation of electromagnetic waves that encompass the spectrum all the way from ultraviolet to infrared light.

In radiation, energy itself is transferred, and in conduction the particles possessing that energy remain in one place. In *convection*, by contrast, the particles themselves move, either of their own accord, or by being forced to move. Convection is related to conduction. In that energy is transferred by means of molecular motion.

Electronics designers must concern themselves with all three types of heat transfer. Conduction is the primary means by which heat is transferred from the internal junction of a semiconductor device to an external surface such as a heatsink, where the effects of both radiation and

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convection then become noticeable. The size and type of material used for heatsinking has a direct effect on the amount of heat radiated. If a device generates more heat than its heatsink can effectively radiate, forced (or natural) convection must be used to maintain the device at a safe operating temperature.

Heat and electricity

In order to quantify discussions of heat flow, an analogy is often drawn between the units used to describe the flow of electricity, and those used to describe the flow of heat. As shown in Table 1, voltage corresponds to temperature; current corresponds to heat flow; and electrical resistance corresponds to thermal resistance. The circuit diagrams in Fig. 1 illustrate how heat-flow problems may be treated in a manner similar to electrical-flow problems.

The basic thermal relationship may be stated as follows: the change in temperature is the product of dissipated power and thermal resistance, or, in short, $\Delta T = P_D\theta$. The equation reveals that if a device must dissipate a certain amount of power, its thermal resistance must be minimized in order to keep its temperature rise to a minimum. A dual subscript on a thermal resistance is used to indicate the resistance at the junction of two materials. For example, θ_{SA} refers to the resistance at the junction of the heatsink (S) and ambient air (A).

Various kinds of semiconductors can withstand different maximum temperatures. Germanium, for example, can tolerate temperatures from 85°C to 100°C, whereas silicon can tolerate from 150°C to 200°C. Generally, however, we try to avoid operating semiconductor devices at such elevated temperatures, because performance decreases drastically when that is done.

For example, the input leakage current of some op-amps doubles each time junction temperatures increase 10°C. For another example, the graph in Fig. 2 shows the effect that temperature has on the maximum power that a typical power transistor can handle. Below about 25°C, the transistor can handle 90 watts of power. But above that temperature, the maximum power that the transistor can dissipate decreases linearly, until, at 100°C, the transistor becomes inoperable. Clearly, then, the more power we need the transistor to dissipate, the lower we must keep its temperature.

Why does the transistor get so hot? We must remember that both the emitter-base and the collector-base junctions generate heat. However, since the collector-base junction is reverse-biased, it has higher resistance, and it thereby produces more heat. In fact, the collector-base junction produces so much more heat than the forward-biased emitter-base junction that the heat generated by the latter may usually be ignored. Doing so allows us to simplify the power-dissipation equation considerably:

$$P_D = I_C \times V_{CE}$$

Here P_D refers to the power dissipated by the transistor; I_C refers to its collector current, and V_{CE} refers to the voltage across the transistor's collector and emitter. As you might suspect, P_D in this electrical equation may be related mathematically to P_D in the thermal equation cited above.

TABLE 1—ELECTRICAL AND THERMAL UNITS

Electrical			Thermal		
Quantity	Unit	Symbol	Quantity	Unit	Symbol
Voltage	Volts	V	Temperature	°C	T
Current	Amps	I	Heat Flow	W	P_D
Resistance	Ohms	R	Thermal Resistance	°C/W	θ

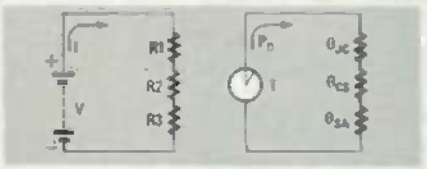

FIG. 1—THERMAL AND ELECTRICAL FLOW are similar conceptually and mathematically.

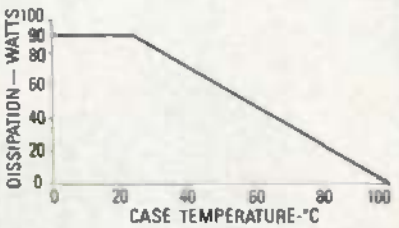

FIG. 2—A TYPICAL POWER TRANSISTOR'S ability to dissipate power decreases rapidly above a case temperature of about 25 °C.

As you know, placing resistors in parallel makes it easier for current to flow. Heatsinks work on the same principle; paralleling thermal resistances makes it easier for heat to flow. So by paralleling the heat-radiating mass and surface area of a semiconductor's case with a heatsink, thermal resistance is lowered, and that allows a more effective path by which heat may flow. Theoretically, in fact, an infinitely large heatsink should reduce thermal resistance to zero. Fortunately, we should never need an infinitely large heatsink—we couldn't manufacture one even if we did need it. What size do we need for a given application? As we'll see, it's rather simple to calculate.

Heatsink calculations

We may rewrite our previous thermal equation in terms of power dissipation as:

$$P_{D(max)} = (T_{J(max)} - T_{A(max)}) / \theta_{JA}$$

Here T_J is the maximum junction temperature (in degrees Celsius) that we wish our transistor to tolerate, T_A is the maximum ambient air temperature (in degrees Celsius) in which we expect our circuit to operate, and θ_{JA} represents the total thermal resistance encountered by the heat trying to escape our device.

That thermal resistance may be broken down into several series resistances that are merely added together:

$$\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA}$$

We may state that relationship in words by saying that the total thermal resistance from junction to air (θ_{JA}) equals the sum of the resistances from junction-to-case (θ_{JC}), case-to-heatsink (θ_{CS}), and heatsink-to-air (θ_{SA}). We obtain θ_{JC} from a data book describing the device used; the other two values must be calculated or assumed. Let's see how, given the following:

- $T_{A(max)} = 60°C$
- $T_{J(max)} = 125°C$
- $I_{C(max)} = 0.8$ amps
- $V_{CE(max)} = 10$ volts

We can see immediately that eight watts (10 volts × 0.8 amps) of power must be dissipated. Typically, a TO-3 case can safely withstand about 2.8 watts; a TO-220 case, about 1.8 watts; a TO-202 case, about 1.5 watts; and small TO-39 and TO-92 packages can handle only about two-thirds of a watt.

If we're using a 78XX-series voltage regulator in a TO-220 case, we must, therefore, provide heatsinking to dissipate an additional 8 − 1.8 = 6.2 watts. Checking the data sheets, we see that the 7800 series has a θ_{JC} = 5°C/W. Rearranging our previous thermal equation, we find that:

$$\theta_{JA} = (T_J - T_A)/P_D$$

Plugging our assumed values in, we find that θ_{JA} = (125 − 60)/(0.8 × 10) = 8.13 °C/W. The sum of the thermal resistances must equal 8.13, and, since θ_{JC} = 5 °C/W:

$$\theta_{CS} + \theta_{SA} = 3.13$$

Now if we use silicone thermal grease between the heatsink and the case of the transistor, we can approximate that θ_{CS} = 0.13°C/W (we'll show you why in a minute), so that leaves θ_{SA} to provide the additional 3°C/W of thermal resistance. The nomograph in Fig. 3 may be used to determine the size of an appropriate heatsink. Note that, to achieve a thermal resistance of 3°C/W, a vertically-mounted piece of aluminum 3/16-inch thick must have an overall surface area of 22 square inches.

However, surface area is not the only thing to consider when designing heat-

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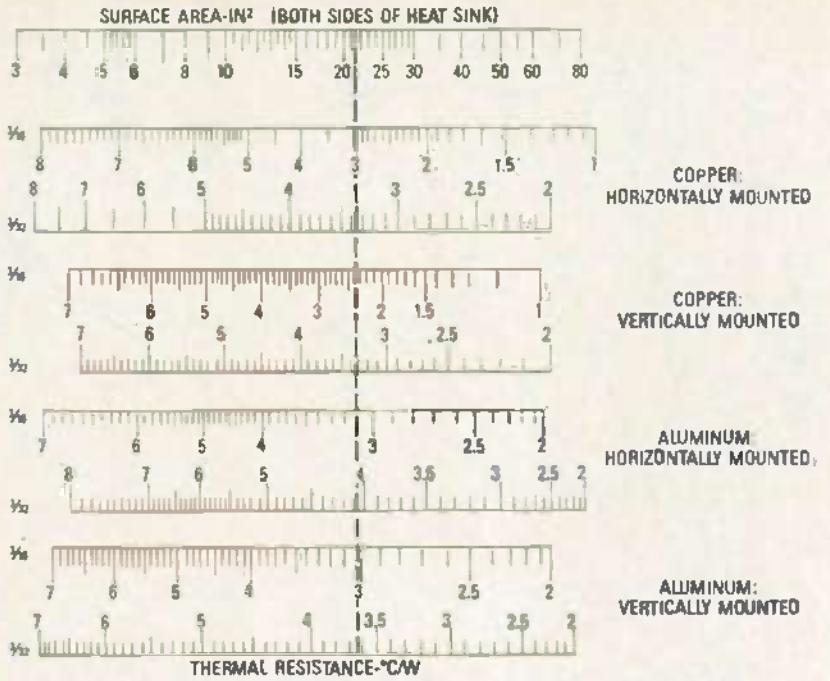

FIG. 3—DETERMINING SURFACE AREA of a heatsink is easy with this nomograph.

sinks. We must also take account of the material the heatsink is made of, the heatsink's surface finish, and the manner in which the heat-generating device is coupled to the heatsink.

The two most popular materials for heatsinks are copper and aluminum. Copper has a thermal conductivity four times that of aluminum, but it also costs much more. Aluminum is, therefore, used more often. Other materials are used to combat special problems. For example, magnesium is very light, and beryllium oxide (BeO) is an excellent insulator.

Emissivity is the term describing the effectiveness with which a given surface radiates energy; in Table 2 we show emissivities of several typical heatsink surfaces. In general, a larger value of emissivity means a better ability to radiate heat. Note that black oil-painted heatsinks radiate most effectively. Commercially available heatsinks are therefore usually painted (or anodized) black.

The third heatsink design consideration is that of device coupling. Often we cannot simply bolt a heat-generating device directly to a heatsink because doing so would cause the device's electrical output to be shorted to ground. To avoid that sort of problem, we usually use a washer that has both low thermal and high electrical resistance. There are three materials commonly used for such washers: mica, anodized aluminum, and beryllium oxide.

Mica is the most commonly used, and anodized aluminum is also fairly widely used, although if the surface of the latter is scratched, an electrical short may result. Beryllium oxide performs better than mica or anodized aluminum, but, unfortunately, it is toxic in powdered form and when vaporized. In Table 3 we compare the thermal resistance of those three insulators to that of an insulator-less junction, both with and without silicone grease. As you can see, the lowest resistance is provided using no insulator and silicone grease; that is what allowed us to assume the value of 0.13°C/W in the discussion above.

TABLE 2—EMISSIVITY OF COMMON HEATSINK SURFACES

Surface	Emissivity (E)
Polished Aluminum	0.05
Polished Copper	0.07
Rolled Sheet Steel	0.66
Oxidized Copper	0.70
Black Anodized Aluminum	0.7—0.9
Black Air Drying Enamel	0.85—0.91
Dark Varnish	0.89—0.9
Black Oil Paint	0.92—0.96

TABLE 3—THERMAL RESISTANCE (°C/W) WITH AND WITHOUT SILICONE GREASE

Insulator	Without	With
None	0.20	0.10
Teflon	1.45	0.80
Mica	0.80	0.40
Anodized aluminum	0.40	0.35

Guide to heatsink use

After all surface-area and thermal-resistance calculations are done, there are a number of practical steps one can take to help increase the effectiveness with which a heatsink dissipates heat:

- Avoid mounting voltage-sensitive devices (power transistors, regulators, etc.) next to other heat-generating components, like power resistors.
- When using heat-sensitive devices in smaller packages (TO-5, TO-39, TO-92), keep lead lengths to a minimum, and maximize copper runs on the PC board.
- Make sure that the heatsink-to-device interface is very flat. With larger heatsinks, that becomes difficult; so, for good thermal conduction, use a thin layer of silicone grease, such as Dow Corning 340, General Electric 662, or Thermalloy's *Thermacote*. Such "grease" is actually a metallic-oxide-filled silicone compound; it effectively increases the surface contact of the two mating devices by filling in air gaps and scratches.
- When a device must be electrically insulated from its heatsink, use an insulating washer 0.003- to 0.005-inch thick. Doing so increases thermal resistance, but that can be partially offset by applying silicone grease to both sides of the washer.
- When using a finned heatsink, maximum heat dissipation will occur when the fins are vertically oriented.
- Be very careful bending the leads of power-sensitive components. Hairline cracks can drastically reduce their heat-dissipating ability.

New heatsinking products

Several manufacturers have introduced products recently in an effort to simplify assembly of heatsinked components. For example, Chomerics Laminates, Inc. (77 Dragon Court, Woburn, MA 01888) has developed a "greaseless" thermal washer, the Cho-Therm *1678*, which is a rugged fiberglass-cloth reinforced, boron-nitride-filled silicone-elastomer material that provides exceptionally good thermal conductivity.

A similar heatsink washer is manufactured by Berquist (5300 Industrial Blvd., Minneapolis, MN 55435); it is shown in Fig. 4 beside a traditional silicone "glob" assembly. The Berquist unit does not require thermal grease, and has a special laminate that helps suppress EMI.

AAVID Engineering (One Kool Path, Laconia, NH 03246) has developed the new heatsink, shown in Fig. 5, for use with plastic DIP's. That slide-on heatsink has two conducting surfaces (one on the

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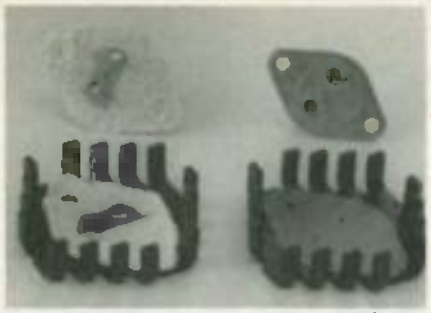

FIG. 4—THE GREASELESS THERMAL WASHER on the right replaces the messy assembly on the left.

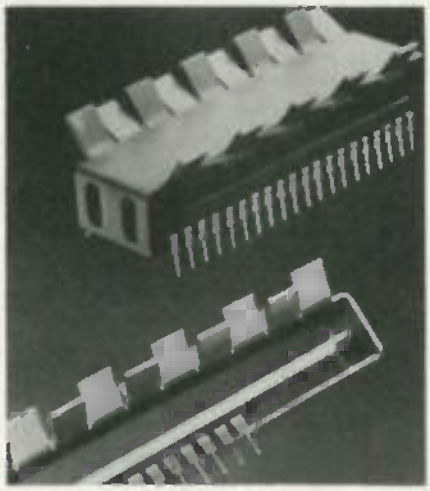

FIG. 5—THIS SLIDE-ON HEATSINK allows an IC to operate 10°C cooler and still dissipate the same amount of power.

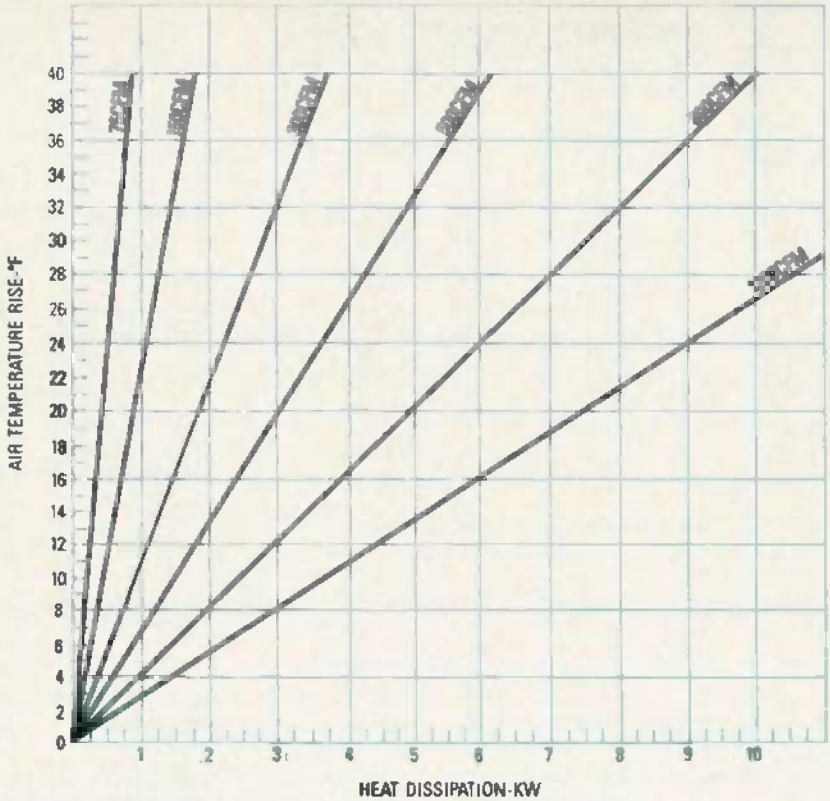

FIG. 7—AIRFLOW is related to temperature rise and heat dissipation for higher-powered units than the nomograph in Fig. 6.

top, and one on the bottom) that provide more effective conduction. Fins are slotted and staggered, to provide better convection. The 40-pin DIP shown in the photo dissipates one watt in normal operation; using the heatsink allows the IC to operate 10°C cooler.

So far we have focused our attention mostly on thermal conduction and radiation using heatsinks. At times, however, heatsinks alone cannot provide sufficient cooling; and that forces us to consider the third means of keeping components and assemblies cool: forced-air convection cooling. Basically, there are four convection-cooling methods

- Forced-air convection cooling
- Air-to-air heat exchange
- Air-to-water heat exchange
- Air conditioning

We will discuss convection cooling and air-to-air heat exchangers in this article. The final two cooling methods are not covered here.

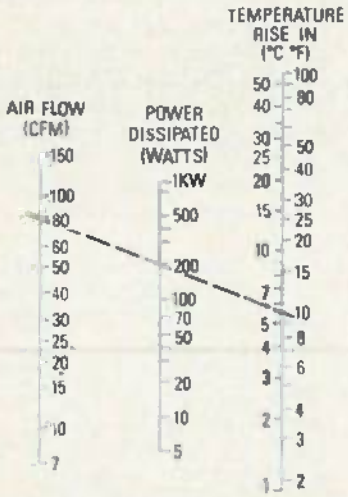

FIG. 6—AIR FLOW IN CFM may be determined easily, given temperature rise and power dissipated.

Fans and blowers

The main component of a blower is a wheel that revolves to displace air; blowers are most efficient when operating near maximum static (non-moving) pressure. The main component of a fan is a propeller blade; fans operate best when moving large volumes of low-pressure air.

Cost (and noise) considerations aside, using a blower to pressurize a cabinet by pumping filtered air in is far more desirable than using a fan to exhaust air. The main advantage is that cracks between panels, around doors, etc., are better used as part of the exhaust area than as sources for the intake of dust and dirt.

For forced-air cooling systems:

- The cross-sectional area of the air stream throughout the flow path should be approximately equal to the total effective area of the intake.
- The exhaust area must be located "downstream" from the heat-producing components.
- A baffle may be used to channel a small volume of air across a hot component at high velocity.
- Ducts may be used to maintain even cooling throughout the cabinet. If an even temperature must be maintained throughout a cabinet vertically, place ducts along the sides of the cabinet.

Calculating the size fan necessary to achieve a specific cooling effect is simple. The volume of air required at the inlet equals 1.76 watts × 1.25/°C, or 3.17 watts × 1.25/°F. The power to be dissipated is expressed in watts, and the temperature rise in the cabinet is expressed in the first equation in degrees Celsius, and in the second, in degrees Fahrenheit. The constant 1.25 provides a 25% safety factor. You may calculate air flow using the equation above, or simply use the nomograph in Fig. 6. The graph in Fig. 7 provides a way of determining the air flow for dissipating power in the kilowatt range.

Now let's go through a design example. Assume we have to dissipate 200 watts of power, and that we can only withstand a 10°F rise in temperature in the cabinet. Our formula is: Air flow = (3.17 × power in watts × 1.25)/°F. So (3.17 × 200 × 1.25)/10 = 79.25 cubic feet per minute (CFM). Note that the dashed line in the nomograph in Fig. 6 indicates a flow of approximately 80 CFM.

That's all we have room for now. Next time, we'll look at yet more convection-cooling schemes and then turn our attention to air-to-heat exchangers. R-E

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Repairing Compact Disc Players

Compact disc players are the most exciting development in audio in years. In this article we'll show you how those devices work, and how you can repair them when something goes wrong.

Part 3 THIS MONTH, WE'LL continue our look at CD player service by looking at some more typical player circuits. We'll also look at the mechanical systems found in a CD player, and finally begin to examine some adjustments that you can make.

Figure 13 shows the D/A converter and audio circuits. The D/A converter IC406 is a 16-bit device and is capable of producing 65,536 audio-output levels. The audio is amplified by IC407 and multiplexed into right and left channels by a sample-and-hold circuit, IC408; the operation of IC408 is regulated by the controller. (Note that only the left-channel circuitry is shown in Fig. 13.) When the left-channel is in the sample status (audio from IC406 is passing), the right-channel is being held (audio not passing), and vice versa. The S/H outputs are amplified by IC409, and applied through low-pass filter CP501 to amplifier IC503. Filter CP501 produces a sharp dropoff between 20 and 25 kHz, so any frequencies above the audio spectrum that might produce distortion are rejected. Further filtering and amplification are performed by IC503 and IC504, both of which are preamp IC's with equalization or emphasis networks. In some cases, the networks are under control of relays and switches (RY552 in the circuit of Fig. 13), which are in turn controlled by the system microprocessor.

The outputs of both channels are routed to the rear and front panels. In Fig. 13, there are both fixed and variable outputs on the rear panel, and a variable output at the front panel (for the headphones). In most players, the audio outputs can be muted by relays. In this circuit the audio outputs are applied to the outputs through RY551. That relay is under the control of the mute signal generated by the system microprocessor; that signal is designated MUT. The same signal is also used to mute the digital signal path.

Figure 14 shows the slide or pickup motor control circuits. A motor is required to keep the beam moving across the disc at a constant speed, even though the

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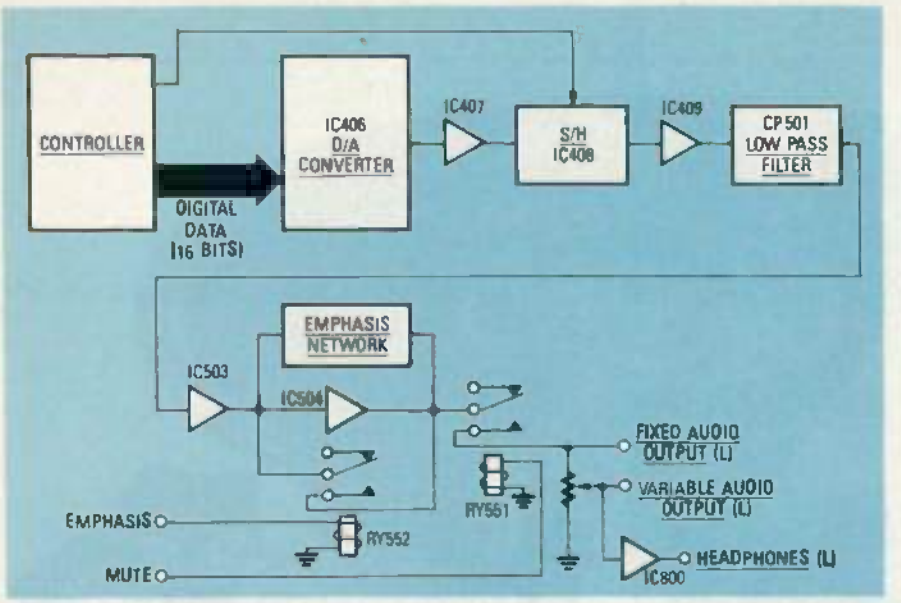

FIG. 13—THE D/A CONVERTER converts the 16-bit digital information into an audio signal. Only the left-channel circuitry is shown here.

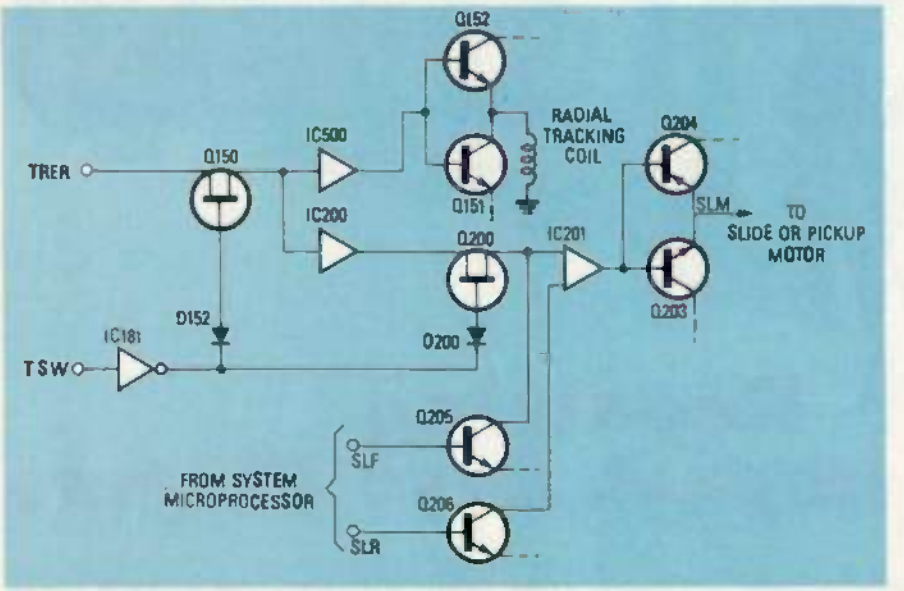

FIG. 14—THE SLIDE- (or pickup-) motor control circuit is used to keep the pickup moving across the disc at a constant speed.

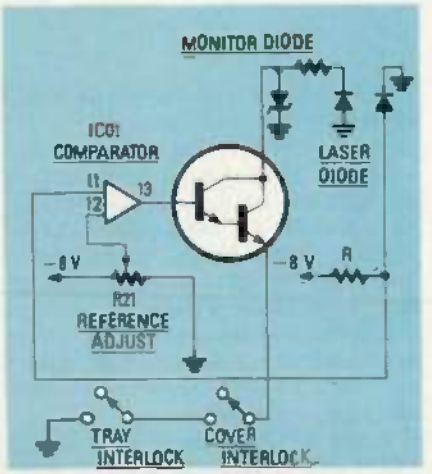

FIG. 15—THIS CIRCUIT MONITORS and controls the amount of light emitted by the laser diode.

disc speed changes. The radial tracking error or TER signal is applied to the slide motor as a fine control. The TER signal is applied through Q150, low-pass filter IC200, analog switch Q200, amplifier IC201, and drive transistors Q203 and Q204. The direction of current through the motor (and the direction of motor rotation) is set by the polarity of the signal applied to Q203 and Q204. Note that the TER signal is passed only when there is a TSW (*T*racking *SW*itch) signal from the microprocessor. The TSW signal is inverted by IC181, and applied to Q150 (through D152) and Q200 (through D200), permitting the TER signal to pass.

During search operation, the pickup must move at a faster rate than during normal play. This is done by SLR and SLF pulses from the microprocessor. The SLR and SLF pulses, applied through Q205 and Q206, produce inputs to IC201 much larger than the inputs from Q200. That produces increased current in Q203 and Q204, and increases the slide motor speed.

The laser monitor and control circuits are shown in Fig. 15. It is necessary to monitor and control the amount of light emitted by the laser diode to ensure proper performance of the player optics. (A low output from the laser can produce tracking errors, as well as audio dropouts.) In those circuits, the output of the monitor diode is applied to the input of a comparator within IC01. The other input to the comparator receives an adjustable reference voltage. If the laser-diode output goes above the desired reference level, the monitor-diode output increases, and the comparator output goes more positive. That reduces the laser-diode output back to normal. It is possible to set the amount of laser output by setting the reference voltage (with R21) to IC01.

The laser diode is cut off when the outer cover is removed or when the tray is in the extended position (ready to insert or remove a disc.) That prevents the user from coming in direct contact with the laser. The drive circuits are controlled by two series-connected microswitches. Both switches must be closed (player cover in place and tray retracted) before the drive circuits can pass the comparator output to the laser diode.

Figure 16 shows the disc-drive motor-control circuits. A CD player disc is rotated at a varying speed so that the rate at which the track is moving with respect to the pickup is constant. Speed variations are necessary since there is less data on the tracks near the inside of the disc (start) than near the outside (end); that's because the tracks are of different lengths. Most CD players use some form of "unitorque" motor with Hall-effect elements to get the variable speed. Typically, disc speed varies from about 480 rpm (inside) to 210 rpm (outside) so as to maintain a constant linear velocity (CLV) of about 1.25 to 1.3 meters per second.

Looking at Fig. 16, the Hall-effect elements are used to monitor and maintain motor speed; their outputs are fed to the control circuits, which in turn control the current fed to the motor-drive windings. In addition to speed information from the motor itself, the Hall-effect elements are fed signals from the controller under the direction of the system microprocessor; those signals contain information that pertains to the appropriate motor speed at a particular moment and are derived by the CLV signals within the controller. The CLV circuits set the appropriate motor speed by monitoring the EFM (*E*ight-to-*F*ourteen *M*odulation) signal to determine the rate at which information is passing the pickup.

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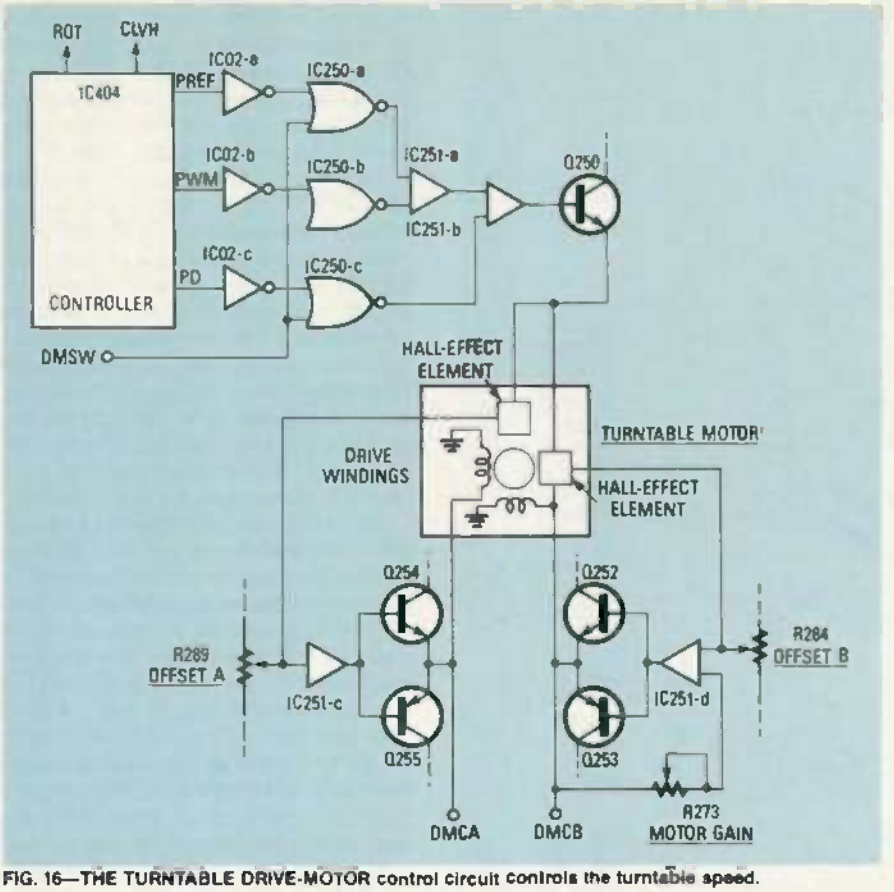

FIG. 16—THE TURNTABLE DRIVE-MOTOR control circuit controls the turntable speed.

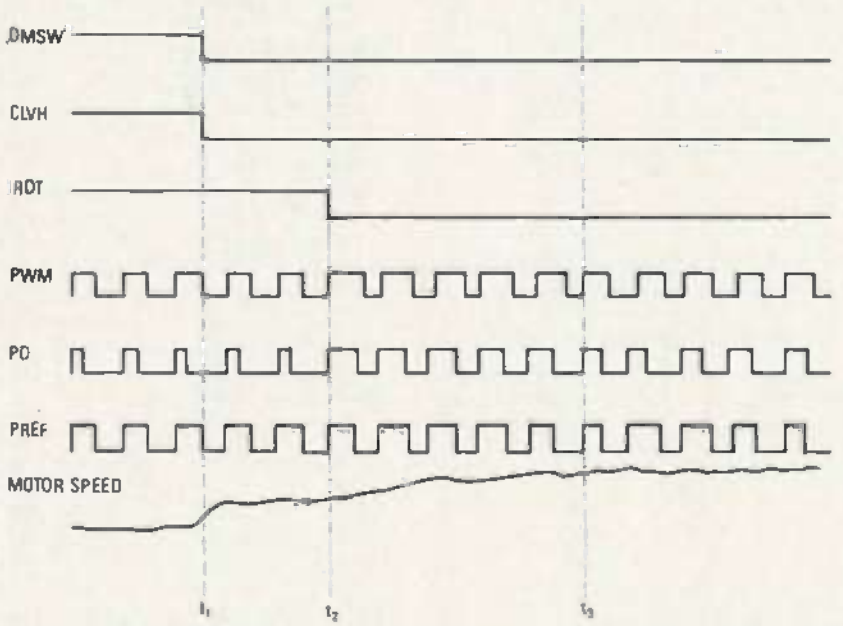

FIG. 17—TURNTABLE MOTOR-CONTROL signals. Note the relationships between the various signals.

Figure 17 shows the relationships of the signals that control the drive circuits in Fig. 16. The outputs of the Hall-effect elements are applied to the motor windings through Q252–Q255, and amplifiers within IC251. Resistors R284 and R289 provide for offset or balance adjustments, and R273 sets the gain. Operation of the disc motor can be divided into two phases: *start servo* and *regular servo*.

Let's start with the *start servo*. When power is first applied, the disc motor runs free, the DMSW and CLVH signals are low, and the ROT output is high (as shown in Fig. 17). Under those conditions, the motor accelerates, and begins to turn at a constant velocity. IC404 produces essentially similar outputs at PMW, PREF, and PD. After a free-run period (set by the system microprocessor), ROT goes low and the motor starts to accelerate. The EFM signal is read by IC404, and compared to a reference. The difference between the reference and the EFM is the PWM output from IC404. During the acceleration portion of initial read, the PWM duty cycle(which varies above and below 50% as determined by motor speed) is compared with the PREF signal (which has a fixed duty cycle). The result of that comparison is applied to the motor circuits to control speed.

Looking next at the *regular servo*, when the motor reaches the desired speed, the PWM signal has a 50% duty cycle, and the pickup reads the disc data at a constant linear velocity. That condition is maintained with a ±1% accuracy by means of the PD pulse from IC404. The duty cycle of the PD pulse is set by comparing the EFM signal to a reference within IC404. In turn, the PD signal is compared with the output from the PWM and PREF comparator (IC251). The result of that comparison is applied to the motor to maintain the ±1% accuracy.

CD mechanics

The mechanical systems in a CD player perform two primary functions: loading and unloading the disc, and driving the optical pickup across the disc. In horizontal front-load players, the tray is opened by a drive motor, a disc is inserted (manually) in the tray, the tray and disc are returned within the player (by the same drive mechanism, and usually the same drive motor). Some front-load players use a fourth drive motor to clamp or "chuck" the disc onto the turntable. Operation of drive motors is controlled by limit switches and the system microprocessor, so it is necessary to study both the mechanical drawings and the wiring. We give you both in this section, but keep in mind that the descriptions here are "typical," and must be compared with the descriptions found in the service literature.

Figure 18 shows the major mechanical components of a CD player. Note that most of the components are part of a *unit mechanism* secured to the mainframe by two rails. The *tray* is moved out of the player front panel by the loading motor (LIDM). This action also raises the *clamp* or *chuck*. A disc is installed manually in the tray, and the tray is pulled within the player by the LIDM. That action also lowers the clamp so that the disc is pressed against the *turntable motor assembly*. In most players, the coil assembly can be separated from the turntable motor, and replaced as a separate component.

As shown in Fig. 19, the LIDM receives open/close drive signals from the system microprocessor through IC110 and Q116/

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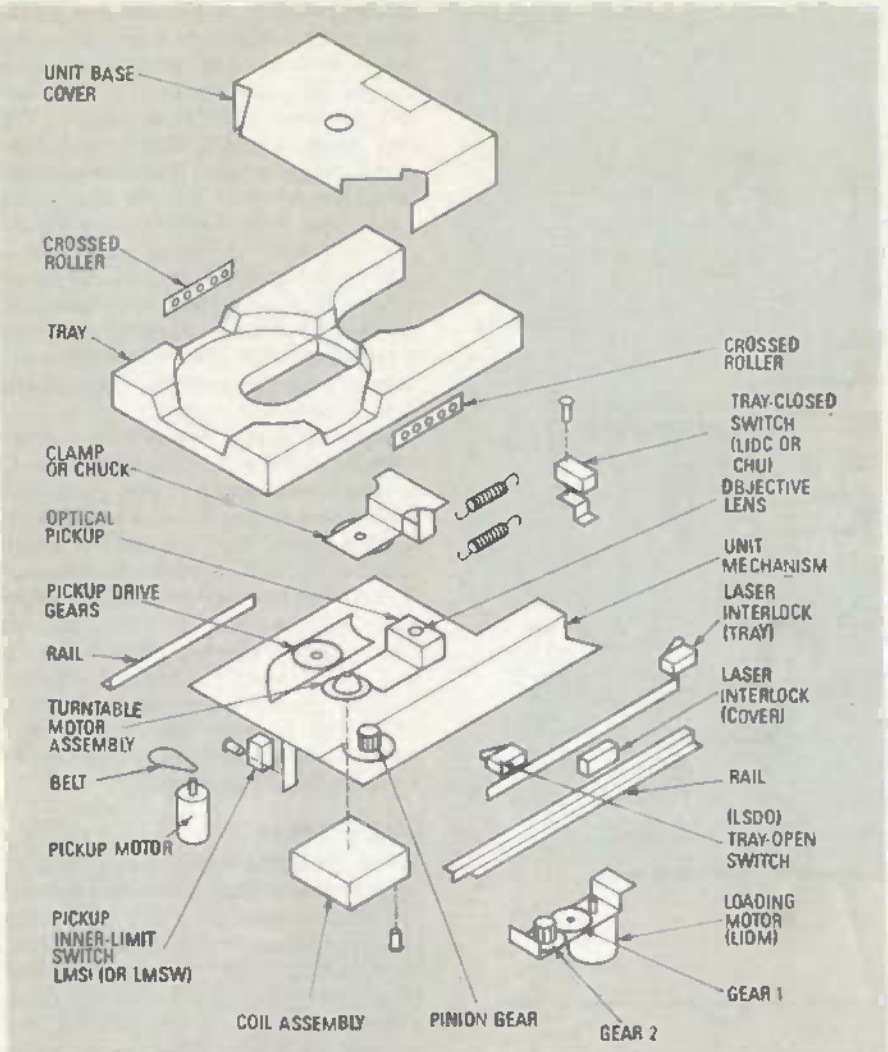

FIG. 18—THE MAJOR MECHANICAL components of a CD player. Most of the components shown are part of the "unit mechanism," which is secured to the main part of the player via two rails.

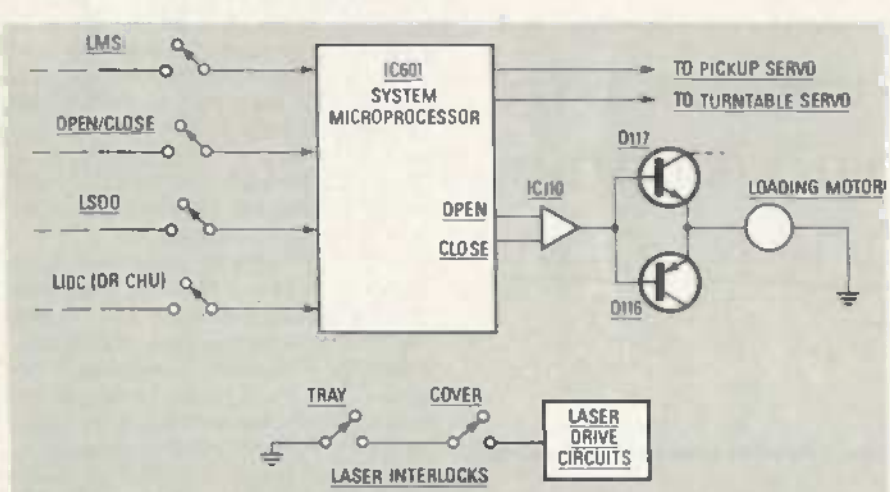

FIG. 19—THE FUNCTION OF most of the mechanical systems in the player are controlled by the microprocessor.

Q117. In turn, the microprocessor receives control signals from the front-panel OPEN/CLOSE switch. The microprocessor also receives indicator signals from the tray-open (LSDO) switch and the tray-closed (LIDC) switch. The LIDC switch is actuated only when the tray is in, and the clamp is in the fully-down position. The LIDC switch is called the chuck or CHU switch in some literature. The LSDO is set to actuate when the tray has just reached the correct open limit, and thus cuts off the loading motor. No matter what it is called, the LIDC or CHU switch actuates when the tray is in and the clamp is fully down, cutting off the loading motor.

The *optical pickup assembly* is driven across the disc by the pickup motor, which is connected to the *pickup drive gears* by means of a *belt*. (On most players, the belt can be replaced when covers are removed, without removing the pickup or motor.) The system microprocessor receives a signal from the pickup inner-limit (LMSI) switch, which is set to actuate and turn off the drive motor when the pickup reaches the inner limit (start) of the disc. (Again, to confuse you, the LMSI switch is often called the LMSW switch).

The entire unit mechanism can be replaced as an assembly (on most players). Some manufacturers also recommend replacement of the motors and limit switches (and they describe the procedures for replacement/adjustment). The mechanical section is one area where most CD player service literature is very good. (If only the other sections were that clear!) So we will not dwell on mechanical replacement/adjustment here. However, as a practical matter, *never disassemble* the unit mechanism beyond the point necessary to replace or adjust a given part. *Never* make any adjustments unless the troubleshooting procedures lead you to believe that adjustment is required.

Adjusting CD players

The adjustment sections of most CD player literature are good, up to a point. That is, they give you the step-by-step procedures, and show you the physical location of the adjustment controls. Unfortunately, they do not tell you what you are doing when you make the adjustments. We will bridge that gap by describing the adjustment procedures for a typical CD player, using adjustment diagrams not found in any service literature.

Laser diode output

Normally, the laser diode should not be adjusted unless the pickup has been replaced or troubleshooting indicates a laser problem. Also, be aware that laser diodes can be damaged by current surges. Typically, the laser diodes used in CD players have drive-current limits in the 40- to 70-mA range, though some may be as high as 100 mA. Generally, 150 mA is sufficient to damage (if not destroy) any CD laser diode. Note that as laser diodes age they may require more drive current to produce the required light. If the current is increased for that reason, it should obviously be kept within the "safe" limit for the diode.

That's all we have room for now. When we continue, we will show you how to adjust the laser's output. R-E

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DESIGNING WITH DIGITAL IC'S

One-shots and clocks are among the most important digital circuits. This month we learn about those circuits and how they are used.

JOSEPH J. CARR

Part 8 THE MONOSTABLE multivibrator (or "one-shot") can be used in a variety of applications. Those circuits are used to clean up noisy digital signals, to "stretch" pulses, as timers, and on and on. The circuit is termed "monostable" because it has only one stable output state. That stable state might be either high or low depending on the design. Normally, the monostable remains in the stable state. But when a valid trigger pulse is received, the monostable goes to the unstable state, but only for a predetermined period of time. The monostable output then reverts back to the stable condition.

There are two main categories of monostable multivibrators: retriggerable and nonretriggerable. Of those, the latter is the type most people think of when considering those circuits. Thus, unless otherwise stated, assume that a monostable multivibrator is nonretriggerable.

Figures 1 and 2 show the timing diagrams for the two types of monostables. Figure 1 shows a nonretriggerable monostable in which the stable state is low. A trigger pulse is received at time t_1, so the output snaps high and remains so for period T. When period T expires, the output returns to the low state. It remains low until another valid trigger pulse is received (t_4).

The essential characteristic of a nonretriggerable circuit is shown in Fig. 1. That characteristic can be seen by examining what happens at t_2. At that time, a second trigger pulse is received, but since the output is in the unstable (active) state that pulse is ignored. The pulse at time t_2 has no effect on the output; such a trigger pulse is considered invalid.

One common application of nonretriggerable monostables is switch debouncing. Ordinary mechanical switches are quite noisy when the contacts close. That's because the two electrical contacts inside the switch "bounce" one or more times before a solid connection is made. The period of contact bounce might be several milliseconds, during which each bounce creates a noise pulse. Those pulses can cause many problems for digital circuits, so they must be suppressed.

To use a nonretriggerable monostable for that task, select one whose output period, T, is longer than the bounce period (5 ms, for instance). When the monostable is inserted in series with the switch, its output will go high when the first bounce pulse is received, and will remain in that state until after the bounce pulses die out. As for the balance of the digital circuit, all it will see is the 5 ms one-shot pulse; it is thus spared the indignity of a noisy signal.

The timing diagram for a retriggerable monostable is shown in Fig. 2. Again, the period of the monostable multivibrator is T, which is initiated by a trigger pulse at time t_1. Normally, the output would remain high until T expired at time t_3. But at time t_2, a second trigger pulse is received. That pulse "retriggers" the circuit for another period T. The total time that the output remains high is not 2T, but T plus the expired portion of the first period (i.e. $T + (t_2 - t_1)$).

One application of the retriggerable monostable is in alarm circuits designed to monitor repetitive events. For example, consider its use in a medical respiration alarm. The alarm senses the patient's breathing and generates a pulse in response to that breathing that is used to trigger the monostable. The period of the monostable is set such that a normal breathing pattern will cause continuous retriggering. If the breathing pattern is disrupted, the monostable does not receive a retriggering pulse so the circuit "times out" and the alarm sounds.

Some circuit examples

The simple circuit of Fig. 3 is an example of a half-monostable or quasi-monostable multivibrator. A1 is a CMOS inverter (or a CMOS gate wired as an inverter). When a trigger pulse is received, the output will snap low (active), and it remains low for a period of time determined by the values of R1 and C1. A serious constraint on that circuit is that the trigger pulse must be longer than the output period set by R1 and C1. As shown, the circuit goes low on the positive (leading) edge of the triggering pulse; that is called positive-edge triggering. To obtain negative-edge triggering (triggering on the negative, or trailing edge of the pulse), tie R1 to +V instead of ground.

Figure 4 shows a monostable based on a 4013 CMOS D flip-flop. In that circuit, the D input of the 4013 is connected to +V, so that input is always high. The CLR

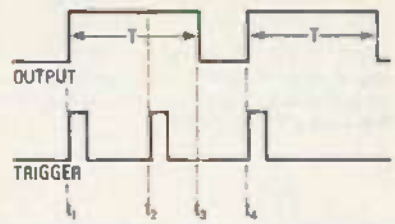

FIG. 1—TIMING DIAGRAM for a non-retriggerable monostable multivibrator.

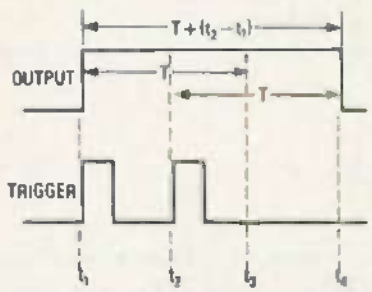

FIG. 2—TIMING DIAGRAM for a retriggerable monostable multivibrator.

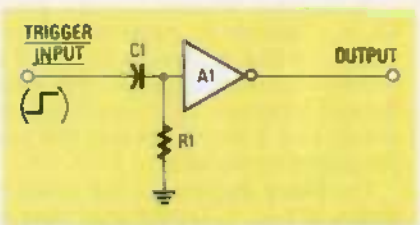

FIG. 3—INVERTER-BASED monostable multivibrator. As shown, the circuit is positive-edge triggered.

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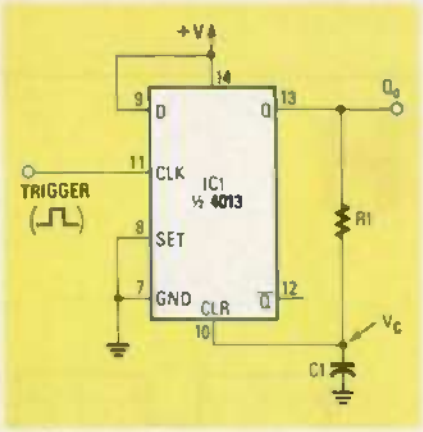

FIG. 4—A FLIP-FLOP can be configured as a monostable multivibrator. Here is one circuit that uses a 4013 D flip-flop.

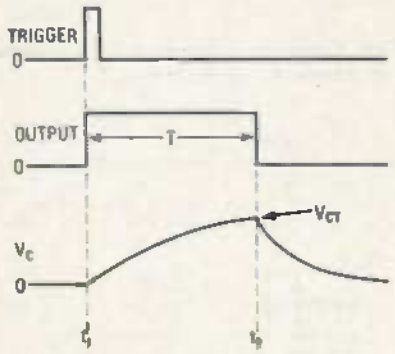

FIG. 5—TIMING DIAGRAM for the circuit shown in Fig. 4.

input is connected to capacitor C1, so it will initially be low. That input will go high, however, when the voltage across C1, V_C, reaches the appropriate level. Since C1 is charged through R1, which is connected to the Q output, C1 will reach the level where the CLR input will go high at some time T after Q goes high (the time determined by the value of R1 × C1).

The timing diagram for that circuit is shown in Fig. 5. Immediately prior to time t_1, the voltage across C1 (i.e. V_c) is zero, and the Q output is low. At t_1, a trigger pulse is received, which causes the Q output to go high. That causes a current to flow through R1, which causes C1 to charge and V_C to rise. Voltage V_C will continue rising until it reaches the "clear trip" voltage. That is the voltage required at the CLR input to force the Q output low. At that instant, t_2, Q snaps low and capacitor C1 begins discharging through R1. The output was high for a fixed period ($t_1 - t_2$) that was determined by the time constant R1 × C1 and the voltage required to clear the flip-flop.

But note what happens between time t_2 and t_3. That time is a "refractory" period during which the flip-flop either won't retrigger, or will produce an erroneous output period, because capacitor C1 was partially charged at the instant the trigger pulse was received (i.e. V_C is not 0).

The refractory period can be shortened considerably by the adding a quench diode (D1 in Fig. 6) to the circuit. The quench diode is placed in parallel with R1 in such a way that it is reverse-biased when Q is low (or unbiased if V_C is less than or equal to 0.6 volts). During the active period ($t_1 - t_2$), diode D1 is reverse-biased so it will not affect the timing. (An exception to this rule is long-duration timers where the value of R1 is very large, and the leakage resistance of D1 is less than 100 × R1.) But when the flip-flop is cleared, and Q goes low, voltage V_C forward-biases D1, forcing it to conduct. The charge on C1 is thus "dumped" through diode D1, shortening the discharge time and, as a result, the refractory time.

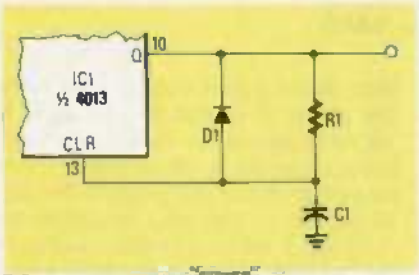

FIG. 6—ADDING A QUENCH DIODE shortens the refractory period.

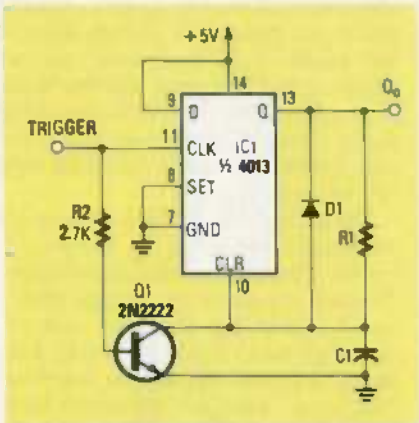

FIG. 7—THE CIRCUIT of Fig. 4 can be made retriggerable by modifying it as shown here.

Figure 7 shows a version of the retriggerable monostable built around a D flip-flop. In that circuit, a transistor switch is added. Its purpose is to discharge V_C when a positive trigger pulse is received. Such a pulse will forward bias Q1, thereby connecting its low collector-emitter resistance across C1. That transistor must have a high enough beta to be fully saturated by the trigger pulse, and a $V_{CE(SAT)}$ rating of 0.6 volts or less.

Note that neither circuit shown in Fig. 5 and Fig. 6 will return to exactly 0 volts until long after the $t_1 - t_2$ period has expired. That's because D1 will quench V_C down to only 0.6 or 0.7 volts, which is the level required to forward-bias the diode. Normally, however, that poses no serious problems.

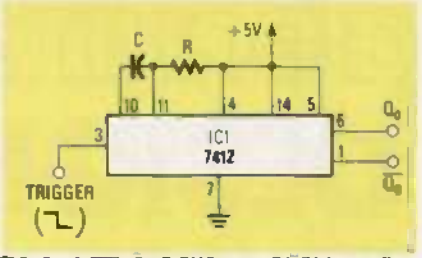

FIG. 8—A TTL ONE-SHOT, the 74121 is configured here to be negative-edge triggered.

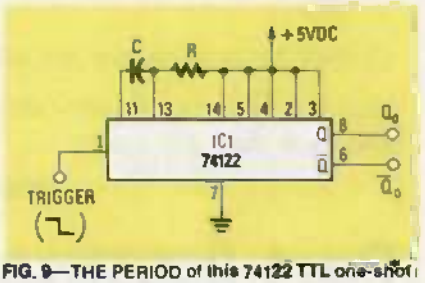

FIG. 9—THE PERIOD of this 74122 TTL one-shot is determined by R1 and C1.

A pair of TTL one-shot devices are shown in Figs. 8 and 9: the 74121 and 74122. Both of those devices are shown with negative-edge triggering inputs. The period of the output pulse is determined by: T = 0.69R1C1, where T is the period in seconds, the resistance of R1 is measured in ohms, and the capacitance of C1 is measured in microfarads.

That relationship can be rearranged to yield either C1 or R1 in terms of T, which is the usual situation when selecting values. (Normally, we know the desired T, will select an arbitrary C1, and then calculate R1.) Let's work out an example. Suppose we want a 10 microsecond (10μs) pulse. Let's select a trial value of .001 μF for C1 and see if the required value of R1 is reasonable:

$$R1 = T/0.69C1$$

$$R1 = \frac{1 \times 10^{-6}}{(0.69)\ 1 \times 10^{-9}}$$

$$R1 = 14{,}493 \text{ ohms}$$

For most applications, a 15 kilohm unit (a standard value) can be used.

Both 74121 and 74122 are TTL devices, so the Q output will be 0 to 0.8 volts for low, and 2.4 to 5.0 volts for high. The $\overline{Q}$ outputs use the same voltages levels.

The 555 is an extremely popular timer/oscillator that uses bipolar technology. The device will operate at supply voltages ranging from +4.5- to +18-volts DC, so it is compatible with most IC digital logic families. In addition, standard 555 outputs sink or source up to 200 mA of current, so the device can be used to drive relays, LED's, and some incandescent lamps without the need for external transistors.

Figure 10 shows a 555 configured as a monostable multivibrator. The trigger in-

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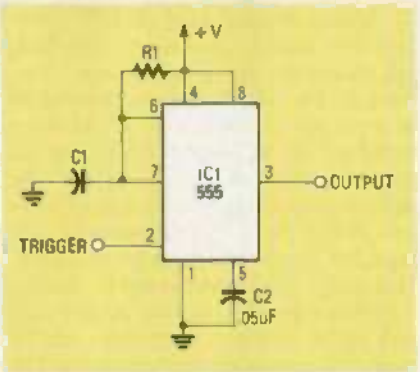

FIG. 10—A POPULAR DEVICE. the 555 timer IC is shown here configured as a monostable multivibrator.

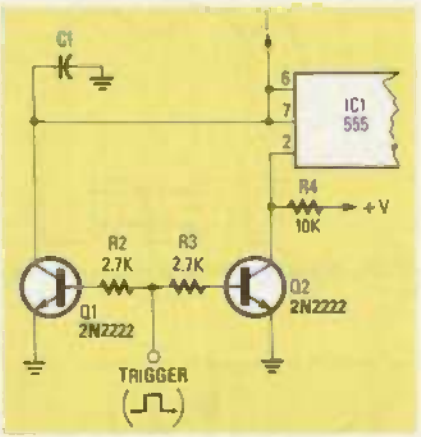

FIG. 11—THE CIRCUIT of Fig. 10 can be modified to make it retriggerable as shown here.

put is normally high. That input must be dropped below $+V/3$ for triggering to occur. When such a trigger pulse is received, the output terminal snaps high for a period that is determined by $T = 1.1R1C1$, where T is the time in seconds, the resistance of R1 is measured in ohms, and the capacitance of C1 is measured in farads.

For example, find the period of the output pulse when $R1 = 47K$ and $C1 = 0.1\mu F$. Solving, $T = (1.1)(47{,}000)(1 \times 10^{-7})$; $T = 0.0052$ seconds $= 5.2$ ms.

A retriggerable 555 monostable multivibrator circuit is shown in Fig. 11. Similar to the D-flip-flop based circuit we looked at earlier, that circuit uses an external transistor switch to dump the charge in the timing capacitor. Both transistors are turned on by the positive-going trigger pulse.

Note that the polarity of the trigger pulse is reversed from the circuit of Fig. 10. Normally, the trigger input of the 555 (pin 2) is held at $+V$ by pull-up resistor R4. But when a positive trigger pulse forward-biases Q2, pin 2 is brought near ground—so triggering is effected. At the same time, transistor Q1 is also forward-biased, so it will have an extremely low collector-emitter resistance. Since that resistance is shunted across capacitor C1, the charge on C1 is bled off rapidly to ground. That action has the effect of resetting the timing of the output pulse to zero. The output pulse will remain high for period $T = 1.1R1C1$, plus whatever percentage of the period that had expired prior to receipt of the second trigger pulse.

Our last monostable multivibrator is the operational amplifier version shown in Fig. 12; its timing diagram is shown in Fig. 13.

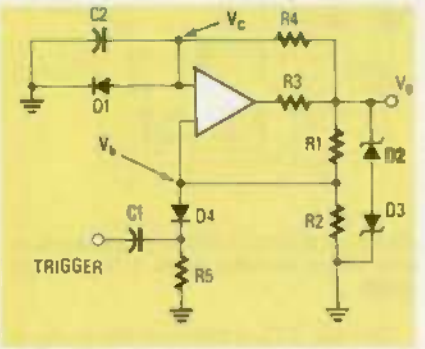

FIG. 12—AN OP-AMP COMPARATOR is used here as the heart of a monostable multivibrator.

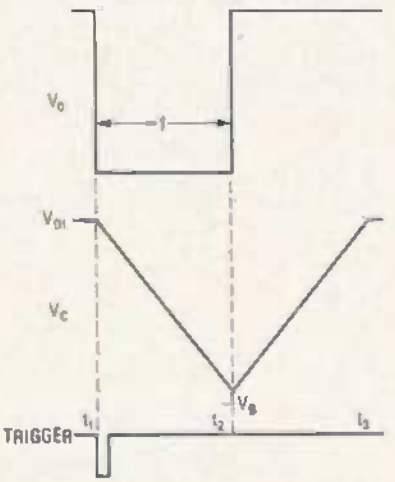

FIG. 13—TIMING DIAGRAM for the circuit of Fig. 12.

That circuit uses an operational amplifier as a comparator. A comparator is an op-amp that is used to compare the relative states of its two inputs. Thus, if one input is a known reference level, and the other is variable, the output of the comparator will indicate whether the variable input is at a higher or lower voltage than the reference.

The stable state of the circuit in Fig. 12 is high. While the circuit is in that stable, untriggered state, the output is at $+V_O$, while V_C is clamped to approximately 0.7 volts by diode D1. On receipt of a trigger pulse, the output snaps to $-V_O$, which causes V_C to begin charging through R4 towards $-V_O$. At some point (t_2), $-V_C$ will be equal to $-V_B$, and the output will snap high again (clamped to 0.7 VDC by D1). The duration of the active-low output pulse ($t_1 - t_2$) is:

$$T = (RC)\ln\frac{1 + (V_{D1}/V_O)}{1 - \beta}$$

Where T is the output duration in seconds, R is the resistance of R4 in ohms, C is the capacitance of C2 in farads, and β is equal to $R2/(R1 + R2)$. If V_O is much greater than V_{D1}, and $R1 = R2$, then that equation can be simplified to $T = 0.69RC$.

Diodes D2 and D3 are used to clamp the output to some specific value. $+V_O$ is clamped to $V_{D2} + 0.7$ volts, while $-V_O$ is held to $V_{D3} + 0.7$ volts. Normally, $V_{D2} = V_{D3}$, and the output voltage is symmetrical.

Clocks

Many circuits and devices depend upon a clock signal for proper operation. Even, certain circuits made from non-clocked devices require a clock signal for synchronization of events.

But, what is a clock signal? It is a chain of squarewaves or pulses that is generated by a circuit called an astable multivibrator. As its name indicates, an *a*stable is a circuit that has no stable states. Once triggered the output of the circuit will snap back and forth between high and low.

Some of the clock circuits we'll be looking at in the rest of this article are based on inverters (TTL or CMOS). Instead of using dedicated IC's to generate a clocking signal, it is often possible to use spare NAND or NOR gates to form inverters. Figures 14-*a* and 14-*b* show two ways to use two-input NAND gates as inverters—either tie both inputs together or tie the unused input permanently high. Figures 14-*c* and 14-*d* show how NOR gates can be used as inverters. That is done either by tying the two inputs together, or by tying the unused input *low*.

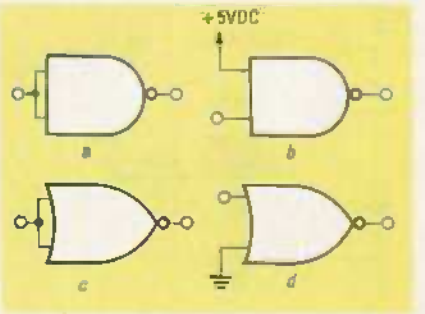

FIG. 14—INVERTERS can be fashioned from leftover NAND and NOR gates.

TTL Clocks

Figure 15 shows the use of two TTL inverters (or inverter-connected gates per Fig. 14) in a clock circuit. Two resistors are used to bias the inverters, and each resistor is connected from the output back

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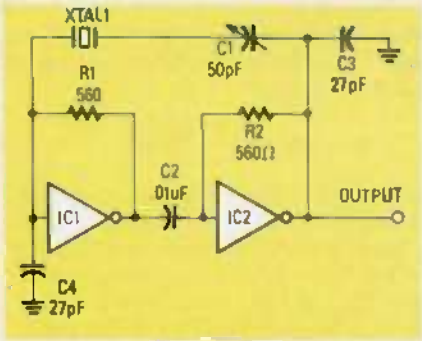

FIG. 15—TWO INVERTERS are used in this astable multivibrator.

to the input of its own inverter. The output of IC1 is capacitor-coupled to the input of IC2. A feedback network, consisting of a variable capacitor and a crystal, determines operating frequency. That network is connected between the output of IC2 and the input of IC1.

The operating frequency is determined mainly by the crystal, and to a lesser degree by capacitor C1. The effect of C1 is to change the resonant frequency of the crystal a small amount by changing its capacitive load. Thus the capacitor acts as a "fine-tuning" control. If operating frequency is not critical, C1 can be replaced with a fixed capacitor.

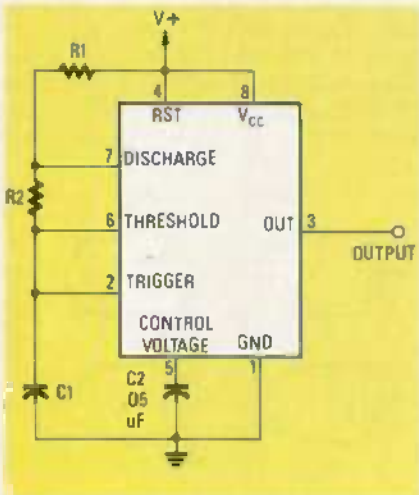

FIG. 16—THE FREQUENCY of this 555-based astable is determined by R1, R2, and C1.

The clock circuit shown in Fig. 16 is based upon the 555 IC timer. The output frequency is a function of R1, R2, and C1, and is found from:

$$f = \frac{1.44}{C1(R1+2R2)}$$

where f is the frequency in hertz, the resistances of R1 and R2 are measured in ohms, and the capacitance of C1 is measured in farads.

Note that the 555 is not actually a TTL circuit. It is a bipolar IC that can operate at supply voltages from +4.5- to +18-volts DC. If a supply voltage of +5 is used, then the 555 will work with TTL circuits. The 555 output (pin 3) will sink or source up to 200 mA, so it can drive more TTL devices than a "standard" TTL output.

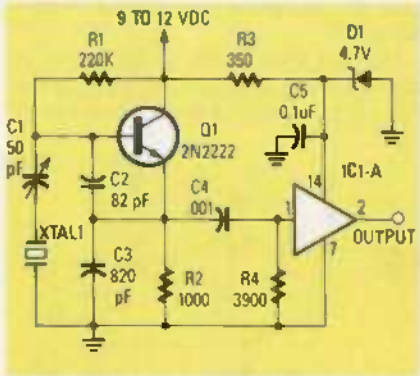

FIG. 17—IN THIS TTL-COMPATIBLE astable a bipolar crystal oscillator drives a 7414 Schmitt trigger.

One last TTL-compatible clock circuit is shown in Fig. 17. That circuit uses a bipolar crystal oscillator that drives a 7414 TTL Schmitt trigger. The oscillator shown operates from about 700 KHz to 15 MHz, depending on the crystal used. The exact frequency is set by using trimmer capacitor C1. Ordinarily one would not use a circuit such as the one shown in Fig. 17 unless a precise oscillator frequency is required.

CMOS clock circuits can operate from a wider range of supply voltages than TTL, and they generally require less current. Several different forms of CMOS astable multivibrator/clock circuits are possible.

Figure 18 shows a simple RC-timed circuit based on the 4093 CMOS Schmitt trigger. The trigger-circuit output will snap high when a positive-going input reaches a given voltage (V1), and snaps low when the same input voltage reaches a second point (V2) in the negative-going direction. The values of V1 and V2 vary with supply voltage used. In the circuit shown, when +V = 5, V1 = 2.9 and V2 = 2.3; when +V = 10, V1 = 5.9 and V2 = 3.9. The hysteresis of a Schmitt trigger is V1 − V2, so it is 0.6 volts when +V = 5, and 2 volts when +V = 10.

The 4093 is basically a two-input NAND gate with Schmitt inputs. Since one input is tied permanently high, circuit action is controlled entirely by the input that is connected to R and C. When power is first

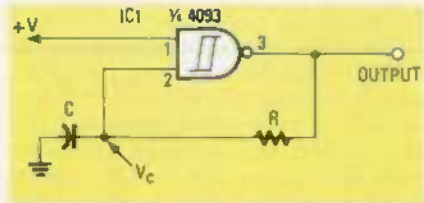

FIG. 18—THIS CMOS ASTABLE is based on the 4093 Schmitt trigger.

applied, the voltage across the capacitor, V_C, is zero, so the input to the 4093 is low. Given the rules for NAND-gate operation, that means that the output is high. Thus, one end of resistor R sees a high potential so capacitor C charges at a rate determined by the RC time constant and the output voltage. When V_C reaches the positive-going trip point, the output snaps low. At that point, the voltage across the capacitor begins to discharge through R. That discharge continues until V_C reaches the lower trip point, and the output snaps high again. That process repeats, and the result is a squarewave output (see Fig. 19).

Figure 20 shows another CMOS clock circuit; that one is based on either a pair of

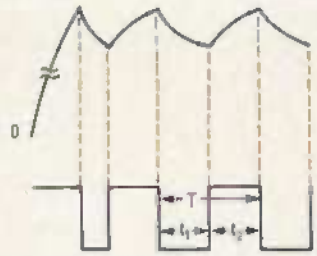

FIG. 19—TIMING DIAGRAM for the circuit of Fig. 18.

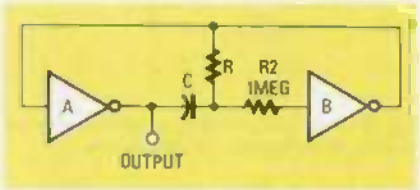

FIG. 20—THE OUTPUT FREQUENCY is determined by the values of R and C.

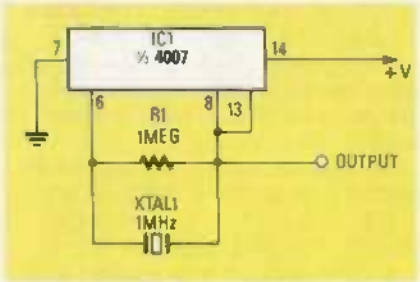

FIG. 21—THE CRYSTAL in this circuit controls the operating frequency.

inverters or inverter-connected gates. The circuit of Fig. 20 bears a certain similarity to the TTL oscillator shown earlier, but its frequency is determined by the R/C combination (not a crystal). The operating frequency, in hertz, is approximately 1/(2.25RC), where R is measured in ohms and C in farads.

A 1-MHz CMOS crystal oscillator, based on the 4007 is shown in Fig. 21. The crystal in the feedback path controls the operating frequency.

The so-called "classic" CMOS crystal oscillator shown in Fig. 22 first appeared in some of the earliest RCA applications

continued on page 112

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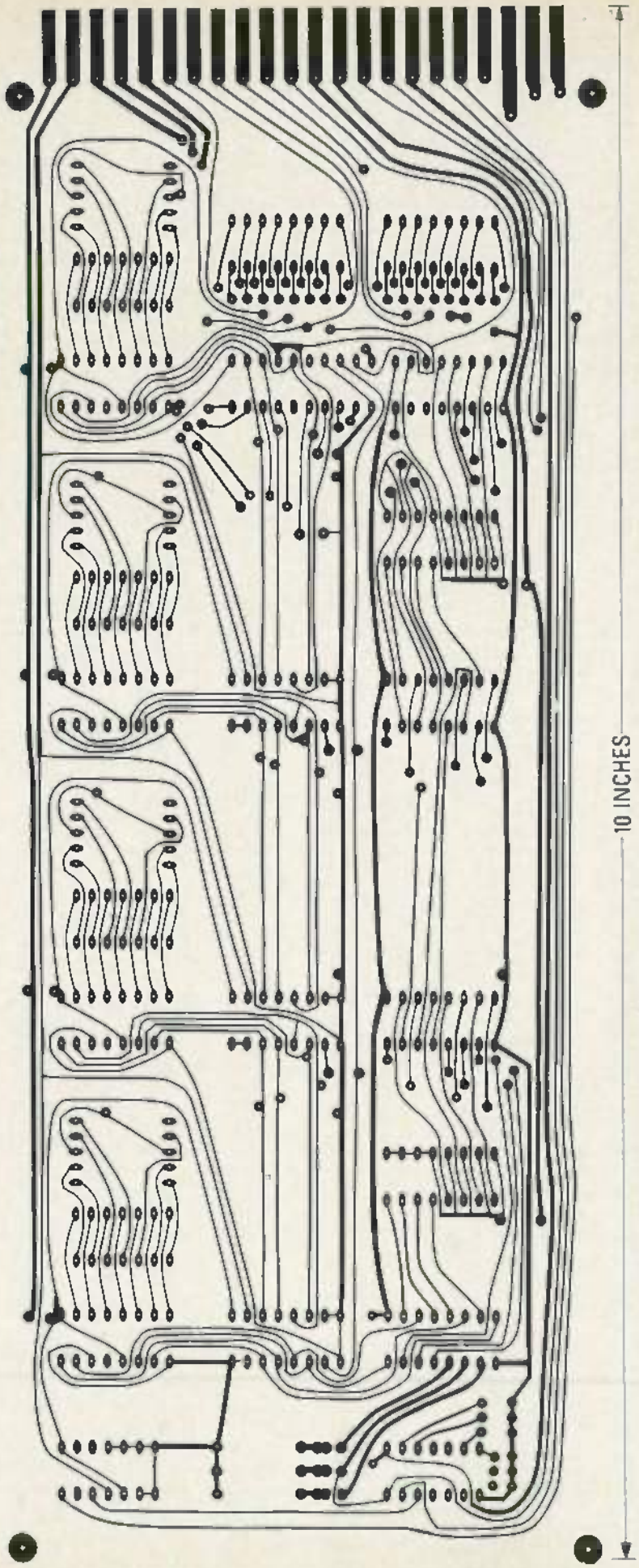

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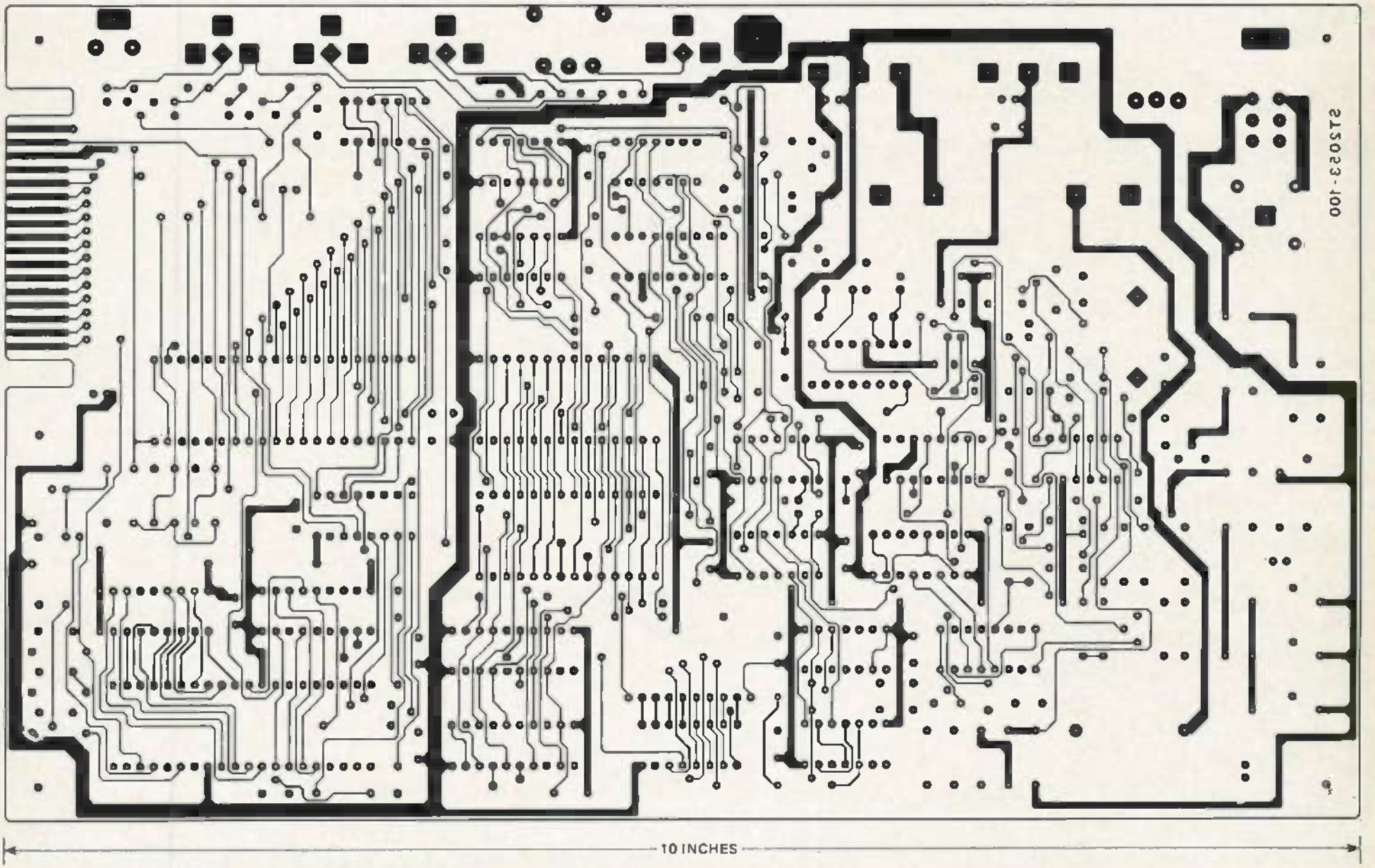

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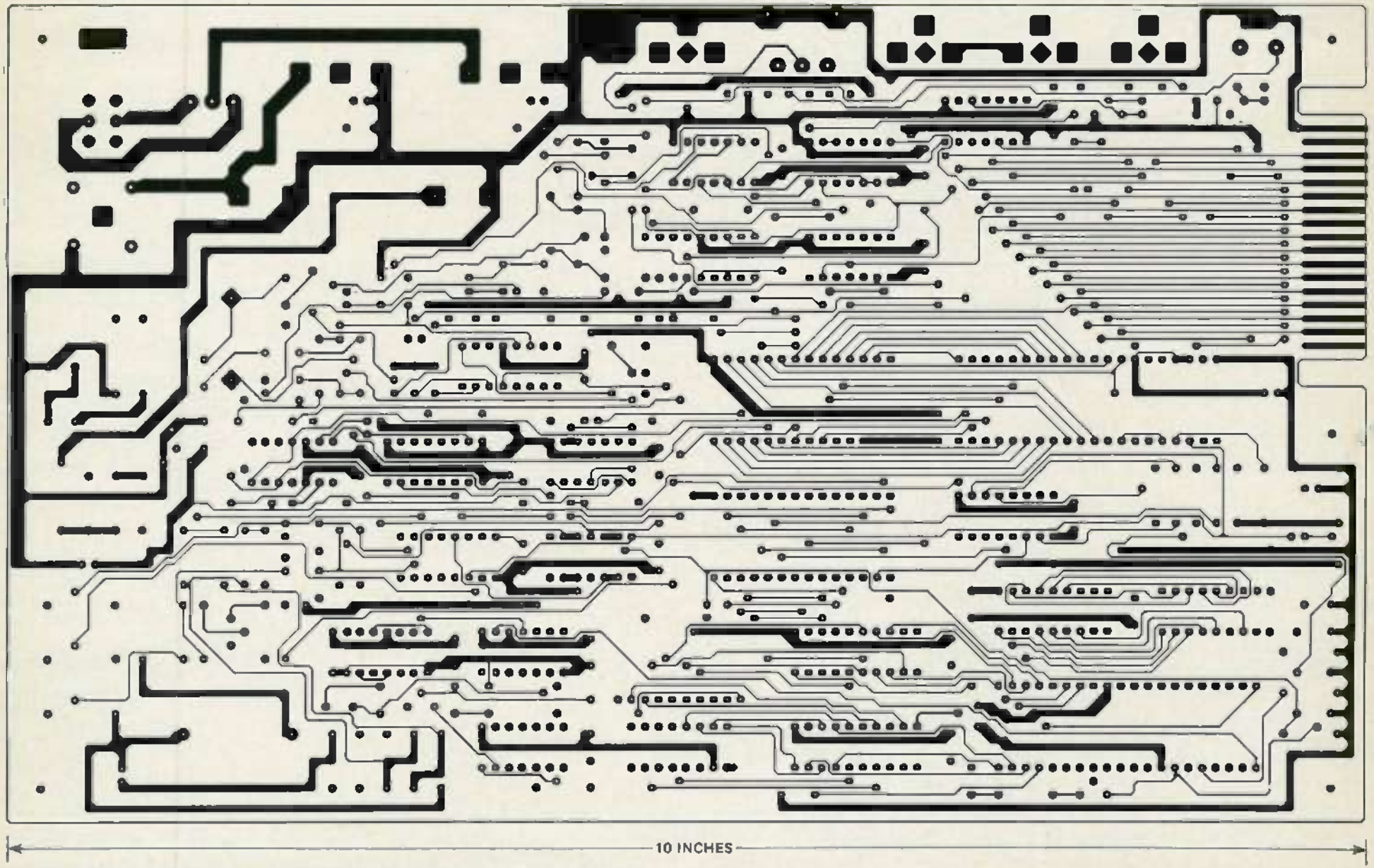

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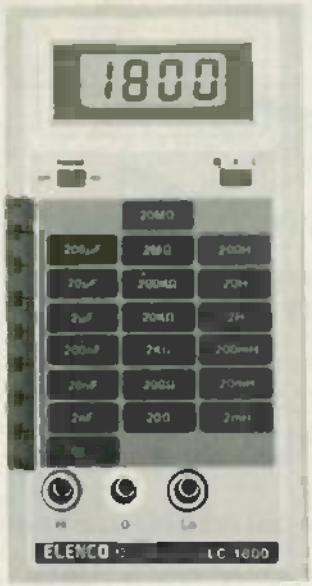

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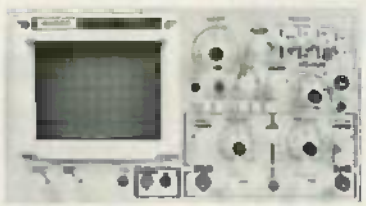

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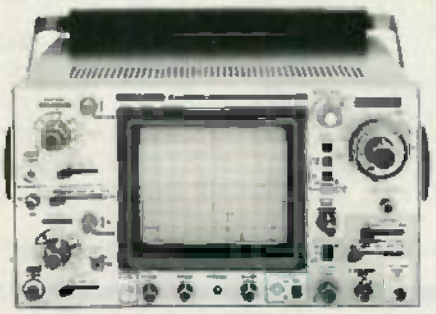
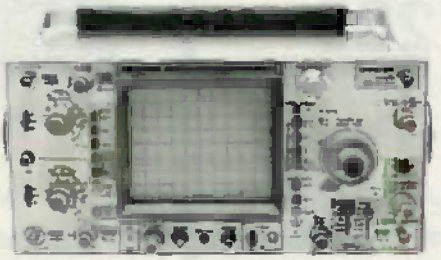


LBO 524L DC to 40 MHz

The LBO-524L is designed to meet a broad range of applications in design, testing and servicing of both analog and digital circuits and equipment. Its large 8x10 cm PDA CRT provides sharp, bright displays even at highest sweep rates. Comprehensive triggering controls including holdoff, alternate triggering and delayed sweep triggered functions permit stable displays for even the most complex signals. With 0.5 millivolt sensitivity, extremely low-level signals can easily be observed. A channel 1 output is available on the rear panel to drive other less sensitive instruments such as a frequency counter with an input level as low as 500 microvolts. The dual time base permits accurate observation and time interval measurements of complex waveforms. Includes probes and 2 year warranty.

$749.00 *Plus free Hitachi DMM. See page 5.*



LBO-516 DC to 100 MHz

The LBO-516 is an economical 100-MHz, 3-channel, alternate time base oscilloscope. It has all of the important features that are expected in a 100-MHz oscilloscope such as full front panel operation, alternate triggering for simultaneous view of asynchronous signals and independent or simultaneous display of main and delayed time bases. The bright 20-kV PDA CRT and 0.5mV sensitivity permit sharp, bright displays of even those normally tough to see critical signals.

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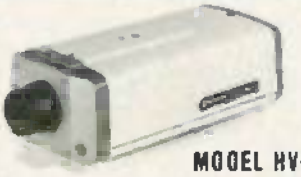

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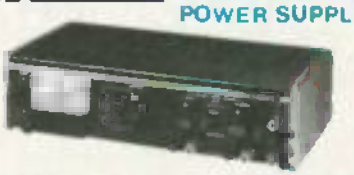

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ROBOTICS

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ROBOTICS EDITOR

Robots and voice recognition

THERE ARE FEW THINGS MORE FRUSTRATING than buying one of today's high-tech home appliances and finding out that you have to sit down and read the manual simply to turn the machine on, much less to use it. The ever-increasing performance we demand from our appliances is making it difficult to perform even simple tasks with those machines. And the problems we have communicating with home appliances are miniscule in comparison with the problems we have communicating with robots. But the two are similar in that both involve communication from a living being to an electro-mechanical device.

If you've had an opportunity to work (or play) with a hobby robot, I'm sure you're well acquainted with the fact that there are more than a few not-so-trivial commands to master. Home robots are intended to be used by electronics hobbyists who are familiar with many concepts of computer programming. However, the hobbyist might welcome an easier method of communicating with his robot than the cryptic control language usually provided by the manufacturer. (I think that the popularity of Apple's Macintosh computer also illustrates the point that many people are looking for a more natural way of interacting with computers.) There is no inherent reason for robot communication to occur in a highly technical language.

Communication levels

There are basically three levels of communication: The lowest level is called the device level. From there we move up to the pro-

tocol level, and finally to the presentation level.

The device level is probably most familiar to electronics hobbyists. At that level are the actual electrical connections between two communicating parties. The famous (or infamous) RS-232C is one much-used device-level communications standard. It specifies voltage levels and timing sequences for the serial transmission of data among computers, peripheral devices, and other computers. Since it involves serial transmission, only a few electrical connections are necessary. That may be an advantage when mobility is important—as in robot control.

There are other device-level interfaces by which we might communicate with a robot (parallel, HPIB, RS-422, etc.), but what is important is to bridge the gap from device- to presentation-level communications, that is, the level at which information is presented to human beings. One very effective means of communication is oral. For example, programming your robot by simply stating the commands is probably one of the most desired items on many wish lists.

You might say "keep dreaming," but I've just been playing with the neat voice-recognition system shown in Fig. 1. It sells for only $99; it's called EARS (for Electronic Audio Recognition System); and it requires a separate personal computer to operate. It's available from Speech Systems, 38W 255 Deerpath Road, Batavia, IL 60510.

The reason I'm so impressed with EARS is that in my office I have a voice-recognition system that cost well over $5000 when it was introduced, and the accuracy of the new unit appears to be better than that of the higher-priced system. EARS is also more versatile.

The CoCo connection

I do a tremendous amount of robot-control work using a simple *TRS-80 Color Computer* (CoCo for short). The 64K model sells for well under $200, and it has the most advanced graphics BASIC of all the eight-bit personal computers. The 6809-microprocessor bus is accessible through a cartridge port connector, and the EARS system plugs directly into that bus.

Because the system is well integrated into the *Color Computer*, voice recognition can be an integral part of your BASIC programs. So it is simple to write a program to recognize your spoken commands and translate them to the commands required by your robot. Those commands could then be sent out the *Color Computer*'s RS-232 port to your robot. You can train EARS to recognize 64 different words, sounds, musical notes, etc.

The voice-recognition hardware is contained in a small module that

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Do you hear bullets ricocheting across your living room, or turbulent waterfalls crashing down the stairs when you watch TV?

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consists of a PC board with a General Instrument SP1000 IC, and assorted bus-interface circuitry. The manufacturer provides a useful control program and several useful demonstration programs. Also, an optional speech-synthesis unit is available at extra cost.

The control program gives fifteen new commands to the *Color Computer's* BASIC. The most important are LISN and MATCH. For example, if you want the computer to learn how you pronounce the word *robot*, you type LISN "ROBOT". The computer and EARS then wait for you to say "robot" into the microphone (which is provided with EARS). Your voice is sampled, stored in memory, and it will be associated from then on with the string "ROBOT". You may save the word patterns in memory to disk or tape and reload them later.

When you type the command LISN:MATCH, the computer and EARS again wait for you to speak, but this time, your speech sample is compared to all the patterns you have stored in memory. The string representing the closest match will be returned.

Remote communication

Using a computer to control your robot from a remote location is useful, but it might be even more useful to build your robot with a computer as its (local) brain. I know what you're thinking, but the answer is no, you don't need a 117-volt AC power source for the computer! Many computers use only five volts internally. A twelve-volt car battery with a suitable DC-to-DC converter will work just fine. In fact, next month we'll look into ways of doing just that. R-E

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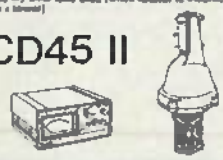

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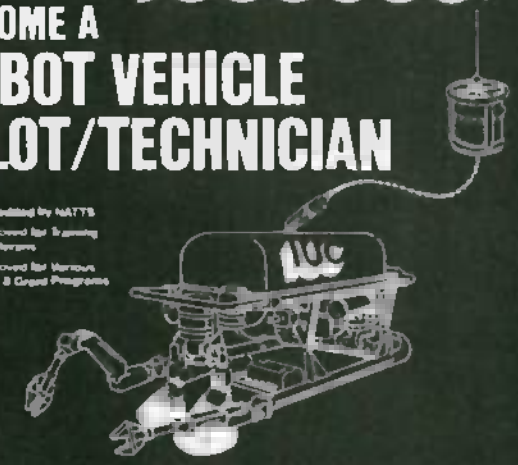

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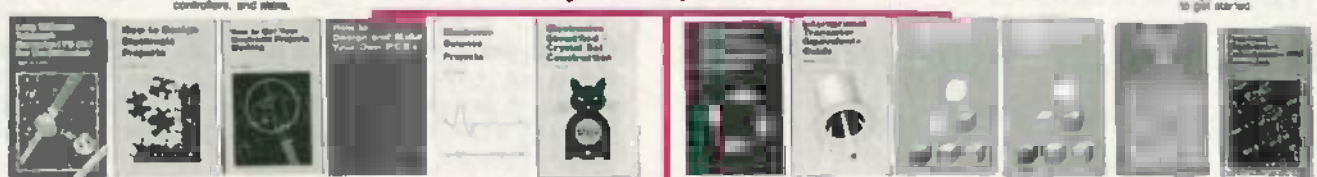

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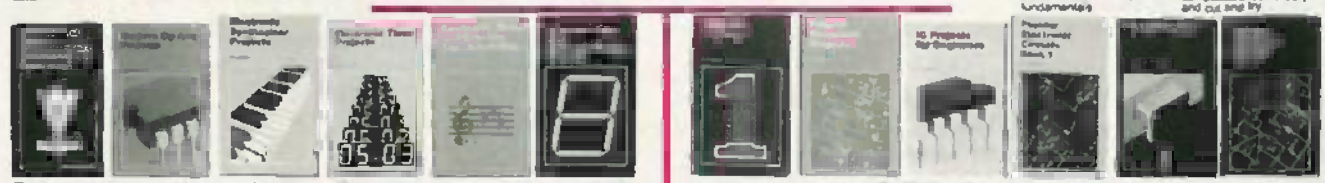

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CIRCLE 302 ON FREE INFORMATION CARD

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THE MARK III

HV CIRCUIT SCANNER

- ★ Checks the horiz output circuit for open / shorts.
- ★ Checks the flyback, yoke, PC, and HV mult.
- ★ Checks all scan derived B+ sources.
- ★ Checks all circuits that rely on scan derived B+ voltage.
- ★ Checks for open safety capacitor.
- ★ Checks the emitter circuit of the horiz output.

THEN,

- ★ Provided the green normal light is lit, the Mark III will safely power up the TV set so that you can "look" for open circuits by examining the picture on the CRT.
- ★ Circumvents all start up and horiz drive related shut down circuits.

APPLICATIONS: The Mark III will analyze the horiz, flyback, hi-voltage, scan derived B+ sources, yoke, pin cushion, HV multiplier circuits in any TV set that employs either an NPN transistor or a single SCR for its horiz output device. This applies to any age, any model, any chassis, any brand - - - including Sony.

In brief, the "test" function scans for shorts, the "run" function permits you to observe any "open" circuits via the symptoms that appear in the CRT screen.

HOOK - UP: Simply remove the set's horiz output device and replace it with the scanner's interface plug. No wires to disconnect, no other connections required (not even a ground connection).

MISTAKE PROOF: No damage will result if an error is made during hook up. The scanner simply won't turn on until the error is corrected.

PUSH THE TEST BUTTON Just one of the four lights will lite.

RED OPEN LIGHT means the emitter circuit of the horiz output stage is open (no ground path).

YELLOW SHORT LIGHT means the flyback primary, HV multiplier, vertical output, horiz driver, and R-B-G color output stages are **not** shorted. Instead, a circuit that normally draws a small amount of current is shorted (i.e. the tuner, IF, AGC, video chroma, matrix, vertical or horiz oscillator).

RED SHORT LIGHT means either the flyback, the HV multiplier, the vertical output, horiz driver or one of the R-B-G output transistors is shorted.

GREEN NORMAL LIGHT means the TV set's entire flyback circuit is totally free of shorts. It also means that it is safe to power up the TV set with the "run" button so that you can look for open circuits by observing the symptoms on the CRT screen.

FEATURES: All start up circuits and all horiz drive related shut down circuits are automatically circumvented by the Mark III during all test and run functions. During the test function all flyback secondary output is limited to approx 80% of normal. 2nd anode voltage is limited to approx 5 KV.

This means all circuits that are not shorted will have some 80% of their normal B+ voltage during the "test" phase. It also means that any shorted circuit will have zero DC volts on it. This feature makes any short easy to isolate.

The MARK III sells for only $595.00

The money you are now spending for unnecessary flybacks alone will easily pay for your Mark III. Why not order yours today!

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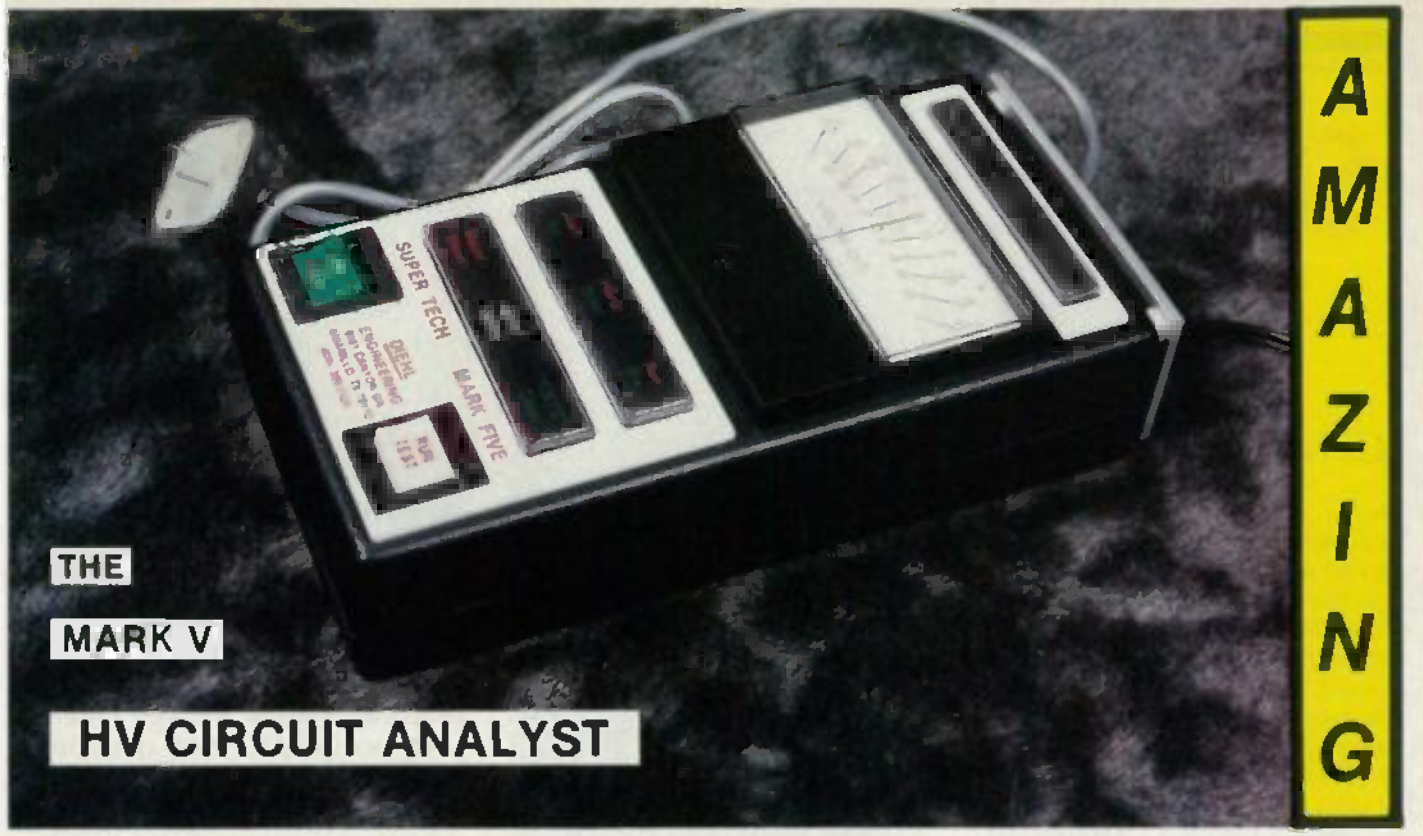

THE MARK V HV CIRCUIT ANALYST

AMAZING

- ★ Checks the horiz output stage for opens / shorts.
- ★ Checks flyback, yoke, PC, and HV mult.
- ★ Checks all scan derived B+ sources.
- ★ Checks for open safety capacitors
- ★ Checks for open ground path for horiz output stage
- ★ Checks for open primary LV supply.
- ★ Checks for error in interface connections.
- ★ Checks for proper LV regulation.
- ★ Checks for proper start up circuit operation.
- ★ Checks for shorted horiz driver transistor.
- ★ Checks the operation of the horiz osc / driver circuits.
- ★ Checks B+ "run" supply for the horiz osc / driver circuits.
- ★ Checks all circuits in the TV set that rely on scan derived B+.
- ★ Automatically circumvents all start up circuits and horiz drive related shut down circuits.

HOOK UP: (Identical to Mark III)

OPERATION: Turn the Mark V on, turn the TV set on, then, simply look at the lights.

RED "HOOK UP" LIGHT means that you have made an error in hook up. No damage has been done, correct the problem then continue.

RED "EMITTER" LIGHT means that the ground path for horiz output stage is open. Correct the problem then continue.

RED "B+ OPEN" LIGHT means that the primary LV supply in the TV set is open. Correct the problem then continue.

No "top row lights" equals normal.

Look at the middle row of lights

RED "START UP" LIGHT means that the start up circuit in the TV set is not working (no start up pulse).

GREEN "START UP" LIGHT means the start up circuit in the TV set is working normally. Yes, it is 100% accurate. Even on Zenith's single pulse start up circuit !

RED "HORIZ DRIVE" LIGHT with a green start up light means that the horiz driver transistor in the TV is shorted (E to C).

GREEN HORIZ DRIVE LIGHT means that the horiz oscillator and driver circuits are operational.

READ THE DC VOLTAGE METER THEN,

PUSH THE TEST BUTTON

If the meter comes up to, or, falls back to, factory specified DC collector voltage, the LV regulator circuit is working. If it fails to do so, it is not working!

RED "B+ RUN" LIGHT means that the B+ source that normally keeps the horiz osc / driver circuits running after the start up B+ pulse has been consumed has become open.

GREEN "B+ RUN" LIGHT means that the B+ resupply voltage (scan derived) is being provided. All is normal if all three lights are now green.

The scan circuit short detector in the Mark V is identical in all ways to that which is used in the Mark III. Operation is also identical. Both units are virtually indestructable when simple directions are followed. Both units carry a full year's warranty against defects in materials and workmanship (parts and labor). Either unit can be easily repaired by almost any technician in his own shop.

If the green "circuits clear" light is now lit

It is now safe to push the "run" button and examine the symptoms that appear on the CRT screen, for the purpose of isolating any "open" circuits.

Except for hook up and CRT filament warm up time, this test can easily be completed in two to five seconds!

The Mark V sells for only $995.00

Stop losing money on start up / shut down scan derived B+ problems; order your Mark V today!

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SATELLITE TV

BOB COOPER, JR.
SATELLITE TV EDITOR

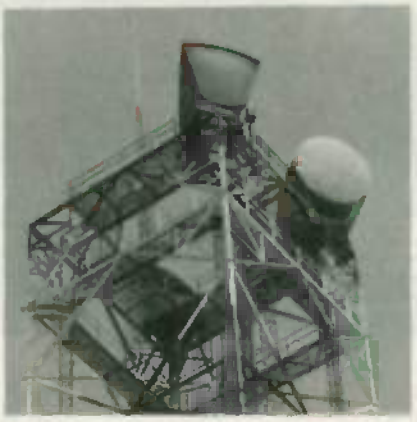
C, Ku, and DBS

MOST DISCUSSIONS OF SATELLITE TV center on the 3.7- to 4.2-MHz C-band that was originally allocated (in the early 1960's) to international satellites like Intelsat. Unfortunately, the C-band is shared with point-to-point microwave-transmission systems, like the one shown in Fig. 1, that are operated by the nation's telephone carriers (AT&T, GTE, MCI, and others).

From a historical perspective, the telephone-company microwave circuits were there first, and satellite TV was allocated shared use of the C-band, provided that the satellite systems didn't interfere with the terrestrial services.

There have been no documented occurrences of a C-band satellite-TV transmission causing interference with a terrestrial microwave circuit. The main reason is that satellite transmitters, located more than 22,000 miles above the equator, simply are not powerful enough to interfere with a terrestrial microwave link receiving a signal from a transmitter 20, 30, or even 60 miles away.

To ensure that shared use of the C-band does not cause interference, the FCC (and similar agencies in other countries) have required satellite transmitters to *dither*, or time-vary, their operating frequency. Dithering disperses transmitter power by radiating it across a range of frequencies, rather than emitting it all on a single frequency. That procedure is similar to the armed forces' spread-spectrum technique. The result is that the total power output of a transmitter is never delivered to a single frequency in the spectrum at any given instant in time.



Further, terrestrial systems are line-of-sight, and they are never aimed "up" at a satellite. As any home-TVRO owner knows, even the slightest misalignment of a dish causes a total loss of received signal. So the sort of interference feared by the FCC is unlikely ever to occur, especially given present power levels.

When it was initially decided that satellite transmitters could share the C-band with the terrestrial transmitters, a nervous terrestrial-microwave industry reluctantly accepted the FCC decision that permitted satellites to transmit with five watts of power. They would have preferred to see much lower power levels: 0.5 watts, for example. But the satellite industry gradually got maximum power levels increased. And that allowed antennas to become smaller.

Power levels increased over time to the point that RCA got approval for an 8.5-watt transmitter in 1980. Hughes then followed with a nine-watt transmitter, and recently some ten-watt transmitters have been approved. But even the latter are a far cry from the 100, 200, and 250 watt-transmitters that will be allowed on the Ku-band.

As we've mentioned in the past, the Ku-band is the next higher internationally-recognized range of frequencies for satellite transmission. There is still a lack of agreement as to exactly which frequencies will actually compose the Ku-band, but for the immediate future the most likely seems to be the 10.95- to 11.70-GHz band. Some time in the future (perhaps as much as ten years), the 12.2 to 12.7 GHz band may also become important to DBS. But more on that in a moment.

The lowdown on Ku

The Ku-band, unlike the C-band, does not compete with the telephone companies. The Ku portion of the electromagnetic

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.

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spectrum does have users, but they are not nearly as important—nor as organized—as the telephone companies. And, with a few minor exceptions, that is true world-wide.

C-band grew as a direct-to-home and direct-to-cable service quite by accident. Government regulators did not sit down in 1965 (or even in 1975) and reason out the probability that satellite TV would become a robust, rapidly-growing industry. Officials simply believed the tales told by Intelsat and telephone-company engineers. For example, it was claimed that an antenna with a diameter of at least 30 feet would be necessary to receive those weak five-watt satellite signals on earth. But the regulators did come up with a new plan in the 1970's: a Direct-to-Home satellite service they called *DBS*.

To make their DBS plan concrete, the FCC had to organize around one specific frequency band. After some searching, and some international negotiation, they settled on the Ku-band; more specifically, the 12.2- to 12.7-GHz portion of it. In a meeting held in Geneva, Switzerland, in 1979, more than 150 nations agreed that that band would be used for DBS worldwide. That was an important decision, because now several things could begin happening.

- Satellite designers and builders like Hughes, RCA, and Spar could begin designing and testing real systems.
- Reception-system designers could also begin designing and testing real systems.
- In countries where DBS would be partially or totally funded by government agencies, funds could be planned for and policies established.
- In countries where system costs would be borne by private investment, corporations could be formed, business plans created, and the search for funding begun.

Activities like those have been going for more than six years now, but we have seen few concrete results. For all practical purposes, six years after DBS was approved, we still have no real DBS systems anywhere. And the reasons for that are mostly technological.

DBS, as envisioned in 1979, was to be a multiple-channel service built with 250-watt transmitters and one- to three-foot receiving antennas. Small antennas, of course, cost less, require less space, are easier to install, and are not as unsightly as big antennas.

Unfortunately, reliable 250-watt Ku-band transmitters have yet to be operated in space; they are something of a curiosity, even in the laboratory. So, in a very real sense, the unavailability of 250-watt satellite transmitters has placed Ku-band DBS on indefinite hold. However, that is not stopping advanced-system planners from trying an end-run.

The officials who determined, in 1979, that DBS would require 250-watt transmitters based their thinking on receiving systems of a performance level that has since been surpassed. Satellite receiving systems have a performance criterion known as *noise temperature;* a low noise-temperature

SATELLITE TV/

The First Five Years!

THE MOST COMPLETE report on the mushrooming home 'TVRO' industry ever compiled, written as only the 'father of TVRO' could have prepared. More than **1000 pages (!)** tracing the complete story of home TVRO, lavishly illustrated with equipment photos, schematic diagrams, equipment analysis reports. **Bob Cooper,** the first private individual to own and operate a TVRO (1976) has collected and polished hundreds of individual reports into a unique 'collector's edition' which clearly explains the TVRO phenominon in North America. From Coop's first 20 foot 'monster' dish to the present day 5 foot 'C-band' TVROs, the fascinating growth of TVRO equipment and its legal status unfolds for you.

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is more desirable than a high noise-temperature. In 1979, a practical receiver noise-temperature was in the vicinity of 800°K. But times have changed, and noise temperatures in the 200°K to 300°K range are now possible. What does the availability of low-noise temperature receivers mean?

The most obvious and important consequence of the foregoing is that lower receiver noise-temperatures allow you to get the same level of performance with smaller receiving antennas on earth, lower transmitter powers in space, or some combination of the two. By using a 300°K receiver, for example, reducing transmitter power from 250 to 100 or 125 watts will give the same reception as with an 800°K receiver (assuming the size of the dish remains the same). That suggests that we could have DBS today by using 125-watt transmitters, and the small antennas those paper planners envisioned back in 1979. But there is a catch to all of that: Can a reliable 125-watt transmitter be built?

The answer to that question is unknown. The 100-watt satellite transmitters launched into space so far have failed at a brisk rate. The most recent of those failures was a Japanese unit put into service early in 1985; two of its three 100-watt transmitters quit within months of turn-on. At best, the results thus far have not been encouraging, even at the 100-watt power level.

The good news is that RCA has recently launched a pair of satellites; each has 16 on-board transponders and each of those transponders is capable of outputs of 45 watts. RCA seems confident, and Hughes and other competitors agree, that the misfortunes of the 100-watt units are not likely to be experienced at the 45-watt level.

We'll have to wait till next month to see what all of that portends for the rapidly changing TVRO industry and those that use TVRO installations. **R-E**

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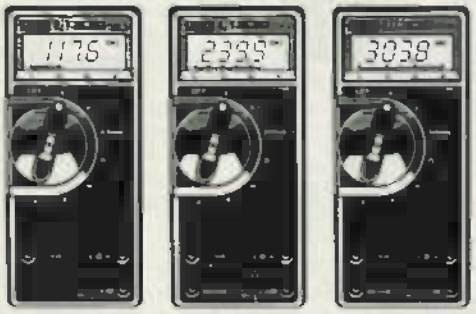

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10 Computerized Speaker Enclosure Design—Part I. How to use your computer to select the best-possible parameters for your new loudspeaker enclosure. **Michael Raleigh and Robert Raleigh**

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3 Computer Products

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ON THE COVER

Alloy's QICSTOR-PLUS is a personal computer subsystem that integrates five additional IBM™ Personal Computer compatible expansion slots, high-capacity hard disk and an advanced, high-speed file-oriented streaming cartridge tape backup unit. It fits under a personal computer and combines a 5¼ Winchester hard disk with formatted data capacities from 30MB to 110MB on a single 600-foot cartridge.

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COMING NEXT MONTH

Look for an in-depth article on Monitors. After you read this one, you'll be far-better prepared to talk to that computer-store salesman! We'll also have the last part of the two-part article on using your computer to help design loudspeaker enclosures, . begun this month, and we'll be starting a three-part article on a hi-res graphics adapter for your Apple II.

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LETTERS

Warning!

The October, 1985 issue had an article by Elliott S. Kanter entitled "Saving Your Delicate Electronic Equipment." I was compelled to write to you at once. General Electric says, "Varistors initially fail in a short-circuit mode when subjected to surges beyond their peak current/energy ratings... When the device fails in the shorted mode, mechanical rupture of the package accompanied by expulsion of package materials in solid and gaseous form can occur. The potential hazard can be minimized by fusing the varistor to limit high fault currents, or by locating the varistor in a shielded container and away from other components"—S. R. B. Ft. Geo. Meade, MD.

Thank you for bringing this to our attention.

No Sale

I don't know anything at all about computers, but I'm willing to learn. If you will provide me with a decent computer system, I'll write an article about how I learned to compute. How much would you pay for such an article. Would you be interested? J. P., Kansas City, KS.

No.

Timex

Timex/Sinclair 1000's used to be everywhere and now I can't find a thing on them. How about peripherals? Did they just disappear?—G. S., Cheektowaga, NY.

I'm afraid they've gone the way of the Reo, the Cord, and the Studebaker. But it was a good computer, low enough in cost so that you didn't mind experimenting with it. Like you, I wish that somebody would bring it (or one like it) back again!

555 Timer

Can you provide some additional information on the 555 timer? It seems to keep cropping up everywhere and I'd like to learn more about it. R. D., Waco, TX.

See page 8 of this issue!

More Space!

I've noticed in recent issues that **ComputerDigest** is not as large as it used to be. I'd like to know if there's anything I might do to help get it expanded again? R. W., Cincinatti, OH.

Hey! Now that's a good idea. Why don't you write a letter to our publisher and tell him you miss those extra pages.

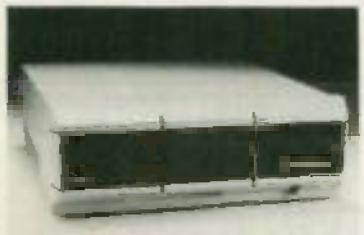
COMPUTER PRODUCTS

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

TAPE-DRIVE OPTION, is a 10-megabyte tape cartridge drive, designed for the *CompuPro 10 Plus* multi-user microcomputer system.

Built directly into the *CompuPro 10 Plus* enclosure, the tape drive replaces one of the floppy-disk drives and has a "start/stop" feature that allows users to backup selected files. The option is also available as an upgrade for users with already installed *CompuPro 10* and *CompuPro 10 Plus* systems.

The tape-drive option can be ordered simultaneously with a *CompuPro 10 Plus* and is priced at $825. As an upgrade, the tape drive has a list price of $1095.00.—*Viasyn Corporation*, 450 Newport Center Drive, Suite 200, Newport Beach, CA 92660.



CIRCLE 11 ON FREE INFORMATION CARD

PERSONAL COMPUTER, the Tandy model *1200 HD*, is functionally identical to the IBM model *PC/XT*, using the same software and option cards. It is designed for business customers who require much higher speed, more detailed graphics, more memory, and more disk capacity than is possible with the model *PC/XT*.

Standard features of the model *1200 HD* computer parallel those of the model *PC/XT* by providing a single 360K full height, double-sided, double-density 5¼ inch floppy disk drive and a 10-MB hard disk drive housed in the desktop unit. The 84-key detachable keyboard with tilt legs has the same layout as in the model *PC/XT*, with improved placement of the keys and other valuable features. The model *1200 HD* is priced at $2999.00.—**Tandy Corporation/Radio Shack,** 1800 Tandy Center, Fort Worth, TX 76102.

CIRCLE 12 ON FREE INFORMATION CARD

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SOFTWARE REVIEW

TYPERITE— $49.00

Now you can get rid of your typewriter!

■When the new girl came into the office, she looked balefully at the computer terminal. "I don't know how to work a computer," she said hesitatingly. "Don't worry about it," we assured her. "This one is different." By lunchtime, she didn't want to leave her new-found love even to go out for a cup of coffee. Why? Because the *TYPERITE* software from Selfware makes your computer so like a memory typewriter, that even the most-raw beginner will interface with a computer with no trouble at all! And once you've developed a facility with it, which might take all of fifteen minutes or so, you'll be looking around to find a place for your typewriter. You aren't going to be needing it anymore.

What makes this software so appealing is the graphic display that is presented to the operator. Along the bottom of your CRT screen, you get representation of the top of a typewriter. It's actually what a typist sees when using an ordinary non-computerized typewriter. The result is a warm, comfortable feeling of security that takes away some of the stigma attached to learning something radically new. What's more, this representation is indeed functional as well. It's not just fancy graphics put up there as a part of the display.

While this system may have originally been designed to facilitate routine typing work on the computer, we've found that it also makes an excellent bridge for people who have been trained on typewriters and are now faced with the problem of learning to operate a computer. However, its value extends far above and beyond that.

But let's get down to the nitty-gritty. With *Typerite* you can easily address envelopes and fill out forms using your computer. The new computer user experiences immediate and positive results. And you can actually type a letter and spend your brain time thinking about what you want to say instead of worrying about complicated computer commands and involved word processing.

Hard to use? Not at all. Put the disk in your disk drive, type the letters TR and hit the carriage return. Just follow the easy-to-understand instructions on the screen. You actually *see* a representation of a typewriter carriage on the screen and can quickly and easily set tabs, margins, underline, and center text. It works with all printers and with no special installation procedures.

Typerite has two operational modes, standard and document. In both modes, you type a single line, review and/or change the line, and when you are satisfied, hit return and the line gets printed. The difference between the two modes is that in document, the software saves what you write.

With *Typerite* you can quickly and easily fill out forms. Simply type the necessary information in just as you would have with a typewriter. Using document, you can set up a template for your form. The template is simply a document that you create with "stop marks" at the places where you want to add information to the form. When you print out, the system stops at each stop mark and waits for you to type what is to be printed on the form. Once you set it up, you can use the template again and again.

Some of *Typerite's* features include: (in the standard mode) Save seven different margin and tab settings, set margins, set and clear a tab, clear all tabs, margin release, bell ring before end of margin, set tab every five spaces. It provides backspace/delete, cursor movement within a line, switch between insert and overtype, center between margins, single or double spacing, underlining and page eject.

In the Document Mode, you have all standard typerite features and can create forms templates, save documents as file, stop marks to allow data entry during printing, print a document line-by-line while creating or turn print off, save initial margins and tabs, save underlines or page ejects. You can change saved margins and tabs, delete or add underlines, page ejects and stop marks, print or not while revising, store with same name or new name, stop at stop marks to allow typing during printing, abort printing at any time, or abandon revisions.

There's a lot more that space won't allow for. For more information, contact Selfware, 3545 Chain Bridge Road, Fairfax, VA 22030.

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HARD DISK DRIVES

A hard disk...And all that memory!

Marc Stern

■Every computer hobbyist faces a time when his needs outgrow his mass storage system. That's when the cassette recorder gives way to the floppy disk and the floppy to the hard or fixed disk. Each new storage medium offers the user a leap in speed and capability.

For example, the typical cassette holds about 500K of information sequentially, but, its data transfer rate is a slow 1200 to 2400 bits per second. A user becomes tired of this slowdown and the lack of random access. He must go through file after file to find the one he wants on the tape.

The next step is the floppy disk and, although some forms have less capacity—190K—they make up for it in speed and random access. Programs that took minutes to load and run with the cassette take only seconds to a minute or two to load and run. Instead of searching through a tape, looking for information, the floppy disk's read-write head sweeps across the surface of the diskette and finds the data in seconds.

Hard disks revealed

Also known as a fixed disk, the hard disk's attraction is its information density. A couple of years ago, the standard hard disk in the microcomputer world was the 5-megabyte unit. Today, the minimum disk density is 10 megabytes, with 20-megabyte units available.

When you compare the capacities of floppies and hard disks, you can see the hard disk wins. Today's double-sided, double-density floppy disk holds about 360,000 bytes of data, while the hard disk holds 10 million bytes. This means it would take 28 or more floppy disks to hold the same amount of information. The access time—the amount of time it takes to find a specific sector of information on a hard disk—is on the order of 35 to 85 microseconds, while a floppy's time can run in the 20 to 40 millisecond range. Its a quantum jump in information retrieval speed.

There are high-density floppy disks on the market, capable of holding 1.25 megabytes of data, but, they are expensive—some running as much as $850 to $1000—and they still don't hold the sheer bulk of which a fixed disk is capable.

These points make the hard disk much more attractive as a mass storage device. Hard disks aren't portable—there are some cartridge hard disk models which allow you to change disks, but their reliability is still in question—and you must backup the hard disk for insurance, which can take as many as 30 floppy disks and can take the better part of a day. But most small-computer users feel the speed and information density advantages outweigh the latter aspects.

Let's look more closely at a typical hard disk for a better understanding of this technology. If you look closely at Fig. 1, you'll see the typical 5.25-inch hard disk drive—now the standard size in the microcomputer world—contains one or more platters or rigid disks, each of which has its own read-write head.

Most disks today are constructed on an aluminum base, whose surface is covered with a paste containing gamma-ferric oxide particles. This layer is cured and polished and then covered with a Teflon-based lubricant. The entire layer is then burnished smooth. The platters are enclosed in a sealed box which also includes air filtering to keep the surfaces free of contaminants which could cause a head crash and damage the disk.

Thin-film plated disks also use an aluminum substrate. However, rather than being coated with the oxide paste during construction, they are dipped in a series of plating solutions and the platter is coated with thin films of metallic material. The top layer, where the data storage and transactions take place, is a cobalt alloy, which can be as thin as three microinches.

A thin-film sputtered disk takes the aluminum platter through another process. The aluminum platter is coated with a nickel phosphorus layer, which is then polished. Then, using the sputtering processing—a continuous vacuum deposition process—magnetic layers are laid down on the disk. In this way, layers as thin as two microinches can be deposited.

The importance of the type of material on the platter can hardly be understated because it relates to the information density of which the hard disk is capable.

As the platter's coating becomes thinner, the disk is capable of greater information density for a given diameter. Therefore, the thin-film plated and sputtered disks are capable of greater information densities than the oxide-coated disk.

This advantage extends to another area which also affects disk information density, the read-write head. Unlike floppy disk read-write heads which literally

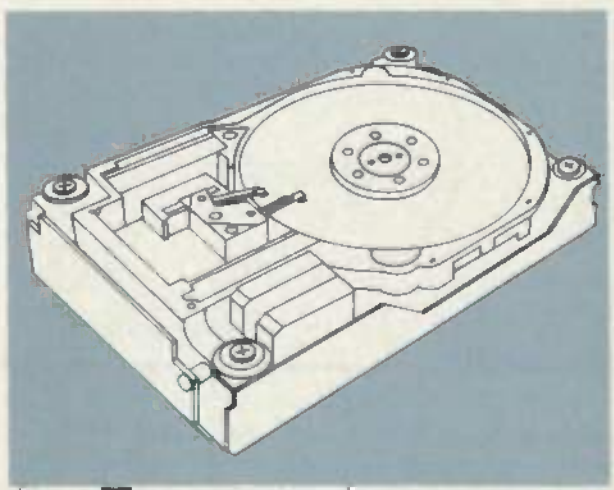

FIG. 1—TYPICAL HARD DISK DRIVE contains one or more rigid disks made of aluminum substrate coated with a magnetic material.

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touch the surface of a disk, the read-write heads of a fixed disk fly above the surface on a layer of air. The closer the head skims along the surface the greater the information packing capability. The ability to fly near the surface of the plate is directly affected by the smoothness of the surface.

If you were to look at the oxide-coated surface of a traditional hard disk, it would look smooth. However, a microscopic examination of it would reveal that it is filled with peaks and valleys. (See Fig. 2) The same is true for a plated hard disk.

The read-write head must run as much as 8 microinches off the surface of this type of disk to prevent the head from coming into contact with those peaks.

By contrast, the sputtered disk is so smooth that the head can fly as little as two microinches off the surface, which means its data density can be greater. Thus, it's possible to achieve data densities of up to 20 megabytes on 5.25-inch hard disks.

Head examined

Another critical factor in hard disks is the read-write head itself.

Typically, the read-write head is like that found in a cassette recorder, it is a ferrite unit. The nature of this head effectively constrains the information transfer speed and density of which the fixed disk is capable. A more recent development in read-write heads, the thin-film electromagnetic head, allows the fixed disk to read information more quickly and in greater density than the conventional ferrite read-write.

The head's construction also affects its speed capability and long-range reliability. Look at Fig. 3 and you can see the number of pieces which make up the fixed disk's so-called Winchester arm. It carries the read-write head. From its construction—side rails, load beam and slider—you can see how complicated the mechanism is. This contributes to its aerodynamic inefficiency and affects the speed at which it can fly across the disk surface. The number of moving parts also makes this mechanism more prone to wear.

A newer development—the Whitney arm—promises higher speeds and consequently greater data packing and transfer rates. More efficient aerodynamically (See Fig. 4) it has several advantages over the mechanisms used today.

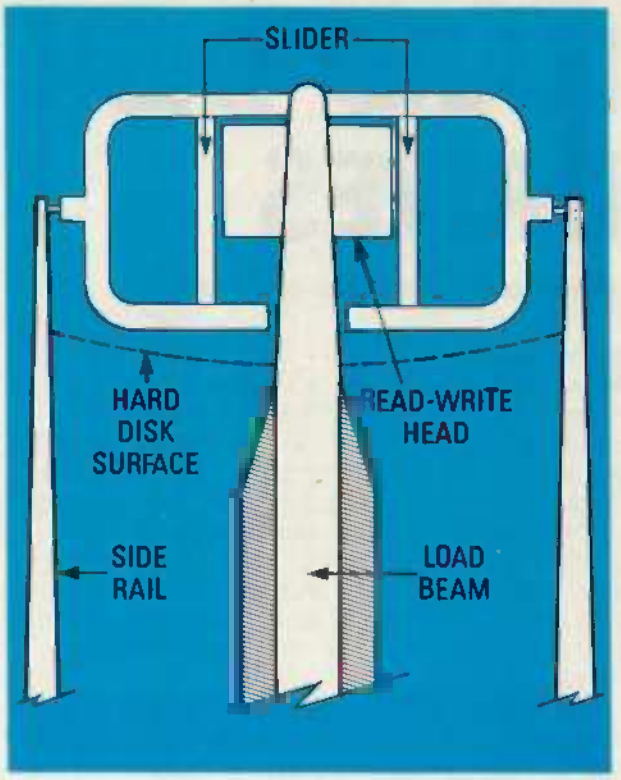

FIG. 3—WINCHESTER ARM is complicated mechanically and aerodynamically. It is less efficient than the Whitney arm.

Speed demon

This adds up to a capable unit which has another innate advantage over just about any other form of mass storage, high speed.

With a rotational speed of 3,600 revolutions per minute, the hard disk drive has a tenfold advantage over the standard floppy disk's 300 to 360 rpm.

This means programs which normally take a minute or two to load and run from a floppy disk will load in seconds. Huge data files will be stored in seconds.

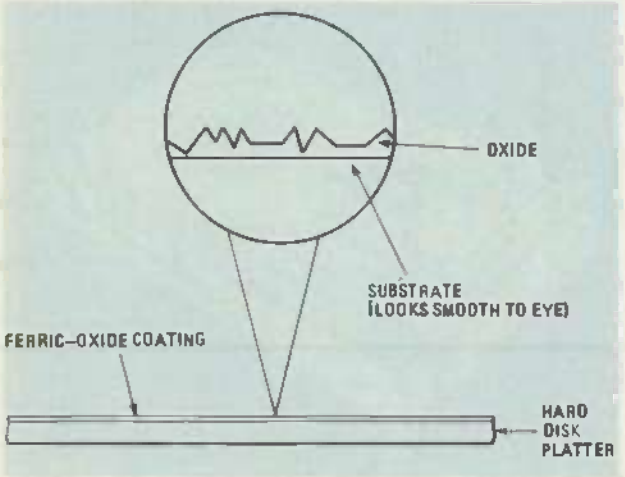

FIG. 2—MICROSCOPIC VIEW of oxide-coated hard disk. Note peaks and valleys in coating (not to scale).

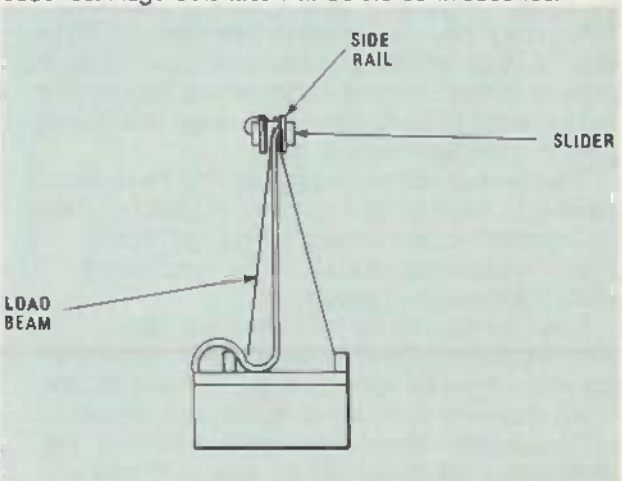

FIG. 4—THE WHITNEY ARM is much more streamlined and efficient.

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And data can be manipulated quickly.

With this type of speed, you need a precise read-write head positioning mechanism and there are currently two types used, the open-loop stepper motor and the rotary voice coil positioner.

The open-loop stepper motor is a mechanical system which relies on the stepper motor for precise head positioning. In action, the open-loop stepper motor works with the commands issued by the hard disk controller circuitry. When a program makes a request for data, the circuitry issues a command to the head positioning system which instructs the motor to move the head to a certain track on the disk. As it begins to move, the stepper motor clicks off the number of tracks until it reaches the required spot.

The chief drawback of this method is wear over the long term. The mechanical parts wear and exact head positioning becomes more difficult and data access times become longer.

The voice coil system relies on closed-loop positional feedback for head positioning. In action, the system works in conjunction with information contained either in a special buffer area on the hard disk or in each track to locate a particular track and sector. This information tells the head-positioning circuitry its location in relation to the specific spot the system is seeking and the head uses this information as it moves to the spot. Since it has fewer moving parts than the stepper motor system, it is more reliable than the conventional stepper motor. Its chief drawback is in increased cost.

Read the specifications

With all the foregoing information, there are still several other items to think about, especially if you're in the market for a hard disk. The first is average access time and the second is latency. The first is actually a function of the second.

Average access time refers to the amount of time it takes for the read-write head to move from one piece of data on a hard disk to another. It is a function of the latency or rotational delay of the high-speed hard disk.

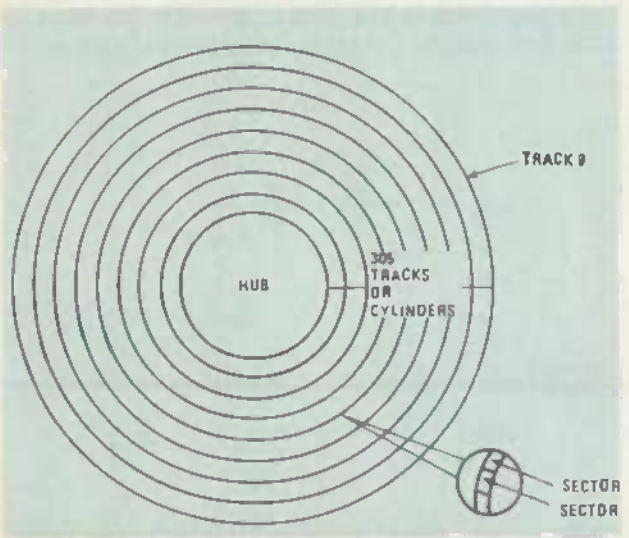

FIG. 5—TRACKS ON HARD DISK are laid out concentrically. Track 0 is used for positional and other data.

Average access time also varies from hard disk to hard disk and with the type of head positioning arrangement used.

Another specification which can prove confusing is the data transfer rate. It is the speed at which data moves from between the hard disk controller and the drive. Most manufacturers quantify this in terms of bits per second of data transfer and some hard disks can have a transfer rate of up to 5 million bits per second. To lessen confusion, you can compare this to the baud rate of a serial communications device, although its speed is manifestly higher.

Disk organization

The final piece of the hard disk puzzle is the organization of the disk. To help put this into perspective it is useful to picture the hard disk as a phonograph record.

Each hard disk is divided into a series of tracks. (See Fig. 5) A typical 10 megabyte hard disk has 305 tracks for information, each of which contains 34,816 bytes of information. Like the grooves in a phonograph record, the tracks are laid out concentrically on the disk's surface, with each track concentric to the one inside it. Unlike a record, the tracks are separate, while the grooves are actually interconnected.

Each track on the disk surface is divided into specific sectors. An index sensor indicates the start of each track.

In action, the hard disk controller head looks first at Track 0—at the outside of the disk—rough positional information and then hunts for the specific track on the disk containing the information which has been requested. When it arrives at the right track, it hunts for the sector containing the header data for that particular file. The header is the identification mark for the file. The head then reads that identification mark, determines where the rest of the information is stored and moves along from sector to sector assembling it. When it has finished, it's ready to use.

The 5.25-inch standard

When hard disks were first introduced more than a decade ago, they were huge, routinely 14 inches in diameter. They didn't make their appearance in the microcomputer world until about four years ago when the first 5.25-inch hard disks were sold. These early disks were only 5 megabyte affairs and it looked for a time as if these would become the standard of the microcomputer world. But, times quickly changed.

Within a year or so, 10-megabyte 5.25-inch hard disk drives began to appear and within another year, these units became the standard as the lower density disks began to disappear from the scene.

About the only thing which was common to the two units was their size. Both were 5.25-inch units, which is still the most common size for a hard disk unit.

Times are changing on this front, too, as 3.5-inch drives make their appearance. Further, even the standard sized drive is changing as it is becoming thinner and half-height drives, capable of 10 and 20 megabytes of data storage are appearing.

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555 DESIGN PROGRAM

Use your computer to shortcut those tedious 555 oscillator design problems.

Jeff Holtzman

■Some design chores in the electronics lab are quite repetitive, and after the 1000th time we think, "there must be a better way!" Well, if you have a personal computer in your lab, here's a little program that will reduce the tedium of one such chore: Designing 555 monostable and astable oscillator circuits. It's fast, allowing you to make several "runs" quickly, so you can see the effect different component values will have on circuit operation.

Our program will help you determine resistor and capacitor values for the standard circuits shown in Fig. 1a and 1b. The program has been written in MBASIC-80, and it should run as-is on just about any personal computer. We also include several suggestions for improving the program, if you have a taste for such experimenting.

What the program does

When you run the program it asks you to choose between Astable and Monostable circuits (or you may just Exit). If you choose Astable, the program then asks you the frequency you will be working with. Next, you're presented with a menu (lines 220-320) allowing you to choose which parameter you want to work with. Choices 1 and 2 calculate values for R2 and C1, respectively, assuming a value of 1K for R1, and a value entered by you for the third component—C1 and R2, respectively. We chose a default value for R1 of 1000 ohms, but if that doesn't suit your fancy, feel free to change it.

Choice 3 also calculates a value for C1, but here no assumption is made regarding the value of R1: You must enter the values for both resistors. Choice 4 allows you to calculate the frequency that will be obtained; and with that choice, you enter the value for all three components. That allows you to try values for components you can actually buy—which probably won't be the same as the ones calculated above—to see what frequency will result.

For example, suppose you need a 1 kHz oscillator. Suppose further that you happen to have a junk box full of .01 disks that you want to use. Well, run the program, enter "1000" at the "Frequency?" prompt, choose the first item, and enter ".01" at the next prompt. The program will tell you that you need a resistor of 71,500 ohms for R2. The closest standard value is 72,000 ohms, so choose item 4. Entering values of .01, 1000, and 72,000 yields a frequency of about 993 Hz—pretty darn close! In fact that's an error of 7/1000, or .007%. Not bad. Of course, that's only a calculated value; chances are the components you use won't have exactly their nominal values. For more accuracy you could use a 47K resistor in series with a 50K trimmer, and adjust the 555's output with a frequency counter.

The monostable circuit works on a similar basis, but is even simpler, since there are only three variables to take account of: The duration of the trigger pulse, and the values of R1 and C1. The menu (shown in lines 580-710) has three choices. Each asks for two values and then calculates the third. For example, assume you need a pulse one second wide, and that you want to use a 1 µF capacitor. You want to find the appropriate resistor to use, so choose two from the menu. You should get an answer of 909091 ohms. The closest standard value is 1 Megohm, so to find the time those components would give, choose one from the menu, enter the values for C1 and R1, and you should get an

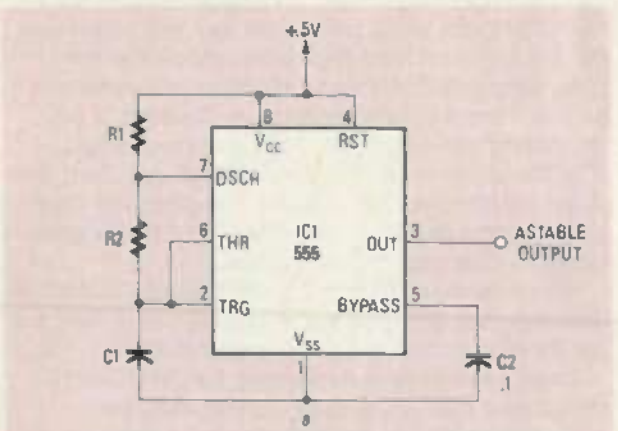

FIG. 1a—The value of R1, R2 and C1 determine the frequency of oscillation of this circuit, and the program simplifies calculating the values of those components.

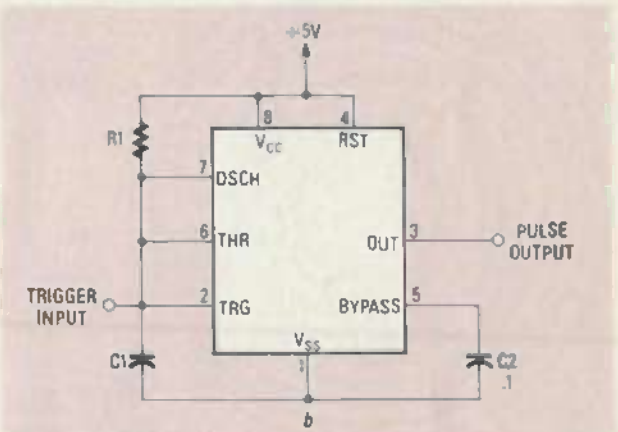

FIG. 1b—A negative-going trigger will cause the 555 to output a pulse with a width determined by the values of R1 and C1. The program simplifies calculating the values of those components.

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```
100 REM 555 timer calculations
    for RE mag.  jkh  3 August
    1985
110 FOR I=1 TO 24:PRINT:NEXT I
120 PRINT "555 Timer
    Calculations   jkh   3
    August 1985"
130 PRINT:PRINT:PRINT:PRINT:
140 INPUT
    "Astable/Monostable/Exit
    (A/M/E)? ", IN$
150 IF IN$="E" OR IN$="e" OR
    IN$="" THEN END
160 IF IN$= "M" OR IN$="m" THEN
    GOTO 580
170 IF IN$="A" OR IN$="a" THEN
    GOTO 190
180 GOTO 140
190 REM do astable calculations
200 PRINT
210 INPUT "Frequency? ",F
220 PRINT
230 PRINT "0.  END"
240 PRINT "1.  FIND R2, GIVEN
    R1 = 1000, C1 = USER ENTRY"
250 PRINT "2.  FIND C1, GIVEN
    R1 = 1000, R2 = USER ENTRY"
260 PRINT "3.  FIND C1, GIVEN
    R1 = USER ENTRY, R2 = USER
    ENTRY"
270 PRINT "4.  FIND F, GIVEN
    C1, R1, R2 USER ENTRIES"
280 PRINT
290 INPUT "    CHOOSE: ",IN
300 PRINT
310 IF IN=0 THEN GOTO 140 ELSE
    ON IN GOSUB 330, 390, 450,
    510
320 GOTO 220
330 REM FIND R2 GIVEN R1=1K, C1
    ENTERED
340 R1 = 1000
350 INPUT "C1 = ",C1
360 R2=(1.44/(F*C1/1E+06)-R1)/2
370 GOSUB 870
380 RETURN
390 REM FIND C1 GIVEN R1=1K, R2
    ENTERED
400 R1=1000
410 INPUT "R2 = ",R2
420 C1=
    1.44/(F*(R1+2*R2))*1E+06
430 GOSUB 870
440 RETURN
450 REM FIND C1 GIVEN R1, R2
    ENTERED
460 INPUT "R1 = ",R1
470 INPUT "R2 = ",R2
480 C1=1.44/(F*(R1+2*R2))*1E+06
490 GOSUB 870
500 RETURN
510 REM FIND F GIVEN C1, R1, R2
    ENTERED
520 INPUT "C1 = ",C1
530 INPUT "R1 = ",R1
540 INPUT "R2 = ",R2
550 PRINT
560 PRINT "NEW FREQUENCY WOULD
    BE:";
    1.44/(C1*.000001*(R1+2*R2));"Hz"
570 RETURN
580 REM do monostable
    calculations
590 PRINT
600 PRINT "0.  END"
610 PRINT "1.  FIND T, GIVEN R
    AND C"
620 PRINT "2.  FIND R, GIVEN T
    AND C"
630 PRINT "3.  FIND C, GIVEN R
    AND T"
640 PRINT
650 INPUT "    CHOOSE: ",IN
660 PRINT
670 IF IN=0 THEN GOTO 140 ELSE
    ON IN GOSUB 720, 770, 820
680 PRINT
690 PRINT
    "C=";C1;"uF";TAB(15);"R=";R
    1;"ohms";TAB(30);"T=";T*1000;"msec"
700 PRINT
710 GOTO 580
720 REM FIND T, GIVEN R AND C
730 INPUT "R = ",R1
740 INPUT "C = ",C1
750 T=1.1*R1*C1*.000001
760 RETURN
770 REM FIND R, GIVEN T AND C
780 INPUT "T = ",T
790 INPUT "C = ",C1
800 R1=T/1.1*C1*1E+06
810 RETURN
820 REM FIND C, GIVEN R AND T
830 INPUT "R = ",R1
840 INPUT "T = ",T
850 C=T/1.1*R1*.000001
860 RETURN
870 REM PRINT ASTABLE VARIABLES
880 PRINT
890 PRINT
    "F=";F;"Hz";TAB(15);"C1=";C
    1;"uF";TAB(30);
900 PRINT
    "R1=";R1;"ohms";TAB(45);"R2
    =";R2;"ohms"
910 PRINT
920 RETURN
930 END
```

answer of 1.1 seconds.

In both the astable and monostable sections of the program, enter resistor values in ohms and capacitor values in microfarads. For example, 100 pF would be entered .0001. In the monostable section, time would be entered in seconds, although time is reported in milliseconds. For example, you would enter one millisecond as .001; the program would print it "1 msec."

Improvements

The program is very useful as it is, but some improvements could be made (they always can). First of all, in the astable mode it's sometimes necessary to know the duty cycle a combination of components will give. Doing the calculation is easy; the formulae are available in standard databooks.

A somewhat more complex improvement would be to have the program suggest only standard values for the resistors. One way to do that would be to create an array and fill it from DATA statements containing scaled standard values (1.0, 1.1, 1.2, . . . 9.1). Then after calculating a resistor's value, it would be scaled down to a number between one and ten, and the array would be searched for the closest match. That value would then be scaled up by the same amount the original value was scaled down. That's all there is to it!

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COMPUTER-AIDED DESIGN OF LOUDSPEAKER ENCLOSURES PART I

Here's how to let your computer predict an enclosure's performance.

Michael Raleigh and Robert Raleigh

■The most-complex system is the ducted port enclosure. The other systems can be thought of as simplifications of this type. Figure 1 shows a cross section of a dynamic loudspeaker mounted in a ducted port enclosure. When driven at low frequencies, the behaviour of this system is simpler than it is at higher frequencies. The cone moves as a single, rigid mass. All the air inside the duct moves in unison, acting as another single mass. The volume of air within the enclosure acts like a spring, coupling the cone mass to the mass of air in the duct. The front of both the cone and the air in the duct experience a frictional drag due to the acoustic power they radiate. This effect is called the radiation resistance, and is frequency dependent. The program retains only the first term in the Taylor expansion of the Bessel function that gives this frequency dependence. A small additional mass is added to the cone and the duct by the effect of the outside air and, here too, we keep only the first term of the Taylor expansion. Additional springiness and resistance result from the cone surround and the coil spider. More resistance is sometimes included in such enclosures in the form of fiberglass batting lining the box, across the port, or behind the woofer.

When the simplifications described are applicable, a ducted port enclosure behaves much like the lumped parameter mechanical device shown in Figure 2. For this mechanical system comprised of masses, springs and dampers there are two electrical circuits composed of capacitors, inductors and resistors which exhibit analagous behaviour. They have the same governing equations with a renaming of the quantities

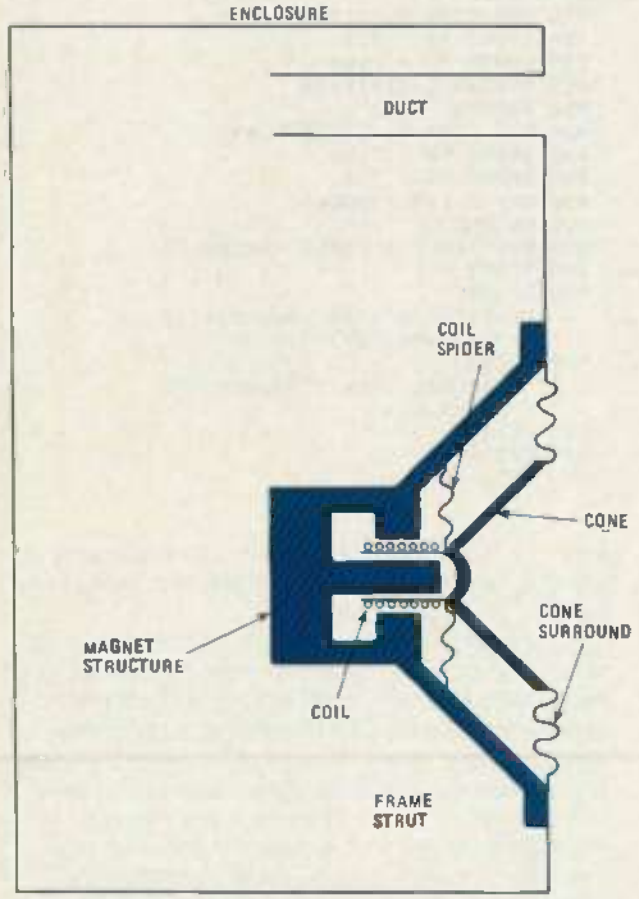

FIG. 1—CROSS SECTION of a dynamic woofer mounted in a ducted port enclosure.

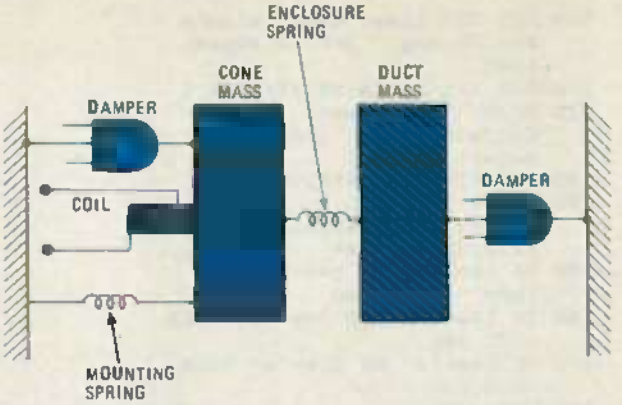

FIG 2.—MECHANICAL SYSTEM, equivalent at low frequencies, to the speaker shown in Fig. 1. Cone mass and the mass of air are assumed to move only in one direction, indicated by arrows. Coil applies oscillatory force to cone in this direction. Dampers are sources of mechanical resistance. One end of each damper and mounting spring has a fixed point of attachment.

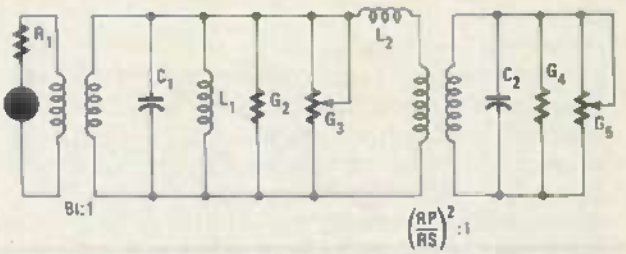

FIG. 3—ELECTRICAL CIRCUIT analagous to systems in Figs. 1 and 2. Corresponding parameters are: R1 = Coil resistance, C1 = Mass of cone and co-moving air, L1 = Compliance of cone mountings, G2 = Mechanical resistance of cone mountings, G3 = Radiation resistance of cone, L2 = Compliance of enclosure volume, RP = Port (duct) radius, RS = Speaker radius, C2 = Mass of air in duct and co-moving air, G4 = Mechanical resistance, G5 = Radiation resistance of duct.

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involved. In Figure 3, you see one of those circuits which is equivalent to Figure 2. The equivalent quantities are as follows:

Voltage = Velocity
Current = Force
Capacitance = Mass
Inductance = Spring Compliance
Electrical Conductance = Mechanical Resistance

Each mass in Figure 2 has associated with it a capacitor to ground in Figure 3 whose voltage is numerically equal to the velocity of the mass. The force being applied to the mass equals the current flowing into the capacitor. The sources of this current (force) are the resistors (dampers) and inductors (springs) attached to the capacitor (mass).

The computer program assumes that a 1-volt AC source is attached across the coil. The program establishes a set of differential equations (the node equations) which describe the behaviour of the circuit in Figure 3. The assumption of a steady-state response causes these equations to take the form of a set of simultaneous algebraic equations in terms of complex variables. These are solved for a selection of frequencies between 15 and 250 Hz. Outputs from the program include the acoustic intensity one meter from the speaker (resulting from the vector sum of the woofer and port amplitudes and given in watts per square meter), and the current drawn at the speaker terminals (which is the admittance since we assume a one-volt input, given in mhos). The program asks only for fundemental system parameters and does so using prompts to guide the user. Quantities such as the radiation resistances as a function of frequency are calculated internally. The program is listed and may be checked by running the design example described. The tabular output for this case is also given.

Parameter measurements

There are several of the woofer parameters which must be determined experimentally. These include cone radius, DC coil resistance, the Bl product for the magnet-coil combination, the compliance of the cone mountings, the free resonance of the woofer and the mechanical resistance of the cone mountings. Let's talk about how to make these measurements and present typical numbers from a design example using a 12-inch woofer. We use MKS units exclusively.

The effective cone radius may be measured from the center line of the cone to the mid-point of the cone surround. This number will be less than the nominal radius of the woofer. In the design example, the effective cone radius is .125 meters (4.92 inches).

The DC resistance of the coil may be measured with a multimeter. For the design example, this was 5.3 ohms. (This number is not to be confused with the nominal AC impedance of eight ohms.)

The Bl product is the product of the magnetic induction (B) in the magnet gap, and the length of coil wire, (l) in the gap. B is measured in Teslas. The Bl product determines the force exerted on the cone for a given coil current. This product is measured, as shown in Figure 4, by placing the woofer face-up on a

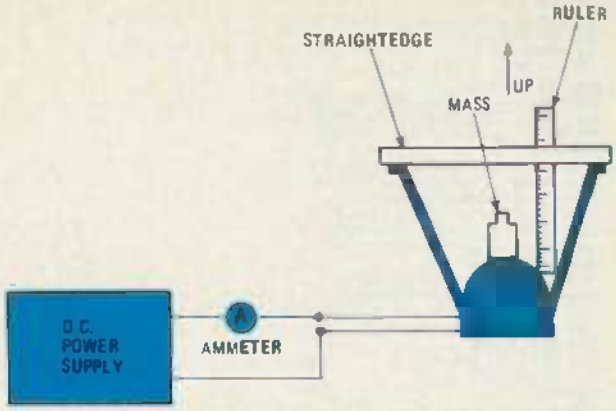

FIG. 4—ARRANGEMENT USED to measure the Bl product and the mounting compliance.

horizontal surface with a DC power supply and an ammeter attached to the coil. A straightedge is laid across the face of the woofer, and a light plastic ruler is stood upright in the cone so that the vertical position of the cone may be measured. Determine the position of the cone with no current in the coil, a known mass (M) is then carefully placed in the cone and current (I) necessary to lift the cone and mass back to the unloaded position is determined. The Bl product is then given as:

$$C\left(\frac{M}{NI}\right) = \frac{d\ (M)}{9.81 \times M\ (kg)}$$

The design example needed .237 amps to lift a .305 Kilogram mass back to the unloaded position, implying a Bl of 12.6 (T × M).

The compliance is also measured while the woofer is lying on its back with the straightedge and plastic ruler in place. The power supply is disconnected. The distance, d, which the mass causes the cone to depress is determined from the difference in the readings on the plastic ruler in both loaded and unloaded conditions. The compliance is then given by:

$$Bl\ (T \times M) = \frac{9.81 \times M\ (kg)}{I\ (A)}$$

For the design example, the .305 kilogram mass depressed the cone by .002 meters thereby implying a compliance of .000668 (Meters/Newton).

The free resonance and mechanical resistance of the woofer are determined using the arrangement shown in Figure 5. The bare woofer is suspended in a large room away from any objects or walls. We measure the current drawn and the voltage applied at various frequencies. At each frequency, we divide the current by the voltage to obtain the admittance. Note that if the same multimeter is used for both current and

Fig. 5—HOW WOOFER ADMITTANCE was measured. Admittance is used as a diagnostic to determine several parameters.

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```
10 DIM G(4,4)
20 DIM C(4,4)
30 DIM B(4,4)
40 DIM A(4,4)
50 DIM T(4)
55 E=1
60 INPUT "COIL RESISTANCE?";RC
70 INPUT "MOUNTING COMPLIANCE?";MC
80 INPUT "SPEAKER RADIUS?";RS
90 INPUT "ENCL VOLUME?";V
100 INPUT "BL PRODUCT?";BL
110 INPUT "FREE RESONANCE?";FO
120 INPUT "PORT RADIUS?";RP
130 INPUT "PORT LENGTH?";LP
134 INPUT "SPEAKER DAMPING?";SD
136 INPUT "PORT DAMPING?";PD
140 B1=1/MC
150 C1=B1/(39.47841B*FO*FO)
160 B2=1.43E6*RS*RS*RS*RS/V
170 C2=(3.83*LP+5.69*RP)*RS*RS*RS*RS/(RP*RP)
180 B(1,1)=-(B1+B2)
190 B(1,3)=B2
200 B(2,2)=-(B1+B2)
210 B(2,4)=B2
220 B(3,1)=B2
230 B(3,3)=-B2
240 B(4,2)=B2
250 B(4,4)=-B2
260 C(1,1)=C1
270 C(2,2)=C1
280 C(3,3)=C2
290 C(4,4)=C2
300 IS=BL/RC
305 PRINT#-2,TAB(5)"FREQ.";TAB(20);"POWER";TAB(40)"ADMIT."
304 PRINT#-2
310 F=10
320 FOR Z=1 TO 40
330 F=F*9
340 G0=.219*F*F*RS*RS*RS*RS
350 G1=G0*BL*BL/RC*SD
360 G(1,2)=G1
370 G(2,1)=-G1
375 G2=G0*PD
380 G(3,4)=G2
390 G(4,3)=-G2
400 FOR I=1 TO 4
410 FOR J=1 TO 4
420 A(I,J)=39.47B4*F*F*C(I,J)+6.2832*F*G(I,J)+B(I,J)
430 NEXT J
440 NEXT I
450 GOSUB 1010
460 A0=D
470 FOR I=1 TO 4
480 T(I)=A(I,1)
490 A(I,1)=0
500 NEXT I
510 A(2,1)=-6.2832*F*IS
520 GOSUB 1010
530 A1=D
540 FOR I=1 TO 4
550 A(I,1)=T(I)
560 T(I)=A(I,2)
570 A(I,2)=0
580 NEXT I
590 A(2,2)=-6.2832*F*IS
600 GOSUB 1010
610 A2=D
620 FOR I=1 TO 4
630 A(I,2)=T(I)
640 T(I)=A(I,3)
650 A(I,3)=0
660 NEXT I
670 A(2,3)=-6.2832*F*IS
680 GOSUB 1010
690 A3=D
700 FOR I=1 TO 4
710 A(I,3)=T(I)
720 A(I,4)=0
730 NEXT I
740 A(2,4)=-6.2832*F*IS
750 GOSUB 1010
760 VA=A1/A0
770 VB=A2/A0
780 VC=-A3/A0
790 VD=-D/A0
792 IA=IS-VA*BL*BL/RC
794 IB=-VB*BL*BL/RC
796 IM=SQR(IA*IA+IB*IB)/BL
800 P=3.49E-2*(F^2*RS^4)
810 PS=P*((VA+VC)*(VA+VC)+(VB+VD)*(VB+VD))
880 PRINT#-2,TAB(5)F;TAB(25)PS;TAB(45)IM
900 NEXT Z
910 END
1010 D=0
1020 FOR I=1 TO 4
1030 FOR J=1 TO 4
1040 IF J=I THEN GOTO 1220
1050 FOR K=1 TO 4
1060 IF K=I THEN GOTO 1210
1070 IF K=J THEN GOTO 1210
1080 FOR X=1 TO 4
1090 IF X=I THEN GOTO 1200
1100 IF X=J THEN GOTO 1200
1110 IF X=K THEN GOTO 1200
1190 D=D+E*A(1,I)*A(2,J)*A(3,K)*A(4,X)
1195 E=-E
1200 NEXT X
1210 NEXT K
1215 E=-E
1220 NEXT J
1230 NEXT I
1240 RETURN
```

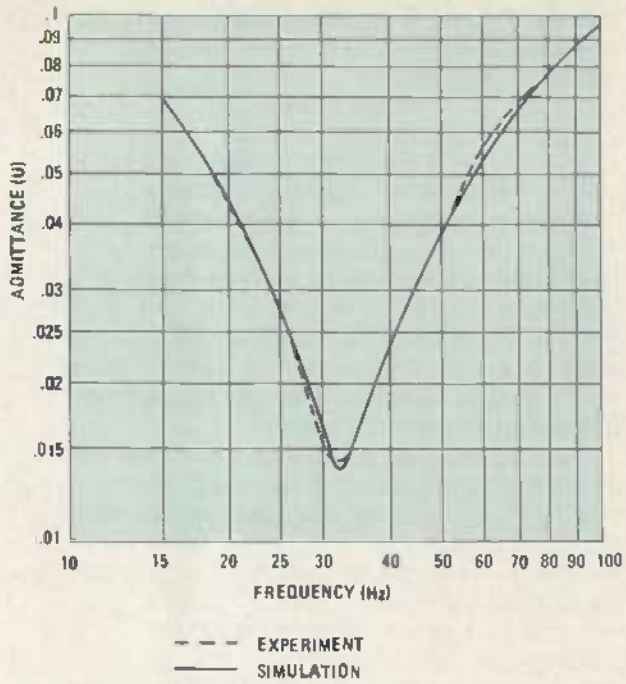

FIG. 6—MEASURED AND COMPUTER SIMULATED admittance of the woofer used as a design example in text. Curves represent behaviour of bare, unenclosed woofer.

voltage measurements, the low-frequency roll-off of that instrument is cancelled in the division of one quantity by the other. A graph of the admittance for our design example is offered in Figure 6. The free resonance is that frequency at which the minumum admittance occurs. (33 Hz for the design example.)

We determine the mechanical resistance by running the computer program with various assumed mechanical resistances until the computed admittance versus frequency matches the experimental results (Fig. 6). In the program we approximate suspending the bare woofer in a large room by assuming a very large enclosure volume (1000 cubic meters) and port dimensions (.001 meter radius, 1000 meter length) for which the port has no effect at any frequency of interest. The design example shows a good match between the computer result and the experimental measurement for an assumed mechanical resistance of 2.45 mechanical ohms.

Computer experiments with various enclosures

Continuing with the design example previously introduced, we use the measured parameters and compute the response for this woofer in several different enclosures. Figure 7 shows the response given by an infinite baffle of .2 cubic meters. For this run, the lack of a port is simulated by using a port radius of .001 meters and a port length of 1000 meters. As it happens, this is a rather lightweight woofer and does not perform well in a small closed box. The frequency response begins to roll off above 100 Hz.

We're sorry, but we've run out of space in this issue. This article will be concluded next month.

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ANTIQUE RADIOS

RICHARD D. FITCH
CONTRIBUTING EDITOR

Battery-powered antique radios

MOST OF OUR PREVIOUS DISCUSSIONS have concentrated on antique radios from the 1930's. Alternating current was available then, but it wasn't completely standardized. For example, power-line frequencies of 25, 40 and 60 Hz (or CPS, as we said at the time) were used, as were assorted DC voltages. Those inconsistencies did little to hold down the prices of radios produced then. And that problem continued on into the 1940's.

Power-line standards were not the only problems facing radio owners and manufacturers. You must remember that, back in the 1930's, not everyone enjoyed the convenience of home wiring. Thus, there was still a great demand for battery-powered radios. Of course batteries were not without their own set of problems. They often had to be removed and charged (or replaced!) weekly.

One attempted solution was the so-called "battery-electric radio," a receiver that got its "B" (plate) supply from the light socket, and its "A" (filament) supply from batteries. However, batteries for the A, B, (and, sometimes, C) supplies were the main sources of power until well past the mid 1920's. (I'll discuss some of those early radios, many of which were built from kits, or just schematics, in a future column.) As more areas became wired, the old battery sets could be used by purchasing an ABC power supply.

Antiques of the month

This was a busy month, so we have the three radios shown in Fig. 1 to talk about. All three are battery-operated, broadcast-band receivers that got *all* of their power from batteries. Both the Westinghouse (shown on the left) and the Crosley (shown on the right) are from the pre-electric-light-socket era, around 1925. The oversized Silvertone (shown in the center) received the standard broadcast band and two short wave bands that "put the world at your fingertips," as the sales pitch went. That later-model battery-operated Silvertone was marketed to rural America where most of the homes and farms were still not wired. Radios like the Silvertone were originally purchased via catalogue.

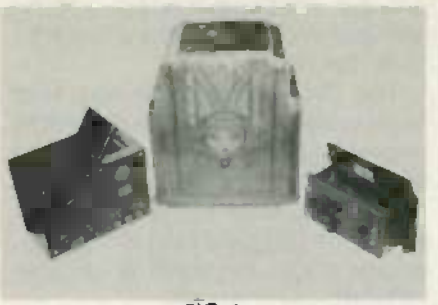

FIG. 1

The Crosley *Model 51*

The Crosley compares in size—although certainly not in weight—to a modern table radio. The weight differential is due, of course, to the cumbersome batteries. They were usually stored beneath a specially-built table. The battery leads plug into terminals on the front panel. Antenna and ground wires, and headphones, also plug into terminals on the front panel.

The Crosley *Model 51* was a regenerative receiver licensed for manufacture under Armstrong's 1914 patent. The circuit rarely regenerated into neighboring receivers, since they were few and far between. The Crosley's tube compliment consisted of two 01A's. Two WD11 tubes could be used by changing the filament voltage. The WD11 has a 1.1-volt filament, and the 01A has a 5-volt filament. Neither has a cathode because the filament serves as the cathode. It's interesting to note the Crosley type "D" tuning capacitor and the volume control (which is wired in series with the filaments.) The 0–100 graduations on the tuning dial were popular in that era.

The Crosley *Model 51* was popular in its day, and some modern-day interest has also been generated since we first discussed that antique in the February 1985 issue of **Radio-Electronics**. Probably there are not enough originals left to go around, but duplicating the cabinet and the chassis for a replica would be fairly simple. Let me know if you're interested; we can publish complete plans for both cabinet and chassis.

The Westinghouse

The Westinghouse (shown on the left in the photo) is also a battery-operated radio; it has one 01A tube used as a detector, and more as two audio stages. That radio has two chassis in the cabinet that are identified as No. 307189 and No. 307180, the receiver-tuner and detector-amplifier sections, respectively. The tuning range of 180 to 700 meters well overlaps the AM broadcast band. Like the Crosley, that radio has 0–100 graduations on the tuning dial.

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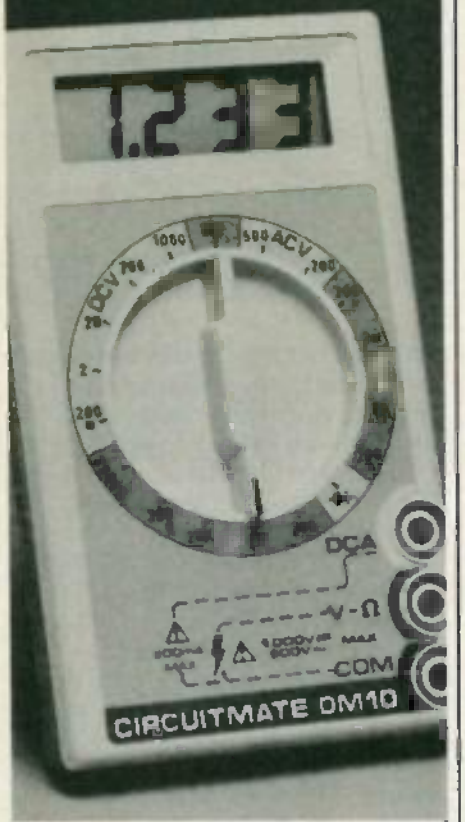

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Before any further technical talk, let me mention that when I bought that radio I noticed there was insulation missing from many of the wires in the receiver chassis. Nearby, there was an elliptical hole in the lid of the cabinet. Opening the lid revealed a huge ball of yarn inside. Not wanting the seller to think I didn't know all about antique radios, I didn't ask what that ball of wool was doing in the radio.

When I got it home, I disassembled it, and then I found out more about the wool, the hole and the missing insulation. I realized a rodent of some sort lived in that antique. That's just one other thing antique radio collectors have to look out for.

The Westinghouse has five front-panel controls and three sets of earphone jacks. The jacks were provided for the first, second, and third audio stages. The earphone would be plugged into the appropriate stage depending on the strength of the signal.

The detector and both amplifiers each had "rheostats" in their filament circuits for controlling volume. The rheostat also came into play as the batteries weakened. A horn-type loudspeaker could also be plugged in the jack from the second audio stage.

The main tuning, tickler, and vernier dials complete the front-panel controls of that Westinghouse; they are all mounted on the receiver-tuner chassis. The vernier dial fine-tunes the main tuning capacitor. The tickler-coil adjustment is part of the regenerative circuit.

Battery-operated antique radios often lacked on/off switches; the batteries had to be disconnected from the terminals. On our Westinghouse, batteries are also conserved by the headphone-jack arrangement. When the detector or first audio jack is used, the following stages are disconnected by the headphone plug.

The Silvertone *Model 1923*

The Silvertone was used mostly in rural areas, and by some urban dwellers whose homes were still unwired. All batteries are concealed in the oversized table-model cabinet. A separate patent notice protects each circuit used in that superhet. Unlike many early radios, an ON/OFF switch disconnects the batteries from the circuit. As we said, the Silvertone receives two short-wave bands in addition to the broadcast band. One knob changes bands without your having to plug in different coils.

Needs and haves

B. R. Pogue, Route 1, Box 786, No. 8, Thatcher, AZ 85552 offers to help readers needing help with antique radios. Enclose an SASE. Antique-radio information and parts can be obtained from E. G. Rountree, Box 269, Norris City, IL 62869. Antique radio tubes and schematics are also available from Byron Ladue, 13 Revere Dr., Rochester, NY 14624. Tubes (many of which are new) can be obtained from Maurer Sales, 29 S. 4th St., Lebanon, PA 17402. Send an SASE.

Bob Fabris, 3626 Morrie Dr., San Jose, CA 95127, is interested in contacting anyone with E. H. Scott Sets. An Atwater Kent Model 49 wiring diagram is needed by Greg Schelin, as the mice ate the insulation. I know what you mean, Greg: They usually don't disconnect the wires after their meals. Just replace them one at a time. Write to Greg at Star RTE Box 80, Culver, MN 55727.

FADA collectors: Jim Collins would like to correspond with you. Write to him at 8622 14 St. NE, Everett WA 98205. Information on an Atwater Kent Model 20 battery eliminator is needed by John Grey, 3348 Wildridge Road NE, Grand Rapids, MI 49505. John also has some antique radio tubes available cheap. A schematic diagram or other information on a U. S. Navy Crew Entertainment Radio, Model RBO2, is needed by George W. Gurner, 4417 Monmouth Castle Road, Virginia Beach, VA 23455.

Supreme Publications, 1926-1947 radio schematics are wanted by H. Penowarur, 1535 No. 8th Ave., St. Cloud, MN 56301. He also has issues of *Radio News* (post-Gernsback), and *Radio Craft* (the forerunner of R-E) from the 1930's for sale. Send an SASE for information. William C. Swater would like to contact Zenith collectors or clubs. Write P.O. Box 909, Senatobia, MI 38668. R-E

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STATE OF SOLID STATE

ROBERT F. SCOTT
SEMICONDUCTOR EDITOR

IC temperature sensors and more

TEMPERATURE SENSORS HAVE COME A long way since the invention of the mercury-bulb thermometer. In the past, electronic devices that indicated changes in temperature were often based on the principle that a device's resistance varies as temperature changes. That variable resistance would cause a change in voltage that could be sampled, scaled, and output in human-readable form. Thermocouples, for example, work according to such principles. But the latest in electronic temperature sensing is based on integrated-circuit technology.

National Semiconductor has introduced two new series of precision IC temperature sensors; each series consists of five different devices with different temperature ranges. In each device, output voltage is linearly proportional to temperature. The LM35 series is used for Celsius readings, and the LM34 series for Fahrenheit readings.

All devices in the series are trimmed and calibrated during manufacturing to provide high accuracy and linearity; hence the circuit designer need not provide either calibration or trimming. The LM35 series features accuracy of ±0.25-degree at room temperature, and ±0.75-degree over the full −55 to +150°C range. The accuracy of the Fahrenheit units is ±0.5-degree at room temperature, and ±1.5-degree over the −50°F to +300°F range. Those devices have one advantage over similar units calibrated in degrees Kelvin. It is unnecessary to subtract or to null out a large constant in order to obtain readings directly in either degrees Celsius or degrees Fahrenheit.

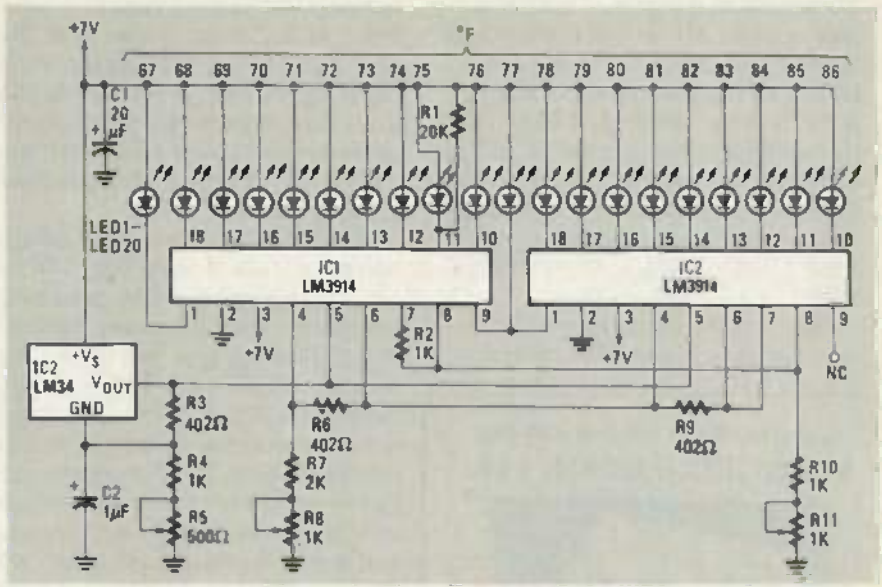

FIG. 2

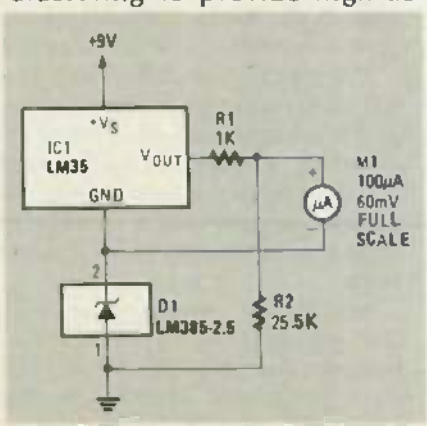

FIG. 1

All devices feature low output impedance, linear output, and precise inherent calibration, all of which make interfacing to readouts or control circuits especially easy. They can be powered by single-ended supplies ranging from +4 to +30 volts, or by split (plus and minus) supplies.

Quiescent current drain is very low. The LM35 series draws 56 µA from a 5- to 30-volt supply at 25°C. The LM34 series draws 75 µA. Self-heating due to thermal resistance is less than 0.1°C or 0.2°F in still air. Devices in the series measure temperatures ranging all the way from −55°C to +150°C (LM35, LM35A), and −50°F to +300°F (LM34, LM34A). Other models are available with more restricted ranges.

Thermal resistance of the LM35 in the TO-46 package is 400°C/W junction to ambient and 24°C/W junction to case. Thermal resistance in the TO-92 package is 180°C/W junction to ambient. The LM34 has a thermal resistance of 292°F/W junction to ambient, and 43°F/W junction to case in a TO-46

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metal-can package. Thermal resistance is 324°F/W junction to ambient in the TO-92 plastic package.

All devices in the series produce a linear 10.0 mV/degree (°C or °F) output over the range of +2°C to +150°C for the LM35, and +5°F to +300°F for the LM34. Figure 1 shows the LM35 as an expanded-scale Fahrenheit thermometer with a +50°F to +80°F range.

Figure 2 shows the LM34 used as a bar-graph temperature display that displays temperatures ranging from +67 to +86°F. Two LM3914 bar-display LED drivers control twenty LED's. All fixed resistors are 1% or 2% film types. Adjust trimmer resistor R11 so that the voltage at pin 8 of IC3 is 3.525 volts; adjust R8 so that the voltage at pin 4 of IC2 is 2.725 volts; and adjust R5 so that the voltage at the output of IC1 is 0.085 volts + 40mV/°F × T_A (ambient temperature). For example, for an ambient temperature of +80°F, V = 0.085 + (0.04 × 80) = 0.085 + 3.2 = 3.285 volts.

The data sheets on these two device families come with complete specifications and a dozen or so practical circuit applications. Request copies from **National Semiconductor**, Public Relations, 2900 Semiconductor Drive, Santa Clara, CA 95051.

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New transient suppressor

The *Surgector* is a new type of device capable of diverting dangerous transient energy away from sensitive electronic equipment like telephones, computers, and other types of equipment subject to sudden voltage surges.

The monolithic device is a thyristor whose gate region contains a special diffused section that functions as a Zener diode, and that also permits anode-voltage turn-on of the device. It is claimed that this feature provides high-speed protection not available with many transient-protection devices presently used.

Risetimes of transient voltage spikes are often very fast; for example, lightning often produces transients with risetimes exceeding 1000 volts per microsecond. Gas tubes and many other protective devices cannot act fast enough to limit the voltage across the protected circuits. The *Surgector* uses Zener action to clamp the voltage until the integral thyristor turns on and drops the voltage to a safe value. In most cases the peak voltage reaching the protected circuitry does not exceed 130% of normal operating voltage. For example, it is claimed that a lightning surge with a risetime of 1500 volts/μs is clipped at about 100 volts.

Presently, RCA offers four types of Surgector: the SGTO3U13, SGTO6U13, SGT23U13 (2-terminal devices), and the SGT10S10 (a 3-terminal device). The 2-terminal devices are available with voltage ratings of 30, 58, and 226 volts. Those ratings refer to the voltage that can be continuously applied without tripping the device.

When a high-voltage transient arrives, the Zener diode in the gate region of the SCR conducts, and that turns the SCR on. The transient is thereby clamped to the forward drop of the SCR so the protected circuitry cannot be damaged. After the transient has passed, and after normal circuit current has dropped below the holding current of the Surgector, the device turns off, and normal circuit operation resumes. The devices have holding currents above 100 mA, and that insures they will operate in average telecommunication circuits.

The SGT10S10 is unidirectional, and its third terminal allows the user to control the SCR's turn-on voltage. That voltage is normally 100 volts, but, by using external gate-control circuitry, voltages less than 100 can be used to trigger the device.

All devices in the SGT series are housed in modified TO-202 plastic packages, whose small size makes them ideal for telephone handsets and PBX's. However, the SGT devices' low cost and high speed also make them suitable for applications in computers, alarm systems, TV, aircraft electronics, and CATV. In 10,000-piece lots, the SGT03U13, -06U13, -23U13, and -10S10 are $0.58, $0.72, $1.06, and $0.85, respectively.—**RCA Solid State**, Route 202, Somerville, NJ 08876.

One-IC AM receiver

The ZN416E is the latest addition to Ferranti's line of single-IC AM broadcast-band receivers. Similar to the ZN415E in packaging and pin-out, the new device is a buffered-output version of the TO-92 style ZN414Z. A typical ZN416E delivers 120-mv RMS into a 64-ohm load.

Powered by a single 1.5-volt dry cell, the device may be used in a wide range of applications, including personal receivers, novelty radios, remote telephones, and radio-control circuits. The ZN416E, like others in its family, can be used as the IF-strip and detector of an AM superheterodyne receiver.

The ZN416E features a 150-kHz to 3.0-MHz input-frequency range, and it includes an RF amplifier, a detector, AGC and an audio amplifier. The output stages provide 18-dB voltage gain that is suitable for direct-drive headphone applications.

The ZN416E comes in an 8-pin DIP, operates over a 0°C to +70°C temperature range, and costs $1.12 each in lots of 10,000.—**Ferranti Semiconductors**, 87 Modular Ave., Commack, NY 11725. R-E

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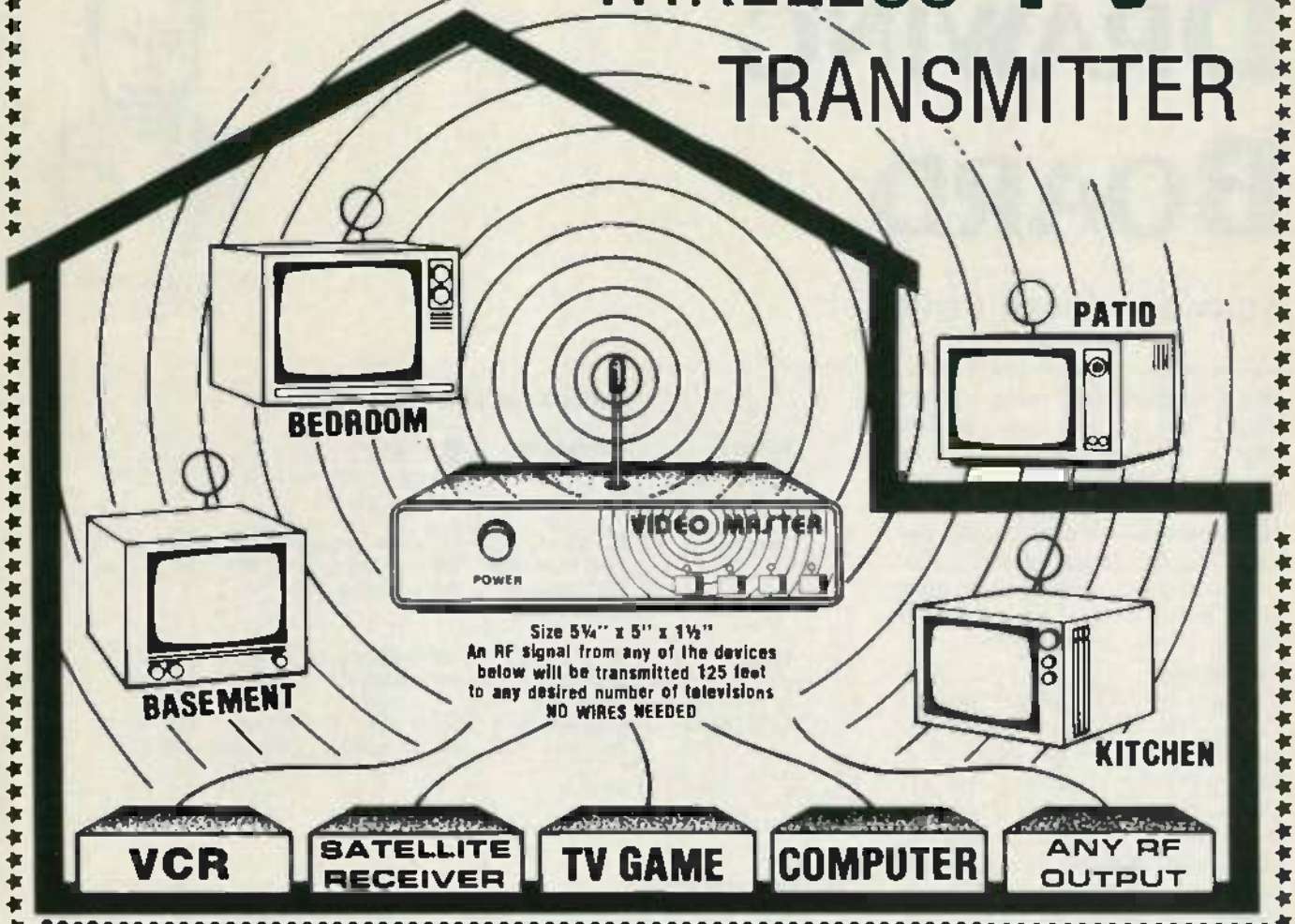
WIRELESS TV TRANSMITTER



The video master is a small wireless UHF TV transmitter which transmits channel 3 or 4 RF signal you insert to all the televisions within your home. Input from any of the devices above can be inserted into the video master. The video master will transmit this signal on an unused UHF channel up to 125 feet to as many TV's as you wish to receive.

AND NO WIRES TO HOOK UP!

Use a separate video master on each device and let your TV act as the selector.

Example:

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ROBERT GROSSBLATT
CIRCUITS EDITOR

Software doesn't smoke!

WE ENDED LAST MONTH ON A SOMEwhat depressing note—sorry about that. I didn't mean to turn anyone off, but I know it can be disconcerting for hardware hackers to come to grips with the fundamentals of Z80 circuit design. The fact of the matter is that the hardware represents *at most* only about 50% of the work required of any microprocessor circuit design.

If you hooked up last month's circuit, the experience probably turned out to be an exercise in unqualified frustration. You got the parts, connected them together—and absolutely nothing happened! The reason is simply that even though microprocessor-based circuits are very powerful, they're also very stupid. They can do anything you want them to do, but they can't do anything at all without very explicit instructions from you.

I'm sure you know I'm talking about software. That is a *big* subject, and there's simply no way we can cover it here in any depth. The best I can do is point out a few fundamentals, and try to steer you in the right direction to get more information.

We've mentioned the *instruction set* here before; it is simply the set of commands recognized by the microprocessor. Each instruction is passed from memory through the INSTRUCTION DECODER, and then carried out by the arithmetic logic unit (or ALU for short). All Z80 circuits must have space to store those commands; in last month's circuit we used an EPROM, although it could have been some other kind of memory.

TABLE 1—Z80 INSTRUCTION TYPES

Function	Instructions	Descriptions
Data Movement	LD EX EXX IN OUT	This family moves data to and from CPU, memory, and I/O.
Data Changing	BIT SET RES ADD SUB AND OR XOR S R CP INC DEC	This is the largest series of instructions. They alter the data by doing arithmetic, bit level, and logical functions.
Program Flow	JP CALL RET	These can change the sequence of instructions in a program.
CPU Control	DI EI IMO IM1 IM2 HALT NOP	These let the Z-80 respond to events that aren't checked by the program being executed.

The hex problem

Since we'll be dealing with the Z80 in low-level machine language (as opposed to BASIC or Pascal, which are high-level languages), there's one thing you'll have to come to grips with right away: dealing with hexadecimal numbers.

Instructions are presented to the Z80 on its eight-bit data bus in binary (that is, as ones and zeros), but straight binary is too difficult to deal with, so designers almost universally use hex. For example, the code for a JUMP instruction (similar to a GOTO in BASIC), is 11000011 to the Z80, but to human beings, it's C3.

If you're serious about using microprocessors, you've got to get to the point where you can look at a hex number and have a good intuitive feel for what it means. I know that's a pain in the neck, but it's easier than constantly converting to and from decimal numbers.

Both data and instructions are specified in hex. The Z80 has 158 basic instructions, but if you count all the different addressing modes, the actual number of instructions is almost three times as many. Since a byte (8 bits) can have only 256 different values, and since there are over 400 different instructions, some instructions must be more than one byte long. In fact, some instructions are four bytes long. Anyway, in order to give you a basic idea of the Z80's instruction set, I've grouped all the instructions in four categories, as shown in Table 1.

The first group of instructions in Table 1, "Data Movement," has the most members. Those instructions include the LOAD series used to move data to and from external memory, the Z80's internal registers, and the I/O (input/output) devices connected to your system. Whenever you use one of these instructions, you have to supply two pieces of information: 1.) The source of the data (i.e.,

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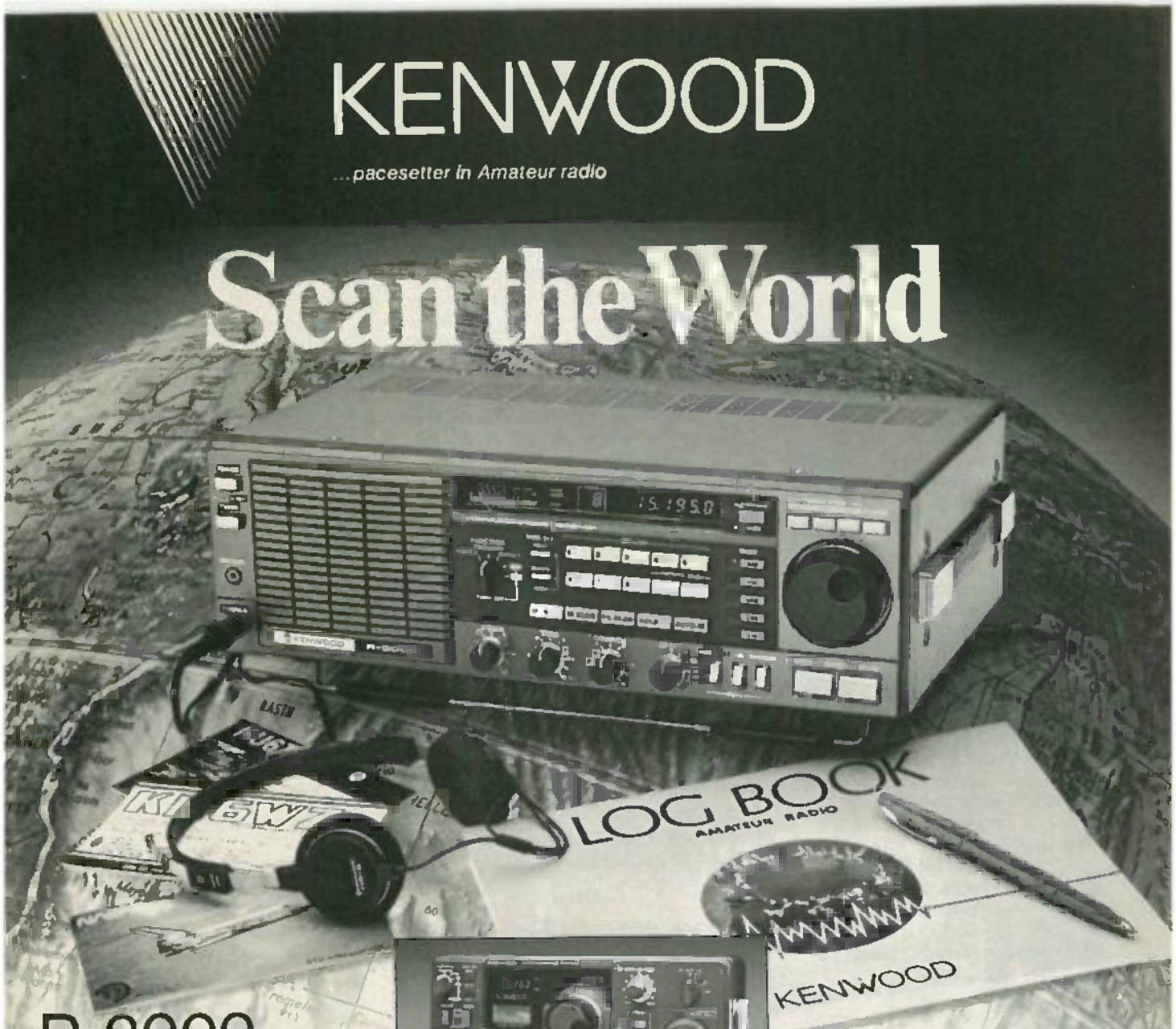

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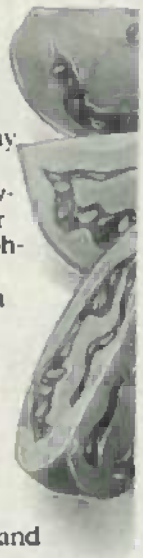

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which register or memory location), or the data itself. 2.) The destination of the data.

There are 134 different data-movement instructions. Some of that variety is due to the fact that the Z80 has two main sets of registers. The alternate B'C' pair corresponds to the BC pair, D'E' to DE, H'L' to HL, and A'F' to AF. Now, even though it's correct to say that there are 14 registers in the Z80, it's a bit misleading as well. Only one set of those registers is available for use at one time.

The Z80 has two types of instruction that allow access to the alternate registers: EX and EXX. The former exchanges the AF pair and the A'F' pair, and the latter exchanges the other three pairs, (BC, DE, and HL for B'C', D'E', and H'L'), all at once. There are four other EX instructions that swap registers, but they operate only on the main register set.

The IN and OUT instructions are the last of the data-movement instructions. Some of those instructions operate only on a single byte of data, and others make it easy to move whole blocks of data. A simple I/O instruction would be:

IN A,n

The accumulator is symbolized by *A*, and *n* is a one-byte hex number specifying a particular port address. Since one byte is used to specify that address, the Z80 can address 256 different I/O ports.

When the Z80 executes an I/O instruction, several things happen. First, the port address specified in the I/O instruction is placed on the lower bits of the address bus (A0–A7). Second, the contents of the accumulator are put on the upper half of the address bus (A8–A15). Third, the $\overline{IORQ}$ line and the $\overline{RD}$ line go low. Finally, the data is transferred via the data bus to the accumulator. The whole process is quite similar to the way data is transferred to and from RAM (Random Access Memory). An OUT instruction would work in much the same way, but the $\overline{WR}$, rather than the $\overline{RD}$, line would go low.

Data changing instructions

The second group of instructions covers many of the things we commonly do with hardware: arithmetic operations (ADD, SUB, CMP), that allow you to add, subtract and compare individual bytes, and logical operations (AND, OR, XOR), and bit operations (BIT, SET, RES, SHF, ROT) that allow you to examine and change individual bits.

If you've programmed in a high-level language like BASIC, the instructions in the third group should look familiar, since there are equivalents in all high-level languages. As mentioned above, the JUMP instruction is similar to BASIC's GOTO; CALL is similar to GOSUB, and RET is similar to RETURN.

The last group of instructions controls the operation of the Z80 itself, rather than directly manipulating or moving data. One very commonly used instruction is NOP, for NO OPERATION. It causes the Z80 simply to bide time for a full clock cycle. Among other things, programmers use NOP's to generate timing loops, and to reserve space in the middle of a program for code that will be added later.

The remaining instructions of that final group are all concerned with *interrupts* in one way or another. The Z80 allows three different types of interrupt, but they all operate in a similar manner. When a low is received on either of the Z80's two interrupt pins, normal program flow stops and, depending on how the Z80 is set up, program flow will continue at a special location in memory.

Unfortunately, to find out more about interrupts, software and other Z80 vitals, you're going to have to do some homework. We need some software to wake up our Z80 circuit, and we'll get into that next month. However, that software won't make much sense if you don't spend some time on your own reading about the Z80's instruction set.

So do some investigating, and don't be afraid to try burning an EPROM and telling our circuit to do something. Learning software design is very similar to learning hardware design—but with one big advantage: It might not work, but it won't smoke or blow up! See you next month. R-E

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DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT
CIRCUITS EDITOR

A simple CMOS switching circuit

WE RAN A CONTEST, A FEW MONTHS ago, to come up with clever hexadecimal display circuits that would display the digits *0 through 9* and the letters *A* through *F* on standard 7-segment LED displays, given binary inputs ranging from 0000 to 1111. Of course, I received quite a few interesting ideas, but I was surprised to learn that a number of you are interested in using LED display drivers to control devices *other* than LED's!

It seems that people want to use devices like the 4511 to control everything from lightbulbs to relays to high-current motors. I have to admit that I don't really understand why you would want to do that, since the 4511 (and most common display drivers) put peculiar signals on the outputs while the inputs are changing. After all, those IC's were designed to be display drivers, and for display purposes, that's not a problem. But it could be a major problem if you are controlling other devices.

But with the proper interface circuitry, you can have those drivers control anything you want, as long as you don't exceed the IC's current-drive capability. Using a 4511 to drive a device that uses half the available power output of the TVA is possible, given the proper interface. *(For a more extended treatment of this subject, see the article on switching transistor circuit design in next month's issue.—Editor)*

An example

The circuit in Fig. 1 shows how you could use a 4511 (or any other CMOS gate, for that matter) to control low- to medium-power devices. That circuit should look familiar; we've used it, or variations of it, many times in this column. The transistor, which could be a 2N2222, is set up as a switch. When the CMOS output goes high, the transistor will turn on, assuming that R1 allows enough current to flow. Current will then flow through the output device and the transistor's collector-emitter junction.

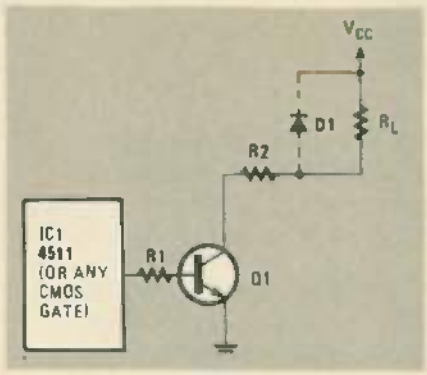


FIG. 1

In that circuit, R_L symbolizes the load you need to control, be it a lightbulb, an LED, a relay, etc. Resistor R1 is there to protect the CMOS output, and R2 is there to limit the current through the transistor. Optional diode D1 should be used if you're driving an inductive load; it will protect the coil from inductive spikes.

Working out the values of the components you need for your application is simple—just follow the design rules below and you shouldn't go wrong.

1) R1 limits the transistor's base drive.

2) R2 limits the transistor's collector current.

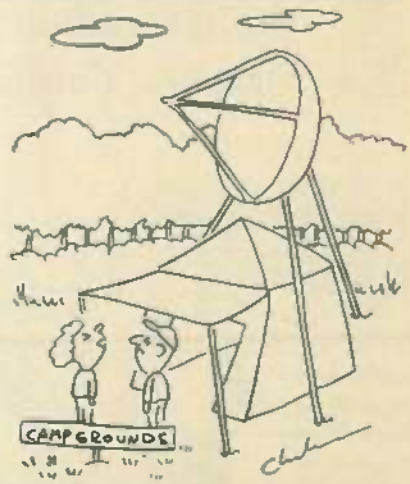
3) Both values can be found from a straightforward application of Ohm's Law. Figure the transistor voltage drop as .6 volts.

4) Make sure that the transistor you choose has high enough ratings to withstand the voltage and current you'll be using.

5) If your circuit doesn't work, the transistor probably doesn't have enough gain. Try another one with higher gain, or else use a Darlington.

6) The diode's PIV rating should be at least twice the value of V_{CC}, and it should be able to handle at least twice the current drawn by the coil.

That kind of circuit is one of the most basic building blocks in electronics. Learning how to work with transistor switches is a good first step if you want to learn how to design your own circuits. So feel free to experiment—the parts are cheap. **R-E**



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SERVICE CLINIC

JACK DARR
SERVICE EDITOR

Repairing old TV's

WE'VE TALKED ABOUT REPAIRING OLD radios in past columns; now let's talk about repairing old TV's. The same basic procedure is followed as in fixing modern TV's. Before you start, take a minute to check some of the really obvious trouble spots; doing that could save you a lot of trouble later on. In particular, check the picture tube and the HV (high voltage). If either is bad (for example, if the picture tube has an open heater, or the flyback is burned up), it might be wise to consider whether that TV is really worth fixing. Of course, if the customer says, "Fix it, regardless of the cost," go ahead and do it.

If, in your preliminary examination, you find that the flyback is a charred mess in the bottom of the chassis, contact the customer, tell him that the TV has a serious problem, and explain that a new flyback is going to raise the cost of the repair quite a bit. New flybacks for some old TV's can cost as much as 35 or 40 dollars!

The next step is to look through the chassis for obvious problems like weak tubes, leaky transistors, burnt resistors, open capacitors, etc. If nothing is found, there's a good chance the TV will function correctly.

B+ is first

After getting the go-ahead from your customer, get the B+ up to normal, and then check through the circuit stage by stage to see if anything else is out. Check the sync separator, the video-output circuits, and each portion of the circuit, as shown in Fig. 1; and then check the alignment.

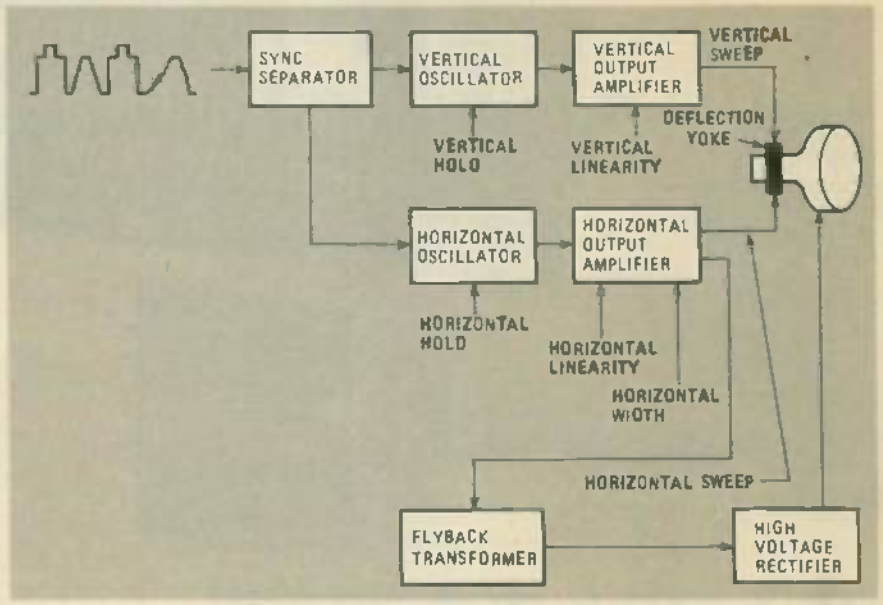

FIG. 1

I'm a great believer in "non-alignment" whenever possible. That is, if the TV works, and if the coils seem not to have been fiddled with—the adjusting slugs are not all the way in or out—there's a good chance that the coils haven't been touched. And if they haven't, then the chances are also good that the alignment is still OK. So, if it ain't broke, don't fix it!

You can check the alignment with a sweep-generator; hook the generator up and get a curve on your scope. If all your markers and traps (sound, picture, etc.) are in the right places, that's even better evidence that the coils haven't been fiddled with. I've put a sweep generator on any number of old TV's, and found a picture-perfect IF curve on them!

Here's another thing to check when working on an older set: Make sure that all of the controls (brightness, horizontal and vertical hold, etc.) are clean and that they work smoothly throughout their useful range of adjustment. Controls in old sets are often functionally OK, but dirty and noisy; and that makes them hard to adjust. If one is dirty, give it a shot of volume-control cleaner spray, and work the control back and forth till the noise goes away. Do that to each control, if necessary.

If the focus control can't make the scanning lines clean and sharp, check for correct focus voltage; about 4,000 to 4500 volts is normal. If the focus voltage *is* too low, the beam won't focus properly. If it is too low, check the focus supply; usually it is separate from the main HV supply, but sometimes it is derived from the HV through a high-value dropping re-

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sistor, possibly ten megohms or more. If the focus voltage is too low (or too high), check that dropping resistor. It may have drifted off-value.

All in all, if a TV has survived a few decades with no really serious problems, there's a pretty good chance that it can be successfully restored at not too great an expense. Problems like no B+ are usually simple to diagnose and track down if you're patient. Alignment is often OK, but if the picture is fuzzy, the alignment may be out. Check the tuning-slugs, as mentioned above. Other than that, be on the lookout for suspicious-looking components: burned resistors and the like.

It's usually not too difficult to fix up one of those old soldiers; and if you do, you should wind up with a good working TV. R-E

SERVICE QUESTIONS

RED-HOT DAMPER TUBE

An Admiral came in with a blown fuse. I replaced the horizontal output tube, the oscillator and the damper. The set worked for 2 days and now it runs for about 15 minutes, after which the damper tube gets red hot before the fuse blows.—L.H., Keene, NH

A variable transformer would be a big help, here. You could run the chassis at a low AC voltage to keep the damper from glowing while checking out the rest of the circuit. With or without a transformer, wrap your fingers around the flyback. If it's hot, it's defective. The same is true for any component in the output circuit.

VERTICAL BAR IN PICTURE

A Sears model 564-4173 TV set comes on with a 1-inch vertical bar that appears to be an overlapping of the left and right portions of the picture. It gradually narrows and, after 30 minutes, eventually opens into a nearly-full picture. I have no scope. Can you help?—A.H. Atascadero, CA

A scope certainly would help here so that you could take before and after measurements. Nevertheless, it looks like a thermal problem, doesn't it? Once the picture opens up, why not spray components in the horizontal circuit with cooler and look for a breakdown? If you're successful in localizing the problem, you can use the reverse technique—heat the components with a lamp or soldering-iron tip and look for a reaction.

SHRUNKEN VIDEO

I have a Zenith 25DC56 chassis, in which the picture is short by about one inch on each side. I've changed everything in the horizontal circuit and the power supply. Every once in a while I hear the high-voltage crack.—G.E. Bow, KY

My hunch is that the high voltage is too high, hence the arc-over. If so, try replacing the retrace cap (a .0018 µF capacitor from the output collector to ground). I believe what's happening is that the excessive high voltage causes a faster beam through the kine, resulting in a shorter deflection angle, and thus a smaller picture. R-E

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SECURITY SYSTEM

continued from page 52

vary by rotating R7. The LED's connected to IC4-a should be counting from zero to seven in a binary sequence; the group should change state once for every eight flashes of LED1 if IC2–IC4 are operating properly.

Install a short jumper for sense-loop connector P9 in SO3 and press the TEST switch. The TEST lamp should light up. Press the MASTER RESET switch; DSP1–DSP4 should all read "0," and LED2–LED4 should be off. After releasing the switch, counting will begin. After IC4 has counted to seven, LED5 on the timer board and LMP5 (ARMED) in the control panel should illuminate. Removing the jumper should trigger RY1, and ALARM lamp LMP3 should light. Re-inserting the jumper and pressing ALARM RESET switch S20 should turn off RY1 and LMP3. If everything worked as expected, you're ready to install your real sense loop.

Now test the keyboard circuitry. Set the desired entry code using switches S1-a–S1-h and S2-a–S2-h. Press the MASTER RESET switch and, after the ARMED lamp turns on, punch in your code. LED7 on the display board should light, and so should LED10 in the keyboard panel. Pressing ENTER switch S19 should now cause pin 3 of IC6 to go high, which should clock flip-flop IC7 and turn on RY4.

Incidentally, you may have noticed that the ALARM RESET switch is mounted on the control panel in our prototype. It is likely that you will want to relocate it to a less conspicuous place. One good location would be near the main chassis.

After any problems have been corrected, the sub-assemblies should be sealed up and mounted in their final positions, and the interconnecting cables and sense-loop wiring completed. The alarm should be fully functional now.

Power failure

In the event of a power failure, after power is restored the system will automatically go into the timing cycle and then arm the alarm. If the five-volt power supply fails and the twelve-volt supply remains operational, you would have no way to enter the secured area without tripping the alarm, because, without five volts, the display board would be inoperable, so the proper code could not be punched in. Therefore, you may want to add failsafe keyswitch S23 (shown in Fig. 10); for maximum security, that switch should be located in an out-of-the-way place. If you do not wish to use a keyswitch, an alternative would be to add a battery backup circuit that would take over in the event of a power failure.

Other uses

For automotive or marine use, the timer board might be used by itself as an intrusion alarm. In addition, the digital combination lock could be used as a theft prevention device. By inserting the lock in series with the ignition circuit of an automobile or boat, the vehicle would not start until the correct digital code were punched in. Power could easily be derived from the automobile's (or boat's) electrical system.

If you have any difficulties during either construction or operation of the alarm, feel free to drop the author a line. If you require a reply, be sure to include a self-addressed, stamped envelope, and write to 908 Broadhurst Dr., St. Louis, MO 63011. R·E

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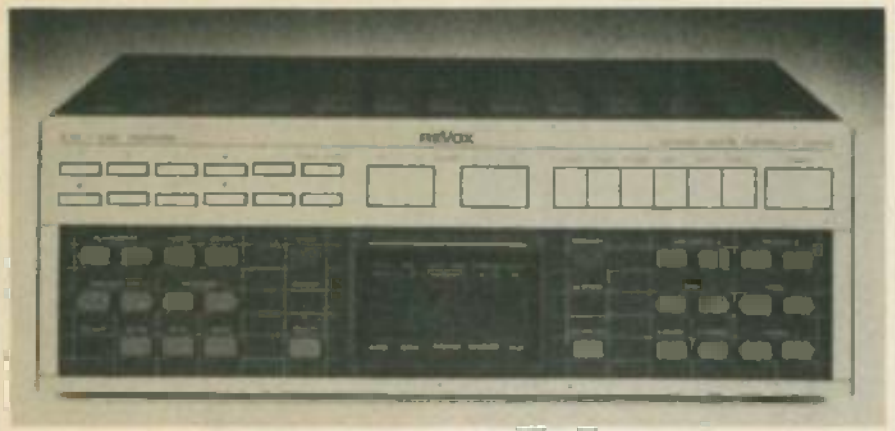

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TUNER-PREAMPLIFIER model *B286*, features a ten-square-inch liquid-crystal panel that displays operational status of 17 different functions, including the call letters, locations, and frequencies of 29 FM and AM stations. It is designed for use with powered speakers—or separate power amplifiers—in a programmable, interactive music system that is remotely controllable, even from other rooms.

The model *B286* is easy to program—either by its front-panel controls or by the model *B205* remote. With the help of two microcompressers and a nonvolatile memory, 34 separate levels can be programmed for each of the 29 FM and AM stations—along with similar programming for source inputs. The music listener can now switch from station to station, or source to source, without annoying volume changes.

The model *286* is priced at $1400.00.—Studer Revox America, Inc., 1425 Elm Hill Pike, Nashville, TN 37210.

TEST-EQUIPMENT LINE includes two battery testers and five multimeters; here is the data on those seven units.

The model *23-170* multi-purpose battery tester is a large diagonal meter that measures actual voltage and has a "good-weak-replace" scale. There is also a simple mechanical system that allows the user to drop in batteries of different sizes and push a button for accurate readings. The suggested retail price is $12.50.

The model *23-175* multiple-range deluxe battery tester is a 3" diagonal analog meter with multiple multi-color scales for easy reading, to tell if the battery is good, marginal, or needs replacement. The suggested retail price is $19.90.

The model *23-200* day-in day-out versatile multi-tester is a 2000 ohm-per-volt multi-tester that measures AC voltage, DC voltage, DC current, decibels, and resistance. There are 16 measurement ranges in all. The suggested retail price of the model *23-200* is $15.95.

The model *23-204* 10,000 ohm-per-volt multi-tester has 19 ranges, an anti-parallax mirror, jeweled movement, and overload protection. The suggested retail price is $23.50.

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The model *23-215* pocket-size pushbutton meter is a ten-megohm multimeter with 3-½-digit liquid-crystal display. It features high accuracy, compact size, RF shielding, pushbutton range selection, and a meter-overload protection circuit. The suggested retail price is $79.96.

CIRCLE 22 ON FREE INFORMATION CARD

The model *23-220* 3½"-digit LCD multimeter (shown in photograph) has 10-megohm input sensitivity and professional accuracy of 0.25%. It measures 24 ranges and features an auto-zero function and automatic polarity sensing to prevent overload and minimize potentially damaging voltages. The suggested retail price of the model *23-220* is $119.95.—Midland International Corporation, 1690 North Toping Ave., Kansas City, MO 64120. R-E

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SATELLITE-TV RECEIVER

continued from page 48

to pin 6 of IC8, an NE564 phase-locked loop. That IC is used to lock in the audio subcarrier by varying the voltage on varactor diode D12. The tuning range (5.0 to 8.0 MHz) is set by C72, while front-panel SUB-CARRIER TUNING potentiometer R110 fine-tunes the audio sub-carrier.

Audio de-emphasis is provided by R80 and C55, and Q8 amplifies the signal to drive the RF modulator. A separate audio output is provided at jack J3. Trimmer potentiometers R111 and R112 set the narrow- and wide-reception bandwidths of the PLL, respectively.

As mentioned above, satellite-TV signals for the U.S. are broadcast in two polarities: horizontal and vertical. In order to receive signals of either polarity, we must have some way of rotating the antenna probe. The receiver offers a PULSE output at its rear-panel terminal strip TS1 for that purpose. When POLARITY switch S2 is toggled, the pulse width at the PULSE output changes, and that causes the motor-driven antenna probe (in the feedhorn) to rotate 90 degrees.

The control pulses are generated by IC6, an NE555 timer IC functioning as an astable multivibrator. Its pulses are output on pin 3; R47 protects the IC's output stage in case a short develops in the cable leading to the feedhorn. The SKEW control, R108, varies the pulse width for fine tuning of the received signal.

The pulse width of the output of the 555 circuit can vary from about 0.6 ms to 2.6 ms, which corresponds to a probe movement of about 160 degrees. Ideally, with SKEW control R108 centered, the output pulse width with S2 in its HORIZONTAL position would be 1.9 ms, and it would be 1.0 ms in its VERTICAL position. Then, each time the POLARITY switch is toggled, the probe will rotate 90 degrees. Because polarization may vary slightly from satellite to satellite, the front-panel POLARITY selection switch S2 is supplemented by the front-panel SKEW control (R108) for fine-tuning.

The RF modulator delivers a signal that is compatible with all standard TV's and VCR's to TV Channel 3 or 4. The modulator is crystal controlled, so no fine tuning is required.

Now you should have a pretty good idea of how the satellite receiver works. The next step is to build a unit. Unfortunately, that will have to wait until next time as we are out of room for this month. Meanwhile, if you want to get a head start and gather the parts, a complete parts list has been provided. Most individual parts are available from the kit supplier mentioned. R-E

DIGITAL IC'S

continued from page 74

literature, but it is still a popular circuit.

The circuit in Fig. 23 is based on the 4060 CMOS oscillator divider. That IC has an internal oscillator that drives a chain of binary counters. Either R-C or crystal timing of the oscillator is possible. (In the circuit shown, a crystal is used to determine the operating frequency.) Each output is equal to the fundamental frequency divided by a power of two, up to $f/2^{14}$; note, however, that outputs of $f/2$, $f/4$, $f/8$, and $f/2048$ are not available.

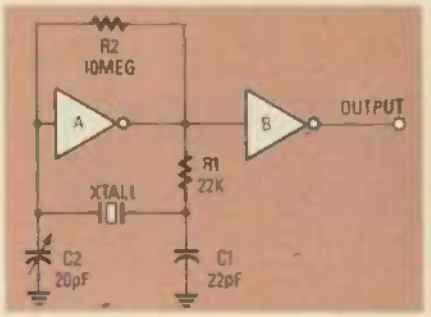

FIG. 22—THIS "CLASSIC" CMOS oscillator first appeared in some of the earliest CMOS applications notes.

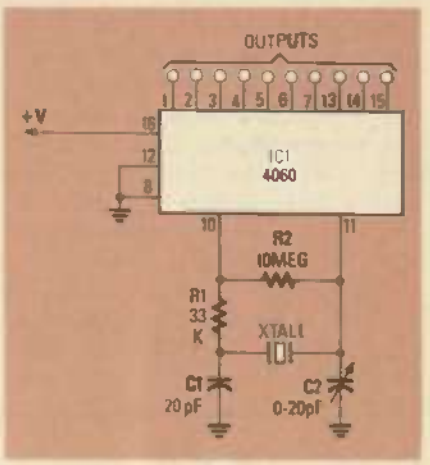

FIG. 23—THE 4060 CMOS oscillator/divider contains an internal oscillator that drives a chain of binary counters.

Op-amp clock circuits

Figure 24 shows how an op-amp can be configured to uperate as an astable multivibrator. The negative feedback loop consists of R3 and C1, and it is that network that sets the operating frequency of the circuit, although the voltage-divider bias network, R1-R2, also has a role.

The Zener diodes across the output are connected back-to-back and are used to limit output-voltage swings. In addition, because they prevent saturation of the op-amp output on extreme swings, those diodes also tend to sharpen the squarewave signal. Resistor R4 is used to limit current

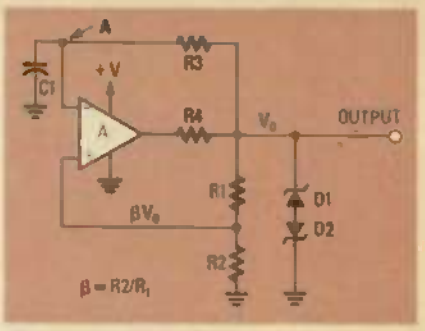

FIG. 24—THE ZENER DIODES are used to limit the output voltage swings.

through the Zeners to a safe value. In most cases the voltage across D1 is equal to the voltage across D2, so the output waveform is symmetrical. Under that condition, the output voltage has a peak-to-peak value of $2(V_{D1} + 0.7)$.

Timing of the output signal is shown in Fig. 25. On both halves of the output squarewave (V_O), capacitor C1 charges through R3. At time t_1, we assume that

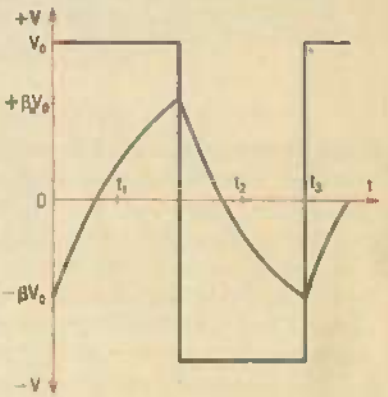

FIG. 25—TIMING DIAGRAM for the circuit of Fig. 24.

the output voltage is positive ($+V_O$), and that voltage V_C (measured at point A in Fig. 24) is at $-V_O$, where β is equal to R2/(R1 + R2). Since V_O is positive, and V_C is negative, capacitor C1 will discharge toward zero and then recharge toward $+V_O$ at a rate that is determined by R3, C1 and the output voltage.

The op-amp works as a voltage comparator. As long as V_C is less than βV_O, the output voltage will remain at $+V_O$. But as soon as V_C is equal to, or greater than βV_O, the output snaps to $-V_O$.

The transition of output states occurs at time t_2. Since the output is now negative, and V_C is positive, the capacitor now discharges toward $-\beta V_O$.

The period of the squarewave, T, is $t_3 - t_1$; frequency, of course, is 1/T. For any values of R1 and R2, T is equal to:

$$(2)(R3)(C1)\ln\left(\frac{2R1}{R2} + 1\right)$$

or, if R1 = R2, T = (2.2)(R3)(C1) R-E

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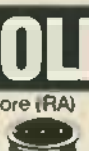

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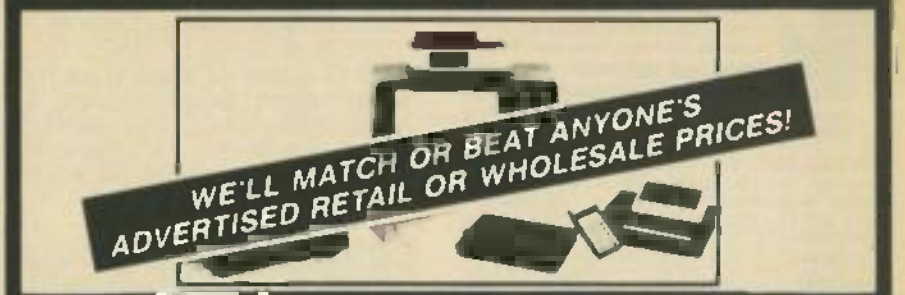

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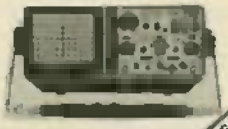

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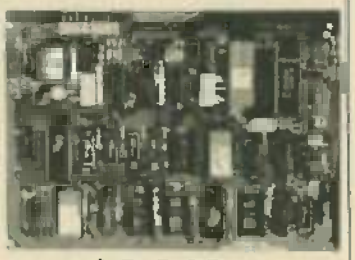

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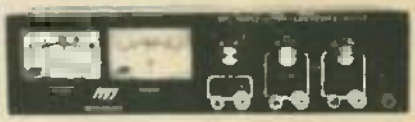

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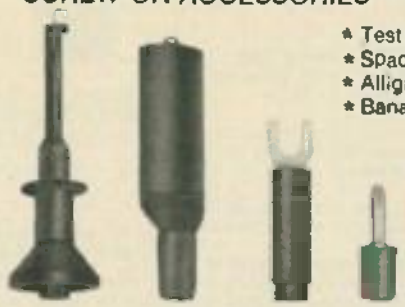

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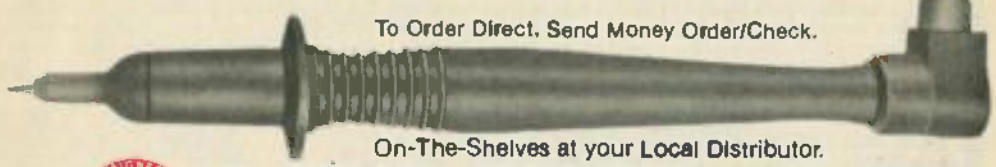

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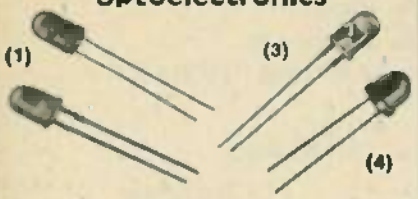

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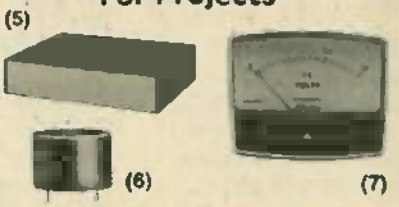

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74148	5.95	9602	1.60
74144	2.95	9637	2.95
74149	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.45
74S19	.35	74S196	1.49
74S30	.29	74S197	1.49
74S32	.35	74S225	3.88
74S37	.89	74S240	1.49
74S38	.89	74S241	1.49
74S74	.49	74S244	1.45
74S85	.95	74S287	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S260	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.89
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S472	2.95

DATA ACQ / INTERFACE

ADC0800	15.95	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	3.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	.69

OTHER VOLTAGE REGS

LM323K 5V 3A	TO-3	4.79
LM338KA 5V 5A	TO-3	3.95
78H05K 5V 5A	TO-3	7.95
78H12K 12V 5A	TO-3	8.95
78P05K 5V 10A	TO-3	14.95

IC SOCKETS

	1-99	100
8 PIN ST	.13	.11
14 PIN ST	.16	.12
16 PIN ST	.17	.13
18 PIN ST	.20	.18
20 PIN ST	.23	.27
22 PIN ST	.30	.27
24 PIN ST	.30	.27
28 PIN ST	.40	.32
40 PIN ST	.49	.39
64 PIN ST	4.25	CALL
ST-SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.62
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.35	1.29
24 PIN WW	1.49	1.35
28 PIN WW	1.59	1.46
40 PIN WW	1.99	1.80
WW-WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	4.95	CALL
40 PIN ZIF	6.95	CALL
ZIF-TEKTOOL (ZERO INSERTION FORCE)		

LINEAR

TL066	.99	LM733	.99
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.00
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.69
LM309K	1.25	LM1458	.49
LM311	.69	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320 see 7900		XR2206	3.75
LM322	1.65	XR2211	2.95
LM323K	4.75	KR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340 see 7800		CA3146	1.29
LM350T	4.00	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	5.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.48	MC4024	3.49
LM394H	4.60	MC4044	3.99
TL494	4.20	RC4136	1.29
TL497	2.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.89	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H-TO-5 CAN, K-TO-3, T-TO-220

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE		
IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95
CEN36PC	RT ANGLE PC MOUNT	4.95
FEMALE		
IDCEN36 F	RIBBON CABLE	7.95

INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	RUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.46	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.60	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.95	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.96	---	---	---	1.75	---	2.99

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW

DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.65	MCT-2	.69
KBU8A	.95	MCT-6	1.25
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

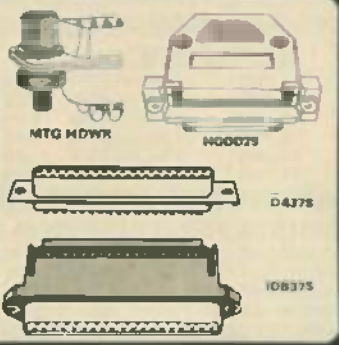
D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.60	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.38	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.29	1.95	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.59	5.60	---
	FEMALE	DBxxSWW	2.75	4.27	---	6.84	5.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.95	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.75	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.85	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED

EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM CATHODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-312	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

SWITCHES

SPST	MINI-TOGGLE ON ON	1.25
DPDT	MINI TOGGLE ON ON	1.90
DPDT	MINI TOGGLE ON OFF ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON OFF	.49
BCD OUTPUT 10 POSITION 6 PIN DIP		1.95

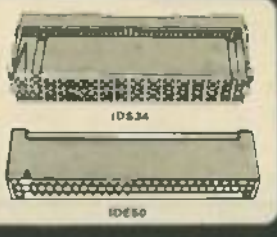
DIP SWITCHES

4 POSITION	.95	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.75	2.31	2.72	3.39
WW HEADER	IDHxxW	1.95	2.95	3.84	4.95	5.29	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.06	3.29	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.00	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



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CONTACTS	SINGLE COLOR 1'	10'	COLOR CODED 1'	10'
10	.16	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.88
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.38
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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IBM PR2

IBM

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14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
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22	16V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001µ	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

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.01µ	50V	.14	.1µ	50V	.18
.047µ	50V	.18	.47µ	50V	.25

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1µ	25V	.14	1µ	50V	.14
2.2	35V	.16	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.28	470	50V	.50
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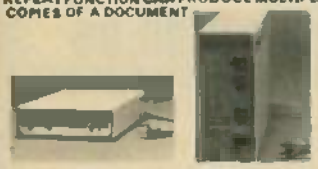
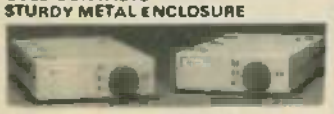
- REPEAT FUNCTION CAN PRODUCE MULTIPLE COPIES OF A DOCUMENT



SP120 SP110

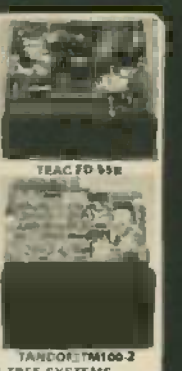
3-WAY SWITCH BOXES

- SERIAL OR PARALLEL
- CONNECTS 3 PRINTERS TO 1 COMPUTER OR 3 COMPUTERS TO 1 PRINTER
- ALL LINES SWITCHED
- HIGH QUALITY ROTARY SWITCH MOUNTED ON PCB
- GOLD CONTACTS
- STURDY METAL ENCLOSURE



SWITCH-3P	CENTRONICS PARALLEL	99.95
SWITCH-3S	RS232 SERIAL	99.95

FLOPPY DISK DRIVES



TEAC FD 55B

TANDON TM100-2

TEAC

FD-55B	½ HEIGHT DS/DD	$89.95
FD-55F	½ HEIGHT DS/QUAD	$99.95

SHUGART

SA460	5¼" (80 TRACK) DS/QUAD	$199.95

TANDON

TM100-2	5¼" (FOR IBM) DS/DD	$99.95

MPI

MPI-B52	5¼" (FOR IBM) DS/DD	$89.95

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FD200-8	DS/DD SA851R EQUIV	$159.00
JFORMAT-2 SOFTWARE		$49.95

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- SHIELDED CABLE

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8 INCH DRIVE ENCLOSURES BY JMR

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CAB-1FHS CAB-2SVS CAB-2FH8

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5¼" SOFT SECTOR
DS/DD WITH HUB RINGS

$9.90 BOX OF 10 — **89¢ea** BULK QTY 50 — **79¢ea** BULK QTY 250

NASHUA DISKETTES WERE JUDGED TO HAVE THE HIGHEST POLISH AND RECORDED AMPLITUDE OF ANY DISKETTES TESTED. SEE "COMPARING FLOPPY DISKS", BYTE 9-84.

DISKETTE FILE

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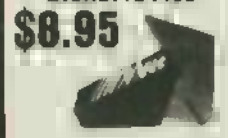

HOLDS 70 5¼" DISKETTES

DISKETTES

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N-MD2F	DS/QUAD SOFT SECTOR	$34.95
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- NUMERIC KEYPAD WITH CURSOR CONTROL
- CAPS LOCK
- AUTO-REPEAT

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MODEL 2000

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- SWEEP TIME - .2 µSEC TO .5 SEC/DIV ON 20 RANGES
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MODEL 3500

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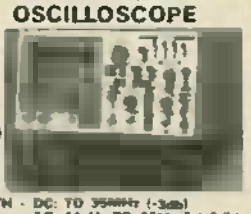

- BAND WIDTH - DC: TO 35MHz (-3db) AC: 10 Hz TO 35MHZ (-3db)
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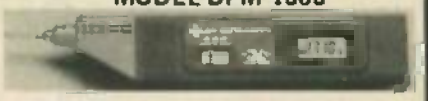
- TRIGGERING OF CH-A, CH-B, ALTERNATING, LINE OR EXTERNAL
- X-Y AND Z AXIS OPERATION

DIGITAL MULTIMETER PEN MODEL DPM-1000



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- PARALLEL PORT
- GAME PORT
- SOFTWARE INCLUDED

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FULLY COMPATIBLE WITH IBM COLOR CARD

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- MONO GRAPHICS MODE: 640 x 200
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- INCLUDES SERIAL PORT!
- ONE YEAR WARRANTY

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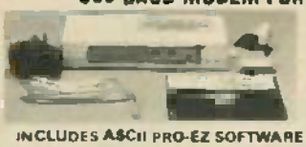

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- 13" COMPOSITE VIDEO
- RESOLUTION: 280H x 300V
- INTERNAL AUDIO AMPLIFIER
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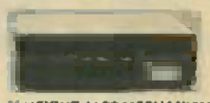
DISK DRIVES
FOR APPLE COMPUTERS



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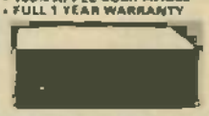
- ½ HEIGHT-ALPS MECHANISM
- 100% APPLE COMPATIBLE
- FULL 1 YEAR WARRANTY



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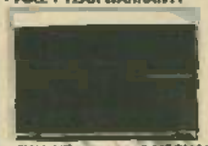
- TEAC MECHANISM DIRECT DRIVE
- 100% APPLE COMPATIBLE
- FULL 1 YEAR WARRANTY



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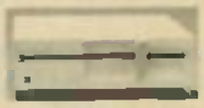

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OUTPUT: + 12 vdc @ 350 ma
+ 5 vdc @ 1.2 amp
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8 ohms coil
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Typical response range 100 – 10,000 hz
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Drilled to mount line matching transformers

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6' 18/2 SPT-1 flat 3 for $1.00
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6' 18/3 flat $1.50 each
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2,000 mfd. 200 VDC 1⅝" DIA. x 5" HIGH	$2.00
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COIL: 120 ohms
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3 amp contacts
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6 vdc
TTL compatible

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± 12 Vdc or 24Vdc POWER SUPPLY

DELTRON MODEL QD12/15-1.7
Dual plus and minus 12Vdc open frame power supply. Can be used as 24Vdc @ 1.5 amp. INPUT: either 115 Vac or 230 Vac
Fully regulated computer grade supply
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560 high, 7 segment L.E.D. read outs. Mount in 24 pin DIP sockets

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8 ohm impedance. Full range speaker. 4 oz magnet. 4" diagonal mounting centers.

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Two color coded terminals on a sturdy 2⅜" x 3⅛" bakelite plate. Great for speaker enclosures or power supplies.

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New Stereo cassette mechanism includes record/playback and erase heads. 2-12VDC motors drive belts, pulleys, 3-12VDC solenoids, pinchwheels and other mechanical parts. These parts used on other current model decks would cost several times our selling price if purchased separately. Build your own audio or data recorder or use for spare parts. 5¼" X 3½" X 3½"

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ALL ARE RATED 5 AMPS @ 125 VAC

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			*6567	VIC-II	$44.95	NOTE: 223100 = 6517 IC-641		

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DYNAMIC RAM

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TRS-16K3 200ns (Model III). $5.95
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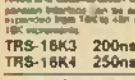

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JE525 Interface Module Features
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• CP/M Compatible
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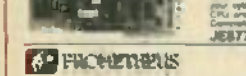

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The JE877 serves as a diagnostic tool, an assurance and insurance tool and a dual disk drive controller. The JE877 will verify and check the operating hardware of your system each time you turn on your Apple II, II+ or IIe. Test your RAM, ROM, CPU and disk drives. Diagnostic routines may be executed at the flight of a key. Complete with instructions

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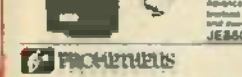

PROMETHEUS — **Parallel Printer Card For Apple II, II+ and *IIe*** — *Parallel Printer Card*

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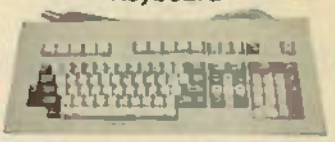

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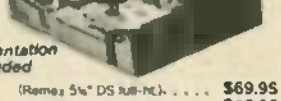

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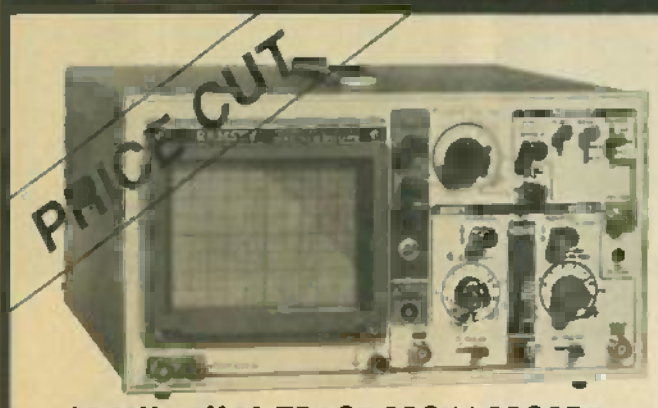


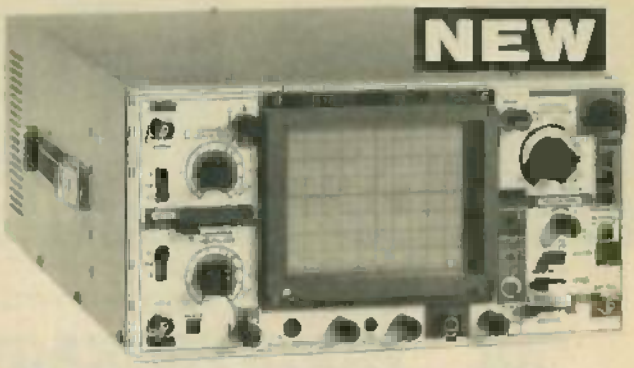
20 MHz DUAL TRACE OSCILLOSCOPE

Unsurpassed quality at an unbeatable price, the Ramsey oscilloscope competes 10 others costing hundreds more. Features include a component testing circuit for resistor, capacitor, digital circuit and diode testing • TV video sync filter • wide bandwidth & high sensitivity • internal graticule • front panel trace rotator • Z axis • high sensitivity X-Y mode • regulated power supply • built-in calibrator • rock solid triggering

*USA—Add $10.00 per unit for postage, overseas orders add 15% of total order for insured surface mail

~~$399.95*~~ high quality hook on probes included

$369.95



45 MHz DUAL SWEEP OSCILLOSCOPE

The Ramsey 625 is a dual time base, delayed sweep unit that includes a built-in signal delay line to permit clear viewing during very short rise times of high frequency waveforms. Other features include variable trigger holdoff • 20 calibrated sweep time ranges from 0.5 s/div to 0.2 µS/div • fully adjustable sweep time • x1 sweep magnification • five trigger sources, CH1, CH2, LINE, EXTernal and INTernal (V mode) • front panel x-y operation, Z axis input • burn difference of CH1 and CH2 waveforms displayed as single trace • sweep gate and sweep output • auto focus • single sweep

*Same as unit to left

~~$799.95*~~ high quality hook on probes included

$669.95

RAMSEY D-1100 VOM MULTITESTER

Compact and reliable, designed to service a wide variety of equipment. Features include • mirror back scale • double-jeweled precision moving coil • double overload protection • an ideal low cost unit for the beginner or as a spare back-up unit.

~~$19.95~~ test leads and battery included

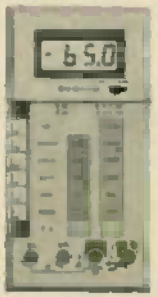
$12.95

NEW RAMSEY 1200 VOM MULTITESTER

Check transistors, diodes and LEDs with this professional quality meter. Other features include decibel scale • 20K volt metering system • 3½" mirrored scale • polarity switch • 20 measuring ranges • safety probes • high impact plastic case

~~$24.95~~ test leads and battery included

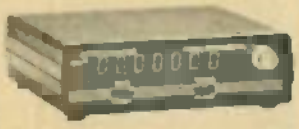
$19.95



RAMSEY D-3100 DIGITAL MULTIMETER

Reliable, accurate digital measurements at an amazingly low cost • in-line color coded push buttons, speeds range selection • abs plastic tilt stand • recessed input jacks • overload protection on all ranges • 3½ digit LCD display with auto zero, auto polarity & low BAT indicator

$49.95 test leads and battery included

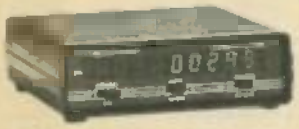


CT-70 7 DIGIT 525 MHz COUNTER

Lab quality at a breakthrough price. Features • 3 frequency ranges each with pre amp • dual selectable gate times • gate activity indicator • 50mV @ 150 MHz typical sensitivity • wide frequency range • 1 ppm accuracy

$119.95 wired includes AC adapter

CT-70 kit $99.95
BP-4 nicad pack 8.95



CT-90 9 DIGIT 600 MHz COUNTER

The most versatile for less than $300. Features 3 selectable gate times • 9 digits • gate indicator • display hold • 25mV @ 150 MHz typical sensitivity • 10 MHz timebase for WWV calibration • 1 ppm accuracy

$149.95 wired includes AC adapter

CT-90 kit $129.95
OV-1 0.1 PPM oven timebase 59.95
BP-4 nicad pack 8.95

CT-125 9 DIGIT 1.2 GHz COUNTER

A 9 digit counter that will outperform units costing hundreds more • gate indicator • 24mV @ 150 MHz typical sensitivity • 9 digit display • 1 ppm accuracy • display hold • dual inputs with preamps

$169.95 wired includes AC adapter

BP-4 nicad pack 8.95

CT-50 8 DIGIT 600 MHz COUNTER

A versatile lab bench counter with optional receive frequency adapter, which turns the CT-50 into a digital readout for most any receiver • 25 mV @ 150 MHz typical sensitivity • 8 digit display • 1 ppm accuracy

$169.95 wired

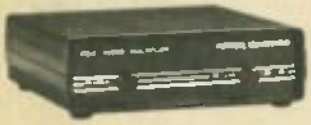
CT-50 kit $139.95
RA-1 receiver adapter kit 14.95

DM-700 DIGITAL MULTIMETER

Professional quality at a hobbyist price. Features include 26 different ranges and 5 functions • 3½ digit, ½ inch LED display • automatic decimal placement • automatic polarity

$119.95 wired includes AC adapter

DM-700 kit $99.95
MP-1 probe set 4.95



PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies up in frequency • great for PL tone measurements • multiplies by 10 or 100 • 0.01 Hz resolution & built-in signal preamp/conditioner

$49.95 wired

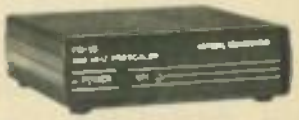
PS-2 kit $39.95

PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for shifting RF • ideal receiver/TV preamp

$44.95 wired includes AC adapter

PR-2 kit $34.95



PS-1B 600 MHz PRESCALER

Extends the range of your present counter to 600 MHz • 2 stage preamp • divides by 10 circuitry • sensitivity: 25mV @ 150 MHz • BNC connectors • drives any counter

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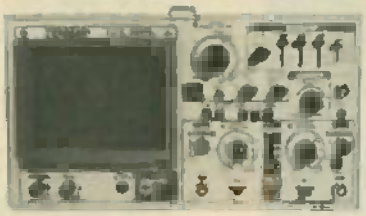

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■ Two High Quality 10:1 probes included
■ Backed by our 2-year limited warranty
■ For specifications see MCM catalog

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DROP PROOF DIGITAL MULTIMETER

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■ Shock-mounted LCD display
■ Overload protection ■ Auto polarity ■ Backed by our 1-year limited warranty ■ For more specifications see MCM catalog

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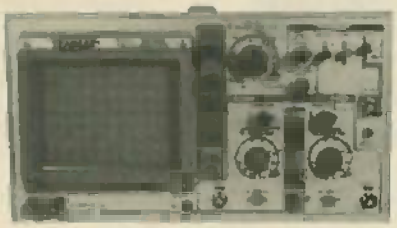

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20 MHZ DUAL TRACE OSCILLOSCOPE

■ Two High Quality 10:1 probes included
■ Backed by our 2-year limited warranty
■ For specifications see MCM catalog

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TENMA
DIGITAL LCR METER

■ Measures inductance, capacitance and resistance
■ L = 1 H to 200 H, C = .1 pf to 200μF, R = .01 ohm to 20 M ohm
■ Carrying case included.

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15 MHz DUAL TRACE BATTERY POWERED OSCILLOSCOPE

■ Two High Quality 10:1 Probes included ■ Backed by our 2-year limited warranty ■ Internal rechargeable batteries provide 2 hours of continuous operation without the need for any outside power source. ■ For specifications see MCM Catalog

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■ Used to check door gaskets, hinges, etc. for leaks in microwave ovens ■ Not intended to be used as a certification instrument.

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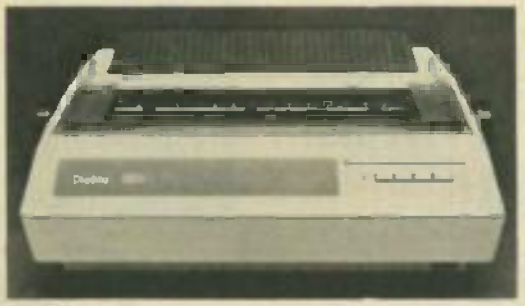

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TY-23B COLOR LIGHT CONTROLLER

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Kit $45.00
Ass. with tested $75.00

TR-100 0-15V 2A REGULATED DC POWER SUPPLY

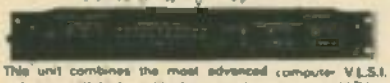
- Output voltage is adjustable from 0-15V DC, two current limit range are available for selection 200mA or 2A.
- An elaborated protection system is specially designed, a 'BB' sound and a sparkle light will appear when the output is overloaded.
- High stability and reliable resulting from employing high quality voltage regulate IC.
- Possessing long size meter makes the reading of voltage and current more clearly and accuracy.

A refined case, meter and all accessory are enclosed for both kit and assembly form. Most suitable for factory, professional or even amateur.

Kit $55.50
Ass. with tested $89.50

TA-2400A ELECTRONIC ECHO AND REVERBERATION AMPLIFIER

REMIX your record yourself!



This unit combines the most advanced computer V.L.S.I. technique with high quality Japan made component, as 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 to your record tapes by using this model. All kinds of infield sound effect can be obtained by skillful use of this control. It has LED display to show reflection and reverberation.

Ass. with tested $99.95

TA-2500 HIGH QUALITY MULTIPURPOSE PRE-AMPLIFIER

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 70KHz, so even in bad listening condition it can improve well. It can accept input from various 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 $60.00

TY-35 FM WIRELESS MICROPHONE

- Transmitting frequency ranges from 88MHz to 108MHz (variable).
- Condenser microphone input makes very high sensitivity.
- Suitable for communication, remote monitoring and demonstration.
- Only need a little external component, it can be used as a remote telephone monitor without power supply.
- Deluxe plastic case is included.

Kit $7.95

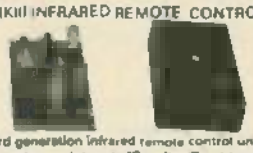
TA-1500 100W + 100W NEW CLASS 'A' DC STEREO PRE-MAIN AMPLIFIER

Features:

1. Preamp employs three LOW NOISE Op.Amp as RIAA equalizer and 20dB flat amplifier and tone control. It has very good transient response and low noise. It is easy to build up.
2. Power Amp. employs our powerful audio transistors and an advanced dynamic bass class 'A' circuit. The dissipation is extremely low and this make the output stage to minimize the switching distortion. It can reproduce high level bass faithfully.
3. A specially designed delay system is included and the functions contains (a) three seconds delay, (b) output short circuit protection (c) DC output protection. It also equips with LED indicator of double display.
6. It includes with microphone mixer, so you can sing with those famous singer together. It can also be used as Public Address Amplifier.

Kit $87.00

TY-41 MKII INFRARED REMOTE CONTROL UNIT



- This third generation infrared remote control unit employs the most advanced decode IC so it will not be effected by common light and electric spark, therefore it is very reliable.
- It uses modern infrared transmitting and receiving component so no antenna is required. The control range is up to 10 meter (30 feet).
- It has two mode of operation "Continuous" and "on-off" suitable for controlling various kinds of electrical equipment whose power consumption is within 500W. It can also be used as a burglar alarm.
- The power supply is DC 9-12V. It is simple in construction and easy to guide and align.
- A Deluxe remote control unit box is free of charge.

Kit $25.00
Assembled with tested $30.00

SM-43 MULTIFUNCTIONAL LED D.P.M

8 different kinds of usages with only one meter, high accuracy (±0.1% ±1 digit), high input impedance, high anti-vibrating ability, the display reset to zero automatically when the input is 0V, and employs 100PPM C temperature compensating zener diode which improves the accuracy and stationary of the meter.

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D.C. VOLTAGE: 1mV – 1000V
A.C. VOLTAGE: 1mV – 1000V
DIGITAL THERMOMETER: 0°C – 100°C
D.C. CURRENT: 1uA – 2A
CAPACITOR METER: 1pF – 2uF
FREQUENCY COUNTER: 10Hz – 20KHz
DIMENSION: 3¾" x 1⅞" x 4⅛"

Kit $29.33
Assembled with tested $35.00

TA-820A 60W + 60W OCL DC PRE-MAIN STEREO AMPLIFIER

- 3 separate sections tone control ensure more smooth and precise tone control.
- Fully symmetrical DC amplifier makes low noise characteristic. New designed U-DH heat sink ensure stable output.
- Specially designed delay system protects the loudspeakers against damage.
- It has a wide dynamic range and can reproduce any input signal faithfully.

Kit $43.00

TY-14 ELECTRONIC SHOCK

- It is very interesting to use it to amuse your friend, since it looks like a box of cigarette you will never miss.
- It can be used to relax the muscles without doing any harm.
- It is simple in construction and easy to build.
- Deluxe plastic case is included.

Kit $3.00

TALKING CLOCK — NEW FOR 86'

1. Talk: push button for voice announcement of time.
2. Read out: twelve hours system display for hour, minute, second (by color flash). AM & PM. (except 9503)
3. Display: three display modes of time, alarm time & date. (except 9503)
4. Alarm: on-off switch with thirty seconds voice alarm.
5. Snooze: reminder voice alarm of thirty seconds after 8 minutes of first voice alarm.
6. Volume: two level of voice output.
7. Language available: English, Mandarin.

Parrot 9541 ..... $39.00
Mynah 9503 ..... $29.00 NOT A KIT!

LCD THERMOMETER CLOCK — NEW!

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.
Resolution reading: ±1.8°F.
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T-1 with In/Out Door sensor $20.00
T-2 with Fahrenheit/Celsius measuring ..... $15.00 NOT A KIT!

YAMATO 4001 3½ DIGITAL MULTIMETER

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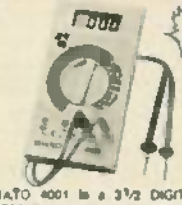

The YAMATO 4001 is a 3½ DIGIT COMPACT DIGITAL MULTIMETER, a employs FE type LCD, with large figures. Its ADVANTAGES. High accuracy in measuring. High impedance assures min. measuring error. One rotary switch allows fast & convenient operation. 26 measurement range enable wider application. Over input indication 5 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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MHz range 1MHz – 150MHz 40mVrms
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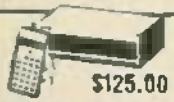

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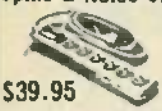

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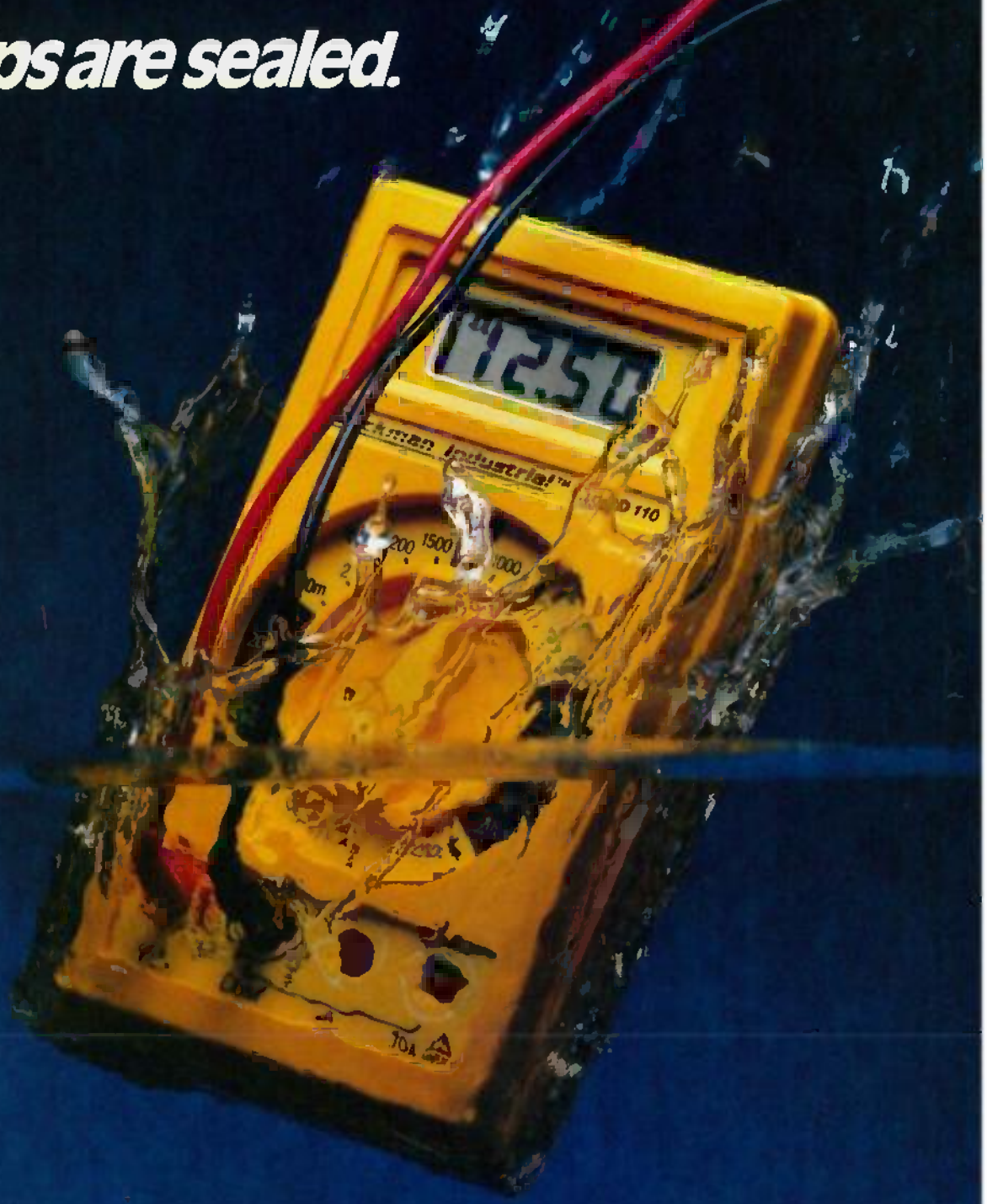

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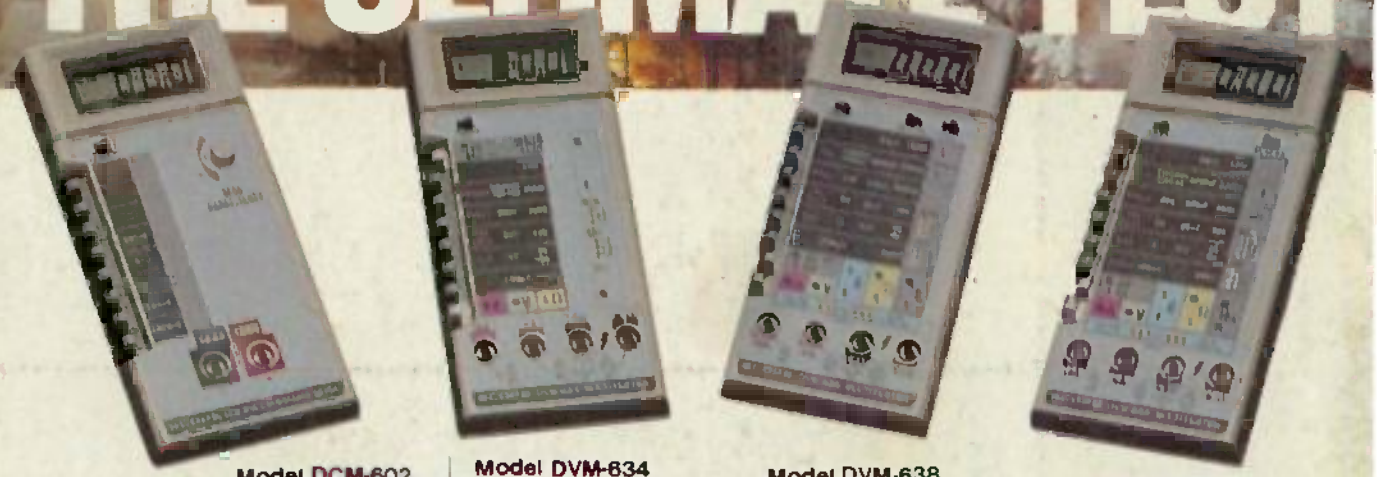

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