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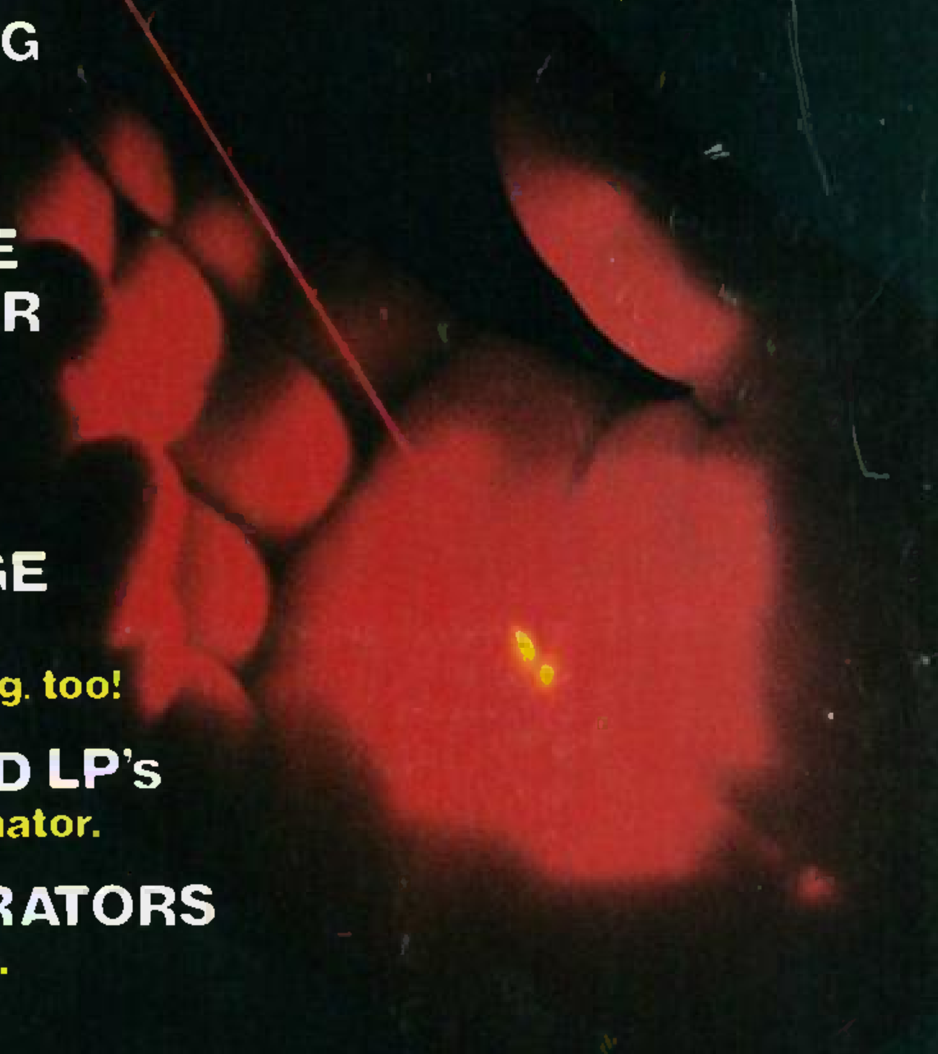

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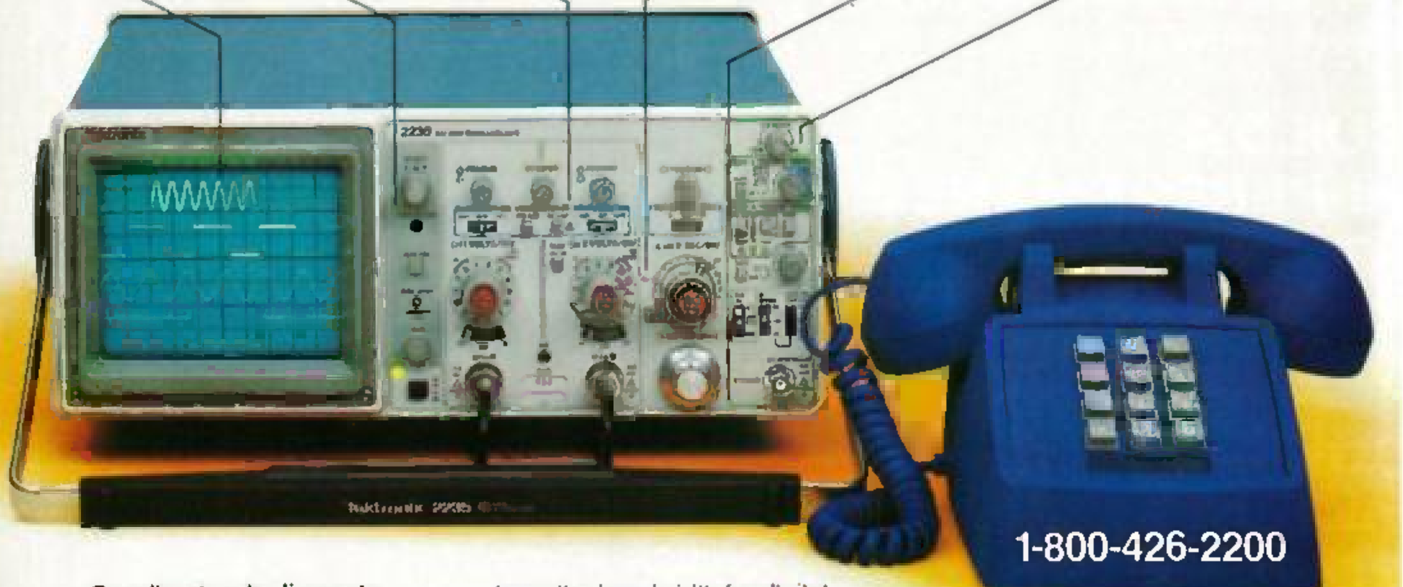

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WHAT'S NEWS

Magnetic resonance analyzes body chemicals without penetrating skin

Using magnetic fields 30,000 times as strong as the Earth's, plus high-frequency radio signals, General Electric scientists have been able to perform a chemical analysis on the human heart by totally non-invasive means. That was made possible by a technique known as magnetic resonance.

Magnetic-resonance technology is based on the fact that, under the influence of high-power magnetic fields and high-frequency radio signals, the atomic nuclei of certain chemicals in the body tissues resonate and produce characteristic patterns of radio spectra. Those spectra can be used to identify the presence of those chemicals. That is useful in medical diagnosis because the spectra from diseased human tissues may differ markedly from those produced by normal tissue.

Magnetic-resonance spectroscopy is a further development of magnetic resonance imaging, developed in 1984, which is used to produce images of internal body-structures. The techniques that made the present breakthrough possible include stronger magnetic fields—up to 1.5 tesla—and depth-resolved surface coil spectroscopy. The latter is a specialized localization method that makes it possible to select resonance signals from the heart or other organ and isolate them from signals from surrounding tissues. That was done with the help of a specially developed surface coil placed directly over the heart. It both emits the signals that excite the heart's chemicals and picks up the faint resonance signals that result.

MAGNETIC FIELDS OF 1.5 TESLA enable scientists to analyze chemicals deep in the human body by non-invasive means. Dr. Paul A. Bottomley, General Electric physicist, examines a spectrogram made with the help of such fields, which are 30,000 times as strong as those of the earth's. Made with a surface coil placed against the body, those analyses may allow doctors to diagnose illnesses faster and more accurately than previously possible.

In a magnetic-resonance examination, the patient is positioned within the circular bore of a powerful magnet and probed with high-frequency radio signals. Under the influence of the magnetic field, the waves cause the nuclei of selected atoms to resonate and produce faint radio signals. These are picked up by the coil and transmitted to a sophisticated image-processing computer for interpretation. The computer then generates a spectrum showing the relative amounts of the various chemicals in the organ being studied.

Radio stations receive digital-stereo broadcast

The nation's first direct-to-local station live digital-stereo broadcast was launched by Radio WGBH, Boston, early last November. The program, an all-Ravel concert by Switzerland's Orchestre de la Suisse Romande, originated at the Kresge Auditorium of the Massachusetts Institute of Technology and was beamed live to public-radio stations across the country.

The concert's analog right and left audio-outputs went into two dbx Model *700* digital audio-processors. The video-format digital-audio signals were then fed to a videocassette recorder and to a modulator on the M.I.T. cable-television system. It then went by microwave link to the Harvard Information Transmission System at Harvard University, which relayed it to WGBH.

The digital-audio signals were then fed to two dbx *700's* in WGBH-FM's control room. Their video output went, via WGBH master control and a 7-GHz microwave link, to WGBH's satellite-uplink facilities in Needham, MA. The program was retransmitted on PBS's Westar IV satellite transponder 10-D.

Motorola joins campaign against drunk driving

Drawing on earlier experience with citizen-driver radio organizations, Motorola has announced a program to help fight drunk driving. The program was announced at a statewide conference of concerned citizens and organizations, including the Illinois State Police, the Illinois Department of Transportation, and the National Committee Against Drunk Driving. The conference was organized by AAIM, the Alliance Against Intoxicated Motorists.

Called DADD (Drivers Against Drunk Drivers), the Motorola program will help to educate and encourage drivers whose vehicles are equipped with cellular telephones to identify signs of drunk driving and to instruct them in reporting the incidents to appropriate law enforcement agencies.

The program will begin, says Motorola spokesman David Weischz, by packing information with each cellular telephone sold by the company. In addition, tips such as using the memory features on a cellular telephone to store key emergency numbers would be provided to get the cellular users started. **R-E**

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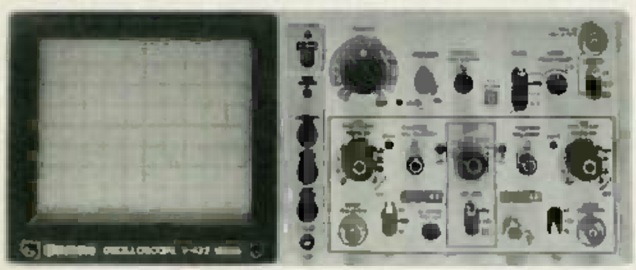

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Philips' Flat Tube.** Another flat video-display device has been announced. Developed by Philips, in that company's British laboratories, the new device is a cathode ray tube three inches thick with a picture display measuring 12 inches diagonally.

The tube itself is in a metal can to which a glass faceplate is sealed. The electron beam travels from a single gun at the top rear of the tube and down the back of the tube to a reversing lens, which turns it 180 degrees, deflecting it to the front of the tube. Frame deflection plates create a field that turns the beam forward to an electron multiplier that amplifies the current several hundred times, accelerating the beam to the phosphor screen. Philips says resolution and gray scale are "appropriate for television applications," but adds that the first uses are likely to be in professional applications such as data display. The system has inherently high picture brightness and requires only low deflection voltages. Philips believes that the ultimate design will use a single gun and a sequential color display.

• **1,000,000 projection TV's.** This is a landmark year for the slow but steadily growing projection television market—the year the 1,000,000th set will be sold. That's the forecast of U.S. Precision Lens, Inc., the main manufacturer of projection TV optics. Sales have been increasing gradually each year as quality improves, sets get more compact, and prices come down. USPL says 90 percent of all projection TV's sold last year were of the rear-projection variety (in which the picture is thrown from within the set onto a translucent screen at the front of the cabinet). Of those, 62 percent were in the "smaller"-screen category (36 to 41 inches diagonally), while 38 percent had pictures measuring 45 to 50 inches.

• **Digital VTR's on sale.** The first digital videotape recorders are now being offered for sale to television broadcasters. Sony started taking orders in April at the National Association of Broadcasters convention for the new world standard D-1 VTR. That system has been approved by world broadcasting bodies as the standard for broadcast recorders and is switchable between 525- and 625-line standards. It uses tape that is 19-mm wide (about ¾ inch). Deliveries of the recorders will start early next year. The price wasn't available at press time.

Also at the broadcaster's convention, Ampex offered a digital cartridge-type VTR, designed especially for automated playing of short segments, such as commercials. Although a digital recorder, Ampex's cart machine doesn't use the standardized world system. The introduction of digital video recorders is regarded as a quantum leap forward in recording quality, and a new bridge between different countries' TV standards, since it is the first time that a single machine can be used to record both 525- and 635-line systems.

• **Cable-ready OK.** The federal district court in Pittsburgh has upheld the legality of cable-ready tuning devices by turning back a challenge by two Pennsylvania cable systems. Shenango Cable TV and an affiliate, Variety Cable TV, both of Sharon, PA, sued Tandy Corporation, parent of Radio Shack, charging that their Archer block converter illegally intercepts and pirates cable channels in violation of federal law.

Block converters, like cable-ready TV sets, change cable channels to UHF frequencies for reception without the use of cable converter boxes. The two Sharon PA cable systems didn't encode or trap their premium programs but merely put them on special cable channels and supplied converter boxes to subscribers ordering them. In throwing out the challenge, Judge Paul Simmons ruled that the block converter wasn't intended as a piracy device, that it wasn't used to tap illegally into the cable systems, and noted that if the systems had trapped or scrambled their signals, those devices wouldn't have been able to violate their security. The case was the first known challenge of its kind, and the decision is regarded as a legal precedent. **R-E**

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WORLD TIME CONVERSION

Some foreign shortwave broadcasters announce time in Greenwich Mean Time (GMT); WWV announces time in Coordinated Universal Time (UTC); and I've heard some hams use *Zulu Time*. What is the relationship between these systems, and how can I convert each to local time?—W. W., White Plains, NY

The three systems are based on a 24-hour clock and they're virtually identical. Greenwich Mean Time is a global standard based on local (standard, not daylight) time in Greenwich, England; GMT is the basis for the other time-keeping systems. In the GMT system, midnight is both 2400 and 0000 hours. The former is associated with the day just ending, and the latter is associated with the day just beginning.

GMT divides the earth into twenty-four time zones. Each zone covers 15 degrees of longitude. Each zone is assigned a number equivalent to the number of hours later (+) or earlier (−) than GMT.

So, moving west from the Greenwich meridian, local time lags one hour behind GMT for each 15 degrees of longitudinal change, until at 180 degrees—the international Date Line—time is 12 hours behind GMT west of the Date Line, and 12 hours ahead of GMT east of the Date Line. Five zones west of Greenwich brings us to 75 degrees longitude, or the center of the Eastern Standard Time zone. The Central Standard, Mountain and Pacific Time zones are centered on 90 degrees, 105 degrees, and 120 degrees, respectively. Those time zones are 5, 6, 7, and 8 hours, respectively, behind GMT.

TABLE 1—TIME ZONE CONVERSION

UTC	EDT/ AST	CDT/ EST	MDT/ CST	PDT/ MST	PST
0000*	2000	1900	1800	1700	1600
0100	2100	2000	1900	1800	1700
0200	2200	2100	2000	1900	1800
0300	2300	2200	2100	2000	1900
0400	0000*	2300	2200	2100	2000
0500	0100	0000*	2300	2200	2100
0600	0200	0100	0000*	2300	2200
0700	0300	0200	0100	0000*	2300
0800	0400	0300	0200	0100	0000*
0900	0500	0400	0300	0200	0100
1000	0600	0500	0400	0300	0200
1100	0700	0600	0500	0400	0300
1200	0800	0700	0600	0500	0400
1300	0900	0800	0700	0600	0500
1400	1000	0900	0800	0700	0600
1500	1100	1000	0900	0800	0700
1600	1200	1100	1000	0900	0800
1700	1300	1200	1100	1000	0900
1800	1400	1300	1200	1100	1000
1900	1500	1400	1300	1200	1100
2000	1600	1500	1400	1300	1200
2100	1700	1600	1500	1400	1300
2200	1800	1700	1600	1500	1400
2300	1900	1800	1700	1600	1500
2400*	2000	1900	1800	1700	1600

*0000 and 2400 are interchangeable. (2400 is associated with the date of the day ending, 0000 with the day just starting.)

So, to convert GMT to local North American time, subtract a number of hours from your local time equal to your zone number. For example, midnight (2400 hours) in Greenwich is, on the east coast, 24 − 5 = 19, or 1900 hours. Or you can use the time-conversion chart in Table 1 to convert local (U. S.) time to and from GMT. Readers in Europe or Asia who live east of the Greenwich meridian should *add* their zone number to GMT to get local time.

If you're an SWL (Shortwave Listener), you have to be careful when you make your reception reports. For example, assume you heard a BBC broadcast on Friday evening between 8:00 and 9:00 pm EST. EST is 5 hours behind GMT, so the program was actually broadcast between 0100 and 0200 GMT on *Saturday*—the next day. Hence your reception report should list Saturday, not Friday, as the day you heard the broadcast.

As to the relationship between GMT, UTC and "Zulu" time: UTC is a 24-hour time system that is based on the GMT. It is coordinated by the International Time Bureau (BIH) through international agreements so that the standard time signals broadcast by WWV (in the U. S.), CHU (Ottawa, Canada), LOL (Buenos Aires, Argentina), and JJY (Tokyo, Japan) will closely agree.

For convenience in specifying time at various places around the globe, the military assigned an identifying letter to each of the twenty-four time zones. The letter "Z" (phonetically, *Zebra* or *Zulu*) was assigned to the time zone around the prime meridian. So, in some circles, GMT came to be called Zebra or Zulu time.

ZERO CROSSING

What is meant by "zero-crossing" as applied to relays and opto-couplers?—S. S. K., Brooklyn, NY

Zero-crossing (also called zero-voltage switching) refers to the practice of applying AC power to a load at the instant that the voltage crosses the "zero" point in the AC cycle. Doing that allows the operating current to rise gradually with the applied voltage. When power is applied to the device at any voltage other than zero, the load current abruptly surges from zero to a high value limited only by the impedance of the load. That current

continued on page 79

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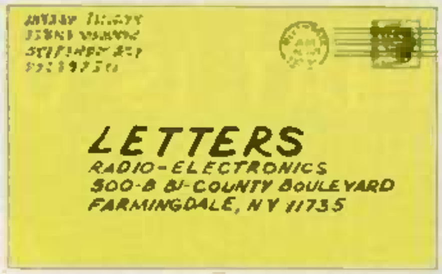

DON'T ENLARGE COMPUTER DIGEST

In the March 1986 "Computer Digest" part of **Radio-Electronics** a reader asks for more pages in that section. I have a strong response to that request.

Computer magazines come and go; few are cherished or missed. **Radio-Electronics** is the last of the oldtimers for the hardware hacker. One or two new ones exist, but **Radio-Electronics** is the granddaddy of them all.

If you want to read about computers, get the computer magazines (as I do). If you want the best in general electronics, then get **Radio-Electronics** and don't push it into extinction.

And you other **Radio-Electronics** fans: I urge *you* to speak up, because I have a feeling that **Radio-Electronics** is on the endangered-species list. I've been an unfailing subscriber for too many years to let it go without a fight!

RICK McGUIRE
Trenton, NJ

Don't worry, Rick. **Radio-Electronics** *is not on any endangered-species list. We'll be here covering circuits, technology, video, and even computers for years to come.*—Editor

OOOOPS!

It seems that we played an April Fool's joke on ourselves in the article "Build This Telephone Line Tester," which appeared in the April 1986 issue. First of all, the schematic that accompanied that article was incorrect; the correct schematic appears here as Fig. 1.

Secondly, there are two resistors identified as R6. The resistor located at the anode of D5 is actually

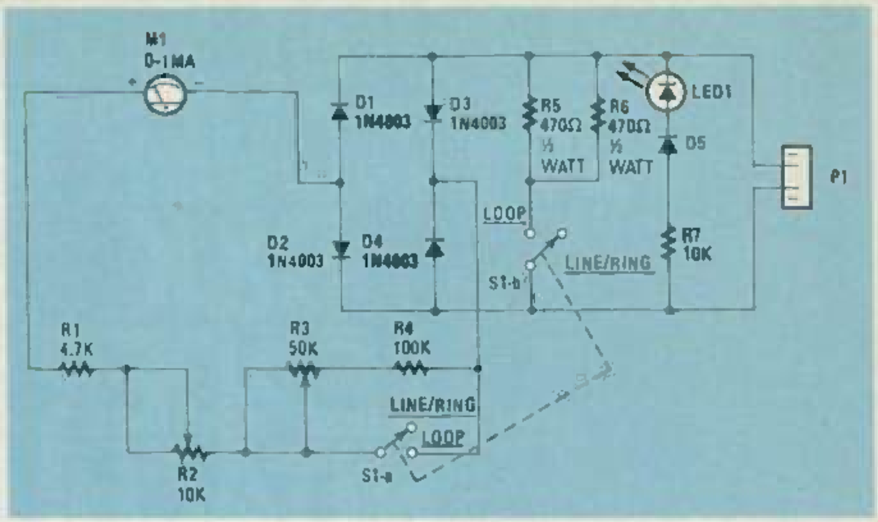

FIG. 1

R7; it is a 10K unit as originally shown.

Finally, in the parts-placement diagram, diodes D1, D3 and LED1 were shown installed backward.—Editor.

TELETEXT REMOTE SCHEMATIC

It seems that April's gremlins also drew the remote-control circuit (Fig. 8) in the story "Build This Teletext Decoder." The front end of the receiver circuit, which is shown inside the dashed box in the figure, has a few mis-labled components. For example, R70 should be 680 ohms. The 0.047-µF capacitor between ground and chassis should have been labled C48, and the capacitor directly above it should

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have been labled C47, 47 µF. Unfortunately, that's not all. The anode of LED3 should, of course, go to +12 volts, and the 1K resistor in series with it should be labled R71.—Editor

CHANGES IN THE SAM MODEL *3001*

The review in December 1985's "Computer Digest" of HiTech's SAM *3001* was very well done. We at HiTech would like to take this opportunity to thank you for your comments

The system reviewed was actually delivered this past August (1985) when it was still relatively new. Since then, there have been a few changes. Our motherboards feature a clock speed of 8MHz. Instead of 640K we now offer 1MB RAM; and a 30MB voice-coil hard-disk drive has replaced the 20MB hard disk. Despite all of those enhancements, the $4395.00 list price remains the same.

The power-on-reset problem was attributed to lack of proper documentation. That was overlooked in our attempt to meet the initial market demand for out AT compatibles. Since its revision, the manual that accompanies the unit now fully illustrates the change in the reset circuits.

As for the floppy-disk drive, we have indeed switched over to Mitsubishi Electronics as our supplier of drives. As of now, all SAM *3001*'s come equipped with the Mitsubishi M148 1.2MB floppy.

Again we thank Radio-Electronics' staff for the review of our product.

KENNETH KIM,
President, HiTech International, Inc.

SCHEMATIC NEEDED

I recently acquired a Motorola TV, no. VT71M-A that was manufactured in 1949. I would like to rebuild the chassis, but cannot find a schematic. I've tried Sams and Motorola. Can you or your readers help me?

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R-E

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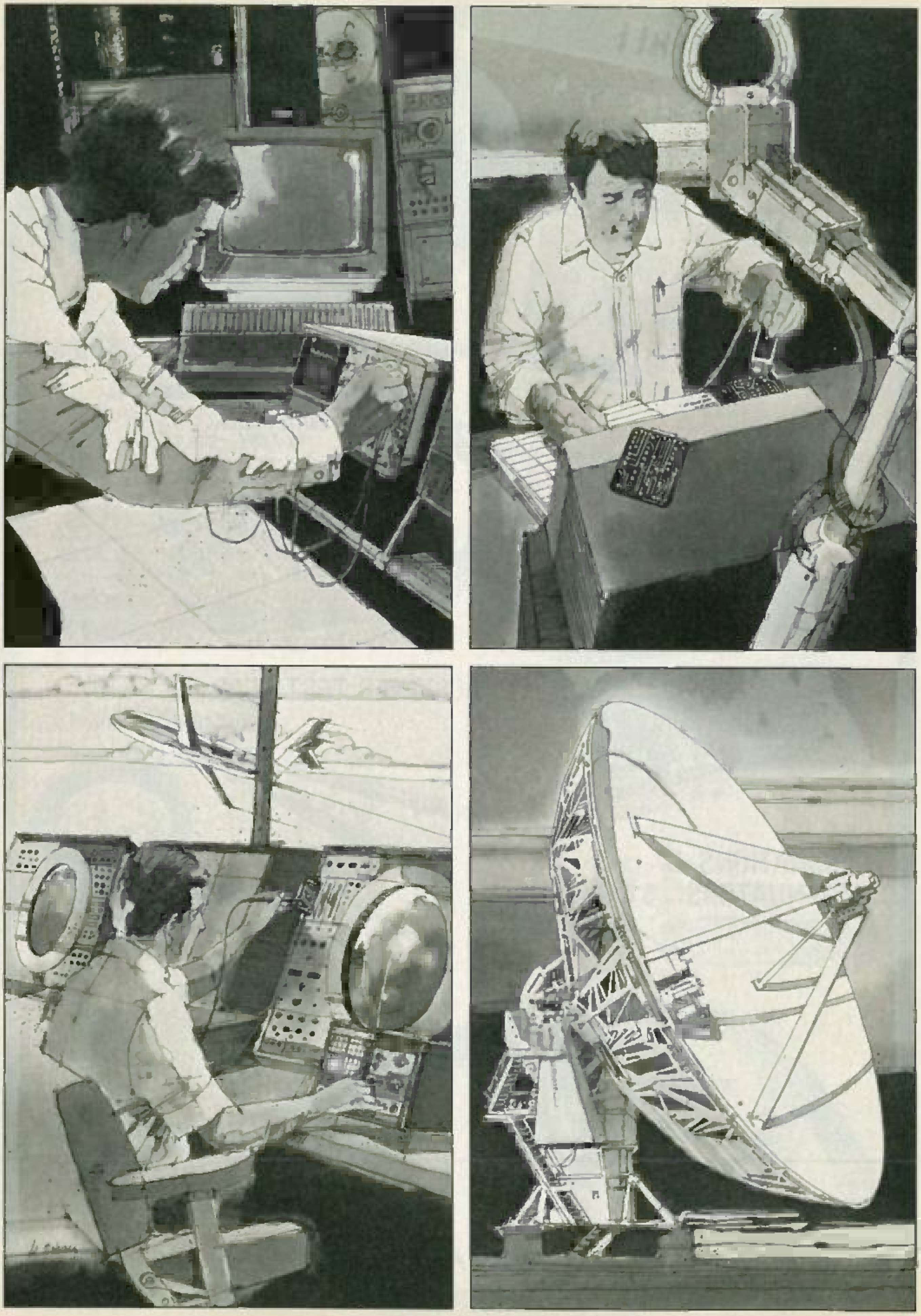
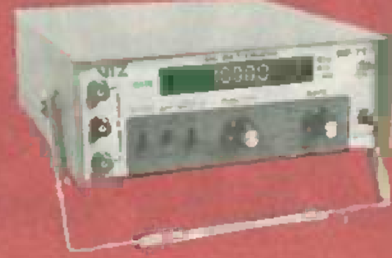


EQUIPMENT REPORTS

VIZ WD-757 Frequency Counter

A sturdy and fuctional universal counter.



CIRCLE 5 ON FREE INFORMATION CARD

THE ON-GOING REVOLUTION IN DIGItal electronics benefits not only consumer products like stereos, VCR's, and personal computers, but also the test instruments we use to keep those devices in top-notch condition. The VIZ *WD-757* is one beneficiary of the LSI revolution; it is a capable, 1-GHz frequency counter available from VIZ Test Equipment, 335 East Price Street, Philadelphia, PA 19144. It is based on Intersil's ICM7226 LSI Frequency Counter IC.

External view

The *WD-757* comes in a metal case that measures about 3⅝ × 8¼ × 11 (all dimensions in inches), and weighs about 3½ pounds. All circuitry is enclosed in an EMI-resistant metal cabinet. The instrument's front panel has three BNC input jacks, three input-select slide switches, two function-select rotary switches, a push-on/push-off power switch, and a momentary contact RESET switch. Its display consists of eight seven-segment LED's, and four discrete LED's. A rotatable metal handle allows you to prop the *WD-757* at a comfortable viewing angle. The rear panel has a BNC connector for an external clock input, a

switch to control the clock signal, and a fuse holder; the line cord also exits the rear panel.

Two of the front-panel BNC connectors provide the *A* and *B* inputs that are common on frequency counters built around Intersil's ICM7226 IC. The *C* input is for VHF/UHF inputs; it feeds the prescaler circuitry. *A* has an input impedance of 1 megohm and a sensitivity of 25 mv. The figures for *B* are 100K ohms and 20 mv; and, for *C*, 50 ohms and 50 mv.

Two of the slide switches allow you to choose the frequency range: under 10 MHz, under 100 MHz, or under 1 GHz. The third slide switch controls a 10:1 attenuator. The attenuator may only be used on the under-100 MHz ranges.

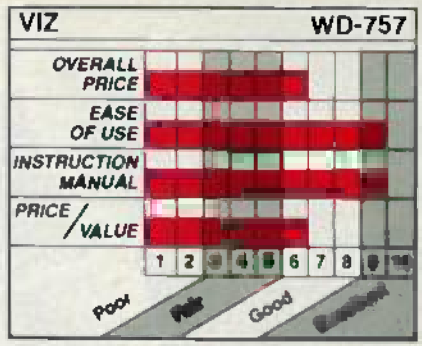
The rotary FUNCTION switch allows you to measure frequency and period, to count events, to measure the *A:B* frequency ratio, and to make time-interval measurements. To measure time interval, a start pulse is applied to the *A* input, and a stop pulse is applied to the *B* input. The display will then indicate the elapsed time.

The rotary RANGE switch allows you to control the resolution and accuracy of your frequency and period measurements. When measuring frequency, you can select a gate time of 10 seconds, or 1, 0.1, or 0.01 second. In the ten-second "range," for example, the *WD-757* counts pulses for ten seconds and then divides by the appropriate factor for display. When measuring period, the *WD-757* will make 1, 10, 100, or 1000 measurements and then calculate their average for display.

The discrete LED's light up to indicate: *MHz* or *KHz* when measuring frequency; μs when measuring period; *gating*. The *gate* LED blinks each time a counting period has elapsed—every 10 seconds, or every 1, 1/10, or 1/100 second.

What's inside

The heart of the *WD-757* is Intersil's ICM7226 *Universal Frequency Counter*, so, if you're familiar with that IC, the *WD-757's* variety of functions should also look familiar. Frequencies under 10 MHz are handled by the ICM7226 through a FET-input differential amplifier



that is built from discrete components; frequencies from 10–100 MHz are first fed through a Schottky TTL decade divider; frequencies above 100 MHz are fed to a prescaler built around the MC5121, CA3199E, and MC12009L IC's.

Documentation

A 13-page manual is included with the *WD-757*; it includes basic instructions on how to operate the instrument, as well as complete technical information on the *WD-757*. Schematic diagrams, parts lists, PC-board patterns, and a section on theory of operation are all included. In addition, instructions on how to calibrate the *WD-757* are included, should calibration become necessary. The manual is written in a somewhat stiff manner, and it contains a few typos, but all in all we'd like to see more manuals provide as much information as that one.

Impressions

In a sense, there's not much to say about the *WD-757* other than that it does everything VIZ claims it can do. The switches and connectors all have a good solid feel, and we had no difficulty integrating the *WD-757* with our odd assemblage of test instruments.

Our only complaint with the *WD-757* is that, for $525, a few things might have been included that would have made the *WD-757* much more versatile and accurate. For example, a variable trigger-level control and an LED to indicate when triggering has occurred would be useful. In addition, the crystal timebase is *not* a proportional-oven type. Finally, no probes are included, and a good pair good low-capacitance probes could easily cost an additional $100. **R-E**

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5¼" DSQD Soft Sector (96 TPI)	6501-FA	1.09
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SSSD = Single Sided Single Density; SSDD = Single Sided Double Density; DSDD = Double Sided Double Density; DSQD = Double Sided Quad Density; DSHD = Double Sided High Density; TPI = Tracks per inch.

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The answer to that problem might be as simple as putting up an outdoor antenna, such as one we recently tried, the *JV-2X* from Mirage-KLM (16890 Church St., Morgan Hill, CA 95037).

If you're relying on an indoor antenna now, just about any outdoor antenna will improve your reception. But if you have an outdoor antenna now and still are not getting the performance you need from your VHF rig, then it's important to remember that in the world of antennas everything isn't created equal.

For instance, a ⅝-wave antenna will show about 3 dB of gain over a ¼-wave antenna, and a longer antenna can show an even greater gain improvement. The *JV-2X* is an extended J-pole antenna that is roughly two wavelengths long (about 12 feet) at 144 MHz. That is extremely long compared to the majority of VHF antennas that we have seen, but the size is the key to

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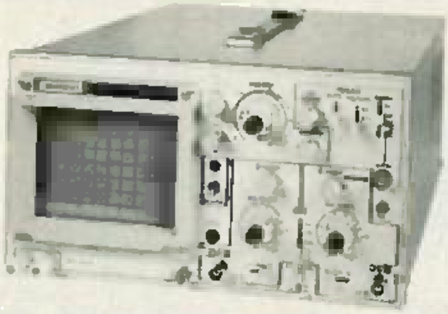

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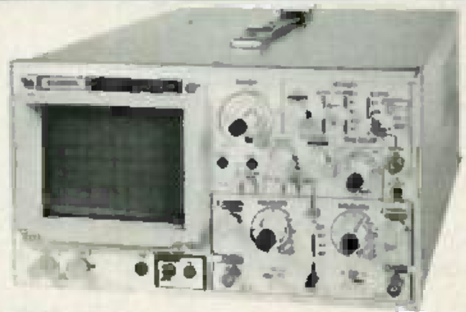

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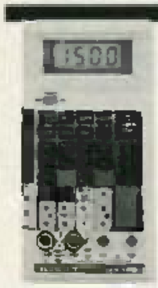

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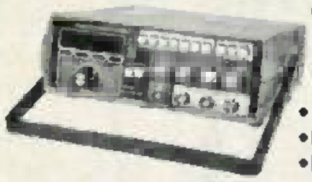

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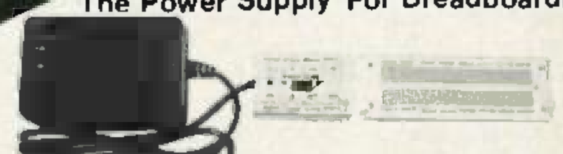

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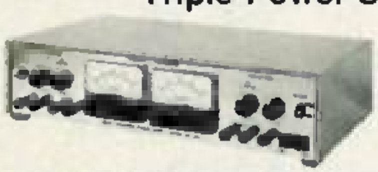

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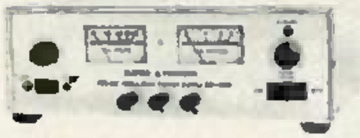

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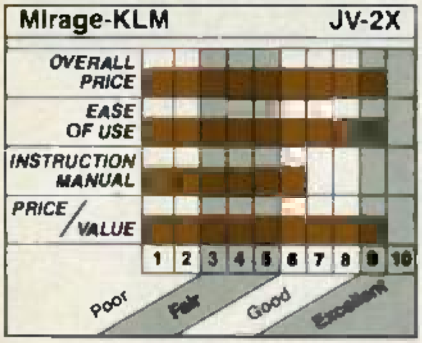

the unit's superior performance. In our tests we found about a 6-dB increase in received signal strength over a ¼-wave antenna. That's about all the gain you'd need for a scanning radio. For transmitting applications, similar gain figures are obtainable.

Set-up and use

Our first impression after pulling the unit out of the box was that assembly would be a formidable task. That was due to the large number of pieces involved, and a set of instructions that were vaguely written and confusing. (According to the company, the instructions have since been revised.) What saved the day was the fact that those instructions were accompanied by some very clear illustrations. Following those, assembly was not difficult at all. The entire operation went smoothly and took less than an hour. Using the antenna lengths suggested in the instructions, the unit tuned up easily.

Once the antenna is set up there's little else to do except connect the coaxial cable and use it.

Overall, the *JV-2X* is a worthy successor to the *JV-2*, which is a shorter version of the same antenna. With a suggested list price of $39.95, it's a bargain, too! **R-E**

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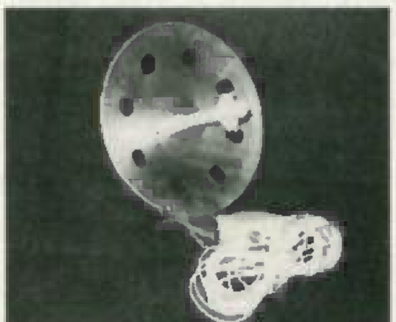

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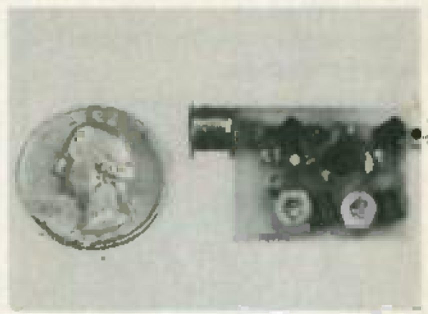

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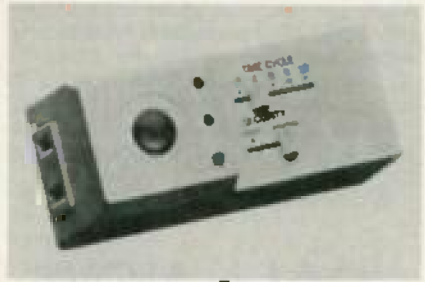
LAMP TIMERS, models *ST1B* and *ST2B,* feature random-setting control to vary the time that the lamps turn on and off. (If lights turn on and off at the same time each day, burglars might not be fooled.) The timers' built-in photocell automatically detects when it is time to turn a lamp on for up to 10 hours. To vary the time lights turn on and off, the user merely activates the "random setting" control. No seasonal adjustments are necessary to ensure that the light turns on at the right time, and the timer doesn't have to be reset after a power failure.

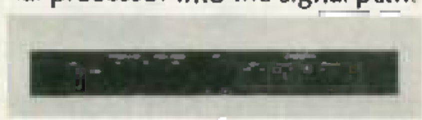


CIRCLE 21 ON FREE INFORMATION CARD

The tabletop model *ST2B* is used when wall outlets are hidden by curtains or furniture. It features a smoke-tinted lid, dimmer, and a six-foot power cord, and is designed for incandescent lightbulbs up to 500 watts. It has a suggested retail price of $21.95.

The model *ST1B* is used when wall outlets are exposed to natural daylight. It plugs directly into any standard 125-volt outlet, and is designed for incandescent lightbulbs up to 300 watts. The suggested retail price is $17.95. Both timers are UL-listed.—**Intermatic Inc.,** Intermatic Plaza, Spring Grove, IL 60081.

STEREO PREAMPLIFIER, model *DX300,* in addition to two tape monitors and tape-dubbing capability, features signal-processing capability for insertion of any signal processor into the signal path.



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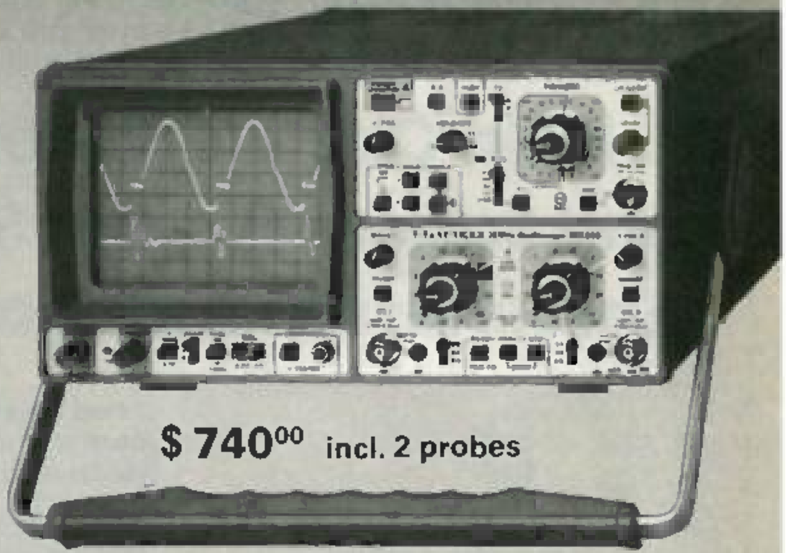

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through a component stereo system. Compact disc inputs are designed to match the high dynamic-range capabilities of CD's.

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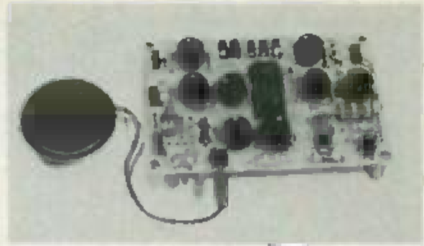
SOUND-EXPERIMENTER KIT, the model *JE755,* generates white noise, tones, and low-frequency sounds independently or in combination. It uses the Texas Instruments complex sound-generator IC, the 76477, to provide unlimited sound-generation capabilities.

The model *JE755* may be expanded with external parts; for example, an external amplifier or stereo system may be added to provide richer sound. The kit comes complete with compo-



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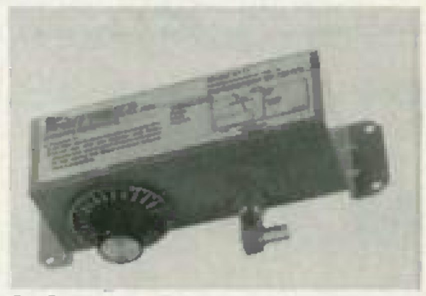
nents and instructions for assembly. The overall size of the model *JE755* is 5½" × 3⅝" × 1¾". Suggested retail price is $34.95.—**Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002.**

INTERFERENCE FILTER, model *5111,* tunes the entire 910-1440 MHz band to handle two common downconverter bands to suppress microwave telephone carriers. Channel interference is suppressed by tuning the single-turn dial to "notch out" the interfering carrier. The single-turn knob tunes a narrow 15-dB notch through the



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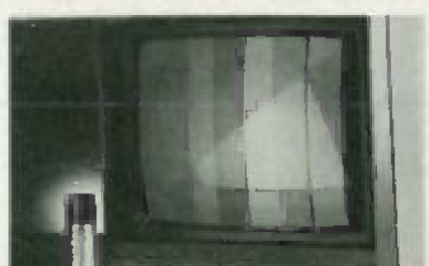
entire standard block-downconverter band. The 2" × 2" × 7⅜" case has type F connectors, adhesive mounting feet, and operating instructions on an etched label.

Suggested retail price of the model *5111* is $295.00.—**Microwave Filter Company, Inc., 6743 Kinne St., East Syracuse, NY 13057.**

ANTI-GLARE SPRAY, *Telefix,* is an aerosal spray that creates a nonreflective surface by coating the



CIRCLE 25 ON FREE INFORMATION CARD

glass with a crystalline film. It is particularly effective in brightly lit rooms where the picture can be washed out by reflected light.

Color and black-and-white sets of any size and shape can be sprayed. The *Telefix* film has a smooth spectral transmission curve that does not change the color that the viewer sees. One can cover up to eight TV screens. The price is $20.00 per can.—**Telefix, U. S. A.**, 140 Bradley Drive, Santa Cruz, CA 95060.

TVRO NOISE FILTER, the model *3278(2)*, is one of a series of bandpass filters that reduce background noise and are available for TVRO receivers with final IF frequencies in the UHF range of 385–700 MHz.

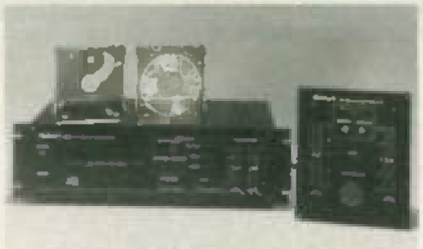
CIRCLE 26 ON FREE INFORMATION CARD

The typical 3-dB bandwidth is 14 MHz to produce clearer pictures in low-signal situations (due to small-dish use, partial dish blockage, or weak transponders, etc.). The filter will also suppress "sparklies" due to mild downconverted terrestrial interference.

Connectors are F-type. Center frequency is factory-tuned at prescribed IF but is field-tunable to compensate for receiver local-oscillator error, if any.

The model *3278(2)* is priced at $132.00.— **Microwave Filter Company, Inc.**, 6743 Kinne Street, East Syracuse, NY 13057.

VARIABLE SPEED CD PLAYER, the model *CD9000* is designed for the serious musician who wants the fidelity of a compact-disc player and the flexibility of variable pitch and speed control, for altering the



CIRCLE 27 ON FREE INFORMATION CARD

tonality and tempo of musical selections.

In addition to variable speeds and pitch of ±10%, the model *CD9000* features slide-in CD carriers to facilitate disc handling. There is a special program indicator, memory, playback, forward and reverse search modes, and a start/stop control. A remote control with all those functions is included.

The model *CD9000* is housed in an EIA standard rack-mount chassis and it has a suggested list price of $1669.00.—**Numark Electronics Corp.**, 503 Raritan Center, P.O. Box 493, Edison, NJ 08818. **R-E**

NEW IDEAS

Telephone-answering system

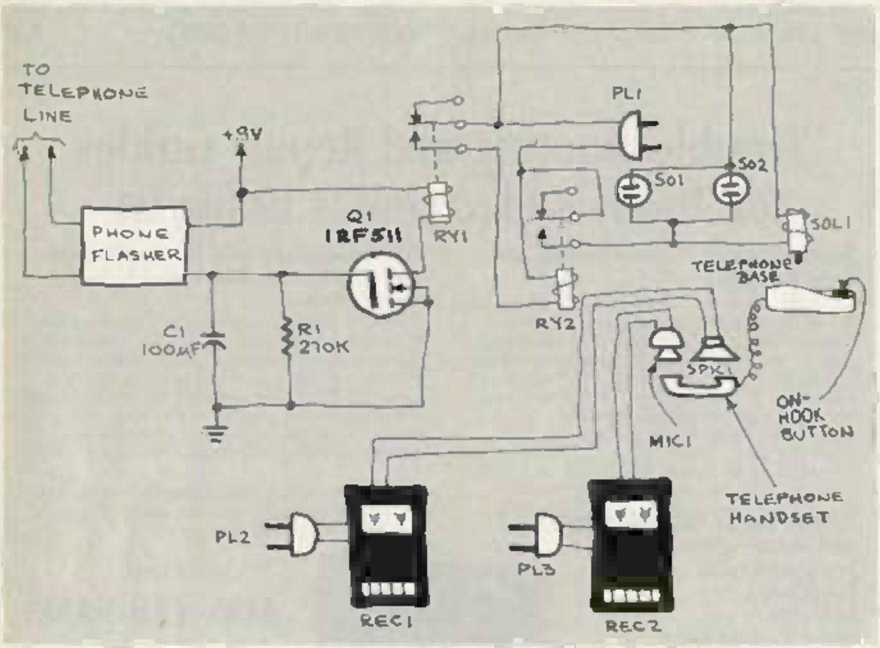


FIG. 1

IN ORDER TO AVOID MISSING IMPORtant phone calls, many have gone out and gladly borne the expense of purchasing telephone-answering machines. Such units can range in cost from under a hundred dollars to more than a couple of hundred dollars. But, there is a way to avoid missing calls (without that expense), and have fun building the system yourself. The only real requirement is that you have two tape-recording machines.

How it works

The basis of the scheme shown in Fig. 1 is the *Fone Flasher* (available from Radio-Shack, catalog number 43-177), which is normally used to flash a light when the phone rings. That unit has an internal relay that, upon receiving a ring signal, closes, outputing a signal to a timing circuit.

The signal output by the *Fone Flasher* causes C1 to begin charging. When C1 is charged, a voltage is applied to the gate of transistor Q1, turning it on. That provides a ground path for RY1, energizing it. Relay RY1, in turn, activates RY2, which is used to handle the power requirements of the two recorders and SOL1.

The core of solenoid SOL1 rests against the on-hook button in the base of the telephone. When the solenoid is energized, its core is retracted releasing the on-hook button. At that point, one recorder plays its prerecorded message into the mouthpiece on the handset.

At the end of that message, the caller is allowed ample time to leave his message, which is picked up by the second recorder through a small microphone attached to the handset earphone. After a period, determined by the time constant of R1 and C1, relay RY1 is turned off. Relay RY2 then opens, removing power from the entire system. Relay R1 can be any 9-volt unit with 117-volt, 1-amp contacts. Relay RY2 has a 117-volt coil and its contacts are rated 117 volts AC at 10 amps.

With power cut off, the core of SO1 is once again extended, pressing down on the on-hook button in the telephone base. The two tape recorders are plugged into sockets SO1 and SO2, so that when RY2 is energized, they are fed 117 volts AC. When using that scheme, the recorder with the prerecorded message should be left in the play position, while the other is left in the record mode.

—Donald J. Youkersur

NEW IDEAS

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

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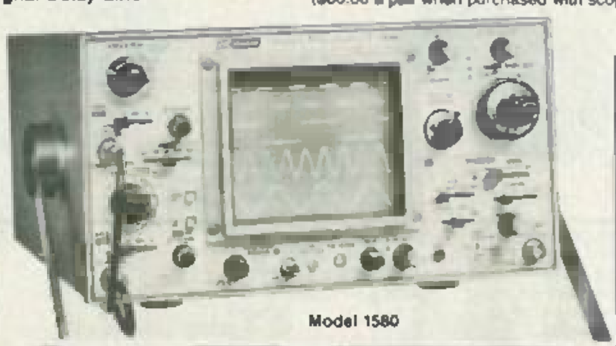

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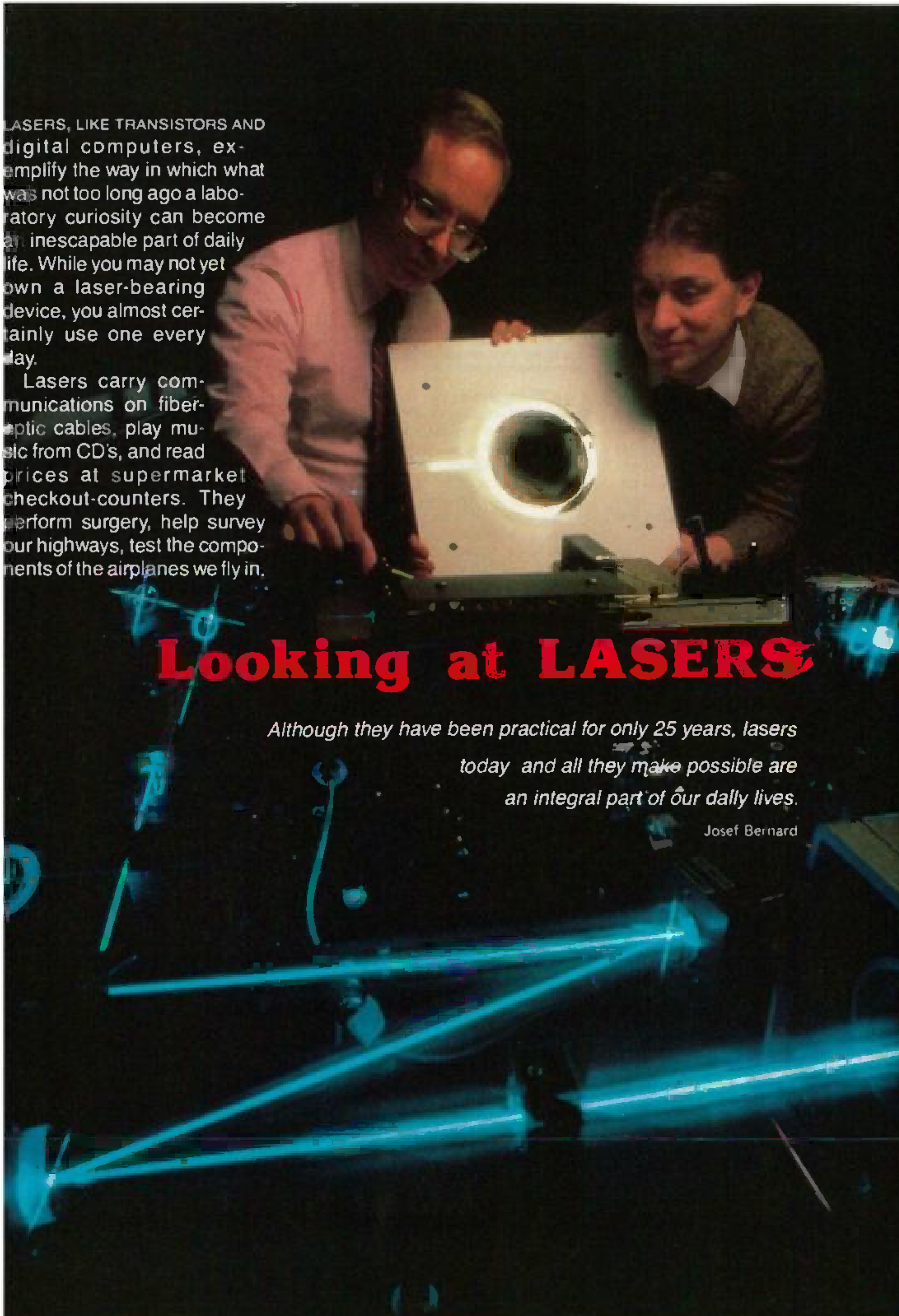


LASERS, LIKE TRANSISTORS AND digital computers, exemplify the way in which what was not too long ago a laboratory curiosity can become an inescapable part of daily life. While you may not yet own a laser-bearing device, you almost certainly use one every day.

Lasers carry communications on fiber-optic cables, play music from CD's, and read prices at supermarket checkout-counters. They perform surgery, help survey our highways, test the components of the airplanes we fly in.

Looking at LASERS

Although they have been practical for only 25 years, lasers today and all they make possible are an integral part of our daily lives.

Josef Bernard

and entertain us at rock concerts. They also make formidable weapons.

What is a laser?

A laser (which stands for *L*ight *A*mplification by *S*imulated *E*mission of *R*adiation) is a source of intense light that has several unusual and useful properties. The light is monochromatic, which means that it is a single, very pure, color whose frequency can be measured and used as a precision standard in and out of the laboratory. Laser light is coherent—all the waves of a beam are in phase. Unlike natural and most artificial light sources, whose emissions are incoherent, or phased randomly, a laser produces packets of photons all "marching in step", and possessing a great deal of energy. Finally, because of the way they are generated the rays of light produced by a laser are all parallel to one another, or very nearly so. A pencil-thin beam of laser light aimed at the moon will spread out to a diameter of only 1½ miles. That may not sound impressive—until you consider that the light would travel a distance of about 250,000 miles before diverging that far.

How lasers work

The principle behind the laser is called stimulated emission. That term refers to the fact that an atom, when in an excited state, can be made to emit a photon when bombarded by other photons or by another high-energy source such as a source of electrons.

That needs a little explaining. Figure 1-*a* shows a simple hydrogen atom—just a proton and an electron. The "height" of the orbit of the electron depends on the amount of energy that the electron is carrying and is very strictly defined by nature. Further, for an electron to be forced to jump from one orbit to another requires a precise amount of energy, or quantum, to be added to it.

In its lowest orbit, no energy has been added and the electron is in its normal, or ground, state. When just the right amount of energy is applied, the electron will jump to a higher orbit, and it is said to be excited (Fig. 1-*b*). That excited state, though, is unstable, so the electron quickly returns to its ground state. When it does that it gives up the energy that was applied to it, in the form of a photon, or particle of light. (Light is electromagnetic radiation but it frequently behaves like a particle. For that reason, a photon is sometimes called a "wavicle.") That spontaneous emission of photons is where laser light begins.

If you get enough excited atoms together, spontaneously emitting photons as they undergo the transition from the excited to the ground state, an interesting thing happens. When one of those photons strikes an already excited atom, it changes state and emits its own photon (Fig. 1-*c*).

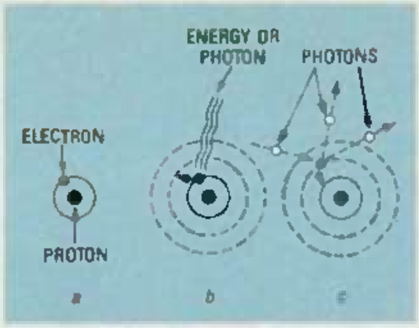


FIG. 1—A SIMPLE HYDROGEN ATOM is shown in a. If a precise amount of energy, or quantum, is added to the atom (*b*), the electron makes a transition from its normal ground state to a less-stable excited state and jumps to the next higher orbit. If a photon strikes the electron while it is in that excited state, the electron will return to the ground state and emit a photon of its own (*c*).

Thus, there are then two photons where previously there was one. Those two photons can go on to strike other excited atoms and generate still more photons—a process very much like what happens in a nuclear-fission reaction. That process of photons generating other photons from excited atoms is known as stimulated emission. A photon of a particular wavelength gives rise only to photons of the same wavelength. Thus, laser light is monochromatic; it contains only a single color.

The trick, of course, is to get together in one place a large number of excited atoms of the same kind, so the that stimulated emission of photons can take place. That is done by pumping the atoms in a material up to an excited state by bombarding them with intense light or with some other source of energy such as a beam of electrons. With a ruby laser—the type used by Theodore Maiman on July 7, 1960 when he demonstrated the first laser—as an example, let's examine the lasing process.

A simple diagram of a ruby laser appears in Fig. 2. The heart of that device is a rod of synthetic ruby whose ends are finely ground and polished so they are optically flat and are exactly parallel to one another. Both ends of the rod are silvered to reflect light back into it, but the reflecting surface at one end is not a perfect reflector—it allows perhaps ten percent of the light generated within the rod to escape. That light is the laser beam.

The rod is surrounded by a spirally-wrapped xenon flash tube similar to those used in electronic flash-units. The light produced by that tube will excite the atoms in the ruby rod. Because of that, that type of laser is known as an optically pumped laser. (As we shall see, there are other types of excitation commonly used.) The cooling equipment is present to remove the heat generated by the lasing device. Lasers are extremely inefficient—only one or two percent of the power they consume is transformed into usable laser light; the rest is given off as ordinary light and lots of heat. That isn't really too bad though—an ordinary incandescent bulb is only about two percent efficient, and the light it produces can't begin to compare with that from a laser.

When the flash tube discharges, the photons it emits enter the ruby rod through its sides and excite the material's chromium atoms, which absorb green and blue light. (Those atoms are what give the ruby its reddish color; you may remember from physics that whatever light a material doesn't reflect or transmit, it absorbs.) When those excited atoms decay from their excited state they give off photons, which trigger other excited atoms to release photons, and so on. The whole process in a ruby laser takes place in about 300 microseconds, and an intense burst of ruby-red light is produced.

We now have lots of light, but we still don't have a laser. That's where the reflective end surfaces of the rod come in. Most of the red light generated within the rod escapes through the sides, but some of it is reflected back into the rod, and that gives rise to the stimulated emission of more red light (hence the "amplification" in the word "laser").

A portion of the light is not reflected, however, but escapes from the rod through the end that is only partially silvered. That

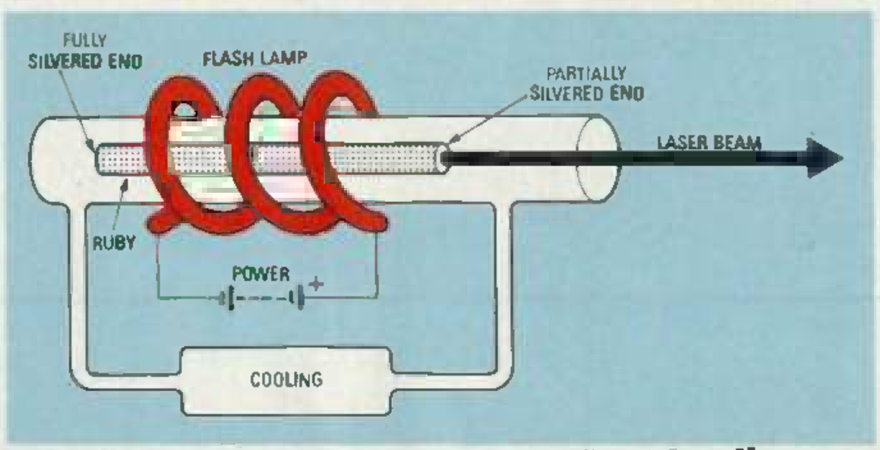


FIG. 2—IN THIS OPTICALLY-PUMPED LASER the light produced by a xenon flash lamp is used to excite the atoms in a ruby rod.

is the laser beam. It is monochromatic because the photons that trigger stimulated emission give rise only to photons like themselves. It is also coherent—all the light waves are in phase. That, too, is a result of the process of stimulated emission; the phase of the photons generated is identical to that of the stimulating photon. The rest of the light reflected by the rod's mirrored ends bounces back to interact with more chromium atoms and produce more photons.

Figures 3-*a* and 3-*b*, respectively, represent coherent and incoherent (random phase) light. As is the case with any wave phenomenon—we're now considering photons as waves rather than as particles—out-of-phase waves tend to cancel each other. Because all the waves of a laser beam are in phase, it is much more intense and powerful than a beam of ordinary incoherent light.

Finally, all of the photons in a laser beam travel parallel to one another. That is the result of the orientation of the reflecting surfaces at the ends of the lasing element. The beam of even an inexpensive laser has a divergence of only about one-twentieth of a degree, which means that the energy it carries is not diffused appreciably over distance.

There are many, many types of lasers, and their characteristics and modes of operation tend to overlap. The following examples are just a small cross section of what has been developed in the past 25 years.

Crystal lasers

This is the category to which the original ruby laser belongs. Those lasers are optically pumped and have a relatively low-power output, in the milliwatt range. The most common type is the neodymium-YAG (for *Y*trium-*A*luminum-*G*arnet) laser, which emits light in the near-infrared. YAG lasers can be operated continuously because the material from which they're made conducts heat, which would otherwise destroy the laser rod, relatively well.

Another member of the crystal-laser family is the neodymium-glass laser. It is less expensive to produce than the YAG type (glass is cheaper than garnet, even the synthetic kind), but it must be pulsed, or operated on a one-shot basis. It cannot sustain continuous operation because of glass's poor heat conductivity.

Gas lasers

There are more gas lasers than there are any other type. Over 5000 types of laser activity in gases are known. Gas lasers are not usually optically pumped, but are energized by passing an electric current at a potential of several thousand volts through the gas, which is contained in a tube with polished and silvered faces similar to the ends of the ruby rod described earlier. As

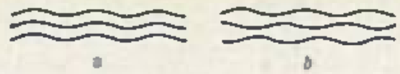


FIG. 3—IN LASER LIGHT, all of the waves are in phase; thus they are said to be coherent (*a*). In normal light, the waves have no phase relationship (*b*).

the current flows through the gas, the electrons transfer some of their energy to it, bringing it to a state where the stimulated emission of photons can occur. Because of the way they're constructed, gas lasers can be cooled more efficiently than crystal types, and lend themselves better to continuous operation.

The most widely used gas laser is the helium-argon laser, which can be built for a modest sum by almost any experimenter. It is able to produce no more than 50 milliwatts, but its tight beam of red light, about a millimeter across, makes it ideal for laboratory and experimental use.

Argon and krypton lasers can produce a wide range of colors, but are still relatively low in power. It is not feasible, for example, to construct an argon laser more powerful than 100 watts. Argon lasers with their green light are frequently used in medical applications.

The infrared carbon-dioxide laser is more of a heavyweight. It can have an output as high as several hundred kilowatts. Moderate-sized lasers of that sort are widely used in industry.

Liquid lasers

Organic dyes dissolved in organic compounds such as alcohol can be made to lase, too. Organic lasers are unusual in that one laser can produce a wide range of colors. That spectrum can be optically tuned, and a very precise selection of light of a single color can be made. That capability makes the dye laser a very valuable laboratory tool.

Semiconductor lasers

Semiconductor lasers (Fig. 4) are members of the LED family. They differ from ordinary LED's in that they consume considerably more current and the edges of the semiconductor die are polished to form interior reflecting surfaces. Because of their extremely small size—about as big as a grain of salt—and the difficulty of removing the heat they generate, those lasers do not have a very high output. Still, there are many applications to which they are well suited, among them fiber-optic communications and compact-disc players.

Laser applications

In the 25 years since they came into existence, lasers have proven themselves invaluable in a diverse range of fields. Here are a few of them:

Industry: The high temperatures produced by focused laser beams make them excellent tools for welding, cutting, and drilling. A pinpoint of coherent light can cut or bore much more cleanly than its mechanical equivalent, with much less waste. (An informal, and entirely unofficial, system for rating the strength of lasers measures their power in terms of "Gillettes"—the number of razor blades that a beam of laser light can successfully punch through.)

Photographs taken by laser light can be used to determine stress regions and faults

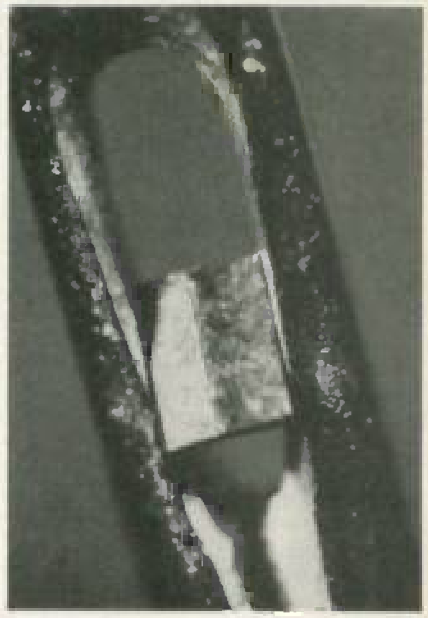


FIG. 4—THIS SEMICONDUCTOR LASER is so tiny that it can fit in the eye of an ordinary sewing needle. Photo courtesy of ATT Bell Laboratories.

in materials, simplifying and improving quality control procedures in critical applications. Lasers are also used in industry for non-contact monitoring of a wide variety of systems. See Fig. 5.

Medicine: Lasers find applications in numerous areas of medicine, among them dermatology, gynecology, and many areas of surgery. The finely focused beam of a laser can operate in areas (such as the inside of the eye) inaccessible to the traditional scalpel.

Science: Lasers have helped scientists both to refine existing knowledge and to learn more about our universe. Using lasers, it has been possible to determine

FIG. 5—LASERS HAVE many applications in industry. Here's a device that uses a laser to monitor the performance of an ultrasonic wire bonder, which is used in electronics production.

the speed of light (186,282.398 miles/second; 299,792.458 kilometers/second) with an accuracy hitherto unknown, and other units of measures have also benefited. A laser beam follows what must be the world's straightest line, a boon for surveyors and the like. Lasers in the laboratory have also allowed the development of new techniques to perform tasks that were previously impossible. Nuclear fusion reactions making possible the generation of enormous quantities of inexpensive electricity from plain seawater will probably be initiated and sustained by lasers.

Communications: Right now fiber-optic communications links using semiconductor lasers are in limited use, but their potential for carrying vast quantities of information makes it certain that as new installations are made, they will become much more common. In space, where laser light cannot be attenuated by air, it may carry communications and data from satellite to satellite, or even to earth. Lasers also are the heart, of course, of the laser printers; those devices, with their high-quality outputs, are now becoming popular in computer circles.

Entertainment: Laser-light shows are popular at rock concerts, and lasers are also used to record and read the information contained on CD's and most videodiscs. Holography, practical only with laser light, makes possible 3-D photography without a camera or special viewing device, and has given birth to a new art form. One day we may enjoy holographic movies, although holographic television at this point seems rather farfetched because of the limited resolution of even the most sophisticated video systems. The applications of holography, of course, are not limited to the world of entertainment. Holographic techniques are also used in devices like scanners for UPC (*U*niversal *P*roduct *C*ode) readers in stores, and in the restoration of artwork.

War: Like dynamite, lasers can be put to both peaceful and destructive uses. Currently in the headlines is the "Star-Wars" technology that will take the science of war into the peace of space. Lasers are also used in the navigation systems of missiles and in targeting devices.

New uses for the unique qualities of laser light are constantly being conceived. Among some of the more unusual and esoteric areas being explored are dental holography, gene manipulation, acupuncture, laser-based optical computers, and the use of lasers to transmit power from solar-energy-gathering satellites. Future applications of the laser may only be limited by the scope of human imagination.

It doesn't take much to see that the invention of the laser is one of the most significant things to come out of the laboratory in this century. R-E

BUILD THIS

HELIUM — NEON LASER

Build this simple helium-neon laser and start having fun with photons!

ROBERT GROSSBLATT and ROBERT IANNINI

BACK IN THE HEYDAY OF SCIENCE FICtion's era of purple prose, tales of bug-eyed monsters, death rays, and the like filled many a pulp magazine. Of course, we knew then that it was all just fantasy; you could no more have a "death ray" than you could travel faster than sound or put a man on the moon.

While those bug-eyed monsters (or BEM's, for short) have yet to pay us a visit (to the best of our knowledge), much of yesterday's science fiction is today's science fact. We even have a death ray, of sorts. Of course, we are referring to the laser, which can be a powerful weapon in the hands of those who wish to use it as such.

But the laser is also a great tool for science and industry. In just 25 years the laser has gone from far-fetched notion, to scientific reality, to common noun. Hardly a day goes by where some part of our lives is not affected by lasers. Today, the laser has joined the transistor as a hallmark of modern electronics.

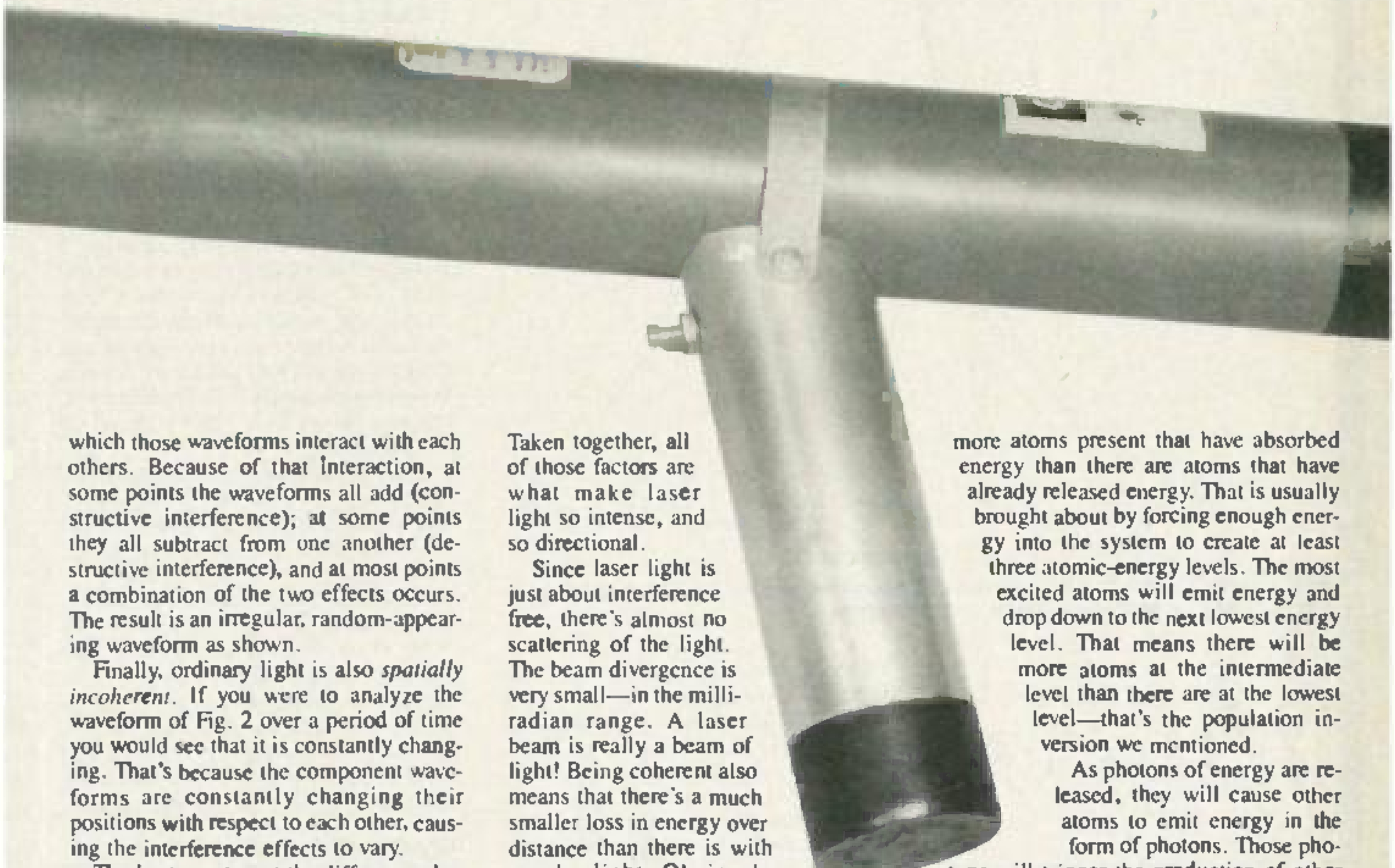
What's a laser?

The word *laser* is an acronym for *L*ight *A*mplification by *S*imulated *E*mission of *R*adiation. But for most of us, that provides a poor explanation of what a laser is and how it works. To find a better explanation, we have to leave electronics for a while, drop into the world of physics, and talk a little bit about the nature of light. You can't understand laser light until you have some familiarity with the properties of light in general.

There are three ways in which laser light differs from ordinary light, and each of those differences contributes to the special characteristics of a laser. Let's begin by looking at some of the characteristics of ordinary light.

Ordinary light has a relatively wide bandwidth. That means that a spectrographic analysis would reveal that regular light is made up of many different wavelengths. Just about everybody has seen, or done, the experiment in which a beam of white light is directed through a prism and split into different colors. The ordinary light we see as white, therefore, is actually made up of different color elements—it's *polychromatic*. Figure 1 shows the composition of visible light, and the relative sensitivity of the human eye to various wavelengths.

Ordinary light is also *temporally incoherent*. By that we mean that the various components of the light do not share any time relationship; they are all randomly out-of-phase with respect to each other. Thus, if you were able to look at the waveform of a beam of ordinary light, you would see something that looks like Fig. 2. The irregularity and random appearance of that waveform is caused by the presence of waveforms of differing frequencies in the light, and the ways in



which those waveforms interact with each others. Because of that interaction, at some points the waveforms all add (constructive interference); at some points they all subtract from one another (destructive interference), and at most points a combination of the two effects occurs. The result is an irregular, random-appearing waveform as shown.

Finally, ordinary light is also *spatially incoherent*. If you were to analyze the waveform of Fig. 2 over a period of time you would see that it is constantly changing. That's because the component waveforms are constantly changing their positions with respect to each other, causing the interference effects to vary.

The best way to put the differences between ordinary and laser light in perspective is to compare light to sound. Ordinary light, because of all the things we just talked about, can best be compared to noise. The waveforms at any moment in time are not only randomly spaced, but there's an unpredictable mix of frequencies as well.

Now, if regular light is like noise, then laser light can only be thought of as the purest sound imaginable. For openers, laser light is highly monochromatic—a spectrographic analysis would show that it is composed of light of only one wavelength. And where regular light is temporally incoherent, a laser is temporally coherent—all of the light waveforms are in phase with each other. That is one of the reasons why a laser puts ut light of such pure color. Being monochromatic helps, of course, but being temporally coherent as well means that there's almost a complete absence of what would be called distortion in a sound wave.

As you might have already guessed, laser light is also spatially coherent. If you looked at the waveforms over a period of time, there would be absolutely no shifting or movement. Considering the absence of interference effects, that is exactly what you would expect to happen.

Taken together, all of those factors are what make laser light so intense, and so directional.

Since laser light is just about interference free, there's almost no scattering of the light. The beam divergence is very small—in the milliradian range. A laser beam is really a beam of light! Being coherent also means that there's a much smaller loss in energy over distance than there is with regular light. Obviously, since laser light is so different from regular light, it can't be produced the same way. And in order for us to understand how it's produced, let's see how regular light is produced.

Electromagnetic waves in general, and light in particular, is produced when an atom gives off energy. Now, an atom either takes on energy (absorption), or gives off energy (emission), by having its electrons move from one energy level to another. Once energy has been supplied to the system, and absorbed by the atom, emission can occur in one of two ways—it can happen spontaneously, or it can be stimulated.

Spontaneous emission is the result of natural atomic decay. The electrons randomly drop in energy level and produce the kind of waveforms shown in Fig. 2. When you power up a light bulb, for example, the atoms in the filament absorb energy and release it as a combination of heat and ordinary, incoherent light.

Stimulated emission is a completely different process. The idea is to keep the atoms from releasing their absorbed energy in a random manner. In order to do that, you have to create a state of affairs called a "population inversion." In simple terms, that means that there have to be more atoms present that have absorbed energy than there are atoms that have already released energy. That is usually brought about by forcing enough energy into the system to create at least three atomic-energy levels. The most excited atoms will emit energy and drop down to the next lowest energy level. That means there will be more atoms at the intermediate level than there are at the lowest level—that's the population inversion we mentioned.

As photons of energy are released, they will cause other atoms to emit energy in the form of photons. Those photons will trigger the production of other photons. And if the emission is bounced back and forth between two mirrors the production of photons will continue to build in phase and the result will be, you guessed it, a beam of laser light with a waveform that looks like that shown in Fig. 3.

Making a laser

Now, understanding the basic theory and putting it into practice are, as we all know, two completely different things. Creating the population inversion you need to produce a laser beam is really an iffy, ticklish business. Everything has to be just so or nothing will happen. The mirrors have to be of a certain type to produce the in-phase coherent energy needed for a laser. And enough energy of the right type has to be forced into the system to make the whole thing work.

The kind of energy you have to pump into the system depends on the type of material you're trying to make lase. Semiconductor and gas lasers are pumped up with electrical energy while crystalline lasers, such as those made from ruby rods or YAG (Ytrium-Aluminum-Garnet) are usually pumped up optically with xenon flash tubes or arc lamps.

The laser we're building here is a gas

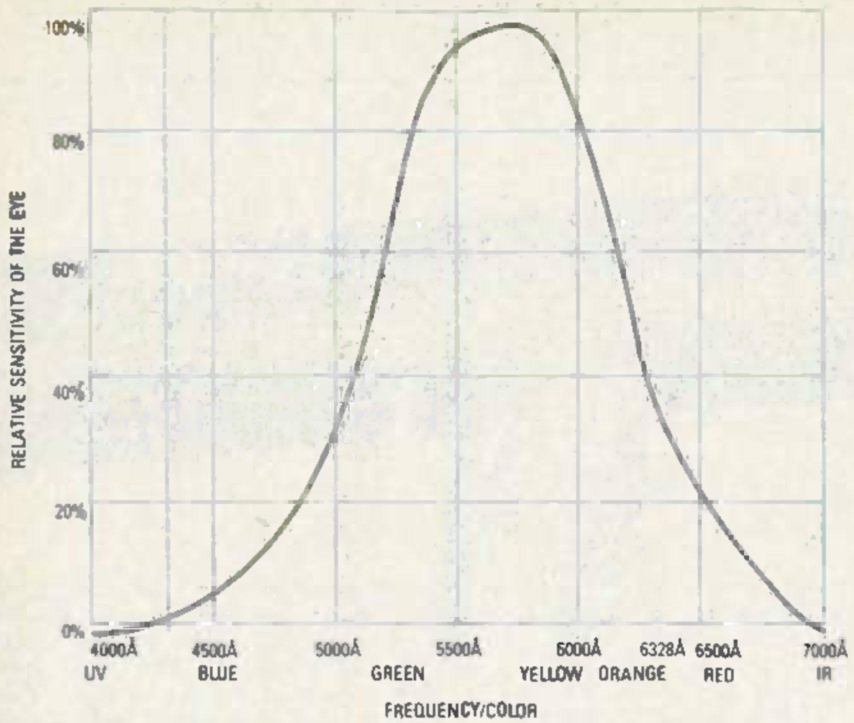


FIG. 1—THE VISIBLE SPECTRUM, and how the human eye responds to it. The wavelength of the light emitted by our helium-neon laser is 6328 Angstroms.

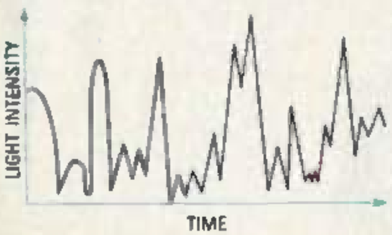


FIG. 2—THIS RANDOM-APPEARING waveform is that of ordinary light. The waveform is made up of all of the various frequencies that make up such light.

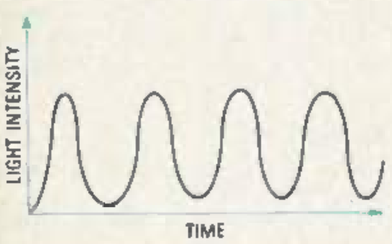


FIG. 3—LASER LIGHT is made up of light of just one frequency. It is the purest type of light possible.

laser—more specifically a helium-neon laser. The frequency of the light is 6328 Angstroms and the laser puts out about 1 milliwatt with a beam divergence of 1.3 milliradians. Now, 1 milliwatt may not sound like a lot of to you, but that's because you're still thinking in terms of regular light. Remember that the laser produces a highly directional beam of coherent, monochromatic light. The laser we're talking about here generates a beam that can be spotted on a wall more than two miles away!

Helium-neon lasers are extremely inefficient and, in order to make them work, the mechanical setup of the laser tube has to be just about perfect. It has to be properly sealed and contain the correct gas mixture. Also, the mirrors have to be perfectly aligned dielectric ones so enough reflection takes place at the proper frequency to cause the device to lase. Those mirrors must be highly reflective, within a couple of decimal places of 100%; by contrast, the silver mirrors we use every day have a reflectance factor of only 95%.

Making a helium-neon laser tube is a project that is beyond the means of most of us as it requires a fair amount of skill and equipment. Among other things, you need to have the skills and equipment required to create a precise mixture of gasses, and you need to be adept at glass blowing. All of that is not impossible, of course, but in most cases its a task that is best left to someone else; we recommend that you purchase rather than build a tube. (One source for laser tubes is mentioned in the Parts List.)

Once you have a working laser tube, actually making it produce a beam is surprisingly simple. The only electronic assembly needed is a power supply that will deliver the right voltage to make the tube fire. Figure 4 is the schematic of a power supply that can be used to trigger the laser. If it looks familiar, that's because its front end is essentially the same one used in the construction of the infrared viewer that appeared in the August 1985 issue of **Radio-Electronics**.

The power supply is a switcher with Q1, Q2, and their related components forming an oscillator that switches a squarewave through the primary windings of T1, a high voltage step-up transformer. That part of the circuit takes the battery voltage and produces about 400 volts AC at the secondary of T1. Diodes D3–D6 and capacitors C2–C5 form a voltage multiplier that takes the 400 volts from T1 and boosts it to the 1600-volts DC needed to ignite the laser tube.

The high-voltage pulse needed to ignite the tube comes from an 800-volt tap on the voltage multiplier. Resistors R3 and R4 divide that voltage to provide the 400 volts needed to charge up C9, the dump capacitor. When the SCR fires, the charge on C9 is dumped into the primary of the trigger coil, T2. Capacitor C11 charges up and, since it's in parallel with the laser tube, when the voltage builds enough to excite the gas, ignition takes place and current flows through the tube. That causes a voltage drop across R10, which turns on Q4 and turns off Q3.

As soon as the laser tube ignites, therefore, the ignition circuitry is turned off. That saves battery power because the laser tube can sustain firing at a lower voltage. The relaxation oscillator made up of Q3 and Q4, and their related components is only needed to control the firing of the SCR. Once the tube starts to lase, the voltage drop across R10 keeps the ignition circuitry turned off. If the tube stops lasing, the R9–R10 junction will drop to ground again and Q4 will turn off and unclamp Q3. The SCR will start firing again and, we hope, re-ignite the tube.

Construction

Before we actually start building the circuit, there's one very important thing you *must* keep in mind:

CAUTION! The power supply can produce as much as 10,000 volts at about 5 milliamps. That is enough juice to do a lot of damage. If you're not careful you can give yourself a severe shock. Remember that the capacitors take a while to discharge completely. You can get a real jolt even if the circuit has been turned off for five or ten minutes. Treat the circuit with respect and make sure to discharge the capacitors if you want to do some work on the circuit.

Now that that's out of the way, you can build the power supply on perfboard or use the PC board that's provided in our PC Service section, elsewhere in this magazine. If you use perfboard, remember to keep the leads as short as possible because there's a lot of high-frequency AC running around part of the circuit. Whichever method you use, make sure to keep any metal objects and your fingers away from the output section located around T2 and R11. Those are the points of the circuit where the highest voltages can be found. One short second of carelessness on your part and you're going to get zapped. If you're lucky, all it will do is hurt a lot.

The only other components in the cir-

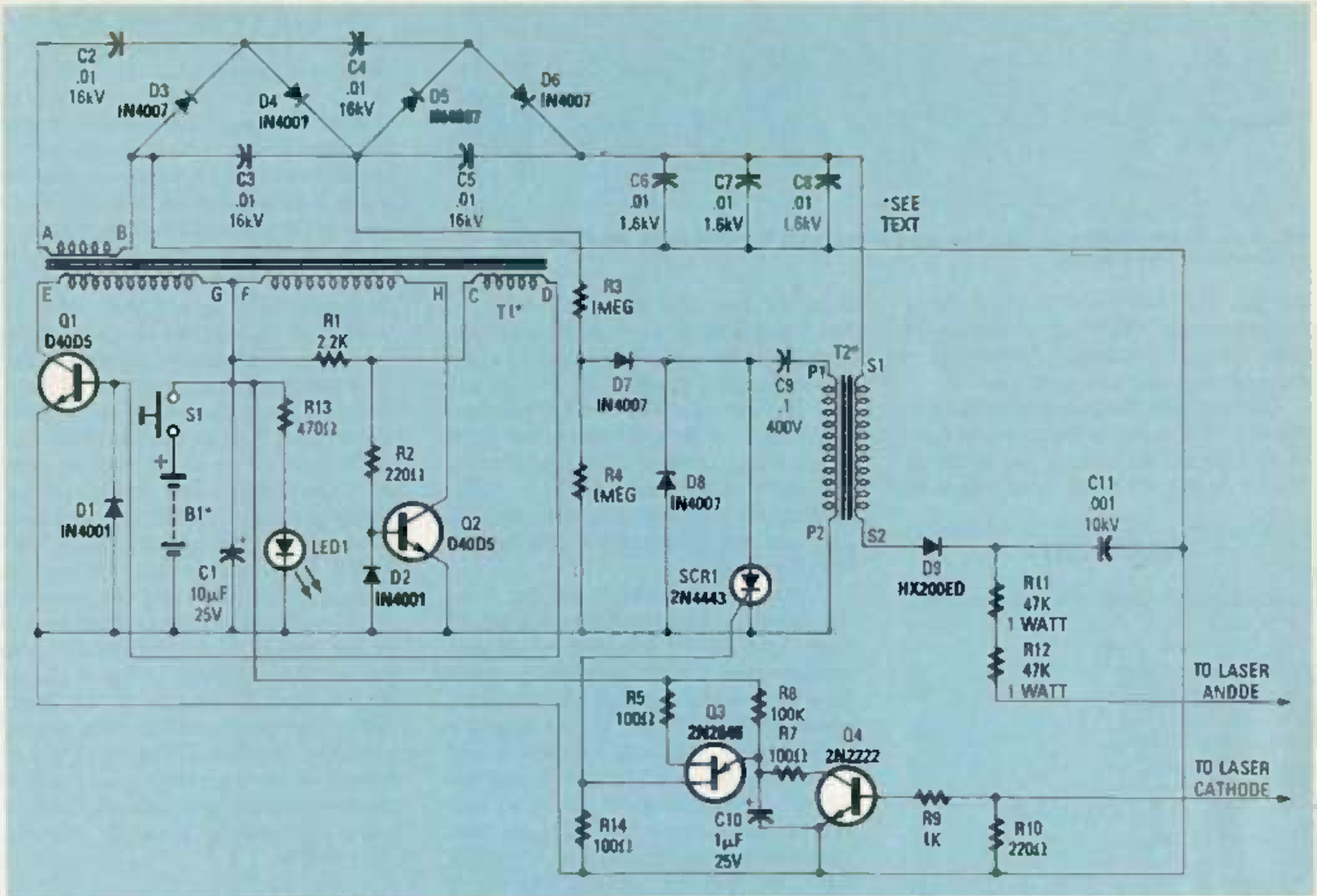


FIG. 4—THIS POWER SUPPLY is all you need to drive a laser tube like the one available from the supplier mentioned in the Parts List.

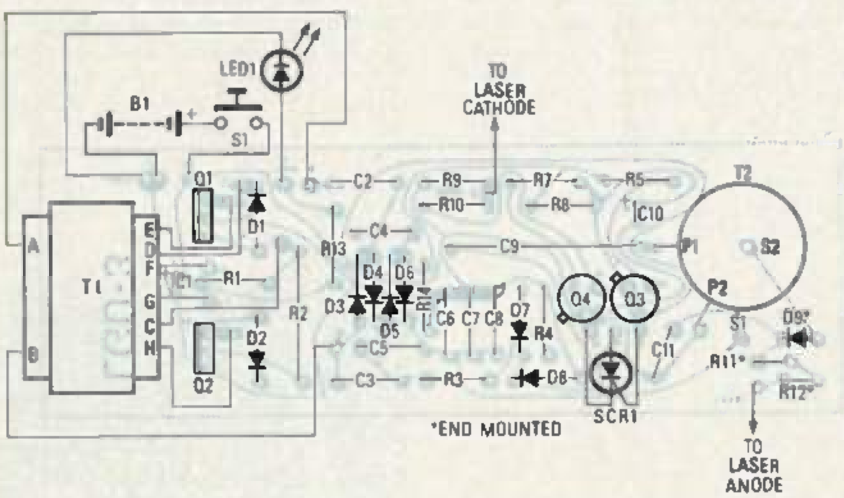


FIG. 5—IF YOU CHOOSE to use the PC board provided in our PC Service section, use this parts-placement diagram.

cuit that require special attention are the switching transistors, Q1 and Q2. The maximum current draw from the batteries is about 750 mA, so those transistors will be handling a lot of juice and getting hot. The PC-board layout shown in Fig. 5 is designed so that the transistors can be placed in such a way that their tabs can be stuck against the laminations of T1. If you are using perforated construction board, be sure that your layout allows for that, too. Use some heat-sink compound to get good thermal contact, and using small heat sinks wouldn't be a bad idea.

After you've identified the components and found their position on the board, solder them in using a minimum of solder. Once you've done that, use some high-voltage putty, paraffin, or varnish to cover the traces (or wires if you're using perfboard) that connect to all the components on the secondary side of T2 and the laser tube. That part of the circuit has the highest voltages and it's likely that arcing will take place if all the bare metal isn't covered. You may find it necessary to use the same material on the component side of the board as well.

When you finish the board, check for bridges, opens, bad solder joints, and so on. If everything seems OK, you're ready to test the power supply. Take the two leads that normally would go to the laser tube and tape them down so that they're ½-inch apart. Connect 10 volts to the power supply. You should see arcing across the laser-tube leads at a rate of about once a second or so; the circuit should be drawing approximately 250 mA. If the spark becomes continuous, the current draw should jump to about 750 mA—the full operating current of the laser tube. If you measure the voltage across the output of the supply, you should see an open circuit voltage of about 2500. Once the laser tube is connected, the voltage will be in the neighborhood of 1500.

If you've gotten this far without any brain damage, you're ready to connect the tube to the supply.

CAUTION! The laser tube is an expensive, delicate piece of equipment. In order to connect it to the circuit you'll be soldering leads to the metal collars at either end of the tube. Use a minimum of solder and apply heat for a minimum amount of time. Don't ever forget that the tube has a high vacuum inside and you can damage more than the tube if you destroy the integrity of

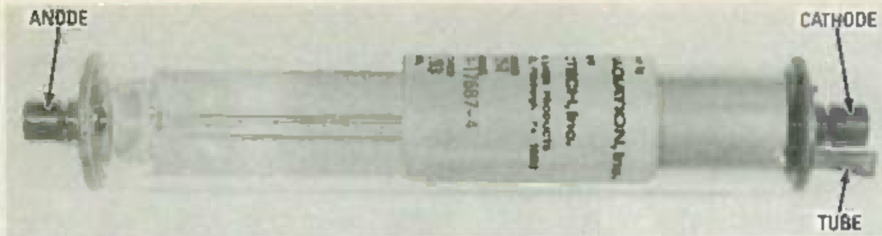


FIG. 6—A HELIUM-NEON laser tube. The cathode end can be identified by the small tube used to fill the laser tube with gas.

the seal. Use a low-power iron and a lot of common sense when you solder to the tube. Tin the wires ahead of time to keep the soldering time to a minimum.

The laser tube has an anode and a cathode end. The anode is the clear glass end of the tube and the cathode can be identified by finding the small metal tube used to fill the laser tube with gas. See Fig. 6. Once you have the ends of the laser tube identified, solder the lead from R12 to the anode, keeping that lead as short as you can. The voltage at R12 is about 1100 volts when the tube fires, so that is the point where arcing or some other type of parasitic power loss is most likely to occur. Keeping the lead as short as possible will go a long way toward eliminating any potential problems.

Connect the cathode of the tube through an ammeter to R10 and apply 10 volts to the supply. The tube should start sputtering as it tries to ignite. As you raise the voltage *slowly*, ignition will take place and the tube will fire. If you raise the supply voltage to 12 volts, you should find the tube drawing about 5 mA and the supply will be putting out about 750 mA. The operating current of the laser tube should be kept in the range of 4.5 to 5.5 mA. Less than that and the tube won't operate reliably; more than that and you'll cut down its operating lifetime. You can trim the values of R11 and R12 to get the operating current into the safe range. Just make sure you keep the total resistance of R11 and R12 at about 100,000 ohms.

The current through the tube is going to vary a lot as the battery voltage changes. If you use nickel-cadmium cells, remember that the operating voltage is going to be 1.2 in each cell for most of the lifetime of each charge. Freshly charged nickel-cadmium cells, however, can have a voltage as high as 1.5. Admittedly that doesn't last very long, but we'll mention it because adjusting the laser tube's operating current with freshly charged batteries could cause you to choose artificially high values for R11 and R12. So before you start trimming the resistors, make sure the batteries are at 1.2 volts per cell

Since the operating current is tied to the supply voltage, it's natural to think about voltage regulation. Well, there is nothing wrong with regulating the input voltage, but there are a few things to keep in mind. If you use 12 nickel-cadmium cells, you'll have a supply voltage of 14.4 and you'll be drawing as much as 750 mA from that supply. A three-terminal regulator like the 7812 would seem to be an ideal choice, but asking it to supply 750 mA is really asking a lot unless you use a 7812C, which can handle 1 amp with a good heat sink. An LM317 can be set up to put out 12 volts and it can supply 750 mA.

The biggest problem with using an IC voltage-regulator is the voltage loss that's inherent in those devices. In order to supply 12 volts, a regulator needs an input voltage of about 14.5 volts. Now that's just about the maximum you can get from the batteries. And if your particular tube wants a little bit more than 12 volts, or some of the power-supply components are a little bit lossy, you're in a lot of trouble.

So, you ask, what's the bottom line. Well, after all's said and done, unless you want to do an awful lot of circuit design, the best thing to do is let the power supply look directly at the batteries. It's not the best solution in the world, but it's probably the best thing in this situation.

The case for the laser can be as simple or as fancy as you like. Perhaps the simplest and most functional approach would be to use some lengths of standard PVC tubing. But if you do that, or completely enclose the circuit in any way, you could run into an overheating problem because of the amount of heat produced by the power supply. Because of that, it's a good idea to limit the on-time to less than a minute; keeping it under 30 seconds is even better. Further, giving the supply a 5-second or so rest between uses will increase its lifetime tremendously. Also, the better you heatsink Q1 and Q2, the better off you'll be.

Having fun

The output of the laser tube is about 1 milliwatt (or 0.4 milliwatt if the lower-powered tube offered by the supplier mentioned in the Parts List is used) and, at that power, it can't do any damage. If you had thoughts of burning your way through steel, forget it. Lasers that can do that are worlds away from the one we're building. However, that doesn't mean you can treat the light from this laser with no respect whatsoever.

CAUTION! Even a 1-milliwatt laser can be hazardous if you look directly at the beam. While we assume that anyone considering building a laser would know enough about those devices to never, never even consider doing something so foolhardy, the very nature of laser might make it very easy for accidents to happen. The beam is highly directional and very intense: to compound matters, the reflected beam is just as dangerous as the emitted beam. It's a simple matter to have the beam bounce off some shiny object and reflect back to you. You can wear safety glasses, but even if you do, be careful where and how you use the laser.

While you can use this laser, which throws an intense red beam, for such things as target spotting, perhaps its greatest use is as an introduction to the world of lasers in general. Watching the tube fire is truly fascinating and the more you experiment with it, the more you'll learn. R-E

PARTS LIST

All resistors ¼ watt, 10% unless noted
R1—2200 ohms
R2—220 ohms, 1 watt
R3, R4—1 megohm
R5,R7—100 ohms
R6—not used
R8—100,000 ohms
R9—1000 ohms
R10—220 ohms
R11, R12—47,000 ohms, 1 watt
R13—470 ohms

Capacitors
C1—10 µF, 25 volts, electrolytic
C2–C8—0.01 µF, 1.6 kV, ceramic disc
C9—0.1 µF, 400 volts, paper dielectric
C10—1 µF, 50 volts, electrolytic
C1—0.001 µF, 10 kV, ceramic

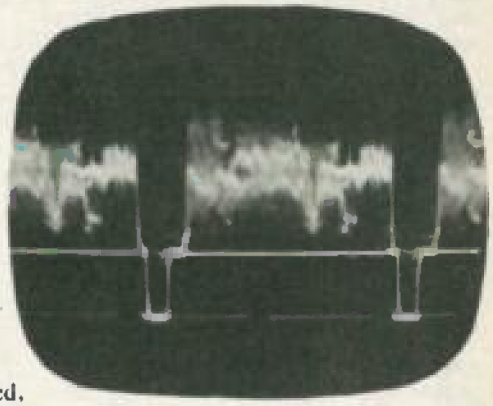
Semiconductors
D1, D2—1N4001
D3–D8—1N4007
D9—HX200ED, 20 kV diode
LED1—Red LED
Q1, Q2—D40D5, NPN power transistor
Q3—2N2646—UJT transistor
Q4—PN2222 NPN transistor
SCR1—2N4443 SCR

Other components
T1—12 to 400 volts, 10 kHz switching transformer
T2—10-kV trigger transformer, 400-volt primary
B1—14.4 volts, 12 nickel-cadmium cells, or equivalent
S1—SPST switch, momentary pushbutton, normally open

Miscellaneous: PC board, helium-neon, laser tube, PVC tubing for case, battery holders, wire, solder, etc.

Note: The following are available from Information Unlimited, PO Box 716, Amherst, NH 03031: PC board, $4.50; switching transformer (T1), $14.50; trigger transformer (T2), $11.50; 1-milliwatt laser tube, $149.50; 0.4-milliwatt laser tube, $99.50; high-voltage diode (D9), $3.50; high-voltage capacitor (C11), $3.00.

TV SIGNAL DESCRAMBLING



Learn all about the techniques used by the pay-TV and cable companies to keep unauthorized viewers from pirating their signals.

WILLIAM SHEETS and RUDOLF F. GRAF

THANKS, IN PART, TO THE EXPLOSIVE growth of the video marketplace, it is rare these days to find a home that does not have access to some form of "pay-TV." By pay-TV we are, of course, referring to some type of premium programming that is provided to the viewer at a cost. Pay-TV can take many forms. It can be delivered via cable, satellite, multi-point distribution system (terrestrial microwave), or over-the-air subscription TV, and pay-TV can be charged for on a fixed-fee or per-program basis.

Obviously, for such a system to succeed, there needs to be some means to collect the charges for the premium channels or individual programs, and to prevent unauthorized reception by non-paying viewers. The most popular way of doing that is scrambling—encoding the signal so that it is unwatchable and/or inaudible to nonsubscribers. If a signal is properly scrambled, there is no way to adjust the television receiver so that a usable signal can be seen or heard.

In order to receive the signal, a device called a decoder or a descrambler must be used; that device is generally located between the antenna (or cable output) and the television receiver.

There are many different scrambling and descrambling techniques. Some scrambling schemes are basically very simple and provide only minimal security. Others are very sophisticated, and expensive. Thus, while they provide a high level of security, they are not currently practical for home-TV use. However, that may not always be the case. The recent development of low-cost, mass-produced digital-TV IC's may make highly sophisticated, secure scrambling economically feasible for home use in the not-too-distant future.

In this series of articles we are going to discuss several scrambling-descrambling systems. All of those systems are either currently in use or possible in theory. Both system operation and circuitry will be described. Also, we will describe several experimental decoders, for those who wish to gain hands-on knowledge of the technologies involved (see text box), and we'll describe a device to scramble an existing video program. You may find the scrambling circuit useful for such things as protecting private information on your own videotapes from either unauthorized viewing or copying.

Incidentally, these articles are not intended to aid anyone with the theft of signal. In most instances, the theft of signal from a cable company, over-the-air pay-TV company, etc., is a crime, punishable by fines, and in some cases jail. Even if it were not, in many cases it would be more economical simply to subscribe and pay the fee. Decoders are expensive to buy and time consuming to build. And if, after you've spent the time and/or money for an illegal decoder, you find you don't like the programming, you are stuck with the equipment.

Over the next few months, **Radio-Electronics** will be presenting a series of articles describing the techniques used by pay-TV and cable companies to scramble their signals. While specific circuits for specific scrambling systems will be discussed, they are presented for *informational and experimental purposes only*. Therefre, parts lists, parts suppliers, and additional technical support *will not be available* for those circuits.

The video signal

In order to understand how scrambling works, you need some knowledge of the structure of a normal (not scrambled) video signal. Figure 1-*a* shows a simplified NTSC signal; in the U.S. and Canada, that is the composite-video signal that is transmitted by your local TV station. In that signal, the video information appears between high-amplitude pulses. The effects of those pulses are not readily apparent on the screen, but they play an important role in the creation of the TV image.

The pulses are actually made up of several components. The widest part is called called the horizontal blanking pulse. The purpose of the blanking pulse is to eliminate the visible effect of the bright vertical-retrace lines. It does that by "turning off" the CRT during retrace. Piggy-backed on the blanking pulse is the horizontal-sync pulse; its purpose is to synchronize the TV's horizontal sweep circuitry to the video signal.

Right after the horizontal-sync pulse's trailing edge, but before the blanking-pulse's trailing edge (that region is called the "back porch") is a signal consisting of eight cycles of a 3.58 MHz sinewave. That signal is the color-sync (burst) signal; it is absent if the transmitted program is black and white. It is used to synchronize the color circuitry in the TV receiver and to turn on the color circuitry for color programs. In its absence (B/W program), the color circuitry in the TV receiver shuts down; that prevents colored noise and streaks from interfering with a black-and-white program.

There are 15,734 horizontal-sync pulses transmitted per second corresponding to each of the 525 lines of 59.94 fields transmitted per second. Each field consists of 262½ lines (interlaced scanning), and two fields make a frame. Alternate lines are scanned on each field. For simplicity, we will round off those numbers to 15,750-horizontal and 30-vertical frames per second. Note that the vertical pulses occur at a 60-Hz rate, but that alternate pulses are slightly different, due to the interlacing.

For our purposes, the main point to remember is that those horizontal and vertical pulses, and the color-burst signal, are used for timing and synchronization necessary to reconstruct the TV picture. If any of those pulses are absent, distorted, or altered, it becomes difficult or impossible to synchronize the TV picture. It will roll, tear, and the colors will be incorrect, rendering the picture unwatchable. Naturally, the video level must not be so great as to exceed the horizontal-sync pulse level, otherwise the level-sensitive sync circuits will be "confused" and the TV picture will not synchronize properly.

Audio information is frequency modulated on a 4.5-MHz signal that is added to the composite-video signal; the audio may also be modulated on a subcarrier, as is often done in scrambling systems (more on that in a moment). The audio signal is like a standard FM-broadcast signal, except the deviation is limited to ±25 kHz instead of the ±75 kHz used in FM broadcasting. The audio circuitry in a TV receiver is much like the corresponding circuitry in an FM broadcast receiver.

The color signal is a bit more complex to understand, but basically it is a 3.58-MHz (actually, 3.579545-MHz) signal that is both amplitude and phase modulated. The amplitude of that signal determines the saturation of a color, (whether it is, for example, white, light pink, rose, or red) and the phase determines the hue (whether it is red, orange, yellow, etc.). Note that the amplitude of the composite color signal is used to determine the difference from white, not the intensity, of a particular color. In that way, a color signal with zero level would produce a white raster making for compatibility between color and black-and-white reception on the same TV receiver.

Of course, we have only touched upon the basics of the video signal. Since a comprehensive treatment of the subject would take much more room than we have available, we suggest you consult a good reference on the topic. You are sure to find several at your local library or technical book store.

Scrambling the picture

As you may have guessed from the foregoing, by altering any of the key components that we've discussed, a picture can be rendered unwatchable. If the alteration is done in such a way that a circuit at the receiving end can counteract such alteration, you have the basis for a scrambling system.

Further, there are still more ways in which a signal can be scrambled. For instance, the video information between the sync pulses may be modified, the scanning sequence can be altered, or various scrambling techniques can be integrated in a time varying way to provide different scrambling by minute, second, or even frame.

Several simple scrambling schemes are generally in wide use today on cable and pay-TV systems. One of the simplest in use is video inversion. In that method, the video information is sent with reversed polarity. The TV may or may not sync on it (depending whether the sync pulses are inverted also). If the set can synchronize the signal, it appears as a negative picture—dark areas are light, and highlights are dark. Colors are reversed, and appear as complementary to those in the original scene. If you do not mind watching blue faces, brown skies, and red grass, then the picture might be watchable.

Usually nothing is done to the sound, although it may be modulated onto an subcarrier, and the main sound carrier may have what is called "barker audio" on it (more on that in a moment).

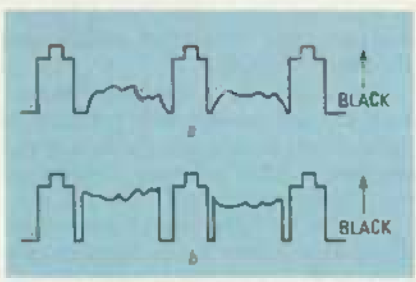


FIG. 1—A NORMAL NTSC video signal is shown in *a*. In one of the simplest scrambling methods, the polarity of the video information, which is located between the horizontal blanking pulses, is inverted, as shown in *b*.

Inverted video is easily unscrambled by merely re-inverting the video polarity in a video amplifier. That can easily be done in the TV set. The only precaution is that it must be done at a suitable point in the video system. For example, if the sync pulses are not inverted, it must be done after sync takeoff. Some sets use separate detectors for sound/sync takeoff. Figure 1-*a* shows what a video signal with inverted video, but normal sync pulses, looks like.

A more sophisticated method is to invert the video at several intervals during the frame, or every several frames, or during positions of scan lines. That results in a picture with a very annoying flicker or a superimposed pattern, which would be unwatchable unless you don't mind severe eyestrain or a headache. Figure 2 shows what a video signal that has been scrambled in that way looks like. Decoding that signal requires an arrangement where the video polarity can be instantaneously changed in synchronization with the scrambling signal. A block diagram of an appropriate decoding system is shown in Fig. 3. The information required by the decoder to sync with the scrambled signal can be transmitted on the sound carrier, sent with the picture itself, or obtained from the sync section of the TV set.

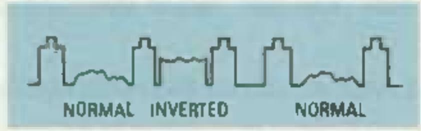


FIG. 2—IN SOME SCRAMBLING SYSTEMS the polarity of the video alternates every frame or every few frames.

If alternate frames are inverted, the eye would tend to add the adjacent frames due to persistence of vision. That would show up as either a weak positive or negative image, or ideally, a blank raster. However, the video inversion method and its more sophisticated versions are not very "secure" in the sense that descrambling is easily done. Video inversion is best used along with a more complex method that also acts on the sync pulses.

Scrambling the sync

There are many ways to alter the sync pulses. One method that is currently popular is called sinewave scrambling. In that method a 15.75-kHz sinewave is added to the video signal. If the negative peak of the sinewave corresponds to the positive peak of the sync pulse (see Fig 4), that suppresses the sync signal below the peak video level. That "confuses" the sync separator circuits in the TV set and they cease to function properly.

The resulting picture tears and rolls, and has a vertical dark band. Colors are lost or out of sync, since the TV set cannot tell where the sync pulse is. Some video signals that have mostly very light areas (highlights) may synchronize properly for a moment, but most will roll, tear, or distort. The picture is generally unstable and cannot be watched.

Unscrambling is done by taking the scrambled signal and mixing it with a sinewave of proper phase and amplitude to cancel the added sinewave. The sinewave

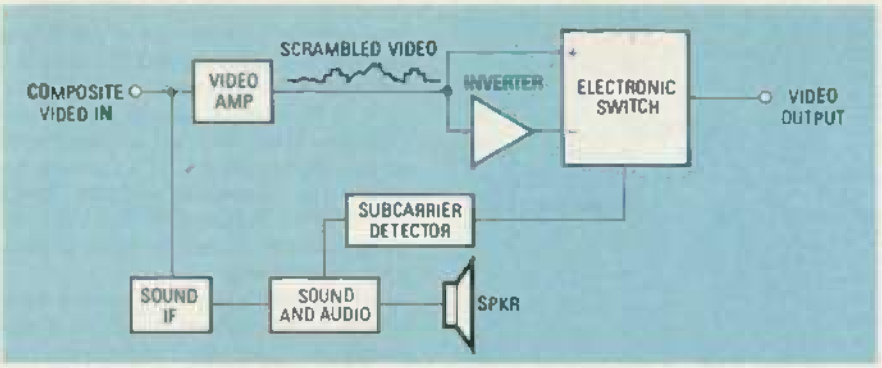


FIG. 3—THIS BLOCK DIAGRAM shows a circuit that can be used to descramble a signal in which the polarity of the video information is randomly switched.

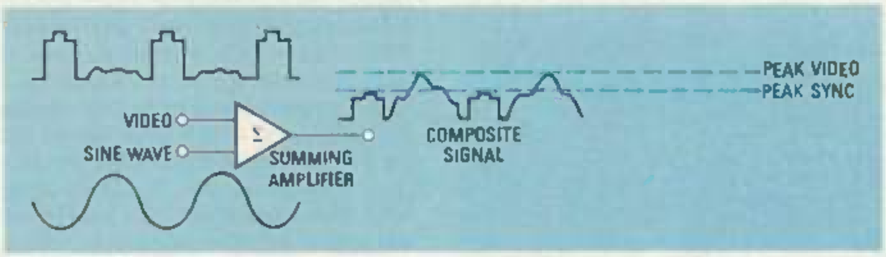


FIG. 4—IN SINEWAVE SCRAMBLING the video information is summed with a sinewave. The result is that the normal relationship between the peak sync and the peak video is altered.

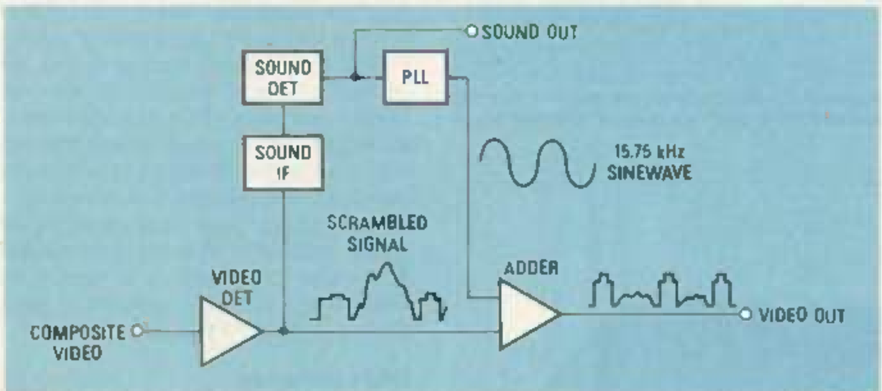


FIG. 5—IN A SINEWAVE DESCRAMBLER, a 15.75-kHz sinewave is summed with the scrambled signal to yield a normal video signal.

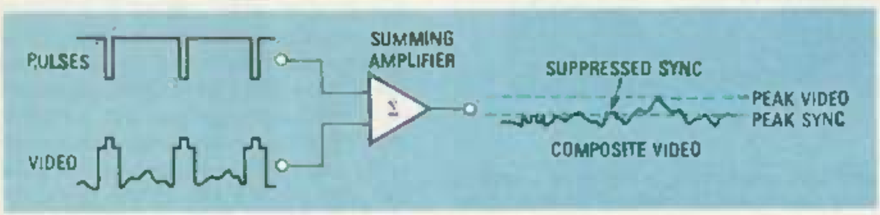


FIG. 6—IN GATED-SYNC SCRAMBLING, a negative pulse train is summed with the composite video to yield a video signal in which the amplitude of the horizontal sync pulses is greatly attenuated. That makes it impossible for a TV set to lock onto the signal.

is usually obtained from a PLL that is locked to a 15.75 KHz signal encoded on the audio signal. That operates very much like a PLL used for stereo FM pilot-carrier regeneration. In fact, the circuitry is very similar and FM stereo IC's can be used to good advantage in a descrambler circuit. A block diagram of an appropriate descrambler circuit is shown in Fig. 5.

Figure 6 shows another method of suppressing the sync. Called gated-sync scrambling, that method is similar to sinewave scrambling in that it operates by altering the relationship of the amplitudes of the sync pulses and the video signal. That is done by summing a negative pulse train with the composite video signal. The result is a composite video signal in which the sync pulses appear to be missing. As a result, the sync circuitry, which generally picks out the most positive signal levels and assumes they are sync pulses, is rendered inoperative and the picture tears and rolls.

To descramble a gated-sync signal, a pulse train of proper amplitude and phase is summed with the altered composite video signal. A block diagram of a descrambler that does that is shown in Fig. 7. The pulse train is generated in the descrambler and is usually locked to the signal from the the decoder PLL circuit via the same technique that's used in a sinewave decoder. In fact, the gated-sync method of scrambling is very similar in theory to the sinewave method, and it is possible to design one descrambler that could be made to decode both of those types of scrambling.

Audio scrambling

A word about audio scrambling: The audio carrier is located 4.5 MHz from the picture carrier. It is a distinct frequency component of the TV signal and can be received on an FM receiver tuned to the appropriate frequency. The signal is identical to standard (broadcast) FM, except that the deviation is limited to ± 25 kHz.

The TV-audio signal can be modulated with subcarriers. Normally a TV receiver has a quadrature or discriminator type detector, with an RC filter on the audio output. As to the IF bandwidth, a rule of thumb in FM receivers is that it is twice the deviation plus the highest modulation frequency. Since TV audio normally goes up to about 10–15 kHz, the bandwidth of the audio IF would be about 2 × 25 kHz, plus 10 to 15 kHz, or about 60–65 kHz. In most TV receivers, the audio-IF bandwidth is about 100 kHz.

If the 4.5-MHz carrier deviation is reduced somewhat, subcarriers can be put into the audio channel up to about 100 kHz or so. They can serve as subcarriers for decoding signals, or even other audio channels. An example of that is the (L − R) audio channel in an FM stereo system, whereby the differences between the left and right channels are encoded on a 38-kHz subcarrier.

In many scrambling schemes, the program audio is stripped away and placed on an audio subcarrier that is some multiple of the horizontal scan frequency. The most common and practical audio subcarrier frequency is 31.5 kHz; the 15.75-kHz horizontal-scan signal is used as the pilot carrier. Those frequencies are close enough to the 19-kHz pilot frequency and 38-kHz subcarrier frequency used in FM stereo to allow the use of mass-produced FM-stereo IC's in TV audio decoders.

If the audio is stripped away in that manner, a viewer without a decoder will receive no sound and a scrambled picture. In many scrambling systems, rather than being empty, the main audio channel can be used as a "barker channel" for advertising for the pay-TV service, music, or anything at all. A block diagram of a circuit that can be used to encode an audio signal in the above manner is shown in Fig. 8.

Note that stripping away the program audio and placing it on a subcarrier is not really scrambling. It is merely relocating

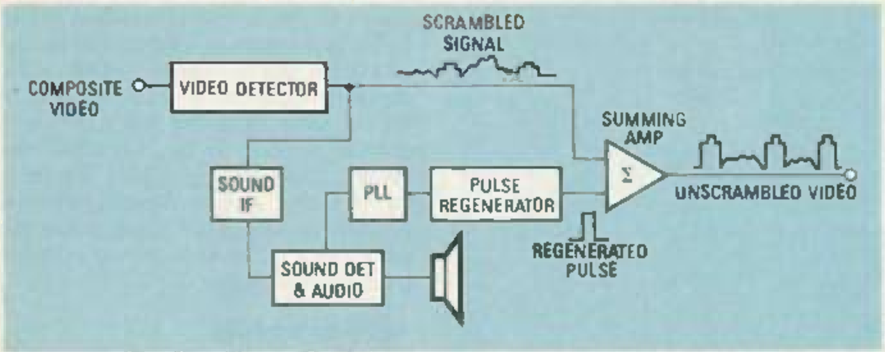


FIG. 7—A GATED-SYNC DESCRAMBLER is very similar to one used to descramble sinewave-encoded video. In fact, it is possible to design a single decoder to descramble both systems.

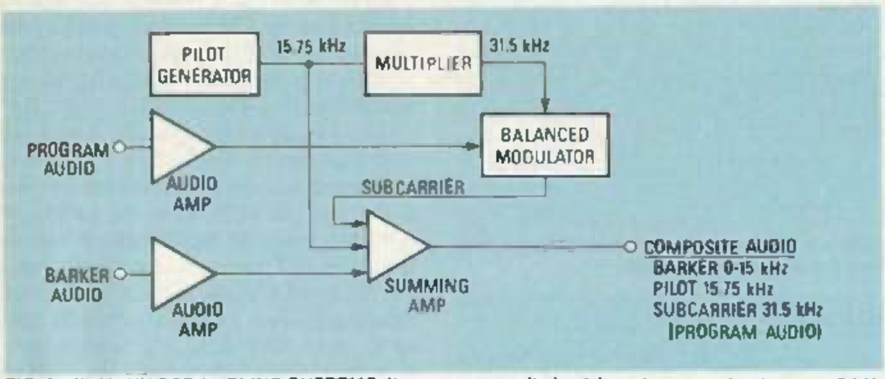
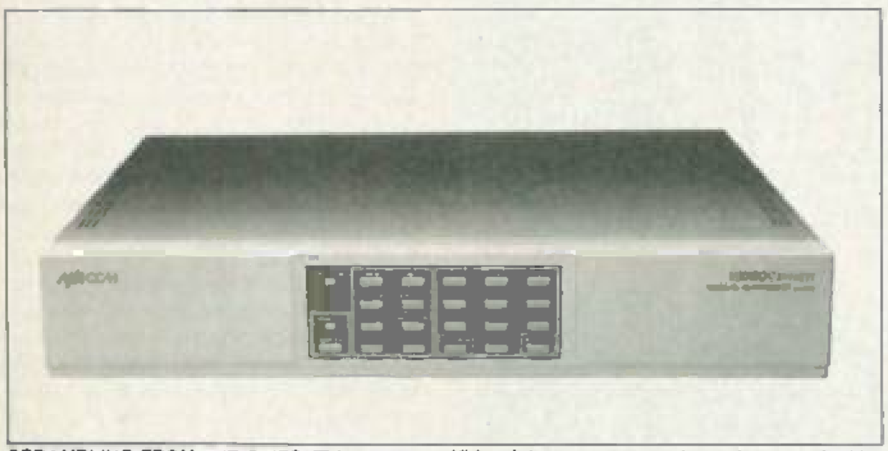


FIG. 8—IN MANY SCRAMBLING SYSTEMS, the program audio is stripped away and put on a 31.5-kHz subcarrier. Where that's done, usually the normal audio channel is used as a "barker" channel, which contains advertising, music, etc.



SCRAMBLING FROM THE SKIES. This M/A-COM *Videocipher* descrambler is the key to unlocking HBO's (and other's) satellite programming. In a future installment we'll be looking at the *Videocipher* system.

the audio program in such a way that it can not be received on a standard TV set. True audio scrambling would involve altering the audio waveform. If that were done, the signal might be receivable on a standard TV set, but it would be unintelligable under any circumstances. True scrambling can be done using any one of a number of techniques, including frequency inversion and digitizing. However, care must be taken to ensure that the encryption technique does not restrict the useable audio bandwidth.

Cable-TV scrambling

The box-type descrambler commonly used in CATV systems generally contains an RF converter to convert all cable channels to one fixed channel, usually Channel 3 or 4. By doing that, the descrambler circuits can be designed to deal with but a single channel.

In the case of sinewave or gated-sync descramblers, some actually detect the video signal, extract necessary decoding signals from it, and use those signals to act upon the channel 3 or 4 IF signals. By using a variable-gain IF amplifier for channel 3 or 4, the decoding signals can modulate the IF gain, reestablishing proper sync-signal level and cancelling the sinewave modulation, or reestablishing sync-pulse level in the case of gated-sync systems. The encoding and decoding signals may also be supplied in CATV systems at frequencies outside the receiver channels. Many different encoding techniques can be used in CATV systems, but gated sync, sinewave, and the Zenith SSAVI (*S*ync *S*uppression *A*nd *V*ideo *I*nversion) seem to be the most popular schemes currently.

Another method used on some cable systems is the deliberate insertion of keyed carriers in the video channel used for premium TV shows. An RF carrier can cause severe crosshatching. Keying the carrier causes an annoying flicker, and the resultant picture looks like a severe case of TVI caused by a CB or amateur station. In order to provide service to a subscriber, a high-Q trap is inserted in the transmission line between the CATV signal tap-off and the TV set. That method, while inexpensive, is easy to defeat. A high-Q cavity notch filter can be made out of a coffee can and several feet of ⅛-inch copper tubing. Those materials can be used to construct a helical resonator; tuning the resonator is merely a matter of adjusting its cavity for a notch at the interfering frequency. Also, a high-Q stub transmission line section can be used to achieve the same purpose. We have known cases where even a few feet of aluminum foil wrapped around the outside of a length of 300-ohm twin lead (the aluminum foil position is adjusted for a null) did a fairly good job of rendering the picture watchable. However, note that that is not true scrambling; it is merely the addition of deliberate, controlled interference to the CATV signal.

Odds and ends

There are several ways we could modify the systems that we've discussed thus far to make them more difficult to decode by non-authorized viewers. For instance, in the sinewave scrambling method, rather than using a 15.75-kHz signal, the scrambling sinewave could have a frequency of 31.5. If that were done, every other cycle of the sinewave would cancel a sync pulse and the picture would be vertically streaked twice instead of once.

Similarly, the gated-sync system could be made more difficult to decode by substituting a more complex pulse waveform for the one we illustrated.

Next time

Thus far, the scrambling techniques we've discussed are relatively simple. Consider, however a system in which the method of scrambling varies with time, or one in which digital techniques are used to alter the sequence in which the video information is transmitted, or both. Thanks to today's low-cost digital IC's such sophisticated scrambling techniques are now possible and practical. We'll look at some of those techniques next time. **R-E**

Versatile Bench Top Power Supply

Here's a high-performance power supply to help get your designs off of the drawing board and on to a PC board!

GREG SWAIN AND FRANCO UBAUDI*

EVERYONE WHO WORKS WITH ELECtronics needs a power supply, but a commercially-produced variable-voltage current-limited power supply can take quite a chunk out of your pocketbook. So we decided to find a better way. Our power supply provides any voltage between 3 and 30 volts, at any maximum current you desire less than 1000 mA. In addition, our supply provides short-circuit protection, load switching, and switchable voltage/current metering. Further, all parts are readily obtainable and inexpensive, and the supply is easy to build and calibrate.

One feature that really sets our design apart is that it's capable of providing a full amp of power over most of its range of output voltage. Many comparable power supplies can provide one amp of current, but only over a restricted range of output voltage.

Output voltage is selected by means of a range switch with two positions: 3–15 and 15–30 volts. A potentiometer varies voltage continuously throughout the selected range. Similarly, current limiting is selected by a switch providing ranges of 150–400 and 400–1000 ma, and by a potentiometer that allows current to be varied continuously over the selected range. Actually, both current and voltage ranges overlap slightly to ensure that there are no gaps in output.

*Adapted with permission of *Electronics Australia*

The graph in Fig. 1 illustrates the high performance you can obtain from our power supply. As you can see, maximum load current (one amp) is maintained up to 27 volts, after which the load curve falls away due to transformer losses. Other specifications include load regulation that is better than 0.2% from zero to full load, and output ripple that is less than 2-mv rms.

Design considerations

Initially we considered using an LM317 three-terminal variable-voltage regulator as the basis for our supply, but we soon ran into difficulties. Despite various approaches, we were unable to come up with a cost-effective circuit that would deliver one amp over the entire voltage range. The problem was thermal limiting in the LM317 with a high input voltage and a low output voltage. Another drawback was that an additional op amp was required to provide current sensing for the current-limiting circuitry, and that would have increased both cost and complexity of the circuit.

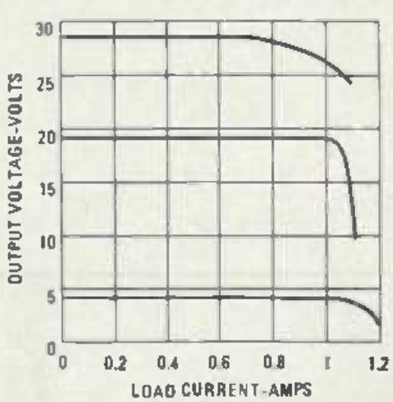


FIG. 1—POWER SUPPLY CAN SUPPLY ONE amp of current all the way to 27 volts, where output drops to about 0.75 amp.

So we rejected the LM317 and adopted the LM723. It requires a current-boosting transistor, but it has built-in current limiting. The guts of the 723 are shown in Fig. 2. It consists of a series-pass transistor, an error amplifier and a voltage reference. The error amplifier compares a portion of the output voltage with the internal reference voltage and continually regulates the base current that is applied to the series-pass transistor. That's what provides regulated output.

The 723's built-in series-pass transistor can deliver a maximum of 150 mA of current, so, in order to obtain more current, an external power transistor is required.

One particularly useful characteristic of the 723 is its built-in current-limiting circuitry. When output current reaches a preset value, the current-limit transistor turns on and that reduces the base drive to the series-pass transistor. The output voltage is thereby reduced.

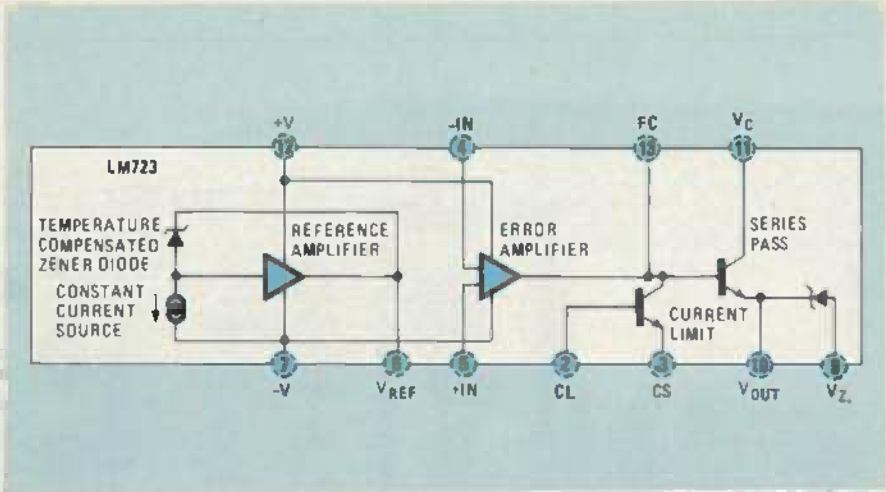


FIG. 2—THE LM723 REGULATOR has most of the circuitry necessary for a complete current-limited power supply built right in.

Circuit details

The schematic of the complete power supply is shown in Fig. 3. A tapped transformer drives a diode bridge (D1–D4) and two 2500-µF filter capacitors (C1 and C2). That provides a no-load voltage of 37 or 47 volts, depending upon the position of switch S2-a. The unregulated DC is then fed to a pre-regulator stage composed of Q1 and D5. Those components protect IC1 (the 723) from an over-voltage condition; the 723 can't handle more than 40 volts.

The LED (LED1) and its 2.2K current-limiting resistor (R1) provide on/off indication. The current through the LED varies slightly according to the transformer tap selected, but that's of no real consequence.

The series-pass transistor in IC1 drives voltage-follower Q2, which provides current amplification. That transistor can handle lots of power. It has a maximum collector current of 15 amps and a maximum V_{CE} of 70V, both of which are more than adequate for our supply.

Heat dissipation could have been a problem when drawing high current at low voltage. We solved that problem by switching the secondary winding of the transformer. For outputs greater than 15 volts, S2-a selects the 30-volt tap on the transformer, and for outputs less than 15 volts, S2-a selects the 24-volt tap.

Voltage regulation

Now let's examine in detail how the voltage-regulator section works. The error amplifier in the 723 is connected as a non-inverting amplifier with variable gain. The input to that amplifier is fixed at about 2.8 volts by R3 and R4, which are fed by the 723's internal reference voltage. Capacitor C3 is included to reduce output noise.

On the 0–15V range, switch S2-b is closed, so feedback resistance—the resistance between the output of the supply and the inverting input of the error amplifier—can be varied between 100 and 5000 ohms. That corresponds to an amplifier gain ranging from 1.1 to 6.1, and that corresponds to an output voltage ranging from 3.1 to 17.1 volts. With switch S2-b open, the gain of the amplifier is adjustable from 5.8 to 10.8, and that corresponds to an output voltage ranging from 16.2 to 30.2 volts.

The current-limiting circuit depends on the position of S3. That switch causes load current from the emitter of Q2 to flow through either R14 or R15. The resulting voltage is applied to a voltage divider network composed of R12 and R13. The voltage developed at the junction of those two resistors depends on the setting of front-panel control R13, CURRENT LIMIT. That voltage is then applied to the current-limiting transistor in the 723.

In the interests of economy, we elected to use a single meter and to switch between measuring voltage and current. It would be nice to have a separate meter for each, but cost is prohibitive. Meters are expensive, and a larger case, which is also more expensive, would be necessary to provide the necessary front panel area.

Our metering circuit is straightforward. When measuring voltage, the parallel combination of a R16 and R17 provides an effective resistance of 30K. That resistance is in series with the one-mA moving-coil meter, so it can measure a maximum of 30 volts full scale. When measuring current, the meter is shunted by the 0.5 ohm resistance provided by the parallel combination of R5 and R6. Trimmer potentiometer R7 is used to adjust the meter for accurate readings.

There's not much else to the circuit. Capacitor C6 prevents switching transients from being delivered to the output, and D6 protects the power supply from an accidentally-applied reverse voltage—from a charged capacitor, for example. Capacitor C5 ensures stability of the supply under all conditions.

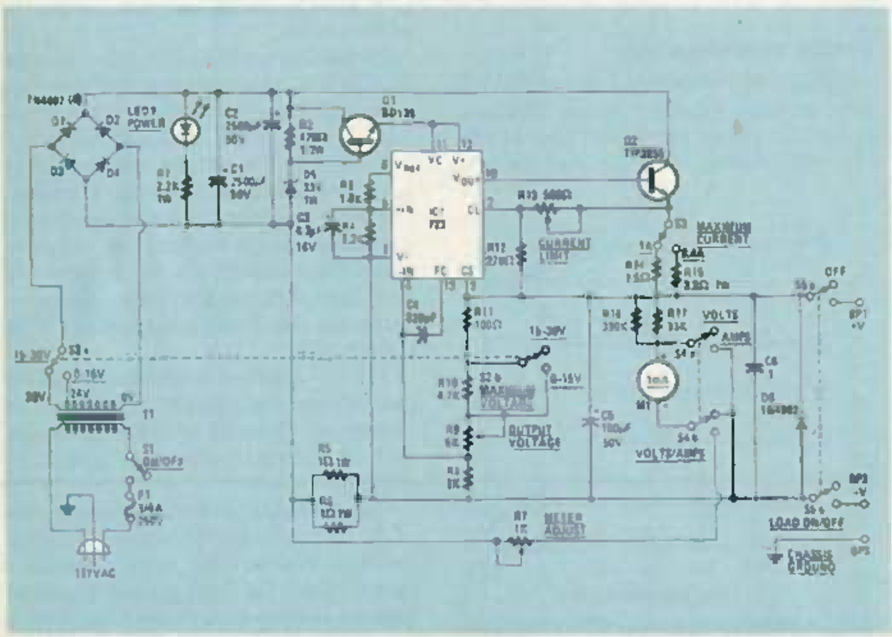


FIG. 3—SCHEMATIC DIAGRAM OF OUR POWER SUPPLY shows how the LM723 can be put to good use with little more than a current-amplifying transistor (Q2).

Construction

Except for the front-panel switches, potentiometers, etc., and the power transformer, all components are mounted on a PC board that measures about 4⅛ × 4⅜ (inches). A foil pattern for the board is shown in "PC Service."

No special procedure need be followed when assembling the PC board, although the job will be much easier if the lower-profile components are installed first. Refer to the parts-layout in Fig. 4 to install all components; be careful to install IC1, the diodes, the transistors, and the electrolytic capacitors in the correct orientation. Also, mount transistors Q1 and Q2 without trimming their legs: the full length will be necessary if you use the heat sink arrangement shown in Fig. 5.

The power supply is housed in an attractive plastic instrument case that measures about 7¼ × 6⅜ × 2¼ (inches). If you purchase the kit from the source mentioned in the parts list, you'll receive special front and rear panels.

The layout of the front panel is shown in Fig. 6. Note that, if you use a different meter than the one specified in the Parts List, you'll have to alter the drilling dimensions accordingly. The kit includes *Scotchcal* artwork that you can affix to the front panel and then spray with a hard-setting clear lacquer to protect the artwork, which can then be used as a template.

PARTS LIST

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

R1—2200 ohms, ½ watt
R2—470 ohms, ½ watt
R3—1800 ohms
R4—1200 ohms
R5, R6—1 ohms, 1 watt
R7—1000 ohms, trimmer potentiometer
R8—1000 ohms
R9—5000 ohms, panel-mount potentiometer
R10—4700 ohms
R11—100 ohms
R12—270 ohms
R13—500 ohms, panel-mount potentiometer
R14—1.5 ohms, 5 watts
R15—3.9 ohms, 1 watt
R16—330,000 ohms
R17—33,000 ohms

Capacitors

C1, C2—2500 µF, 50 volts, electrolytic
C3—4.7 µF, 16 volts, electrolytic
C4—820 pf, ceramic disc
C5—100 µF, 50 volts, electrolytic
C6—0.1 µF, ceramic disc

Semiconductors

IC1—LM723 voltage regulator
D1–D4, D6—1N4002 rectifier
D5—1N5257B, 33 volts, 1 watt, Zener diode
Q1—BD139 or ECG373
Q2—TIP3055

Other components

F1—¼-amp, 250-volt fuse
M1—0–1 mA panel meter
S1—SPST power switch
S2, S4—DPDT switch
S3—SPDT
S5—DPST
T1—117 VAC primary, 0–24–30 volt secondary, 1 amp (Altronic A6672)

Miscellaneous

Line cord, heatsink, mica insulators, silicone grease, PC board, case, binding posts, knobs, solder, wire, etc.

Note: A complete kit of parts, including case, is available for $49.95 from Imtronics Industries, Ltd., 11930 31st Court, St. Petersburg, FL 33702. Florida residents must add appropriate sales tax.

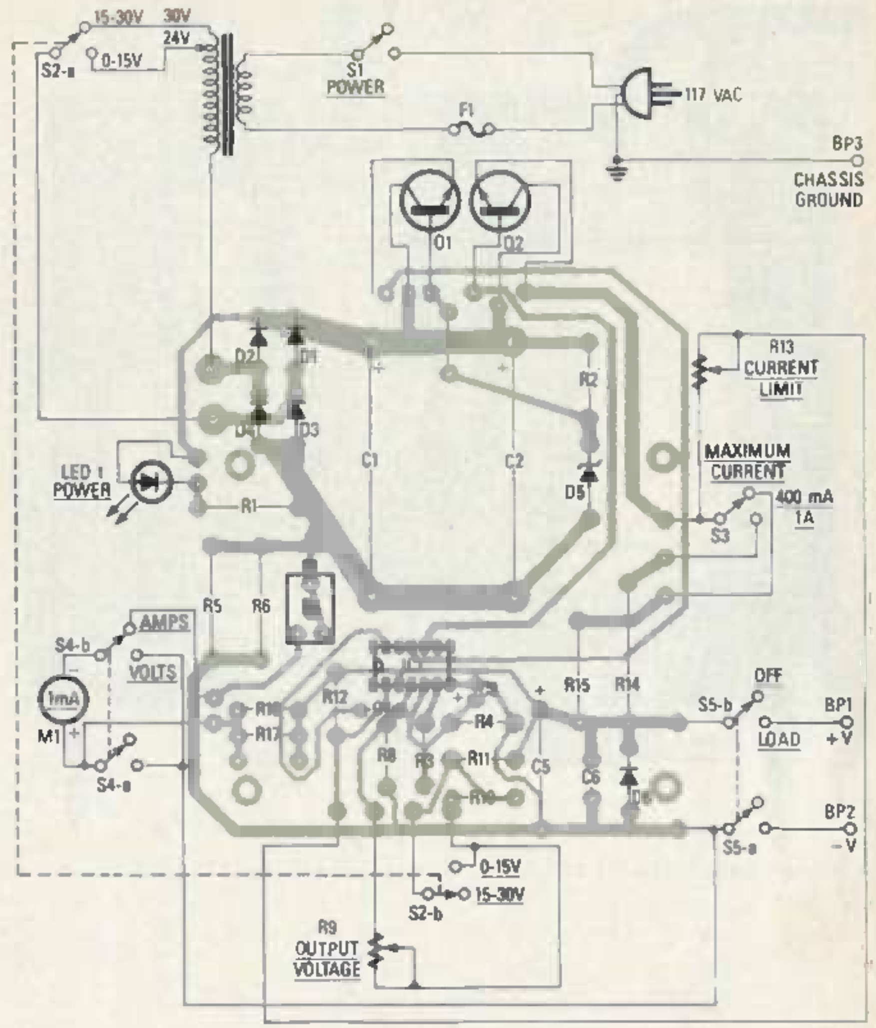


FIG. 4—ON- AND OFF-BOARD COMPONENTS are mounted and wired as shown here.

You'll also have to drill holes in the rear panel for the fuse holder, the power cord, and the heatsink. But, don't drill the heatsink holes yet.

Secure the PC board to four internal mounting posts using self-tapping screws, and bolt the power transformer to the case using machine screws and nuts. Include a solder lug under the nut nearest the rear panel.

Use medium-duty hookup wire (16 gauge) for all wiring that carries the full supply current, and light-duty hookup wire for the potentiometer, the meter, and the LED.

Install the rear panel and then mark the positions of the holes for the power transistors. Drill those holes, and then you can use the rear panel as a template for drilling the heatsink mounting holes. The heatsink may have to be trimmed to fit the rear panel. Both transistors must be insulated from the rear panel using mica washers and insulating bushings. Smear heatsink grease on all mating surfaces, including the rear of the heatsink, and then bolt the assembly together using machine screws and nuts as shown in Fig. 7. Finally, use an ohmmeter to make sure that there is no conductivity between the metal tabs of the transistors, and the rear panel, or the heatsink.

Anchor the 117 VAC power cable to the rear panel with a cable clamp. Solder the "hot" 117 VAC lead to the fuseholder, the neutral wire to the power transformer, and the ground-wire to the solder lug beneath the transformer. In addition, separate ground leads should be run to both the rear and the front panels.

We recommend that you use heat-shrink tubing over all 117 VAC connections to the fuseholder, the transformer, and the power switch. That will prevent you from being shocked while doing the testing and calibration discussed below. Use wire with thick insulation for the 117 VAC circuit, and do not use a miniature metallic switch for POWER switch S1.

Shown in Fig. 8 is a meter scale you can use to replace the scale that comes with the meter. Being careful not to bend the meter's needle, gently pry the plastic

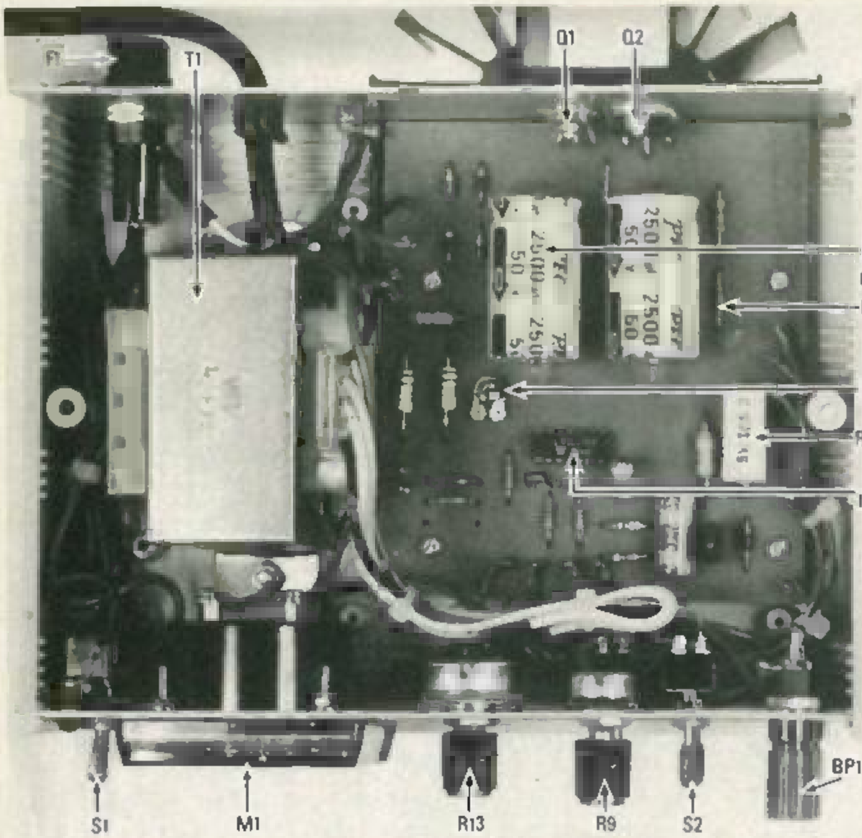


FIG. 5—INTERNAL VIEW OF THE POWER SUPPLY reveals its neat, clean, design.

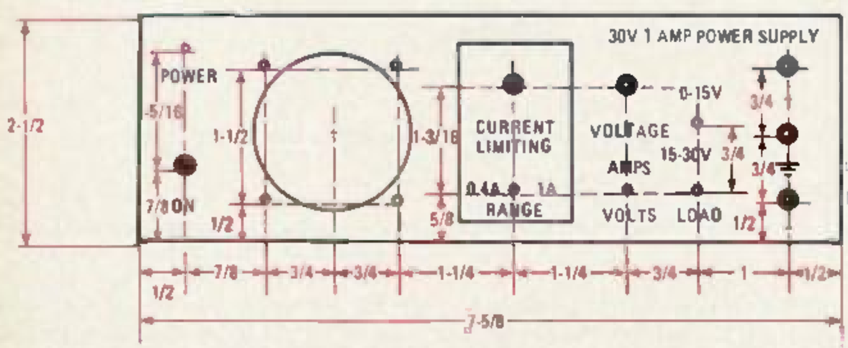


FIG. 6—DRILL THE FRONT PANEL OF THE POWER SUPPLY according to the dimensions shown here.

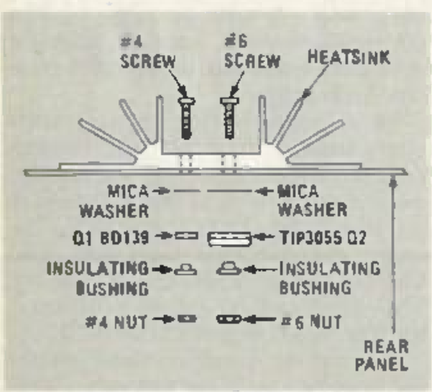


FIG. 7—ATTACH Q1 AND Q2 to the rear panel and the heatsink as shown here. Use heatsink grease on all mating surfaces.

cover off the meter and glue an enlarged copy of our scale over the present one.

Testing and calibration

Connect a voltmeter across the output binding posts, turn the supply on and close the LOAD switch. If all is well, the POWER LED will light up and you will be able to vary the output voltage from three to 30 volts using the RANGE switch and the OUTPUT VOLTAGE control.

Verify that the voltage reading on the supply's meter and on your meter are identical. Note that we left room on the PC board for an additional trimmer resistor that, if used, would parallel R16 and R17. You can install an additional high-

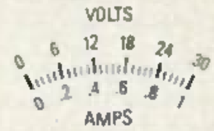


FIG. 8—ENLARGE OR REDUCE THIS METER SCALE to fit the meter you use, and then glue our scale over yours.

valued resistor there to increase the accuracy of the voltage displayed by the meter, if necessary. Just use Ohm's law to calculate the appropriate value.

Assuming all is well, open the load switch, select the 0–15 volt range, and then turn the OUTPUT-VOLTAGE potentiometer fully counter-clockwise. Now set the CURRENT-LIMIT control to the middle of its rotational range, the CURRENT-LIMIT switch to the one amp range, and the VOLTS/AMPS switch to amps. Now connect a one-amp ammeter directly across the output binding posts and close the load switch.

Your meter should indicate a current of about half an amp, although the supply's meter may show something different now. Adjust the CURRENT-LIMIT control so that the multimeter reads 1A, and then adjust trimmer resistor R7 so that the supply's meter reads the same.

Finally, vary the CURRENT-LIMIT control and verify that the meter reading corresponds closely to that on the multimeter throughout its range.

Applications

Why is adjustable current limiting useful? First, it protects the power supply in case its output is inadvertently short-circuited by improper circuitry. Second, it helps prevent that circuitry from being damaged by excessive current due to a fault condition.

Why is a separate LOAD switch useful? It allows you to remove load voltage without turning the supply off. The latter can cause switching transients that might damage the power supply, the circuit under test, or both.

So, when testing out an untried circuit, turn the LOAD switch off, and the voltage and current controls all the way down. Connect the supply to your circuit, turn the LOAD switch on, and gradually increase output voltage to the required voltage. Next set the meter to measure current and turn the CURRENT LIMIT control up *slowly* while monitoring the meter. If the needle of the meter seems to jump at all throw the LOAD switch quickly. But if the needle moves smoothly as you rotate the control, most likely the circuit has no severe power-related problems. In other words, you're not likely to fry anything! So now you're ready to start the real work—testing and troubleshooting your circuit. But that's another article. R-E

BUILD THIS

Click and Pop Filter for your STEREO

JOE GORIN

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

Part 2 THIS MONTH, WE'LL show you how to build our click and pop filter. But before we get to that, let's finish up the discussion that we began last time about how the detector circuit works.

Resistors R27–R30 take a statistical sample of variations in level; that sample is detected by IC5-a, which stores short-term peaks on C13 and long-term peaks on C14. The latter is also part of a circuit (including C15 and C16) that prevents transients—either scratches or music—from changing the comparator's threshold too quickly.

Front-panel SENSITIVITY control R45 varies the gain of IC5-b, whose output sets the comparator's threshold higher when the signal warrants it. For example, signals with much high-frequency content—cymbal crashes, for instance—can cause false triggering. But, in general, very large transients tend to be scratches; a large transient will turn on D8 to slow down threshold changing. Diode D10 allows C16 to discharge rapidly if the transient disappears rapidly, as can happen between wide, two-edged scratches (which are quite common).

When the signal exceeds the threshold, the output of IC6-a goes low and shorts to $-V_{CC}$. And that, finally, is what causes the deleter to delete! The deletion is done by "flipping" the analog switches (electronically, of course) to perform the actions described above.

When the transient ends, IC6-a's output floats high, and C20 delays the return from deletion mode by charging slowly through R41. Capacitor C21 functions as a pulse-stretcher; it charges even more slowly than C20, and that allows LED1 to remain lit long enough to be visible, even if the deletion time was short.

Power supply

The power supply, shown in Fig. 8, is important in this circuit, especially during a deletion, because the gain of the deleter is so high. Our primary design goals were low ripple and freedom from interference by magnetic fields. Low ripple is achieved by filtering the critical negative supply

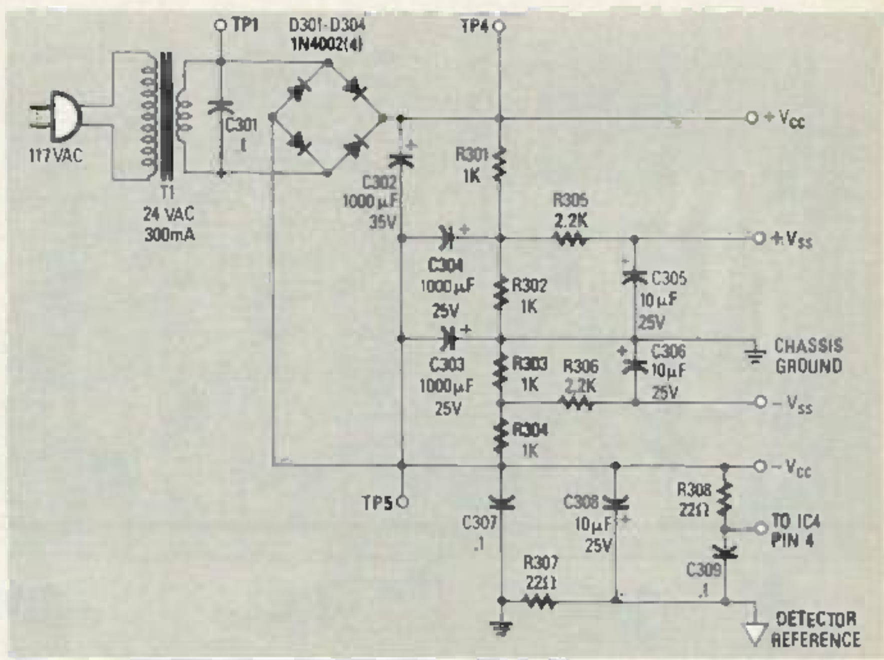


FIG. 8—THE SCRATCH FILTER'S POWER SUPPLY IS SHOWN HERE. Parts are numbered beginning at 300; all components except T1 mount on the PC board. Note the separate detector reference that is derived through R307.

with respect to ground using capacitors C302–C304. Actually, it is the ground that is filtered, not the supply; but the result is the same, except that at low frequencies the ground impedance isn't low.

Magnetic fields are minimized by using a wall-plug transformer and by placing the deleter at the opposite end of the board from the supply. What we get is an inexpensive supply that performs as well as the exotic center-tapped toroidal-transformer supplies often used in high-performance audio equipment. By the way, the $\pm V_{SS}$ supplies are provided to operate the 4016 analog switches, which can't tolerate the ± 15 volts used to power the op-amps.

Input and output circuits

The signal into our Scratch Filter should come after your amplifier's phono preamp via the TAPE OUT jacks that are normally used to connect a tape recorder. Most signal processors (such as graphic equalizers) replace those TAPE OUT jacks by connecting the processor's input jacks in parallel with a *new* TAPE OUT jack. In our case, we chose to locate the TAPE OUT jack, and the TAPE MONITOR switch *after* our processor, so that you can tape record albums with the full benefit of our Scratch Filter.

Construction

Due to the critical nature of the deleter's layout-matching requirements, a PC board is necessary to get good performance from this Filter. If you want to etch your own board, a foil pattern is shown in "PC Service;" you can also purchase a board from the source mentioned in the Parts List. Refer to the component-placement diagram in Fig. 9 and the chassis photo in Fig. 10 during the following discussion.

Begin construction by inserting the resistors. You can bend the leads of most resistors as necessary, but the following resistors in the deleter circuit should be bent as shown in the photo: R114, R222, R215, R216.

Next insert the capacitors, followed by the diodes, and then the transistors. Be careful to get the polarity of those components correct.

Next you can install the IC's. As mentioned above, you must cut off pin 5 of IC4. If you use a metal-can version of that IC, the tab is by pin 8. Be sure to insert that IC—and all the others—correctly. Connect short lengths of wire for the panel-mounted components to the appropriate pads on the board. Carefully check over your work, remove flux from the board, and then install the board in your enclosure.

The chassis used for our prototype is built from a thin piece of aluminum bent in a "U" shape. We used two stained pieces of wood for endpanels. The endpanels are attractive, and they keep the aluminum from scratching the surface of whatever you set the Filter on. The printed-circuit board should be mounted close to the sheet metal so that the circuitry will be shielded from electromagnetic fields that may be radiated from nearby equipment.

Installation

The Scratch Filter must be connected in the tape-monitor loop of your amplifier.

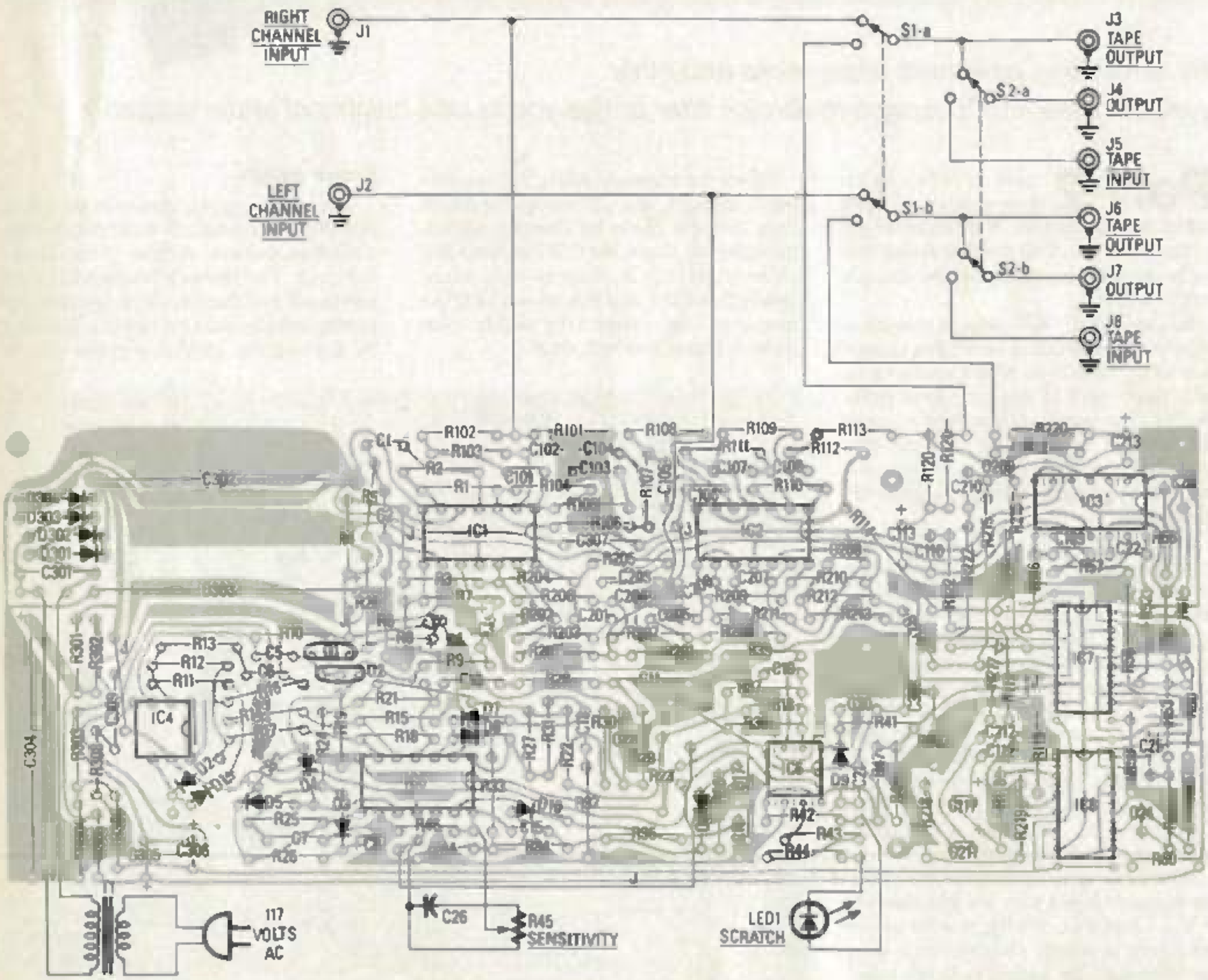


FIG. 9—STUFF THE PC BOARD and wire the front-panel components as shown here. Resistors R114, R222, R215, R216 must be bent as shown in Fig. 10.

PARTS LIST

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

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

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

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

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

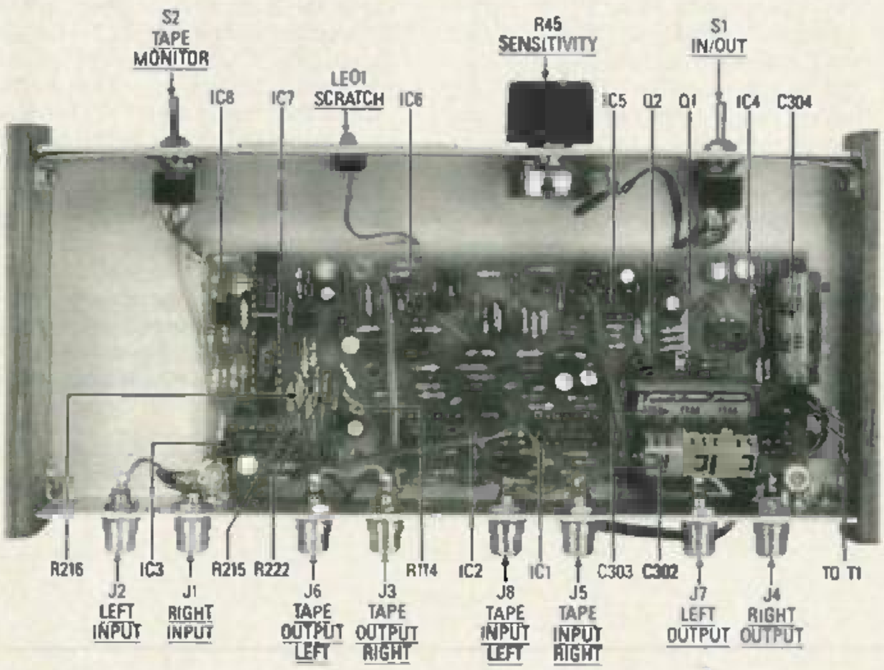


FIG. 10—THE CHASSIS IS BENT from a thin piece of aluminum; small wood blocks are attached to the ends with angle brackets.

In other words, the Scratch Filter's inputs must be connected to your amplifier's TAPE OUT jacks, and the Scratch Filter's outputs must be connected to your amplifier's TAPE IN jacks. Your amplifier's TAPE MONITOR switch must then be thrown to the ON or TAPE position.

That wiring scheme routes all signals from your amp's preamp output through the Scratch Filter, and then back to your amplifier. A tape recorder, or any other equipment that used to be connected to your amplifier's jacks should now be connected to the corresponding jacks on the Scratch Filter.

Operation

You can use the IN/OUT switch to switch the Scratch Filter in and out of your audio loop for testing and evaluating. Once you hear the dramatic improvement the Filter provides, you'll probably leave it "in circuit" permanently. The TAPE MONITOR switch on the Filter works just as the one on your amplifier used to.

Initially the SENSITIVITY control should be set to the middle of its range. Due to the wide dynamic range of the ALC circuit you may never need to change the setting of that control. However, for very scratchy records, you may want to turn up the sensitivity. You risk making deletions audible, but by careful adjustment, you can achieve a good balance between scratch noise and deletion errors.

Conclusions

There are many ways to improve the

continued on page 90

WORKING WITH VOLTAGE COMPARATORS

Voltage-comparators and window-comparators are extremely versatile circuits. Here are some practical circuits that you can put to use.

RAY MARSTON

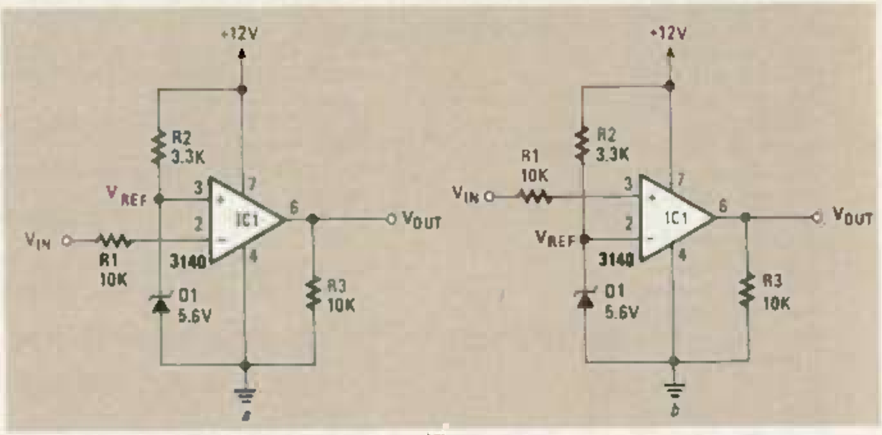


FIG. 1—BASIC VOLTAGE-COMPARATOR CIRCUITS.

WE'RE SURE THAT YOU CAN THINK OF many applications for a voltage comparator: a circuit that abruptly changes its output state when an input voltage crosses a certain reference value. Voltage comparators have plenty of practical applications apart from the obvious ones of over- and under-voltage switches. The number of applications becomes especially apparent when you realize that the voltage can be representing resistance, temperature, light-level, and more.

Voltage comparators can readily be made to activate relays (or alarms, or other circuits) when load currents (or temperatures, light levels, etc.) go outside of—or come within—preset limits. We'll look at some practical circuits in the next few pages.

Basic voltage comparator circuits

The easiest way to make a voltage comparator is to use an op-amp such as the CA3140; two basic configurations are shown in Fig. 1. The 3140 op-amp has a typical open-loop, low-frequency voltage gain of about 100 dB, so its output can be shifted from the high to the low state (or vice versa) by shifting the input voltage a mere 100 μV (microvolts) or so above or below the reference voltage value. The CA3140 can be powered from either a single-ended or split power supply and it provides an output that typically swings to within a couple of volts of its positive rail or to within a few millivolts of its negative (or zero) supply rail. Unlike many other op-amps, the 3140 can accept input voltages all the way down to the negative rail value.

The operation of the circuit in Fig. 1-a is very simple: A fixed reference-voltage (V_{REF}) is generated via the combination of R2 and Zener diode D1. It is applied directly to pin 3, the non-inverting input terminal of the op-amp. The input or test voltage V_{IN} is applied to the inverting input terminal (pin 2) via current-limiting resistor R1. When V_{IN} is below V_{REF} the op-amp output is driven high (to positive saturation), but when V_{IN} is above V_{REF} the output is driven low (to negative saturation). That response is shown graphically in Fig. 2-a.

By simply interchanging the connections to pins 2 and 3, the action of the circuit can be reversed; the op-amp output is normally low, but goes high when V_{IN} exceeds V_{REF}. That circuit is shown in Fig. 1-b, and its response is shown graphically in Fig. 2-b.

There are a few points worth noting about the basic single-supply voltage-comparator circuits in Fig 1. The first point is that the reference voltage can be given any value from zero up to within 2 volts of the positive supply-rail. Thus, either circuit can be made to trigger at any desired value between those limits by simply interposing a potentiometer between a fixed voltage-reference source and the "V_{REF}" pin of the op-amp.

The second point to note is that the voltage-input pin of the op-amp must be constrained to the range from zero volts up to within 2 volts below the positive supply-rail value. Thus, if you want the

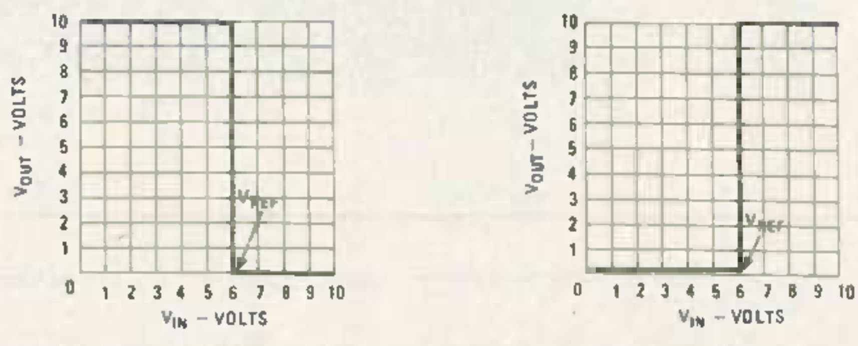


FIG. 2—THE ACTION OF THE VOLTAGE comparators shown in Fig. 1 is shown graphically here.

circuit to trigger at some high value of input voltage, you will have to feed the input voltage to a simple voltage divider before the op-amp input.

The final point to note about the basic voltage-comparator circuits is that they give a non-regenerative switching action, so that the op-amp is driven into the linear (non-saturated) mode when the input voltage is within a few tens of microvolts of V_{REF} Under that circumstance, the op-amp output generates lots of spurious noise and that output will vary with slowly varying input signals. In some applications, that may be unacceptable. The problem can be overcome by using positive feedback, so that a regenerative switching action is obtained. The feedback signal introduces a degree of hysteresis in the voltage switching levels; the degree of hysteresis is directly proportional to the amount of feedback.

Special voltage-comparator circuits

Figures 3 to 7 show how the three points mentioned above can be put to practical use to make various types of "special"

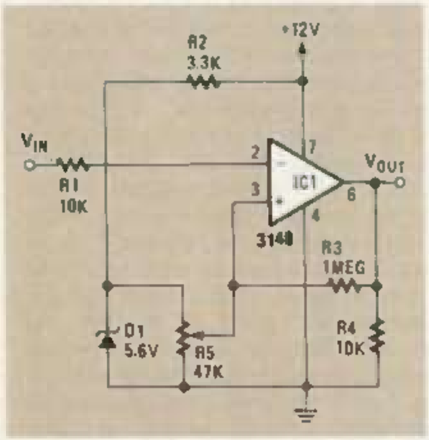


FIG. 3—THIS UNDER-VOLTAGE SWITCH lets you vary the V_{REF} trip point and offers regenerative feedback.

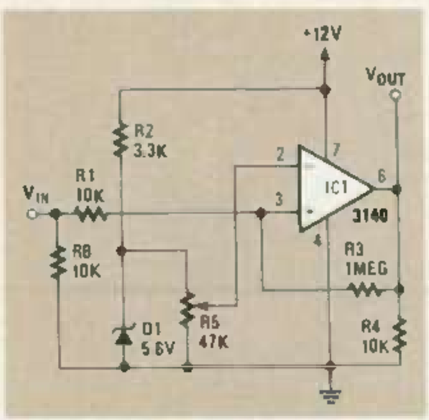


FIG. 4—THIS OVER-VOLTAGE SWITCH also offers regenerative feedback and adjustment of V_{REF}

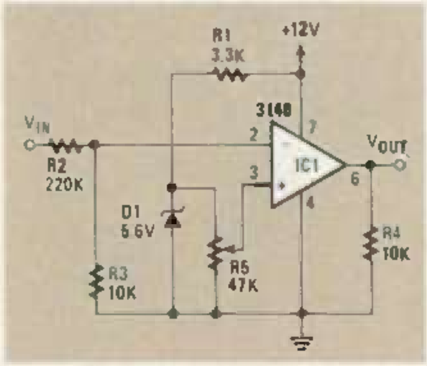


FIG. 5—A VOLTAGE DIVIDER allows us to use the voltage comparator to give high-value, variable-voltage triggering. This circuit does not offer regenerative switching.

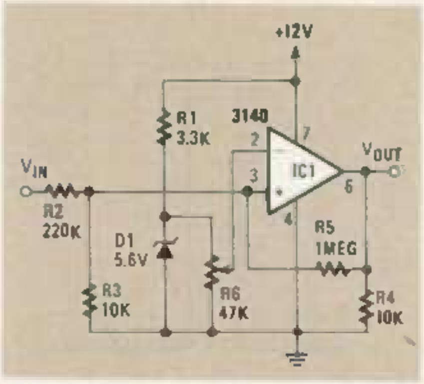


FIG. 6—THIS CIRCUIT, like that in Fig. 5, gives us high-value, variable-voltage switching. It offers regenerative switching.

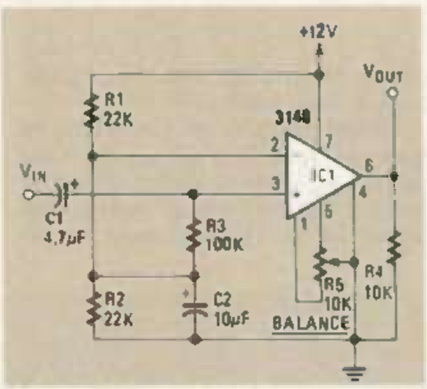


FIG. 7—THIS SINEWAVE-TO-SQUAREWAVE converter needs an input of under 100 mV to provide a 10-volt P-P squarewave output. The circuit can be used to about 15 kHz.

voltage-comparator circuits; plenty of other variations are possible. For example, Figs. 3 and 4 show how the basic comparator circuits can be modified so that the switching voltage can be varied by using a potentiometer (R5) to set the desired reference or trigger voltage at any value in the range 0–5.6 volts and to give regenerative (noiseless, snap-action) switching by feeding part of the op-amp output back to the non-inverting-terminal via R3. Note that in Fig. 4, the circuit's input terminal is terminated via R6 to ensure controlled hysteresis.

Figures 5 and 6 show examples of how the circuits can be modified to give high-value, variable-voltage (0–150 volt) triggering by interposing a simple voltage divider (R2 and R3) between the input signal and the input of the op-amp: The circuit in Fig. 5 gives non-regenerative switching, while that in Fig. 6 gives regenerative switching.

Figure 7 shows how the comparator can be used as a sensitive audio converter that converts sinewaves to squarewaves. It can operate from input-signal amplitudes as low as 10 mV peak-to-peak at 1 kHz and can produce decent squarewave outputs from sinewave inputs with frequencies up to about 15 kHz. The converter's input impedance is 100K. The operation of the circuit is rather simple: The voltage divider made up of R1 and R2, and capacitor C2 apply a decoupled reference voltage to pin 2 of the op-amp and an almost identical voltage is applied to signal-input pin 3 via isolating resistor R3. When a sinewave is fed to pin 3 via C1, it swings pin 3 about the pin-2 reference level, causing the op-amp output to transition at the "zero voltage difference" cross-over points of the input waveform and produce a squarewave output. Potentiometer R5 is used to bias the op-amp so that its output is just pulled low with zero input signal applied (so that the circuit operates with maximum sensitivity and stability). Because of the gain-bandwidth product characteristics of the op-amp, circuit sensitivity decreases as input frequency increases.

Window comparators

The voltage-comparator circuits that we have looked at so far give an output transition when the inputs go above or below a single reference-voltage value. It's a fairly simple matter to interconnect a pair of voltage comparators so that an output transition is obtained when the inputs fall between, or go outside of, a *pair* of reference-voltage levels. Figure 8-a shows the basic configuration, which is known as a window comparator.

The action of the circuit is such that the output of the upper op-amp goes high when V_{IN} exceeds the 6-volt V_U (upper limit) reference value, and the output of the lower op-amp goes high when V_{IN} falls below the 4-volt V_L (lower limit) reference value. By feeding the outputs of the two op-amps to R4 via the D1-D2 diode OR gate, we get the situation where the final output is low when V_{IN} is within the limits set by V_U and V_L, but goes high when the input is outside those limits.

By taking the output via a simple inver-

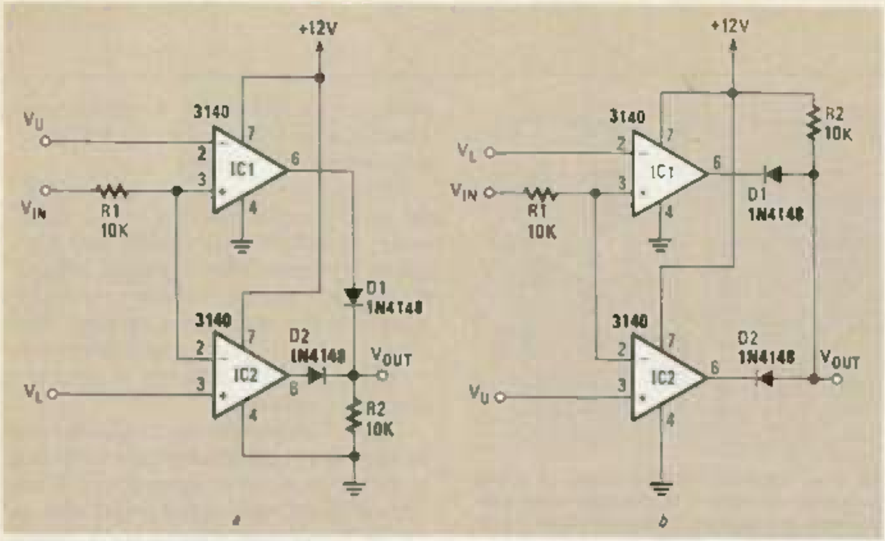


FIG. 8—TWO WINDOW COMPARATORS. When V_{IN} is outside the window determined by V_U and V_L, the output of the circuit in *a* goes high while the output of the circuit in *b* goes low.

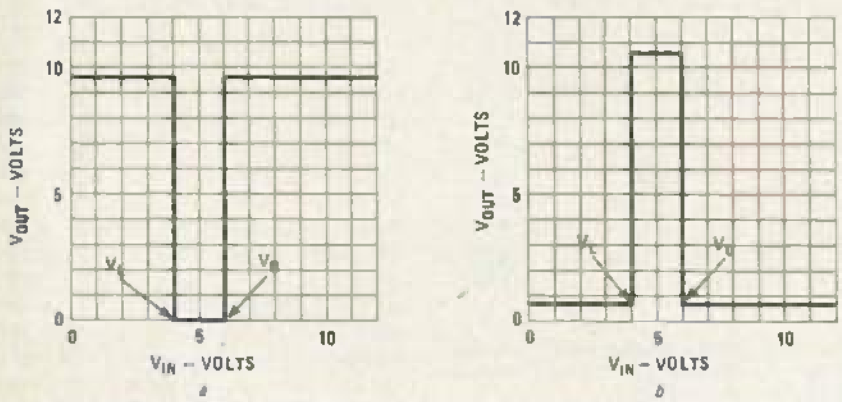


FIG. 9—THE ACTION OF THE WINDOW COMPARATORS shown in Fig. 8-a and 8-b are shown here in a and b respectively.

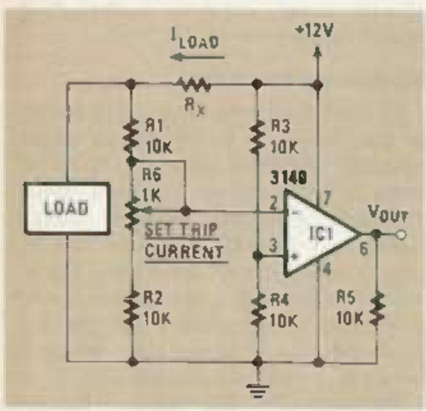


FIG. 10—OVER-CURRENT SWITCH. The output goes high when the load current exceeds a value determined by the setting of R6. By reversing the connections to pins 2 and 3 of IC1, the output will go low to signal the over-current condition.

ter stage, the action of the circuit in Fig. 8-a can be reversed so that its output goes high only when the input voltage is within the "window" limits. Alternatively, the required action can be obtained by transposing the two reference voltages and taking the output via a diode AND gate, as shown in Fig. 8-b. The actions of the two circuits shown in Fig. 8 are shown graphically in Figs. 9-a and 9-b.

Window comparators can readily be made to activate from any parameter that can be turned into an analog voltage, in the same way as a "normal" voltage comparator can. Let's look at some examples.

Analog-activated comparators

Figure 10 shows how a comparator circuit can be made to function as an over-current switch that gives a high output when the load current exceeds a certain value—which you can choose via potentiometer R6. The value of R_X is chosen so that it drops roughly 100 millivolts at the required trip point. Thus, a fixed reference voltage of 1/2 the supply voltage is fed to pin 3 of the op-amp via the voltage divider made up of R3 and R4. A similar but current-dependent voltage is fed to pin 2 via R_X, R1, R6, and R2. In effect, those two sets of components are configured as a Wheatstone bridge—with one side feeding pin 3 and the other side feeding pin 2—and the op-amp is used as a bridge-balance detector. Consequently, the trip points of the circuit are not significantly influenced by supply-voltage variations but are highly sensitive to load-current variations.

By simply transposing the connections to pins 2 and 3, the action of the circuit in Fig. 10 can be reversed so that it functions as an *under-current* switch: The circuit can then be used as a lamp- or load-failure indicator in cars, test gear, etc.

Figure 11 shows the circuit of a sensitive AC over-voltage switch that gives a high output when the input signal exceeds a peak value (6 mV to 111 mV) that is preset via potentiometer R12. The AC input signal is applied to the non-inverting input of variable-gain amplifier IC1. Its gain can be varied from 45 to 850 via R12. Note that the input of IC1 is DC-grounded via R1-R2, so the op-amp responds only to the positive half-cycles of the input signal. Consequently, the output of IC1 is an amplified, half-wave-rectified version of the input signal. That rectified signal is peak-detected via R5, D1, C2, R6, and R7, and is fed to the input of non-inverting voltage comparator IC2. The circuit's output is positive when the voltage across C2 exceeds the value on the junction of R8-R9.

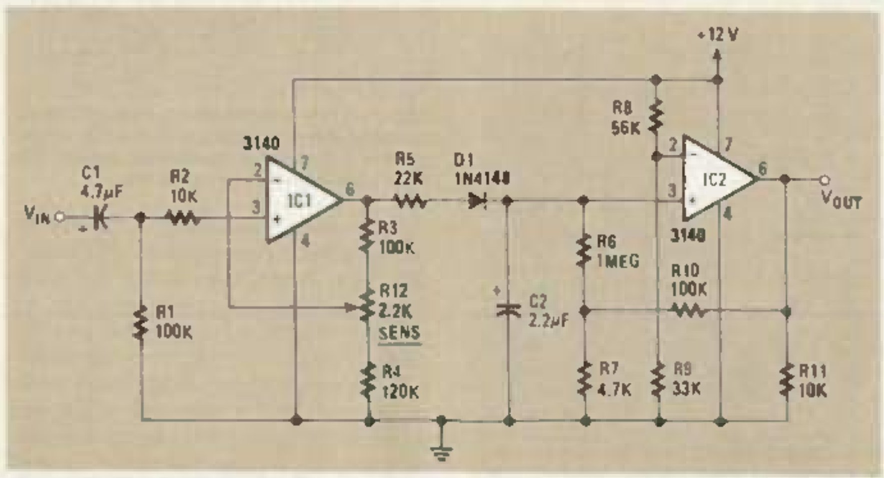


FIG. 11—AC OVER-VOLTAGE SWITCH can be triggered by input signals in the range of 6 mV to 111 mV peak.

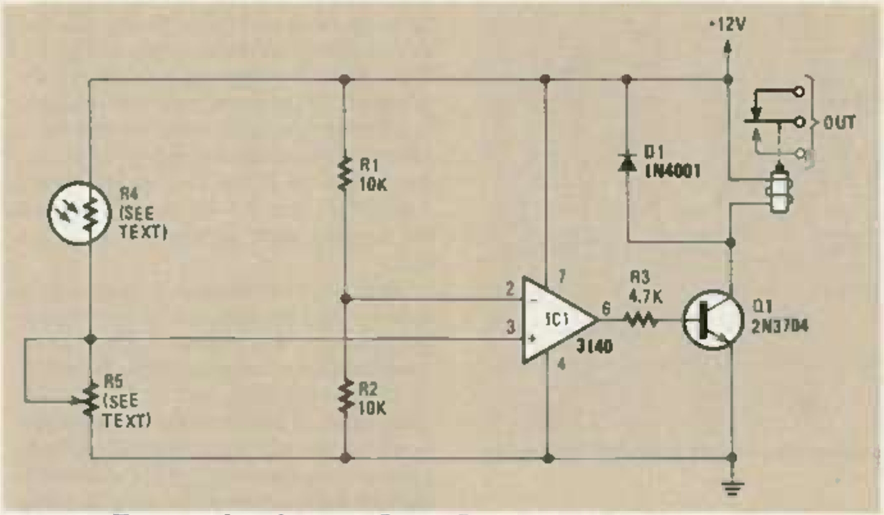


FIG. 12—THIS PRECISION OVER-TEMPERATURE SWITCH will control a relay.

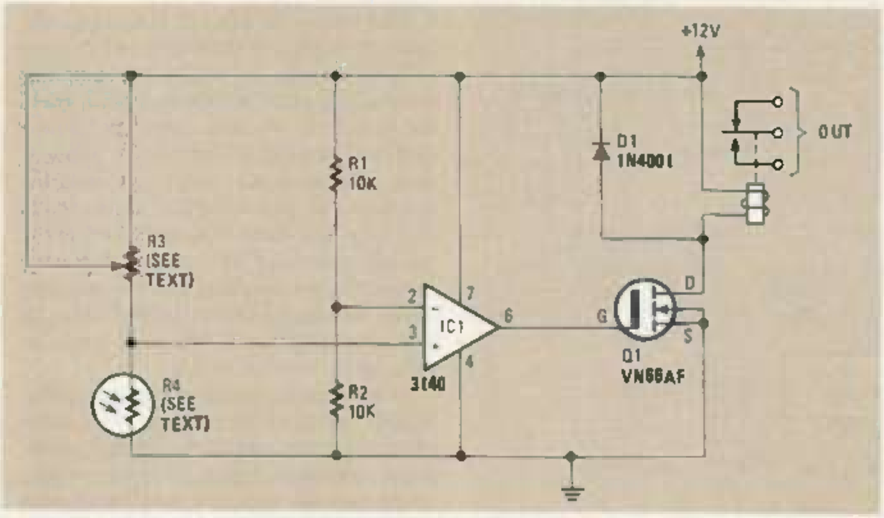


FIG. 13—THIS UNDER-TEMPERATURE SWITCH also will control a relay.

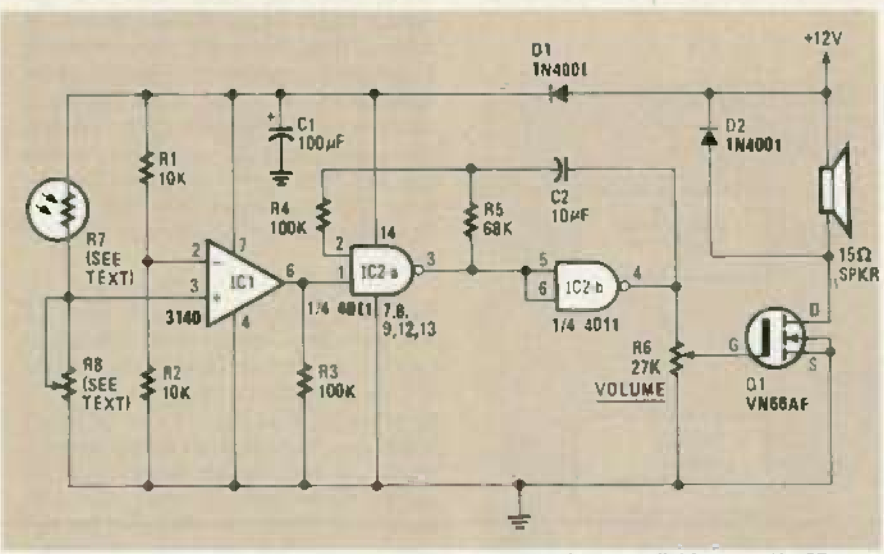


FIG. 14—LIGHT-OPERATED SWITCH. A monotone alarm will sound when the light detected by R7 rises above a value determined by the setting of R8.

Figures 12 to 15 show a variety of ways you can use comparator circuits as light- or temperature-activated switches. For light-sensitive circuits we use a cadmium-sulfide photocell; for temperature-sensitive circuits, we use an NTC (*N*egative-*T*emperature-*C*oefficient) thermistor as the sensing element. The sensing element is used as one arm of a Wheatstone bridge and the op-amp is used as a simple bridge-balance detector. Thus, the trip point of each circuit is independent of supply-voltage variations. In all cases, the sensing element must have a resistance in the range 5K to 100K at the required trip point. The potentiometer is chosen to have the same resistance value as the sensing element at the required trip level.

The circuits shown in Figs. 12–15 also show a variety of ways we can use the output of the op-amp to activate a relay or to generate an acoustic alarm signal. Thus, the over-temperature switch in Fig. 12 has a transistor-driven relay output, while the under-temperature switch in Fig. 13 has a FET-driven relay output. Similarly, the light-operated switch circuit of Fig. 14 generates a monotone alarm output signal in a small speaker, while the dark-operated switch of Fig. 15 generates a low-power pulsed-tone signal in a small acoustic transducer.

Micro-power operation

All of the 3140-based comparator circuits that we have looked at so far are continuously powered; they draw continuous currents of about 4 mA per op-amp. So if you wanted to use a 9-volt battery as a power supply, you'd find it running down after a couple of days of continuous operation. As you can see, the circuits that we've shown you so far are not well suited to battery operation in portable applications. In practice, however, all of those circuits can easily be modified for long-life battery operation by using a micro-power "sampling" technique; the principle behind that technique can be explained very easily with a simple example, as follows.

The under-temperature switch shown in Fig. 13 monitors temperature continuously and draws about 5 mA of quiescent current (with the relay off). In reality, however, temperature is a slowly-varying parameter and thus does not need to be monitored continuously—it can be efficiently monitored by briefly inspecting or sampling it. We can sample it by connecting the supply power and looking at the op-amp output only once every second or so. If the sample periods are very brief (say 300 microseconds) relative to the sampling interval (1 second), the *mean* current consumption of the monitor can be reduced by a factor equal to the interval/period ratio (in this example, by a factor of 3300). Thus, by using the sampling technique, we can reduce the 5-mA consumption of circuit in Fig. 13 to a *mean* value of 1.6 µA.

Figure 16 shows the basic circuit of a "micro-power" or sampling version of the under-temperature switch we saw in Fig. 13. It operates the relay when the temperature of the thermistor falls below a preset value but it draws a mean quiescent

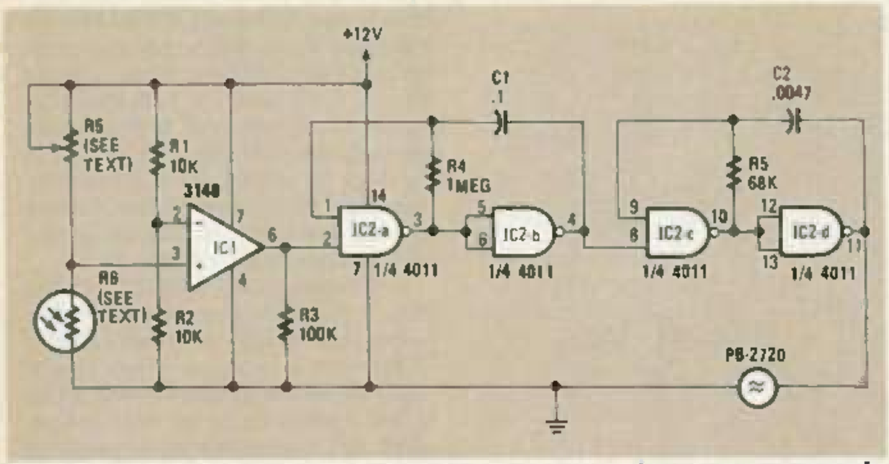


FIG. 15—ANOTHER LIGHT-OPERATED SWITCH. A pulsing tone will sound when the light detected by R6 falls below a value determined by the setting of R6.

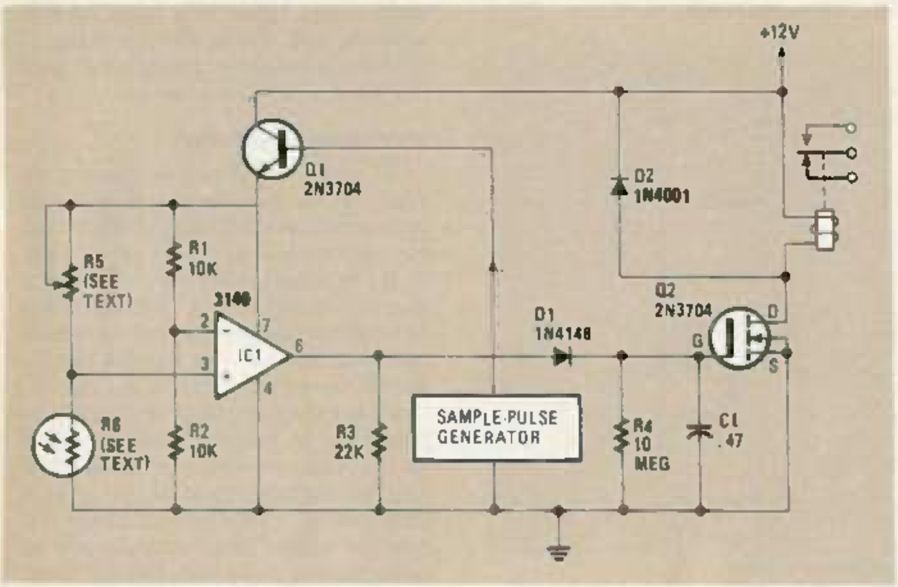


FIG. 16—MICRO-POWERED UNDER-TEMPERATURE SWITCH draws a quiescent current of only a few microamps.

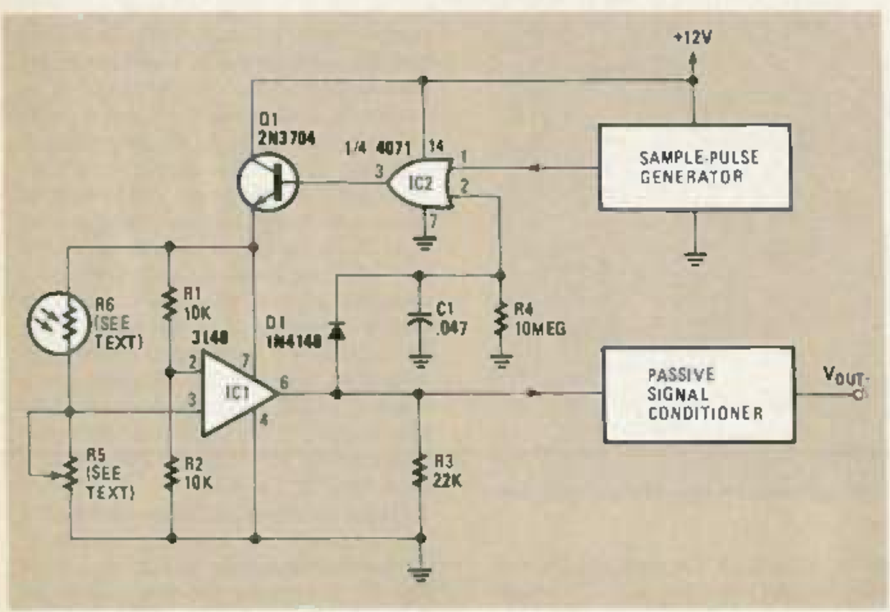


FIG. 17—THIS CODED-LIGHT-BEAM DETECTOR uses a modified version of the sampling technique to monitor for the presence of a coded light-signal.

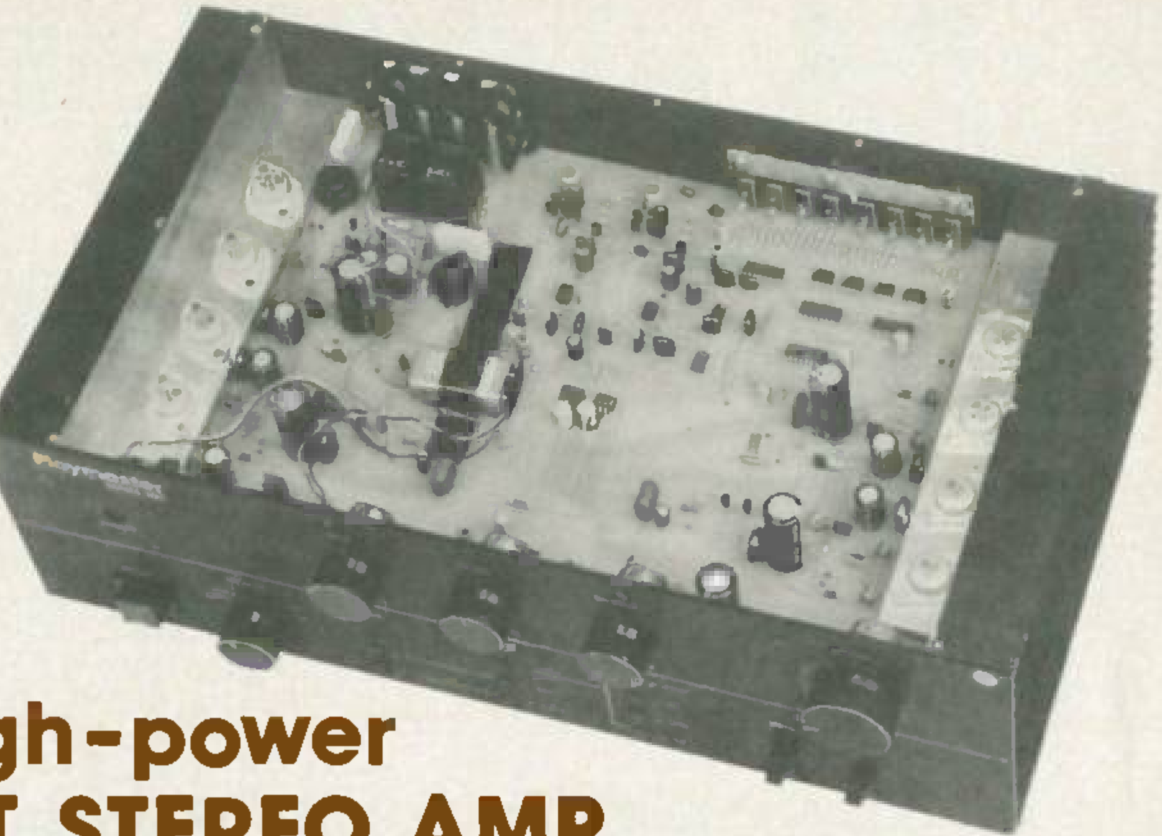
current of only a few μA. The monitor network, made up of R5, R6, R1, R2, and IC1, is almost identical to that of Fig. 13. But instead of being continuously powered, it is powered via a 300-microsecond pulse just once every second via a sample-pulse generator and Q1. Note that the output of IC1 is fed to temporary "memory" store R4-C1 via D1, and that the memory store operates the relay via Q2.

Thus, if the thermistor temperature is outside the trip level when the sample pulse arrives, the output of IC1 will remain low and no charge will be fed to C1, so Q2 and the relay will be off. On the other hand, if the thermistor temperature is within the trip level when the sample pulse arrives, the output of IC1 will switch high for the duration of the pulse and thus rapidly charge C1 up via D1 and drive the relay on via Q2.

The circuit in Fig. 16 illustrates the basic principles of the micro-power sampling technique. In reality the sampling interval and pulse width used (and, thus, the reduction in mean power consumption) will depend on the specific application. If, for example, you wish to monitor transient changes in light or sound levels and know that these transients have minimum durations of 100 ms, you may have to use a 50-ms sampling interval and (say) a 500 μs sample pulse. In that case the mean consumption of your circuit will be reduced by a factor of 100.

In some cases, you may have to slightly modify the operating principle of the sampling circuitry to obtain the desired micro-power operation. Figure 17, for example, shows how the principle may be adapted to make a coded-light-beam detector, in which the "code" light signal is modulated at 1 kHz for a minimum duration of 100 ms. Thus, the sample-pulse generator is designed to produce a minimum pulse width of 1.2 ms so that it can capture at least one full 1-kHz code cycle. Further, the sampling interval is set at 60 ms so that part of a tone burst will always be captured. The sampling circuitry thus gives a 50:1 reduction in monitor-current consumption.

Thus, in the circuit shown in Fig. 17, the sample generator repeatedly feeds 1.2 ms "inspection" pulses to the 3140 detector circuitry via one input of the OR gate and via Q1 to see if any trace of a coded signal exists: If no trace of a coded signal is detected, the output of the op-amp remains low and another sample pulse is applied 60 ms later. If a trace of a code signal *is* detected, the output of the op-amp switches high and the resulting pulse is "captured" and applied to the remaining input of the OR gate. That temporarily applies full power to the 3140 circuitry so that the code signal can be completely inspected via the passive signal conditioning circuitry. R-E



High-power FET STEREO AMP

Our amp's high-power output, low distortion, and easy construction make it a must for audiophiles who demand the very best!

LEO SIMPSON AND JOHN CLARKE*

IF YOU'VE BEEN WAITING FOR AN EXCUSE to junk your prehistoric stereo amplifier, your wait is over. Here's an amplifier that provides a conservatively-rated 95 watts (rms) per channel at eight ohms, with distortion that is less than 0.02%. Our amplifier can be built in a few evenings for under $300, and it will provide you with years of listening enjoyment as well as the satisfaction of knowing that the very latest in audio technology is providing that enjoyment.

The amplifier has all the latest convenience features, such as dual-recorder tape dubbing, speaker switching, muting, and a battery backup so that the amplifier will "remember" its configuration and return to that configuration the next time it is powered up.

The amplifier has four inputs: PHONO, CD, TUNER, and AUXILLIARY. The latter could be connected to a stereo TV tuner, a high-fidelity VCR, or another source. We also provide switching to monitor any one of the main inputs, or one of the two tape inputs. In addition, switching and the appropriate signal routing are provided so that you can dub from either tape recorder to the other. The amp also has provisions for connecting two pairs of loudspeakers; either, neither, or both pairs may be used at any time. In addition, a headphone jack is provided that is always "hot."

The amplifier is rather large. Overall it measures about 19 × 11.5 × 6 (inches). The size of the heatsinks determines the height and depth; those specially-tooled aluminium extrusions are necessary to cope with the large amount of heat dissipated when the amplifier is working near maximum output. Normally the heatsinks are just warm to the touch. The 19-inch width was chosen so that the amplifier could be rack-mounted, if the builder so desired.

Design philosophy

The amplifier represents the latest in a series of amplifiers that have been developed over the last ten years. We took the best features of the previous designs and combined them with the latest technical advancements to produce a truly superior amplifier. For the description that follows, see the block diagram of the amplifier that appears in Fig. 1. After discussing the overall operation of the circuit, we'll discuss each subsection in detail.

One paramount design goal was to eliminate the great amount of tedious hand-wiring of switches, controls, and jacks normally required by a project like this. We wanted to use a one-piece molded assembly for the input jacks so that it could be soldered to the PC board as a unit. That eliminates the need for shielded cabling, but creates a more severe problem: How could we provide appropriate switching for source selection, tape monitoring and dubbing from deck to deck?

We considered a mechanical switching solution, but there didn't seem to be any practical way of integrating mechanical switches neatly. So we considered using CMOS analog switches, since they are cheap and readily available in various configurations. However, analog switches are not without problems of their own. In an improper design, they can generate

*Adapted from material published by *Electronics Australia*

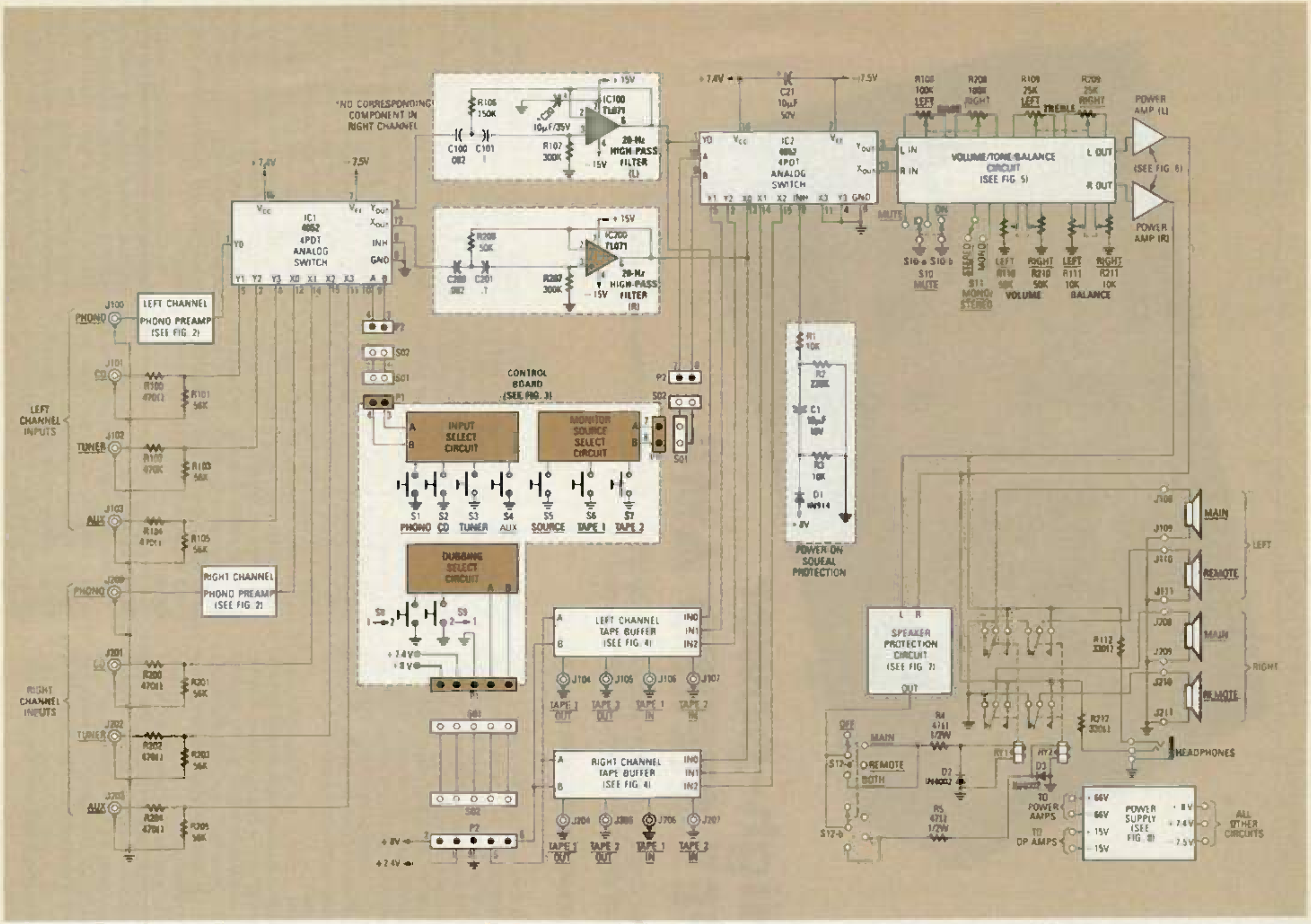


FIG. 1—OUR AMPLIFIER IS COMPOSED OF SEVERAL SUBSECTIONS, and the interconnections between them is shown here. The details of each subsection are shown in separate schematics.

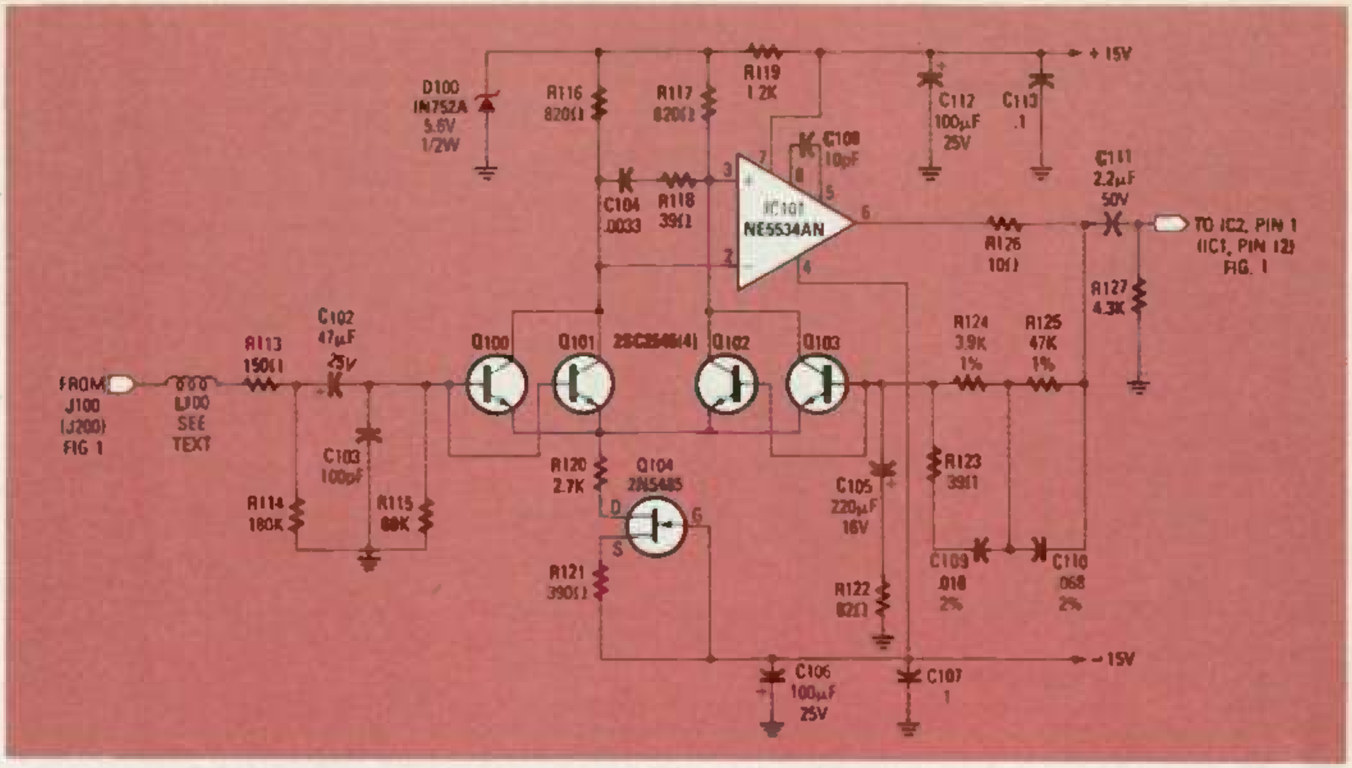


FIG. 2—THE RIAA PHONO PREAMPLIFIER is composed of a bipolar differential amplifier and an op-amp. The transistors are special low-noise types.

distortion. In addition, some sort of memory system would be required so that the amplifier's configuration would be "remembered" when the amplifier was turned off.

We overcame the distortion problem by buffering the outputs of the switches with low-noise FET-input op-amps (TL071's). Since distortion is caused by the non-linear resistance of the CMOS gate, it follows that, if the current through the gate were minimized, distortion would likewise be minimized. We achieve minimum distortion by buffering the output of each CMOS gate with a high-input-impedance, unity-gain op-amp. Buffering requires a few extra op-amps and discrete components, but we believe that the results more than justify the expense.

As for the memory problem, we could have built in some RAM (*R*andom *A*ccess *M*emory) and perhaps a microprocessor to control it, as some commercial Japanese designers have done, but that seemed like overkill. Instead, we chose to implement our memory with several CMOS gates and flipflops, which are powered by a pair of Ni-Cd cells when the amplifier is off. The flip-flops, switches, and indicator lights mount on a separate PC board, the control board.

Several other analog switches are mounted on the main PC board. For example, IC1 is the electronic equivalent of a 4PDT mechanical switch: it performs the input-source selection. Depending on the state of its A and B inputs, one pair of signals presented to the X and Y inputs is passed through to the appropriate outputs. For example, with both A and B low, the left- and right-channel outputs from the phono preamplifiers would appear at the YOUT and XOUT terminals, respectively.

Whichever signals are chosen, they pass through the 20-Hz high-pass (rumble) filters composed of IC100, IC200, and the associated discrete components. Those filters provide a 12-dB/octave roll-off below the corner frequency. (Due to filtering networks in the phono preamplifier, phonograph signals are rolled off a total of 18-dB/octave.) The op-amp rumble filters also provide high-impedance buffering that reduces loading on the analog switches. That loading could cause distortion.

By the way, for the sake of clarity, all left-channel components are numbered from 100–299; right-channel components are numbered from 200–299; and components common to both channels are numbered from 1–99.

Another analog switch, IC2, routes one of the main inputs or one of the tape recorder inputs through to the Volume/Tone/Balance circuit. The network attached to the INHIBIT input (pin 6) of IC2 forces that IC to turn on slowly, and that helps minimize power-on squeal through the headphones.

After passing through IC2, the stereo signals are processed by the Volume/Tone/Balance circuit, which also contains the MUTE switch and the STEREO/MONO switch. The signals are next presented to the power amplifiers and then to the speaker protection circuit and relays RY1 and RY2.

We had a problem with loudspeaker switching. We didn't want heavy wires running between the front-panel selector switch and the speaker output terminals. In addition, switches capable of handling the 10 amps or so of current the amplifier can develop at full power are expensive and not readily available. We solved the problem by letting a couple of relays do the switching. That solution allows us to use a small rotary switch to control just the coils of the relays. Further, that makes it easy to implement circuitry to provide power-on muting as well as to protect the speakers from an output-transistor failure.

The power supply is mounted beneath the main circuit board. Since the power supply is mounted so close to the main circuit board, we had to use a power transformer with a very low external hum field. Low hum is achieved by using a toroidal transformer that has the additional benefit of small size. Other special features of the power supply include 16,000 µF of capacitance on each of the 66-volt supplies, and a special, isolated +7.4-volt source for the CMOS switching components and their battery back-up.

With that background in mind, let's start over. Let's go back to the input of the circuit and examine each stage in detail.

The RIAA preamplifier

The complete schematic of the left-channel preamp is shown in Fig. 2. The right channel is identical, here and in other figures, unless a notice appears in a figure stating otherwise. We use special

PARTS LIST

All resistors ¼-watt, 5% unless otherwise stated.

R1, R3—10,000 ohms
R2—220,000 ohms
R4, R5—47 ohms, ½ watt
R6–R9, R11–R14, R16, R18—100,000 ohms
R10, R15, R17, R19, R100, R102, R104, R158, R163, R200, R202, R204, R258, R263—470 ohms
R20, R21, R22, R23—22,000 ohms, ½ watt
R24, R25, R101, R103, R105, R201, R203, R205—56,000 ohms
R26, R129, R121, R229, R231, R132, R232, R134, R234—270,000 ohms
R27, R128, R130, R144, R228, R230, R244—2200 ohms
R28, R159–R162, R259–R262—220 ohms
R29—130 ohms
R30, R31, R136, R151, R236, R251—1000 ohms
R32—1500 ohms
R33–R99, R165–R199, R2285–R299—unused
R106, R206—150,000 ohms
R107, R207—300,000 ohms
R108, R208—100,000 ohms, potentiometer
R109, R209—25,000 ohms, linear potentiometer
R110, R210—50,000 ohms, logarithmic potentiometer
R111, R211—10,000 ohms, linear potentiometer
R112, R212—330 ohms
R113, R213—150 ohms
R114, R214—180,000 ohms
R115, R215—68,000 ohms
R116, R117, R216, R217—820 ohms
R118, R123, R218, R223—39 ohms
R119, R219—1200 ohms
R120, R220—2700 ohms
R121, R221—390 ohms
R122, R222—82 ohms
R124, R224—3900 ohms, 1%, metal film
R125, R225—47,000 ohms, 1%, metal film
R126, R226—10 ohms
R127, R227—4300 ohms
R133, R135, R149, R150, R233, R235, R249, R250—4700 ohms
R137, R138, R143, R145, R146, R148, R155, R237, R238, R243, R245, R246, R248, R255—22,000 ohms
R139, R140, R239, R240—3900 ohms
R141, R147, R241, R247—680 ohms
R142, R232—68 ohms
R152, R252—12,000 ohms, 1 watt
R153, R154, R157, R253, R254, R257—100 ohms
R156, R256—500 ohms, trimmer
R164, R264—6.8 ohms, 1 watt

Capacitors

C1, C14–C22, C116, C120—10 µF, 50 volts, electrolytic
C2, C3—0.047 µF, polyester
C4, C5—47 µF, 50 volts, non-polarized
C6—100 µF, 16 volts, electrolytic
C7—0.01 µF, 250 volts, polyester
C8–C11—8000 µF, 75 volts, electrolytic
C12, C13—1000 µF, 25 volts, electrolytic
C23–C99, C144–C199, C214, C225, C226, C244–C299—unused
C100, C200—0.082 µF, polyester
C101, C107, C113, C142, C201, C207, C213, C242—0.1 µF, polyester
C102, C202—47 µF, 25 volts, electrolytic
C103, C203—100 pF, ceramic
C104, C204—0.0033 µF, polyester
C105, C205—220 µF, 16 volts, electrolytic
C106, C112, C206, C212—100 µF, 25 volts, electrolytic
C108, C208—10 pF, ceramic
C109, C209—0.018 µF, 2%, polyester
C110, C210—0.068 µF, 2%, polyester
C111, C211—2.2 µF, 50 volts, non-polarized
C112, C212—100 µF, 25 volts, electrolytic
C114—10 µF, 25 volts, electrolytic
C115, C215—10 µF, 50 volts, non-polarized
C117, C217—0.056 µF, polyester
C118—2200 µF, 16 volts, electrolytic
C119, C127, C219, C227—18 pF, ceramic
C121, C221—50 µF, 16 volts, non-polarized
C122, C222—0.01 µF, polyester
C123, C124, C223, C224—0.0047 µF, polyester
C128, C228—6.8 µF, 16 volts, non-polarized
C129, C229—1 µF, 100 volts, non-polarized
C130, C230—330 pF, ceramic
C131, C231—0.015 µF, 250 volts, polyester
C132, C232—47 µF, 25 volts
C133, C233—15 pF, ceramic
C134, C138, C234, C238—100 µF, 100 volts, electrolytic
C135, C136, C139, C140, C235, C236, C239, C240—0.22 µF, polyester
C137, C141, C237, C241—22 µF, 100 volts, electrolytic
C143, C243—0.15 µF, 250 volts, dual-dielectic (Philips type PKT-P)

Semiconductors

IC1, IC2—4052 4PDT analog switch
IC3–IC6—4011 CMOS NAND gate
IC7—74C14 CMOS hex Schmitt trigger
IC8—4013 CMOS dual D flip-flop
IC9—7815 15-volt positive regulator
IC10—7805 5-volt positive regulator
IC11—7915 15-volt negative regulator
IC12–IC99, IC105–IC199, IC205–IC299—unused
IC100, IC102, IC103, IC200, IC202, IC203—TL071 low-noise op-amp
IC101, IC201—NE5534AN bipolar op-amp
IC104, IC204—4053 CMOS triple SPDT analog switch
BR1—400-volt, 10-amp bridge rectifier
D1, D4–D17, D23, D101–D105, D201–D205—1N914
D2, D3, D18–D22, D108, D109, D208, D209—1N4002
D24–D99, D110–D199, D210–D299—unused
D100, D200—1N752A, 5.6-volt, ½-watt Zener diode
D106, D107, D206, D207—1N4739A, 9.1 volt, 1-watt Zener diode
LED1–LED9—Standard red LED
Q1, Q3, Q4—BC547
Q2—BC557
Q5—BC327
Q6–Q99, Q115–Q199, Q215–Q299—unused
Q100–Q103, Q200–Q203—2SC2545
Q104, Q204—2N5485
Q105–Q107, Q205–Q207—BC556
Q108, Q208–BF470
Q109, Q110, Q209, Q210—BF469
Q111, Q112, Q211, Q212—2SK134
Q113, Q114, Q213, Q214—2SJ49

Other components

B1, B2—Size AA Ni-Cd battery
F1, F2—Fuse, 250 volts, 5 amps
J1—Stereo headphone jack
J100–J103, J200–J203, J104–J107, J204–J207—RCA Phono jack
J108–J111, J208–J211—speaker connectors
L100, L200—see text
L101, L201—6.8 µH
P1, P2—9-pin SIP plug, 0.1-" centers
RY1, RY2—DPDT relay
S1–S9—SPST normally open, momentary contact
S10—DPST toggle
S11—SPST toggle
S12—2P4T rotary
S13—SPST toggle switch, 250 volts AC
T1—117 VAC primary, dual secondaries: 90 VCT and 30 VCT

Miscellaneous: Battery holder for B1 and B2, PC-mount fuse clips, Ferrite beads, 11-mm × 25-mm coil forms

Note: The following components are available from Dick Smith Electronics, Inc., P.O. Box 8021, Redwood City, CA 94063; 800-332-5373 (orders) 415-368-8844 (inquiries). Complete kit of all parts (No. K-3516) including PC boards, heatsinks, screened front and rear panels, and transformer T1, $299 plus $10 shipping. Separate components: set of two PC boards (No. KH-0106), $49.00; 2SC2545 transistor (No. KZ-1683), $0.39 each; 2SK134 transistor (No. Z-1815), $4.50; 2SJ49 transistor (No. Z-1816), $4.50; transformer T1 (No. KM-2000), $57.00; case including panels and heatsinks (No. KH-2700), $115. All component orders must add $1.50 for handling plus 5% of total price. California residents must add 6.5% sales tax. Orders outside U.S. must include U.S. funds and add 15% of total price for shipping.

ultra-low-noise transistors made by Hitachi (part number 2SC2545) to form a differential amplifier that drives an operational amplifier. Doing that allows the noise performance to be defined by the transistors rather than by the op amp and you can get better performance from discrete devices than from IC's.

The 2SC2545's are NPN types with very low intrinsic base resistance. We have found the 2SC2545 transistor superior in that respect to all others that we have

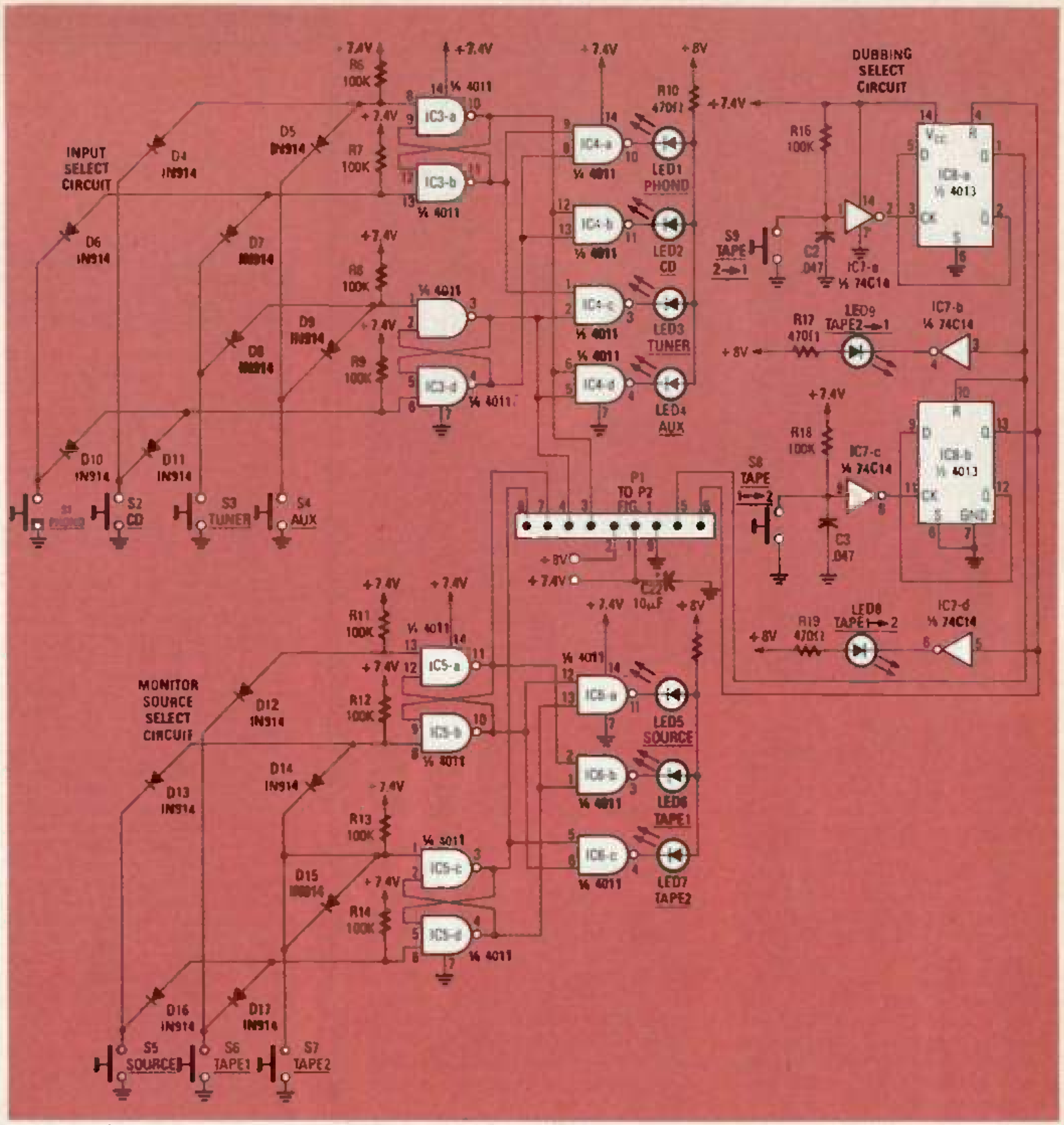


FIG. 3—THE CONTROL BOARD CIRCUITRY is shown here. Each section of the circuit is composed of several momentary switches that drive several flip-flops.

tested. To render residual noise in the phono preamp as low as possible, we use two transistors connected in parallel in each leg of the differential stage. That halves the intrinsic base resistance and improves noise performance a great deal.

Quiescent current through the differential pair is set at about 1.7 mA to optimize the signal-to-noise ratio for typical moving-magnet phono cartridges. That current is set by FET Q5, which functions as a constant-current source and ensures good common-mode performance, good PSRR (*P*ower *S*upply *R*ejection *R*atio), as well as optimum gain. In general, the better the PSRR, the less likely an amplifier will respond to variations in the power supply, including large ripple signals (hum), or to harmonics of the input signal, which increase harmonic distortion. Resistor R120 (2700 ohms) is connected in series with the drain of Q5 to protect transistors Q100–Q103 should Q5 fail. A failure of that sort is unlikely, but a resistor is cheap insurance.

We use a Signetics NE5534A op-amp for output drive; its high-performance capabilities include: low-noise, high slew-rate, and the ability to drive a 600-ohm load. That last capability is important for the circuit since it enables us to use a relatively-low-impedance negative-feedback network. The low-impedance network keeps circuit-generated noise to a minimum.

RIAA equalization is determined by the values of the components in the negative-feedback loop of the preamplifier (R124, R125, C109, C110). To ensure that there is minimum deviation from the ideal RIAA characteristic curve, those components should have tolerances of 1% or 2%.

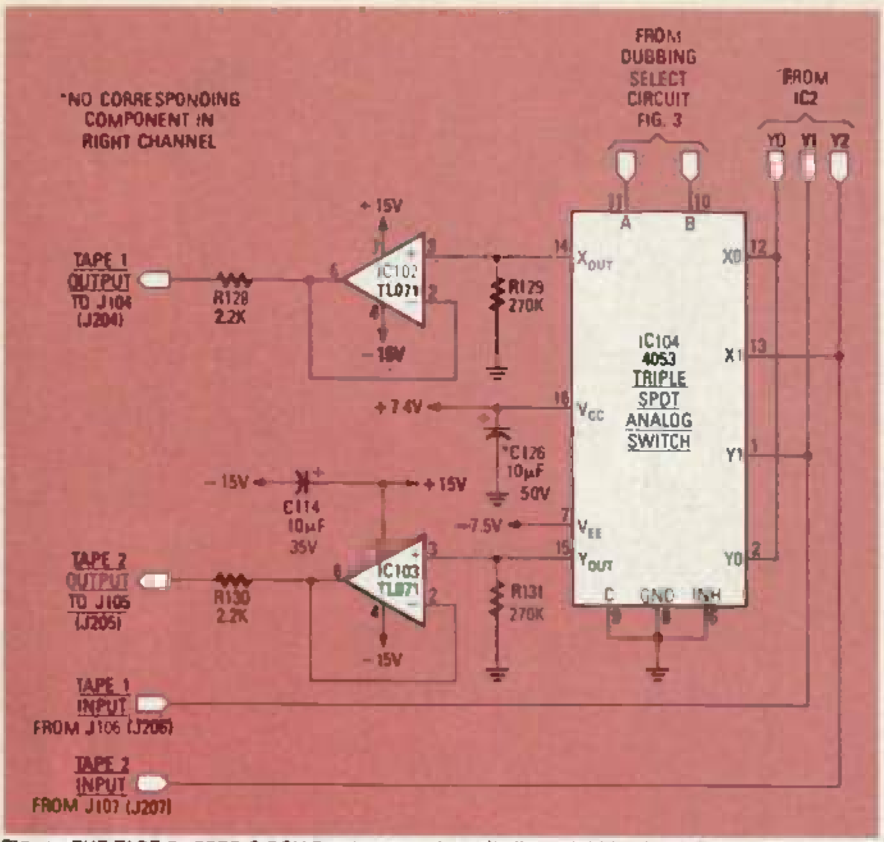


FIG. 4—THE TAPE BUFFER CIRCUITRY is shown here: it allows dubbing from either recorder to the other.

That keeps deviation within ±0.5 dB.

Since the NE5534A is not internally compensated, a 10 pF capacitor is connected between pins 5 and 8 to ensure stability at unity gain, which occurs at high frequencies. In addition, a 39-ohm resistor is inserted in the RIAA feedback loop to prevent gain from rolling off unnecessarily at very high frequencies. That also reduces the distortion that might otherwise occur at high frequencies due to loading of the op-amp by the network.

The hand-wound toroidal inductor (L100) in the preamp's input reduces sensitivity to stray RF signals. Capacitor C102 (47 µF) provides a low-impedance shunt path (via the coil of the cartridge) for noise produced by R115, the 68K bias and input load resistor.

The output of the preamplifier is coupled via a network consisting of a C111, a 2.2 µF non-polarized unit, and R127; those components form a low-pass filter that attenuates frequencies above 20 kHz. Next the signal is fed to IC1, the 4PDT analog switch that also handles the high-level inputs (CD, TUNER, and AUXILLIARY). That switch is powered by +7.4-volt and −7.5-volt supplies. The maximum peak-to-peak signal that can be handled by the switches without distortion is defined by the values of the plus and minus supplies. In our case, the maximum is about 15 volts, but the switch should never see more than about 2.5 volts rms, or 7 volts peak-to-peak.

As we said, the input source fed through to the rumble filters depends on the state of the A and B inputs. Those inputs are controlled by the circuitry on the control board. Let's examine that circuitry next.

Control board

The control circuitry is shows in Fig. 3; let's look at the *Input Select Circuit* first. Switches S1–S4 drive the cross-coupled gates of IC4, which are configured as an S-R (*S*et-*R*eset) flip-flop. Suppose you press S1, PHONO. That will force one input each of IC3-b and IC3-d to go low, which will in turn force their outputs high. Those outputs are connected to the inputs of IC4-a, so its output will go low and LED1 will light up.

The outputs of IC3-a and IC3-c are low now; those outputs are connected to the A and B inputs of IC1. Since both inputs are low, the X0 and Y0 inputs—the outputs of the phono pre-amps—to the analog switch will be fed through to the outputs.

The other switches in that section of the Control Board (S2–S4) work in a similar manner, as do the switches in the *Monitor Source Select* section. The latched outputs of the latter section are cabled to the A and B inputs of IC2, another 4052 4PDT analog switch; it serves to route one of the source inputs (Phono, etc.) or one the tape recorder inputs through to the volume control circuitry.

continued on page 90

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

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

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

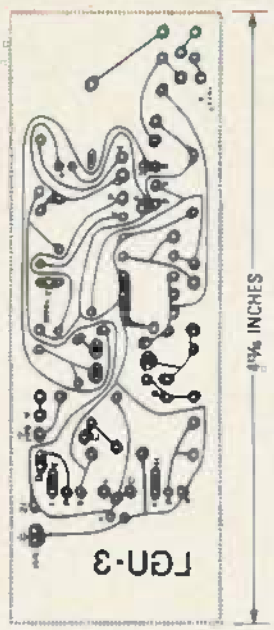
An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are probably used to.

We can't tell you exactly how long an exposure time you will need but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

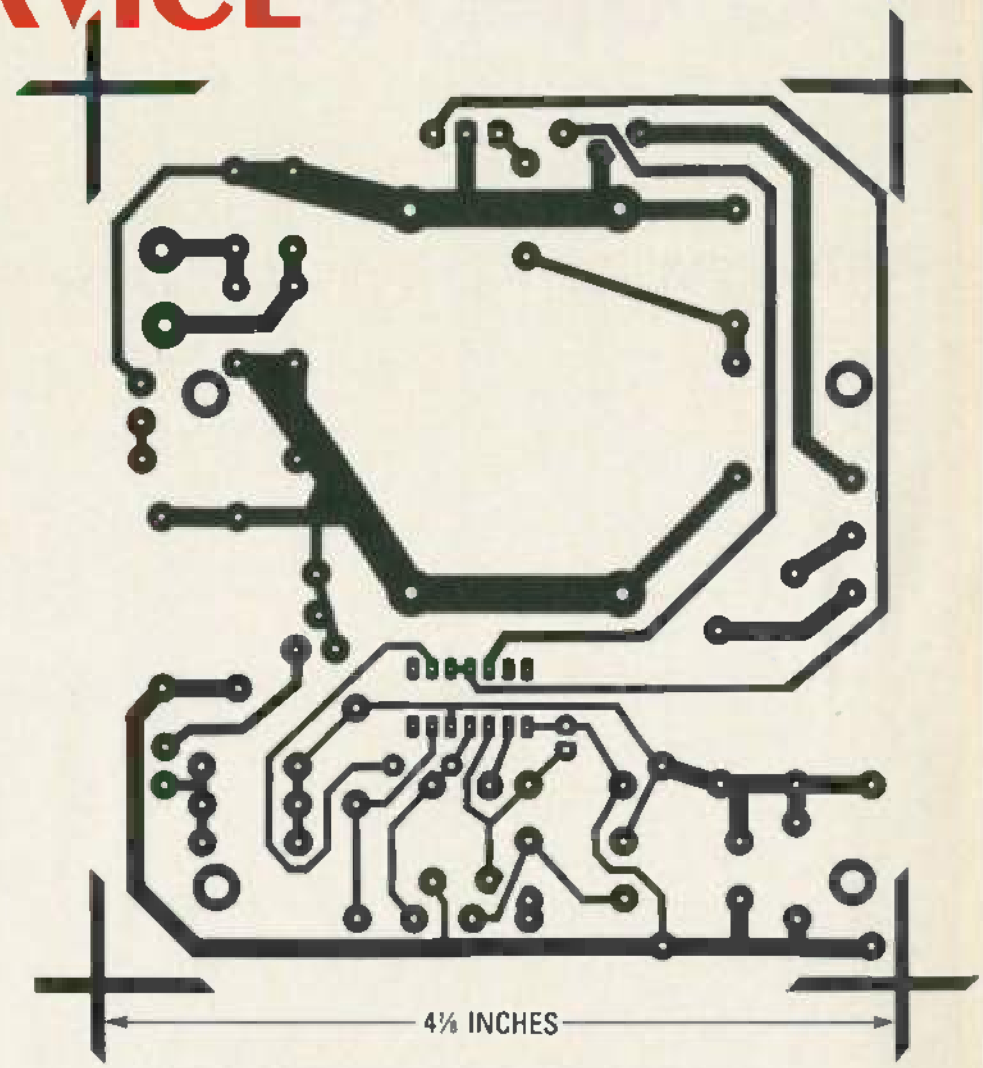
Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

Radio-Electronics
Department PCB
500-B Bi-County Blvd.
Farmingdale, NY 11735

PC SERVICE

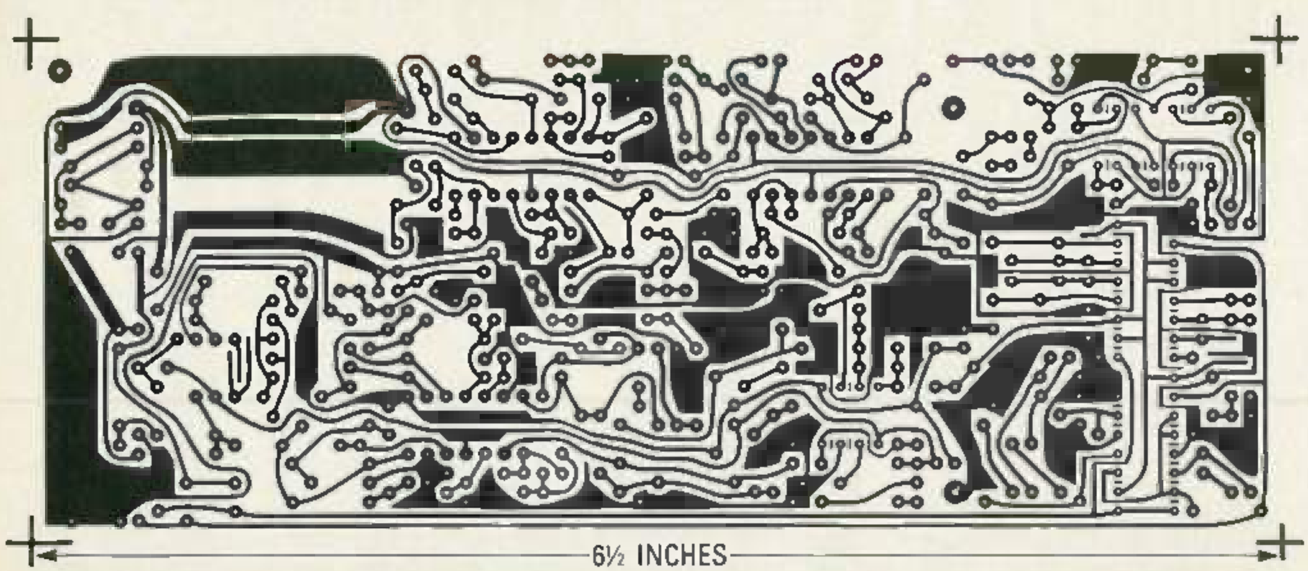


USE THIS board to build your laser.



IF YOU WISH to etch your own board for the 30-volt power supply, use this pattern.

PC SERVICE



HERE'S THE FOIL PATTERN for our Click and Pop Filter.

DESIGNER'S NOTEBOOK

Precision rectifiers

ROBERT GROSSBLATT
CIRCUITS EDITOR

WHEN YOU TALK ABOUT RECTIFIERS, THE first thing that comes to mind is power supplies, but rectifiers are also used in many other circuits. Converting AC to DC is necessary in many RF circuits, and most circuits that measure real-world quantities first have to rectify sensor voltages. But even though regular diodes and bridges are adequate for many rectifying jobs, sometimes a different approach is needed.

The rectifying circuit you build for a power supply will work perfectly well when you're eliminating batteries, but it will be completely useless for RF. The reason is simply that the input voltage is less than the voltage needed to turn a diode on. Even small-signal germanium diodes require about 0.3 volts to turn on. That may not seem like much, but, if you are working with signals in the millivolt range, you'll have to find another way to handle the problem.

Circuit designers have two standard methods of dealing with the situation. They can amplify the AC signal and then rectify it, or they can do both at once with a precision rectifier. All things considered, the latter method is a much better way to get the job done.

The one-step approach to building a precision rectifier requires some way of isolating the positive and negative halves of the incoming AC, but after that AC has been amplified to a usable level. The circuit shown in Fig. 1 is a straightforward way of combining both amplification and rectification.

I designed the circuit with a 741 op-amp since it is cheap and readily available. If the performance specs of the 741 aren't to your liking, you can just as easily substitute any other op-amp. Higher input impedance, lower offset voltage, frequency limit, and slew rate are among the factors you should consider when choosing an op-amp. Examine the requirements of your application and choose an appropriate device.

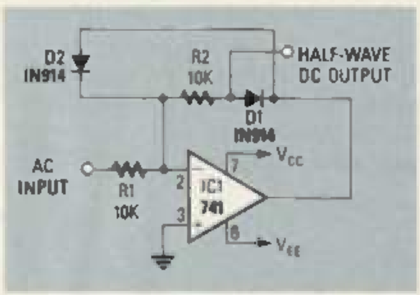


FIG. 1

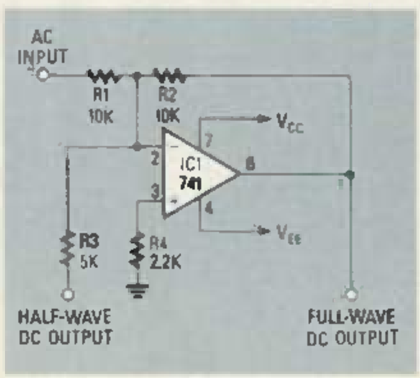


FIG. 2

How it works

The circuit's theory of operation is similar to that of a diodes-only rectifier. During the negative half of the AC cycle the output of the 741 forward biases D2 and current flows only through that diode. During the positive half of the input swing, however, D1 is forward-biased, so current will flow through it and through R2. Therefore, DC will only show up across R2 during the positive part of the incoming AC cycle.

Because we're rectifying the voltage in the feedback loop of the op-amp and not at its input, the circuit will be able to handle very small AC signals. The inherent high gain of the op-amp allows us to rectify signals that are substantially below the voltage needed to forward-bias even small-signal germanium diodes.

The op-amp shown in Fig. 1 is set up as an inverting amplifier, so the output waveform will be 180° out of phase with the input. You could switch inputs on the op amp to turn it into a non-inverting amplifier, but the phase difference comes in handy if you want to build a precision full-wave rectifier.

A simple summing amplifier can be used to turn our circuit into a precision fullwave rectifier, but a bit of thought has to go into picking the summing resistors. As shown in Fig. 2, we're adding the original AC signal and twice the output of the halfwave rectifier discussed above.

If R1 and R3 (in Fig. 2) had the same resistance, the output of the halfwave rectifier and the negative half of the input AC would be equal in magnitude, but 180° out of phase. In other words, the net result would be a voltage of zero. We can solve that problem by mixing in twice the halfwave voltage.

If you decide to build the full-wave rectifier, it's a good idea to use a 747, which has two 741's in a single IC package. R-E

STATE OF SOLID STATE

Single-chip sync/sweep circuit

ROBERT F. SCOTT
SEMICONDUCTOR EDITOR

A COMPLETE TELEVISION SYNC/SWEEP generator in a single IC package has been developed by RCA's Solid State division. The CA3218E Vertical-Countdown Digital-Sync System is a significant advance over the sync and sweep circuits that have been recognized as industry standards for more than a decade. The IC is designed for operation in 525-line televisions, monitors, and video display equipment. The IC's unique vertical-countdown design uses a 10-stage counter and logic circuits to improve noise immunity and to permit elimination of the vertical-hold control.

The CA3218E also provides composite blanking and burst-gate output signals that can be summed in a simple external RC network to produce the "sandcastle" waveform signal needed for the operation of chroma and luminance circuits in color-TV receivers.

The device works with both standard and non-standard sync signals. An automatic mode-recognition circuit forces the IC to operate in the non-synchronous mode when the incoming composite video signal has a scanning rate other than the standard 60-Hz, 525-line format. The CA3218E might be used in a circuit like the one shown in Fig. 1.

How it works

The IC's internal master oscillator is controlled by an external RC network that is connected to pin 5. The oscillator runs at eight times the horizontal rate. The signal is divided several times and fed to other portions of the IC. For example, a divide-by-8 output goes to the horizontal amplifier output (pin 8). A phase-locking AFC circuit controls the precise frequency of the master oscillator.

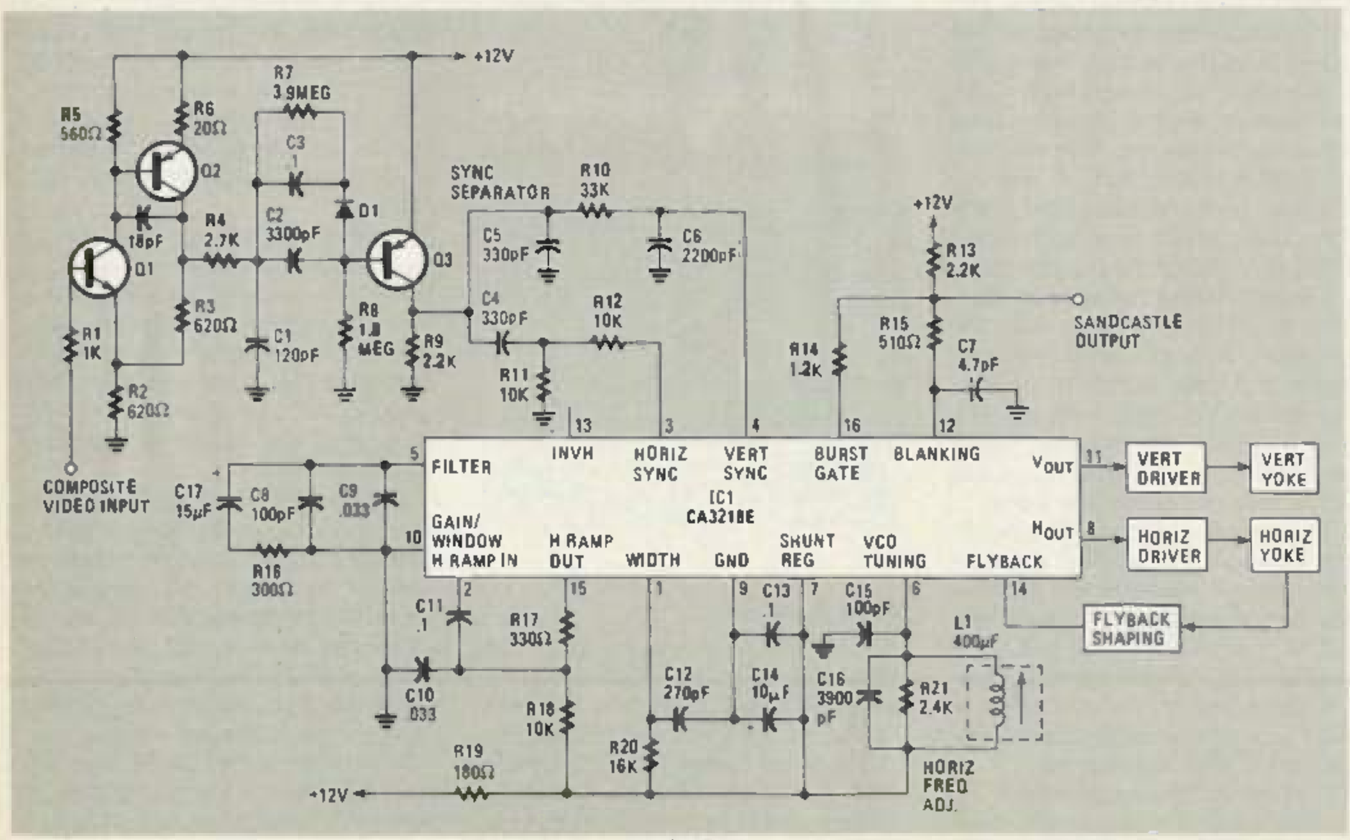


FIG. 1

The horizontal ramp signal input (pin 2) is derived from the flyback pulse that appears at pin 15. Then it's fed to a phase detector where it is compared to the horizontal sync fed in at pin 3. The phase detector generates a correction voltage that keeps the master oscillator phase-locked to the correct frequency.

Divide-by-2 and divide-by-4 outputs of the horizontal divider drive the 10-stage vertical counter. The digital countdown system and associated logic circuits provide good noise immunity and eliminate the need for a vertical-hold control.

The GAIN/WINDOW input (pin 10) is a logic input that controls the vertical-sync "window" during which the system looks for the occurrence of a vertical-sync pulse on the incoming signal.

Upon receipt of the 464th or the 512th clock pulse (according to whether pin 10 is low or high, respectively), the vertical-sync window is "opened." The end of the sync window is marked by the arrival of the 568th or the 592nd pulse, again according to whether pin 10 is high or low.

If the incoming vertical-sync pulse coincides regularly with the 525th clock pulse, vertical blanking and sweep signals are generated in the standard sync mode. If the incoming vertical sync does not coincide with the 525th clock pulse or if it is masked by noise, the 10-stage counter continues to supply an output at the 525th clock pulse. A three-bit counter counts the number of consecutive fields during which a sync pulse does not arrive simultaneously with the 525th clock pulse. If a sync pulse does not coincide with the 525th clock pulse for eight consecutive fields, the 3-bit counter activates a circuit that switches operation to non-standard sync.

When the circuit operates in the non-standard sync mode, the incoming vertical pulse initiates vertical sweep when the input pulse coincides with any clock pulse within the sync window *except* the 525th. If no vertical-sync pulse arrives during the window time, the system freewheels at a frequency determined by the 568th or 592nd clock pulse, depending on the state of pin 10.

The CA3218E generates a composite blanking signal and a burst-gate keying pulse at pins 12 and 16, respectively. Those signals can be summed in a simple external resistive network (R13, R14, and R15 in Fig. 1) to produce the "sandcastle" signal that is used to drive chroma/luminance IC's like RCA's CA3220E. The CA3218E also generates an inverted horizontal sync signal (at pin 13) that can be used to drive the CA3224E Automatic Picture Tube Bias IC.

The CA3218E costs $2.00 each in 100-piece lots. For further information, and a copy of the data sheet (File No. 1637), write to **RCA Solid State, P.O. Box 2900, Somerville, NJ 08876.**

Power supply design aid

Ferranti Semiconductors has made available its Power Supply Design Pack that includes information on its Super E-Line, High-voltage Super E-Line, and MOSFET transistors. To receive the design pack, contact **Ferranti Electric, Inc., 87 Modular Avenue, Commack, NY 11725.**

ROBOTICS

MARK J. ROBILLARD,
ROBOTICS EDITOR

Pet robots?

WE'VE SPENT SEVERAL MONTHS DIScussing the hardware necessary to build robots. The most common applications for the type of robot we've been talking about include automatic assembly equipment and material transport. However, an entirely different type of application is emerging.

As anyone who has ever walked by a pet store can see, the pet industry in America is thriving. And the price for a well-bred dog can be astronomical. Why do people pay those prices? Companionship.

For example, a good dog is soft and furry, and he'll come to you when he is called. Left to himself, he'll fend for himself. Commanding him to speak yields a healthy bark. You can play fetch with him, and maybe he'll even bring the morning paper to you. Strangers will be sensed, "announced," and perhaps chased away.

To obtain those benefits all you have to do is provide a comfortable environment for your dog to live in. You must regulate the temperature, provide clean, fresh drinking water, and provide food. It doesn't hurt to clean your dog occasionally; otherwise you may find yourself caring for several dozen little pet insects as well.

What's all that got to do with robots? It appears, using technology that is available today, that it is possible to build a pet robot that can do most of the things we value our pet dog for. Of course there will be limitations. The robot won't be able to jump or catch a stick in mid air, but it could fetch the morning paper, provided the paper could be found in the same place every day. (And no pooper-scooper is required.—*Editor*)

A new company called Axlon (1287 Lawrence Station Rd., Sunnyvale, CA 94089) is first to apply robotics to the pet market. Their product is a "cat" named *Petster.* It is soft and furry, and it will come to you when you call. It purrs and its LED eyes blink. When you leave it alone, it finds a cozy place to relax and falls asleep. Clapping is used to communicate with the "beast."

FIG. 1

Sound too good to be true? It actually exists. I, and my family, which includes two girls, six and nine years of age, had the pleasure of testing one recently. Because the man-machine interface is not perfect, there are times when Petster does the opposite of what you command. But isn't that sometimes the case with a real pet? The limitations of the technology provide the unpredictability of a real pet.

Petster is based on a single-IC microprocessor that processes sounds picked up by its on-board microphone. Two small motors provide locomotion for the toy.

There is now a deluxe version available, shown in Fig. 1, that purrs when you pet it, and that includes an electronic leash that allows you to take *Petster* for a walk. It can avoid obstacles picked up by an internal sensor. That's the same type of technology we've been talking about here.

A more serious use

Where will that technology lead? Another product recently announced by Axlon attempts to solve a problem of growing national concern. Thousands of children disappear each year. Those of you who are parents undoubtedly remember the sinking feeling you have when you are separated from your child in a shopping mall. And perhaps you have wondered whether a technological solution to the problem could be found.

Axlon's *S.O.S Bear* is one attempted solution. Inside the bear is a radio transmitter that maintains contact with a receiver-alarm unit carried by the parent. If the child and the bear wander too far from the parent, the alarm sounds.

How far is too far? In a relatively quiet area such as a back yard or an open field, the unit allows a maximum separation of about fifty feet. But in a crowded shopping center, an internal sound-level detector automatically compensates and sounds the alarm when the distance between parent and child exceeds ten feet.

One problem with that scheme is this: What happens if the child and the bear are separated, as might happen in the case of a forced abduction? A solution might be to tether the bear to a battery pack attached to the child's clothing. Loss of the signal would then trigger the alarm. **R-E**

SATELLITE TV

BOB COOPER, JR.,*
SATELLITE-TV EDITOR

Black-box descrambling

SOME YEARS AGO A GROUP OF CLEVER college students dedicated themselves to learning how the long-distance telephone network works. Once they figured it out, they began building "blue boxes" with the capability of bypassing toll-call record-keeping systems. The magic boxes allowed a person to dial any number he or she wished, at any time, without incurring any long-distance charges. Naturally, many people enjoyed sticking it to Ma Bell, but Ma Bell lost a great deal of money and set out to discover what was happening.

Eventually the persons involved were caught, and, even though several publications had already printed complete descriptions of the circuitry involved, the practice all but died out. That's because the risk of discovery, and the penalties that could be incurred, were greater than the rewards that might be gained.

We now have a similar situation in TVRO. As reported last time, HBO and Cinemax began transmitting scrambled signals after the first of the year. The basic system is outlined in Fig. 1; note that, at the receiving end, the input to the descrambler can be either the 70-MHz output of a downconverter, or a baseband video signal. M/A-Com has designed different descramblers to handle both kinds of signal.

Since HBO and Cinemax began scrambling, Super Station WOR has joined the ranks of the scramblers; and more broadcasters will undoubtedly follow. As you might suspect, several firms and individuals have begun

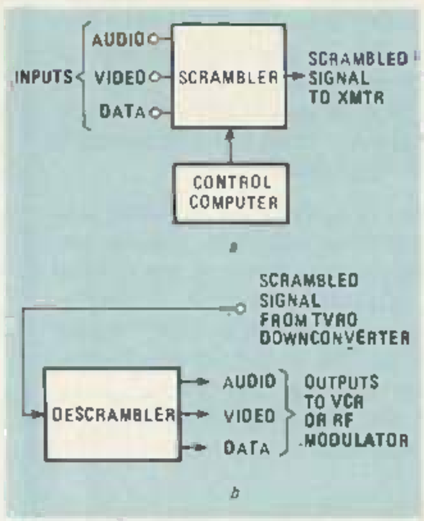


FIG. 1

working on breaking the scrambling system. Is that legal?

Cloudy legalities

The situation is unclear at this time. New telecommunications legislation was signed into law in the fall of 1984 by President Reagan; that legislation deals with the theft of telecommunication signals. What is considered theft? If you use a transmission that is private, and not intended for you, then under the new law you are stealing that communication.

In addition, the 1984 law considers you an accessory to such theft if you help someone else receive private signals, either by teaching him how to do it, or by providing him with equipment to do it. So, for example, if you figure out how to descramble the HBO satellite feed and share hardware or even information with a second party, you may be in violation of the law. Section 705 of the 1984 Communications Act provides for significant financial penalties and possible imprisonment for violations. Further, the penalties are greater if you are involved in a theft-related business—such as building and selling descramblers.

Those potential penalties haven't deterred a few hardy souls. Advertisements are appearing that offer assembled descramblers as well as plans and kits of parts. The legality of those offerings has not been determined yet, but, as potential purchasers of descrambling products, you should be aware of the special circumstances involved here. The law was not very clear prior to the new legislation; it is more clear now than it was, but the courts have yet to test the new laws.

The technical end

To date, a number of interesting tricks have been offered to beat HBO's scrambling system. I'll describe several of the most common systems; they should serve as a warning, in case you're considering buying a black-box descrambler.

- A series of booklets are being sold, some for as much as $50, that claim to disclose circuits that can beat the M/A-Com *Videocipher* scrambling system. I have read all the books I could get my hands on, and in no case does the solution offered descramble the audio signal. Video descrambling on HBO is really simple, since the polarity of the video waveform has been inverted, and the sync pulses have been retarded. All you have to do is re-invert the signal and regenerate the sync. And you don't have to buy a $50 booklet to find out how to do that!

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

• Kits, as well as wired and tested units, are being offered from a company in Canada. The company claims that you'll never have to pay a monthly fee for HBO after you purchase their descrambler. The kits are not yet available, and the wired and tested unit we saw was simply a M/A-Com *Videocipher* circuit mounted in a different cabinet to disguise its origins.

Cleverly, the company enrolls the subscriber in HBO's normal service for several months. When that subscription lapses the user is left with a descrambler that works like the legitimate M/A-Com descramblers: when you pay for service, you'll be able to receive descrambled signals.

• Circuit wizards are looking into modifying the specially-encoded IC's in each *Videocipher* so that you can bypass HBO's scrambling permanently. I don't know if such "bypassing" is indeed possible, but I'd be shocked if M/A-Com left such a gaping hole in their security system; it's an open invitation to being cracked.

It seems that vendors of presently-available non-authorized descramblers are vultures preying on people's desire to get something for nothing from HBO and from other programmers. In fact, it's such an emotional issue that people who normally exhibit good, common buying sense are throwing caution to the winds and buying anything that promises to beat the system. But, as I write this, I have yet to see any gadget or circuit that will recover both the scrambled video and the *scrambled audio* from either the M/A-Com *Videocipher* or the Oak Orion descrambling systems.

So, spend your money wisely, and if you like to play with challenging new technology, have at it. Who knows, you could be the first to break the digital audio scrambling system that is the current rage in commercial telecommunications! **R-E**

Interested in TVRO?

For nearly two years Bob Cooper has provided a no-charge kit of printed materials that describes the challenges of and opportunities in selling TVRO systems today. With the present intense interest in scrambling systems, Coop's *CSD* has made available a new no-charge service.

The SCRAMBLE FAX hotline is a 24-hour-per-day telephone service that provides accurate, detailed, and hard-to-find facts concerning the changeover to scrambling in the satellite communications industry. Information describing satellite receivers tested for scrambling compatibility, sources for authorized descramblers, wholesale rates of scrambling equipment and services—all are provided on the SCRAMBLE FAX hotline. There is no charge for that service, other than your long-distance telephone expenses. Simply dial (305) 771-0575 for a concise and timely three-minute capsule report that covers the latest in scrambling news.

continued from page 8

surge can cause an annoying 120-hertz buzz on nearby AM radios, and it may interfere with the operation of some types of electronic equipment.

For example, consider the high-current incandescent lamps that are used in traffic-control signals and movie projectors. When power is applied at any instant other than the zero-crossing, the lamp's filament is cold and its resistance is low. The resulting inrush of current is typically ten to twenty times the steady-state value.

FIG. 1

Further, thyristors (SCR's and triacs) used in solid-state relays, electronic light dimmers, heater controls, and small-appliance speed controls vary applied power by varying the phase angle over which that power is applied. When power is applied to the device for a period less than 180 degrees, the load current rises abruptly, and that may shorten the life of the thyristor, as well as that of the controlled device. Radio-frequency interference may also occur.

Those problems are reduced or eliminated by using a zero-voltage switch. Those devices are used in a variety of products, including the BSR remote control system. Typical switches now come in IC form, like the CA3059, available from RCA and Motorola, TI's TL4400, and the OPI3030 series from TRW Optron. The latter include opto-isolators in addition to the zero-voltage switch. **R-E**

ANTIQUE RADIOS

Automatic tuners

RICHARD D. FITCH
CONTRIBUTING EDITOR

YOUNG COLLECTORS OF ANTIQUE RAdios may be a little surprised at how advanced some early receivers were. Many modern "innovations" are actually just ideas that were already popular in the early days of radio. For example, the automatic tuning systems used on radios of the 1930's and afterwards provided much convenience for early listeners. By way of contrast, you old-timers might remember having to tune each of four huge dials separately, and possibly several smaller dials.

That's the way it was at first, but improvements came fast. Soon it became possible to control all those dials with a single knob. Next pushbutton-selection of stations became popular. As the 1930's progressed, at least half a dozen types of automatic tuners became available. Our antique of the month presents one novel approach to the two-hands-too-few problem; after discussing it, we'll talk about other approaches.

The Grunow Model *588*

The beautiful set shown in Fig. 1 is a superhet that covers the broadcast band and one shortwave band. Band-selection is accomplished by the center knob in the group of three. Another knob is a tone control. The tuning dial is what makes this radio interesting; it's called a *Teledial*, and it's a manually-operated automatic tuner that made its appearance in the mid 1930's. Later on, similar arrangements were motorized.

It's called a *Teledial* because it works like a rotary telephone dial. You push a button on the circumference of the tuning dial and then rotate the dial until it latches. You could set as many as eight different "stops" on the model *588*. The buttons are set by tuning in the desired station, moving the button to the latch gate, and then tightening the button.

FIG. 1

Against my better judgement, I removed the entire tuning device to see how it works. Removing one hex nut on the mounting bracket loosened the entire assembly and revealed the efficient dial lamp in the center of the dial. The lamp is accessible by removing the dial pointer. It's easy to string the dial cord. The latch-gate stops are mounted on steel springs which retract as the pin passes over the wedge. Some motorized tuners use a similar arrangement.

The Grunow model *588* has five tubes, including an 80 rectifier, a 6A7 first detector and oscillator, a 6D6 IF Amplifier, a 75 second detector, AVC and audio pre-amp, and, finally, a 41 power output tube. The set has an IF of 465 kHz, a built-in power transformer, and connections for an antenna and ground, and it uses a dynamic speaker.

Similar tuners were made by Emerson, Fairbanks, Morse, Philco, Traveler, Erla, Wilcox Gay, and General Household Utilities, who made the Grunow.

Pushbutton Tuners

Of course, the *Teledial* is not the only type of automatic tuner; probably most popular was the mechanical pushbutton type, which can itself be broken down into several different types. Pushbutton tuners often use one switch to control power and another to select a shortwave band, which could then be tuned with the regular tuning dial. A pushbutton system like the one on some Trutone models was about the simplest and least expensive. It uses a system of levers and springs that actually turns the ganged tuning capacitor. It's easy to build and adjust, but it requires considerable pressure to operate the buttons.

Philco manufactured one radio that requires less button pressure than the Trutone. It works by disengaging the ganged tuning capacitor when the pushbuttons are in use. The switching arrangement then connects a different coil in the circuit when the button is pushed. The adjusting screws of those coils are accessible from the back of the cabinet. The only problem is that, if a set is tampered with, it could take a technician a full day to align all those coils.

The Belmont Model *5D128*, which was our Antique of the Month last time, has a mechanical pushbutton arrangement called the "Belmonter." The buttons make chassis removal a little tricky.

You have to to remove the tuning knob, which is always on the side of the cabinet with this type of tuner, before removing the chassis.

WARNING: Don't try to pry the tuning knob off in the usual manner. You'll break it, and then you'll have to glue it back together. There is a screw through the center of the knob that is covered by a decal or possibly by some sort of slug. That screw must be removed first. Then you can unscrew the chassis bolts, remove the volume control knob and then remove the chassis. Of course, it's not necessary to remove the chassis just to tune up the push buttons. Just loosen the tuning knob's lock screw and you'll have no problem.

The tuning system works like this. There are five heart-shaped cams mounted on an extended ganged-tuning shaft. Pushing a button causes the roller part of the mechanism to rotate the cam until the roller part falls into the low spot on the cam. To set a button for a particular station, the station is tuned in with the tuning dial while holding down the button. Then the locking screw is tightened.

Belmont's pushbuttons require less operating force than many others, due to the elimination of the leverage devices, and to rotating the cams directly against the shaft of the tuner shaft. It's interesting to note that pushing the buttons of many automatic tuners actually requires more physical effort than simply rotating the tuning dial!

Here's a few hints on how to set up a pushbutton tuner in an antique radio. Select only strong stations with low noise levels. Also, select stations that don't drift or fade. And any receiver that is prone to frequency drift should be serviced before attempting to set up the automatic tuning system. Last, let the set warm up for at least ten minutes before attempting to set up the automatic tuner. Otherwise the station is liable to drift, so your work will have been in vain.

Motor drive

For those who didn't want to expend the energy necessary to operate a pushbutton tuner, and whose pocketbooks could afford an alternative, there were motor-driven and motor-assisted tuners. Among others, Gilfillan, Zenith, Stromberg-Carlson, United American Bosch, and Crosley manufactured motorized tuners.

Motorized tuners were available in several variations depending on whether the pushbuttons or the tuning dial was motorized. With some, it was necessary to fine-tune the station after letting the motor do its thing. Provisions were made for muting the audio output while the motor was operating so that no objectionable noise would bother the listener.

One thing all automatic tuners have in common is that they are designed for easy use by the consumer. Adjusting the tuning buttons was easy with the *Teledial*, for example. Even systems like the Belmont that require a little effort could be used easily by the average consumer.

Service hints

Adjusting the automatic tuning mechanism should be done only after the set functions normally.

continued on page 87

MARKET CENTER

SATELLITE TV

STEREO TV adapter kit Easily converts any TV/VCR to receive the new stereo TV sound. Contains all parts PCB and instructions to build a quality stereo decoder. For additional information send SASE to **SOKOLOWSKI**, Box 150, Elmont, NY 11003.

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COMPUTER DIGEST

VOL. 3 NO. 6 June 1986

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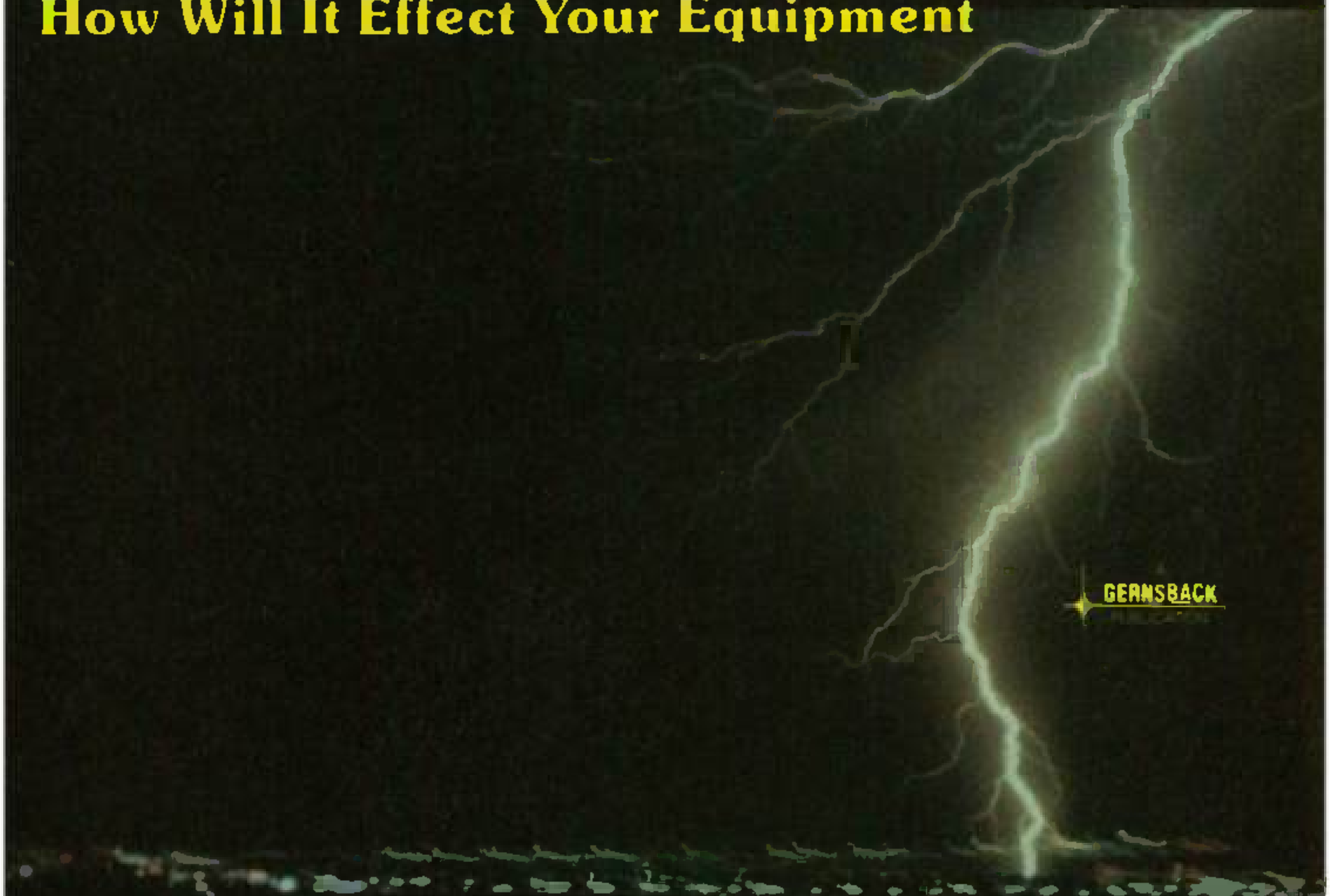

LOCAL AREA NETWORKING

Computers Working Together

THE GENERAL PURPOSE INTERFACE BUS

All You Should Know

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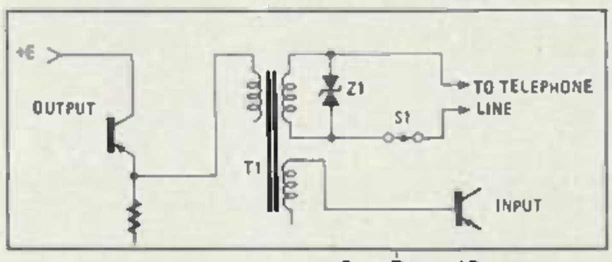

See Page 10

ON THE COVER

Lightning can put on a magnificent display but it has frightening overtones. Just how protective is the protective equipment you've installed? Is your system *really* as safe as you think it is? Our author relates a close call. See Page 10. *(Photo courtesy approved lightning protection, Elmont, NY.)*

COMING NEXT MONTH

If you can't get your modem talking, you might just find the answer in this fact-filled article, More On Modems. And when you need an interface that will make things work together that weren't designed to, you might get some excellent use out of this Protocol Converter that we show you how to build. There's something new in Touch Screen Technology, called Surface Acoustic Wave, and we'll fill you in on that too. Of course, you'll find our usual mix of Computer Products, Software Review and Letters to the Editors. Don't miss it!

EDITORIAL

"If I give a man a fish...

He can have dinner. If I teach him *how* to fish, he can eat for the rest of his life."

A friend opened a school to teach computing at a commercial level. He made the courses available (with suitable grants) to the underprivileged, and envisioned hundreds, even thousands of graduates going out and earning salaries well-beyond their ken when they started the course. The students flocked to the school. To them, it represented an opportunity to learn a valuable skill at little or no outlay of cash.

But a strange thing happened. While many *began* the course, only few completed it! The first part of the course included typing, and this was followed by key punch. It was only after the student had mastered typing and key punch skills that he sat down to a computer keyboard. But very few were actually getting to the computer. They were taking the preliminary skills they had learned to market, and were getting jobs as typists or key punch operators. Certainly, the salaries they earned were not as great as a computer operator could command, but they were far in excess of what could have been earned in a factory as an unskilled laborer.

How many young men have dropped out of high school to take jobs as gas station attendants or truck drivers, because the minimal salaries offered sounded like manna to a single youth? How many have been lured into civil service positions with meagre incomes, eyeing the 20 year retirement? And how many of these could have led far-more prosperous lives, making a far-more meaningful contribution to society, had they but continued their educations?

A very-wise employer, early in my career cautioned me that "meagre security has been the downfall of many an otherwise good man." If you're a youngster, reading these words, please think twice, even three times before you bring your education to a halt. Raise your sights. There's no telling *what* might lay in store for you if you do.

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

Saving Copies

I'm sure we share a common problem. I tear out and save my **ComputerDigest** but have been wondering if you've found a better method than just stacking them? S. T., New York, NY.

Get what is called a "presentation folder" at any office-supply store. This consists of a clear plastic folder with a slide-on plastic backbone. If you cut the plastic folder right along the fold, you'll find that this setup neatly holds a full year's worth of the magazine.

College bound

I'm going to be starting college shortly, with an eye to a career in book or magazine editing. I'm sorry, but you are on my list of editors to write to for advice. What courses would you recommend that I take?—R. J., Bridgeport, CT.

R. J., you'll have to take the usual English lit and composition courses, as well as journalism courses. But do make it a point to get in some time on computer word processing! This will speed your output, make you more accurate, and it's the wave of the future.

Computer "Heroes"

I've heard people involved deeply with computers described as everything from "nerds" to "eggheads." Considering that they've managed to accomplish so very much in this scientific field, why aren't they given the recognition they deserve?
—S.D., Atlanta, GA.

Next time you hear a computerist being put down, notice who's doing the putting down. It's probably some computer illiterate! Usually, it's just jealousy talking.

More help

My very kind, well-meaning father bought me a Commodore Plus-4 from a TV ad. Can anybody direct me to some software—ANY software for the machine? And is there an expert on the hardware out there that I can get some answers from? Please PLEASE write to Jerry Sadofsky, 4839 Manderson, Omaha, NE 68104.

Hope this helps Jerry.

COMPUTER PRODUCTS

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

PROOFREADING PROGRAM, *Sensible Grammer,* is designed to check word-processing files for common writing errors. It goes beyond conventional proofreading programs that check the spelling of individual words, and uses its library of over 1000 commonly misused English phrases to identify pompous, informal, cliche, vague, wordy, repetitive, and other faulty phrases. *Sensible Grammer* also catches many punctuation, capitalization, and other typographical errors, such as repeated words. It shows errors in context, automatically suggests replacement wordings, and lets the user immediately replace problem phrases with correct wording.

Sensible Grammer is fully compatible with AppleMouse and features a Macintosh-style user interface with windows, pull-down menus, scroll bars, and dialog boxes. A complete set of keyboard commands is also supplied for Apple *II* owners without a mouse. A 128K Apple *IIe* or *IIc* with 80-column display is needed.

Sensible Grammar is priced at $99.95.—**Sensible Software, Inc.,** 210 S. Woodward, Suite 229, Birmingham, MI 48011.

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The model *A-200* is IBM PC compatible and also has an IBM-style keyboard layout; it has the capability for many software packages now available. The suggested retail price is $2,295.00.—**Canon USA,**

CIRCLE 8 ON FREE INFORMATION CARD.

SOFTWARE REVIEW

Is there a "universal software?" No, but this comes close...

■When the going gets tough: When the communications circuit is loaded with garbage: When the data must be exchanged absolutely error—free, or when at least one station must be unattended, the software of choice for PC and MS-DOS computers is often Crosstalk XVI. In fact, Crosstalk is the "standard of reference" to which much software is compared.

With few exceptions, all personal computer communications software can do both ASCII (direct keyboard entry and ASCII files) and protocol exchanges, but unlike much of the communications software, which is primarily intended for ease of operation when exchanging ASCII text with bulletin boards and information services, Crosstalk XVI is oriented towards convenient handling of error-free protocol exchange using an automodem.

Crosstalk's protocol exchange is done in blocks of 256K (or a multiple of 256K) which are checked at the destination for accuracy of reception. If the program senses an error the system will keep retransmitting (within limits) until it's received accurately.

The main power of Crosstalk is that the originating computer automatically controls the host (receiving) computer—there is no need to have anyone in attendence at the host. The originating computer can open and close the receiving computer's buffer, write to disk, read from disk, get a directory listing, and even control several DOS functions such as DIR, DELETE and COPY. In the protocol mode all functions and the data exchange are automatic, with the originating computer automatically controlling the write to disk at the host.

Just about every Crosstalk parameter is indicated on a status screen that can be instantly switched to a blank screen for data display of text or messages. Among the parameters shown are the telephone number of the receiving station, all the communication parameters such as baud rate, mode (originate or answer), the state of the capture buffer (on or off), the filter settings, and the automatic send control settings. The filter setting controls such things as automatic line feed after carriage return, filtering of all control characters, and automatic stripping of a received eight bit, etc.

The lower section of the status screen is either a library of lesser-used commands and functions, or a directory of "command files," which are basically saved status screens for individual computers and information services such as CompuServe, MCI, Dow Jones, etc. Status screens are automatically assigned a key number when saved to disk: Simply entering the indicated number loads the pre-set status screen conditions and automatically dials the telephone if you're using an automodem. (In the initial installation of Crosstalk a menu selects the proper modem commands for all commonly-used automodems, and some that are not so commonly used.)

Changes to the screen status can be made at any time by entering the first two letters of the function into a command line which runs across the bottom of the screen. For example, to change from full to half duplex the user need type only DU (plex) on the command line. To select a specific key to function as the transmitted BREAK the user simply enters the command BR (eak) and presses the key he wants to use as the Break key. Similarly, the user can force the program into the originate or answer mode through the MO (de) command. A rather extensive help screen can be called up for any function by entering HELP and the first two letters of the function on the command line.

Although Crosstalk XVI is intended to run on 16-bit PC/MS-DOS computers, it can also do protocol exchanges with 8-bit CP/M computers that use the CP/M version of Crosstalk. Even if one computer is 8 bits, when serving as a host (answer mode) Crosstalk provides two levels of protection against unauthorized use or meddling with the disk files. The first is a password of up to 12 characters: If the correct password isn't given on the third try Crosstalk causes the modem to disconnect from the line. (Yes, the password protection can be disabled.) The second level of protection are file attributes. Through the host's status screen the originating station can be permitted to have full access to the system (including DELETE), read only, write data into an existing file ("capture data"), or append data to existing files or create new files.

Macros or commands can be programmed into the computer's function keys in three levels: Ten normal, ten shifted, and ten control. Function key F4 is an answerback which sends a user prepared string when polled by a Control-E from the receiving or host computer: It's the way in which many Telex and eleconic mail services automatically determine the user's account number or identification.

A particularly advantageous feature is user programming of both the printer and modem parts on the status screen (so a particular configuration is saved in a command file). Crosstalk is not limited to COM1: for communications. If the printer is already connected to the computer through the COM1: serial port, Crosstalk can use COM2: for the modem, or vice versa. You arrange the printer and modem ports the way you want them.

To make the program "universal" Crosstalk also has the XMODEM protocols. The RXMODEM command tells Crosstalk to receive an XMODEM file transfer, the XXMODEM command tells Crosstalk to send a file using XMODEM protocols.

We have touched on only the major highlights of Crosstalk: Those that insure data integrity, which is what it's really all about. Although Crosstalk can be used with a manually switched modem, and like all other communications programs can be used for conventional ASCII exchange, it is really easiest to use in the automodem and protocol modes.

Crosstalk XVI is intended for PC/MS-DOS computers. For additional information write to Microstuf, 1000 Holcomb Woods Parkway, Rosewell, GA 30076.

LAN—
Local Area Networking

How to get lots of computers handshaking—and why.

Forrest Stone

■Broadband! Baseband! Twisted Pair! Star! It's enough to confuse even the most dedicated computer hobbyist, but, Local Area Networking is the wave of the future for many people and these are some of the terms that a network user will be confronted with.

Local Area Networking has developed a terminology all its own. There are nodes and servers; tokens and CSMA/CD, and much more. What it really boils down to is a system of linking microcomputers into a shared network where each micro has access to the system's resources. (See. Fig. 1)

If this system sounds similar to the mainframe or minicomputer worlds with their linked terminals and shared system resources, it should. A microcomputer Local Area Network is a microcosm of a typical mainframe network. But, when you move to Local Area Networking in the microcomputer world you gain an added bonus, you retain the versatility of the microcomputer, while gaining the capability of a much larger system.

Think of your first microcomputer installation. If you've been involved with this hobby long enough then it was probably a small eight-bit system whose storage device was a cassette recorder. The next big advance in this system was the move to a floppy disk and the addition of a printer. At each point, the system gained capability. Eventually, your eight-bit system probably gave way to a 16-bit system, which may even include a 5- or 10-megabyte hard disk, as well as color-graphics capability. Compared to your first system, this is a quantum leap in its capacity and flexibility.

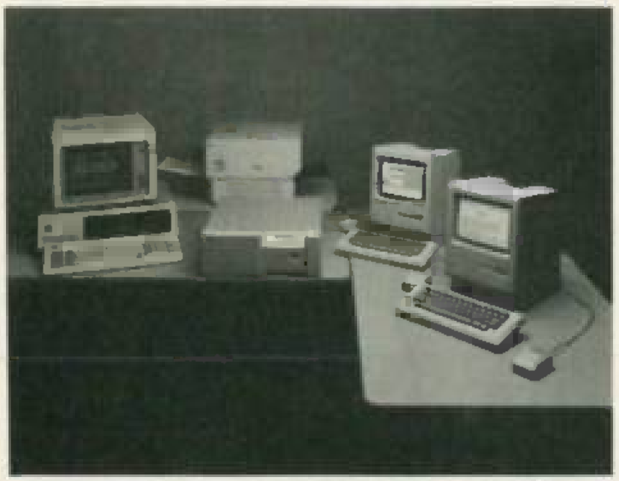


FIG. 1—3COM'S ETHERNET is a shared system with each micro sharing system resources.

For most single users, this type of system is more than adequate—you can move up to a high-speed, high-powered 32-bit processor, to stay at the cutting edge of technology, but for most single users, this type of processor is overkill—it can easily handle any chore. But, a funny thing has happened in the corporate environment. Users want to have access to the corporate mainframe or minicomputer, while retaining the off-line personal computing power of a microcomputer.

They want to use the data contained in various mainframe databases; or want access to the mass storage capability of the system, or, they may simply want to communicate with someone on an electronic mail system.

Whatever the reason, it's at this point that the single-user microcomputer system begins to show its

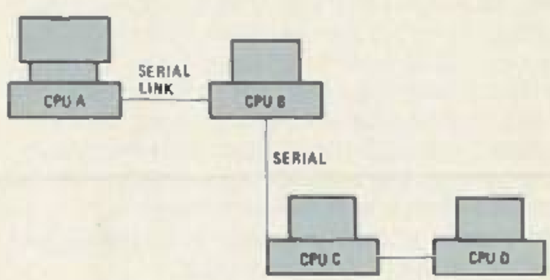


FIG. 2—THE SERIAL NETWORK looks eminently workable, but does have its problems.

inadequacy. Because of its standalone nature, the single-user system is effectively cut off from the rest of the corporate world, unless, of course, a communications modem is attached to a serial port. In that case, the micro can conceivably interact with others in the company. But this is inefficient because of the need for a telephone line on both ends. Effectively, this microcomputer can only interact with a remote, online database or with only one other corporate microcomputer.

Search for solutions

When this point is reached in any corporation, microcomputer users begin to look for alternatives. The simplest and most obvious solution is a serial communications network, or linking the serial communications ports of all the microcomputers involved. While it appears feasible, this type of network has inherent problems. (See Fig. 2)

First, when you daisychain microcomputers into a serial network, the systems on the farthest end of the loop will find performance degraded, unless line amplifiers are included in the network. Further, the speed limit on this type of network is effectively constrained to about 9600 bits per second, providing of course, that the environment is clear of interference which can glitch data as it moves through. This puts an effective limit of between 4800 and 9600 baud on the network and while this may seem fast enough, when you move massive amounts of data from one point to another, you'll find this speed level limiting.

Second, the software needed to make this type of system work—a terminal or communications program—is still essentially for single use. Although some programs will allow you to set up microcomputers as mini-bulletin boards so that others can log on and interact with the information stored on disk, it is still essentially one user-one computer, whether it's remote or not. For example, if you turn your personal computer into a mini-bulletin board so others on the serial network can use the data you have stored on disk—provided the software will let you do this without a modem. And someone wants to log onto your computer. When he does, others are locked out until the job is finished because of the single-use nature of the software.

Finally, the very nature of a serial system imposes real threats to data integrity and transmission within the system because of a factor known as contention or the ability to remain in control of the network long enough to transmit, receive or manipulate data before you lose the system to another microcomputer's data and signal.

A serial system is truly contention-based. It's every user for himself and every data bit for itself. It's like a rush-hour intersection with a broken traffic light and no policeman to control traffic. Only those cars whose drivers push through will make it, timid drivers don't. And, when two aggressive drivers meet, there's the inevitable crackup. To bring this back to the computer realm, put microcomputers in place of the cars and change the intersection to the serial transmission system and you can see what's happening. Data from the strongest microcomputers, usually at the center of the system, controls the system and weaker, peripheral systems must wait and wait.

And when two strong computers try to capture the system, their data usually crashes into one another and its integrity is gone.

Enter the LAN

The obvious solution to this situation, then, is the Local Area Network. It allows users to share system resources and data, while, at the same time, allows users to retain the versatility and power of their personal computers.

In concept, the Local Area Network (LAN) is simple. It is a reliable version of the serial network we've already discussed. However, you'd think from all the jargon that's tossed around relating to LANs, that it was a mystic rite. It isn't, but it does take some explanation to demystify the jargon.

As you wade through the LAN jungle, it's easy to become confused by the seemingly endless variety of systems on the market. A wide variety of LANs does exist, but, they can be identified by their transmission technology, cabling or configuration.

For example, there is one type of LAN which uses PBX (Private Branch EXchange) technology to link all its members. The PBX has traditionally been used to link phones throughout a building and then onto the common carrier network.

Manufacturers of PBX-based systems, traditionally such companies as AT&T, Northern Telecom and ROLM, see the existing base of telephone wiring—twisted pair—installed in major buildings and hope to take advantage of it by using that wiring to link personal computers into local area networks. It is true that this presents a cost-effective way of handling cabling, but it does impose speed penalties. Because the data

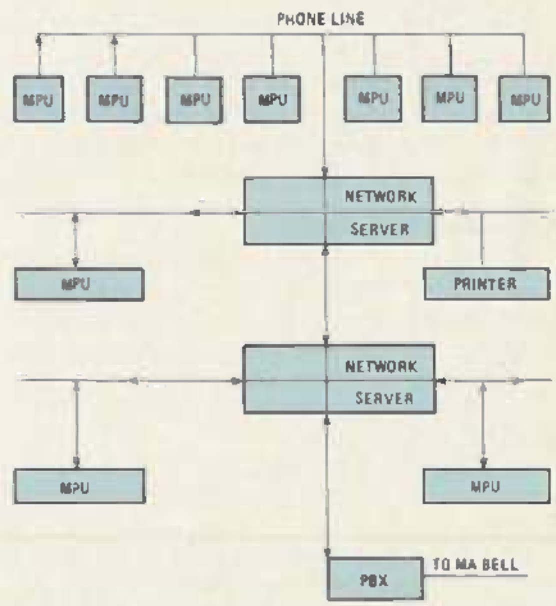


FIG. 3—SIMPLIFIED VIEW of a building's phone wiring and PBX LAN. System uses existing wiring and PBX loop to link CPU's and microcomputers. It has a high limit of 19.2 kilobaud.

transfer rate of PBX technology is only on the order of 9600- to 19,200-baud, it may not be high enough to handle massive amounts of speedy throughput. Data transfer rates on the order of 56K baud are needed to make this type of system effective and even that is a minimal figure in a fairly active network. (See Fig. 3)

When you move away from PBX-based LANs, you enter a realm which requires the installation of separate cabling systems to handle data transmission (even our mythical serial system requires a separate cable). The advantage of this type of LAN is that you can implement broadband or baseband technology.

In a broadbanded system, several discrete channels of information are transmitted on a single cable. It is a complex technology. A simpler solution is baseband technology. In a baseband system, there is only one channel per cable and you can effectively increase the data transmission rate beyond that of either PBX or broadband systems.

Typically, transmission rates in a broadbanded system—Interactive Systems/3M and Sytek offer them—are relatively slow on a per-channel basis at 19.2K- to 56K-baud, although they are much higher than on PBX-based systems. The real savings comes in cabling an installation. Several channels can be superimposed on a cable and because the several data transmissions can occur simultaneously, the amount of cable used in a system (most used coaxial cable) can be kept to a minimum.

Against this savings, there are increased costs for the installation in the form of extra equipment and costly maintenance. A broadband system requires the installation of an RF modem at each network node. These devices translate the analog signals used on the cable into digital signals so that they can be used by the microcomputers and other peripherals on the network. Further, this type of system is more costly and time-consuming to maintain.

Like broadband technology, baseband handles much higher transfer rates than PBX-based systems—some as high as 1 megabit have been implemented. It can also integrate other concurrent applications, including voice and video data transfer. The leaders in this market include 3Com and Ungermann-Bass.

LAN protocols needed

Although LAN technology looks formidable, it isn't. It's just a way of hooking microcomputers into a shared-resource network. Like our allusion to the intersection, each network needs a "traffic cop" to work efficiently. Otherwise, data would continuously crash into other data within the network and little would be accomplished.

The leading protocols are carrier-sense multiple-access with collision detection (CSMA/CD) and token-passing.

With CSMA/CD all microcomputers on the network have equal access to the network and its resources. The software which drives this type of system continuously monitors data on the cable and keeps things in order. For example, if microcomputer A has accessed the system and is moving data to a file server—an intelligent storage device such as a hard disk or a microcomputer equipped with a hard disk that is serving in data storage or transfer role—and microcomputer B wants to access the same server. In a CSMA/CD system, the software will determine which data has priority—actually which one accessed the system first—and will allow that data through. Data from microcomputer B will be held until the network is free for access. Typically, this is all transparent to the user.

In a token-passing scheme—advocated by Digital Equipment and Xerox in their Ethernet—the software polls each microcomputer node in turn asking if it must access the network. If the microcomputer is busy, it returns no answer and the system moves along to the next microcomputer. Polling is handled through the token, which is actually a coded sequence to which each microcomputer responds.

Like passing a baton in a foot race, each microcomputer that is accessing the system takes hold of the token when it arrives and this tells the network to accept its data. When the data is put on the system, the token is freed to pass to the next microcomputer. In this way, data retains its integrity and there is order within the system. It's much like a major highway control system with timed traffic lights. It allows orderly entry from side streets (microcomputers), while minimally disrupting overall traffic flow. And, it prevents collisions.

Network configurations

As you deal with baseband LANs, you'll find three predominant configurations, the star, ring, and bus.

In the star configuration, the network is laid out similarly to the spokes of a wheel. Each microcomputer is at the end of a piece of cable that is, in turn, connected through a central switch. Data is sent to the switch where it waits until the network is free to accept it. Likewise, data which is being sent to each terminal waits at the switch until the terminal is ready to accept it. (See Fig. 4)

The ring network is a closed loop system, with each terminal along the perimeter of the system. Many of the ring systems on the market use the token protocol. (See Fig. 5)

The last configuration is the bus. In this type of installation the network is laid out as a backbone with each microcomputer at the end of a "rib." Information travels down the "ribs" and onto the main bus where it waits until it can be moved down the network. (See Fig. 6)

In all of this, there is a common theme, communication. Like our simple serial system, the LAN is simply a communications system which links and allows all the microcomputers connected to the network to have access to system resources. The typical configuration can be for as few as three machines or for as many as several hundred, depending on the needs of the organization. In a large system, a mainframe or minicomputer is usually used to drive the network. The network can be configured to use the storage capacity of the mainframe or mini, although local storage can also be made available to various network nodes through file servers. Nodes are system devices such as microcomputers, servers, printers or modems. Any device capable of interfacing with a microcomputer can serve as a node.

File servers are microcomputers themselves. For example, a 3Com server uses an 80186 central processor with an 82582 Ethernet coprocessor. Included with this configuration is 512K of RAM. The processor, coprocessor and RAM are all included on one board. The server also includes a 36-megabyte hard disk with a 30 ms average access time. In its own right, it is a powerful computer system. In other systems, hard disks can have as much as 60 megabytes of storage. Many systems have three or more servers in their configuration, each of which interfaces not only with the microcomputers on the network, but also mainframes, if they are used to drive the system. To insure data backup and reliability, most systems also include tape backup systems.

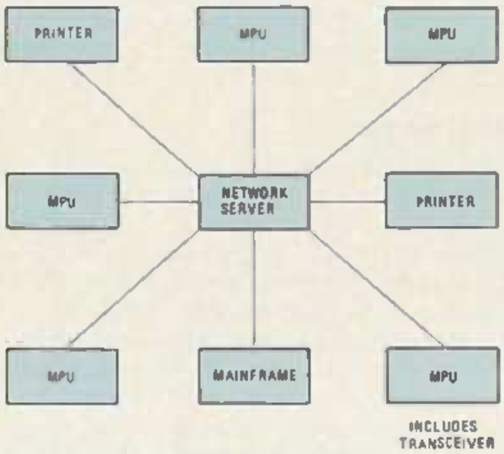


FIG. 4—SIMPLIFIED STAR configuration shows components arranged as the spokes of a wheel.

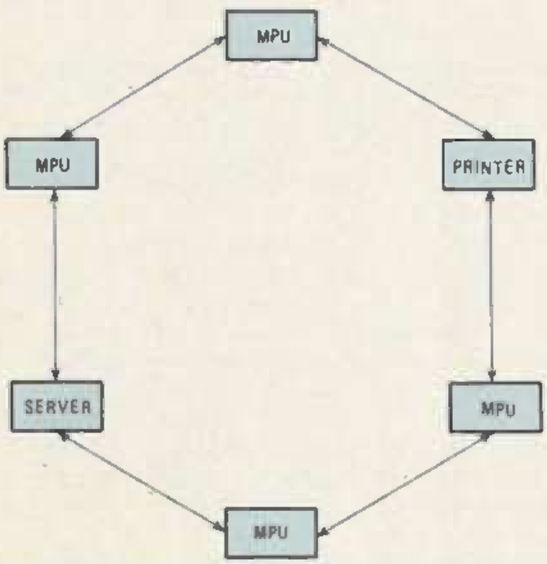


FIG. 5—THE RING CONFIGURATION connects all components in a circular fashion.

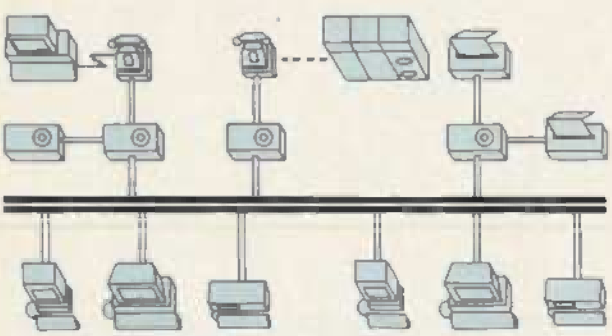


FIG. 6—THE BACKBONE LAN has "ribs" connected to a "spine." Components are connected to the ends of the "ribs" as shown.

LANs are more than just linking microcomputers. A LAN allows users to share system data and storage capacity, and printers, plotters and more. In fact, it makes sense in a network where a laser printer is used because each microcomputer user has access to its capability and it also helps justify the laser printer's cost.

Software's the key

As you would expect, installing a LAN involves more than just linking microcomputers. In a typical 3Com system, each microcomputer has a network transceiver board installed on its motherboard. This transceiver is the link to the network and allows the microcomputer to interact with it. It is the mailbox to which data is sent and received. The cable is attached to it and it is the device which the network software talks to.

When a transceiver is ready to send data to the network, a special software code is generated. It is a query code and an announcement. The query segment polls the central system node to see if the LAN will accept data from the microcomputer. This "Here I Am" code packet is held until the network is ready to accept the data. When the system is ready, it answers the query code with an acknowledgement and the data is transferred to the system.

Each transceiver has its own special address code. This code enables the system to send data to a particular device or microcomputer and, likewise, it enables one microcomputer to send data to another via the network.

Cable types

When you talk about LANs, the last thing that is usually mentioned is the type of cabling. In general, LANs use either coaxial or twisted pair technology. PBX-based systems usually use twisted pair—phone cabling—technology, while broadband or baseband systems use coaxial cable. This isn't to say that a baseband system can't use two-wire, twisted pair technology because it can. On the whole, coaxial, triaxial, too is used for most applications.

As you can see, the LAN will make a great contribution in areas where it makes sense to share resources and if you're involved in the switch to a LAN, there's only one thing to remember: it's basis is network communications; the jargon used is secondary to its mission.

WHEN LIGHTNING STRIKES...

Lightning strikes can be a problem for your computer.

Herb Friedman

■Before the age of electronics, the fear of lightning was not so much its immense electrical energy but the fire caused by the "hit" or "strike." Lightning protection meant some means of directing lightning to where it wanted to go—to ground. This was done by installing grounded metal rods—lightning rods—on top of houses, barns, windmills, whatever. The purpose was twofold. It grounded the energy and it conducted the energy around the structure.

With the electronic age, we inherited the worry of the electronic field produced by the strike. Very high fields are built up in the ground during an electrical storm. The ground field can track under a charged cloud and travel for miles before anything occurs. When the charge between the ground and the cloud becomes sufficient the energies attract and we get the lightning strike. At the moment of strike there is an enormous discharge of ground energy, which creates a rapid expansion and collapse of a local electric field. Any collapsing or expanding field induces both current and voltage in wires. Although lightning might strike a tree in front of a house, the energy field produced during the strike can induce high frequency transient voltages in antenna lead-ins, power lines and telephone lines located 50 to 100 feet or more from the actual hit.

Lightning arrestors

While a lightning arrestor can protect antenna lead-in wires from direct hits and devices such as Zener diodes and MOV's (Metal Oxide Varistors) can protect conventional electronic equipment against powerline surges, microprocessors and other electronic devices are often "blown" by transients induced by the lightning strike which are not of sufficient power to trigger a lightning arrestor, but which are strong enough to blow discrete components. There are many instances on record where the voltage surge induced in electric, telephone and antenna lead-in wires by a local lightning hit has been known to zip through the wiring and blow a TV tuner or the microprocessor of a personal computer, even if the computer is turned off or disconnected from the power line.

Even if disconnected? Yes! Solid state devices—particularly microprocessors—are senstitive to external high-frequency voltage surges because the surge can enter the equipment through any external wire connection, not just the power line. While low and medium frequency AC can be stopped by an open switch, an RF choke or a small reactance, high-frequency energy, such as that produced by a lightning strike, can leap across open switches, couple from one wire to another through otherwise insignificant capacitive coupling, even pass between insulated transformer windings. While we have made great strides in squashing power line transient surges with devices such as the MOV and gas-discharge tube, technology has not caught up with the problems caused by lightning surges in personal computer equipment.

For example, electrical storms are unusual in my locality, we get one or two every five years or so. Between the previous one and this year's electrical storm, several computers and modems have taken up

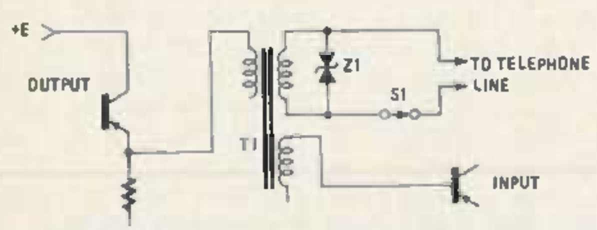


FIG. 1—THE BASIC ELEMENTS of a direct-connect modem's interface to the telephone line. Z1 is a surge supressor that squashes transient voltages appearing across the line to approximately 50 volts. S1, which disconnects the modem from the line, is usually SPST.

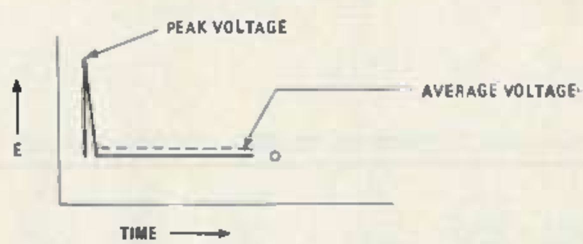


FIG. 2—THE LOCAL GROUND-DISCHARGE FIELD energy is almost an instantaneous rise and decay. This produces high-frequency energy through the upper VHF frequencies. In practical terms, it is high-voltage RFI.

residence in my home. In our most-recent electrical storm, lightning struck outside and disintegrated ten feet of curb. That was the only damage I thought, because my two computers were switched off, as were their modems. However, when I attempted to access an on-line information service, I discovered that both modems were blown, as was one computer's RS-232 driver (the one used for the modem). Coincidently, the same storm passed through the area 20 miles away where my office is located, and lightning had struck the grounded radio/TV tower on the building.

Since my regular modems were inoperative, I borrowed the office modem which had been switched off during the storm, only to find that it too, was "blown."

Interesting situation

Three modems of different design and manufacture had been blown during an electrical storm. All had some form of voltage surge protection, all had been switched off and one didn't even have a connection to the power line because it is powered directly from the phone line. A fourth modem, built into an IBM-PC which was connected on-line because it serves as a "host" for a voice message center, wasn't damaged at all!

What to do

As near as we can determine, the three "blown" modems were damaged because of the way they were switched to the telephone line. Figure 1 is a simplified diagram of a direct-connect modem interface. Transformer T1 is the coupling transformer (repeat coil), Z1 is the telephone line overvoltage or surge-protection device, and S1 is a SPST switch that connects the modem to the telephone line. Normally, a voltage surge on the line is squashed by transient supressor Z1, which might be a MOV, Zener diode, or gas-discharge tube. Usually, Z1 limits the surge to about 50 volts.

As shown in Figure 2, a voltage developed in the telephone line by a lightning strike in the general area will be a steep pulse. Although the average voltage—meaning the peak voltage averaged over a period of time—might be relatively low and safe, the peak value might be several hundred volts, and it is predominantly high frequency—extending well into the upper VHF range. High frequencies don't need a direct connection to pass from one wire to another. What is otherwise a minute capacity between wires and circuits, can appear to be "dead short" to high frequencies.

Imagine that the ground discharge of a lightning strike induces the transient waveform shown in Figure 2 on the telephone line connected to the modem circuit shown in Figure 3. Although S1 is open, disconnecting the modem from the telephone line, one wire is still connected to the line itself because almost all modems switch only one side of the telephone connection. We now have a high-frequency voltage surge on the telephone line which is looking for a path to ground. As shown by the dotted line in Figure 3, it finds the path to ground through the components in what we believe to be a disconnected modem. Notice that the energy represented by the dotted line flows through the capacity between T1's windings. The capacity might be very small, but it is there. To normal speech frequencies the capacity represents essentially an infinite imedance, but to the high frequency component of a lightning-caused transient surge the small capacity represents a low impedance, or even a "dead short," so the spike produced by the voltage surge passes through T1's secondary (telephone side) to the primary (modem side) to the modem's voltage supply bus. Now we have a high-voltage transient on what is usually a five- to nine-volt power bus. The result? ZAP!!! A fistful of blown IC's. If the surge is sufficiently high, it can ride through a blown IC in the modem and into the RS-232 driver, ZAPping another handful of parts.

You might ask why Z1, the modem's internal transient supressor(s) didn't stop the surge. Refer back to Figures 1 and 3. Z1 is conencted across the telephone line: It is supposed to clamp surges appearing *across* the line, between both wires. But when switch S1 is opened to disconnect the modem from the telephone line, the transient supressor has no effect on anything in the circuit. Z1 provides protection only when S1 is closed and the modem is connected to the line. This is probably why the direct-connect modem, connected on-line during the storm, wasn't damaged. Essentially, the risk of damage during an electric storm is increased when the modem is switched off the line.

My "cure"

Most likely, modems should be manufactured with a double pole output switch so that both sides of the telephone line can be disconnected from the modem. Until such time as the manufacturers get around to changing their designs, I have installed a DPST knife switch on each telephone line to make certain the modems are really disconnected from the line. The inconvenience of "throwing the switch" is a lot less costly than the charges to repair or replace three modems and an RS-232 port.

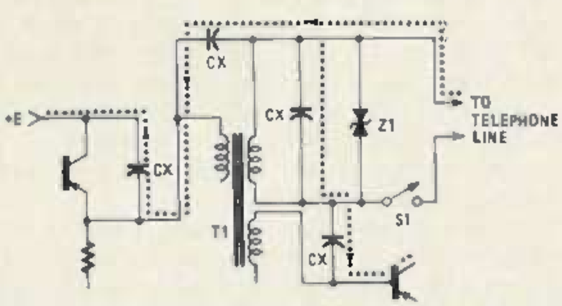
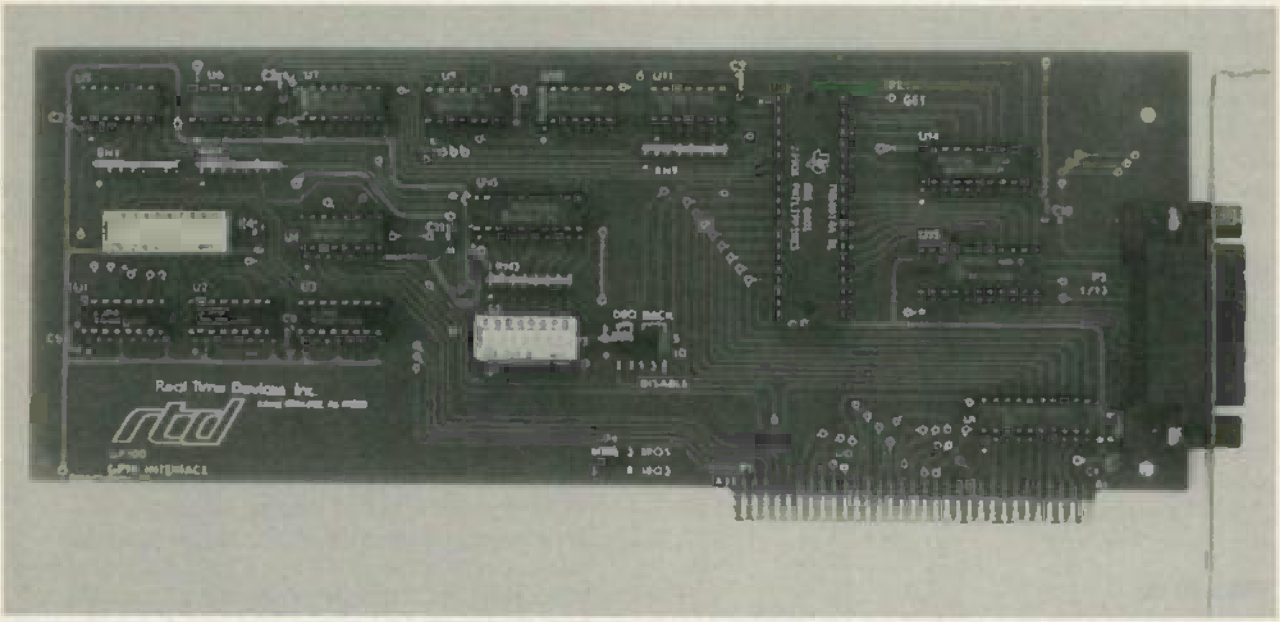


FIG. 3—CAPACITOR "Cx" IS THE NORMAL circuit capacity between transformer windings, solid-state device elements and component interconnecting wires. Cx is usually so small that it doesn't exist at audio frequencies but can represent a low impedance or "dead short" at the high frequencies of a lightning strike. When S1 is opened the lightning strike energy can follow the dotted path into the modem and eventually the high voltage bus where it is distributed throughout the modem, even to the modem's special driver.

GPIB

The General-Purpose Interface Bus...



REAL TIME DEVICES GPIB interface is shown here. It functions with all IBM PC and compatibles to expand the value of your computer.

Marc Stern

■ If you look at your test bench, chances are you'll see the General Purpose Interface Bus (GPIB) connector. Also known as the HPIB (Hewlett-Packard Interface Bus), its been around for some years and has become the standard for data acquisition.

GPIB was developed for tying one manufacturer's equipment together. But, because of the widespread use of that equipment in the scientific, test and measurement and repair arenas, it became standard. By the mid-1970s, it was formalized into the IEEE-488 standard. And even a computer giant such as IBM must use it rather than imposing its own.

Look at any modem test or measurement equipment that has a computer interface. You'll see it adheres to the IEEE-488 standard as to the size and shape of the connector; the construction, and the pinout.

Why not give your PC more function by having it interface with and act as part of your test equipment setup? It's easy to do, and, in fact, there are add-on boards on the market which will turn your PC into a machine capable of using the GPIB interface. One of the newer boards is from Real Time Devices of State College, PA. Other boards are available from the major add-on board manufacturers.

GPIB Basics

Before we go any further, there are several basics to be established.

First, GPIB is a 24-line communications bus that is made up of three primary groupings, an eight-line data bus, a three-line data byte transfer control or handshaking bus and a five-line general interface management bus. The remaining eight lines are for signal ground and provide electronic shielding to prevent bus signals from interfering with one another.

Second, there are four types of devices which can be linked to the GPIB, a controller, "talker," "listener" and "listener/talker." As you'd expect, the controller is the device which controls the network, while a "listener" is a receive device. A "talker" is a transmit device and a "listener/talker" is a device which can go both ways. It can transmit and receive on the bus. Prime examples include the PC as controller; digital voltmeter or frequency counter as "talker;" printer as "listener," and modem as "talker/listener."

Third, it's a programmable. As implemented on the GP-100, the GPIB can be programmed to more than 50 functions in not only BASIC, but also Fortran, Pascal and Forth. And, as implemented, it becomes the major input-output (I/O) device on the PC in a test and measurement setting. It can also serve as a listener/talker if the network is controlled by still another computer.

Finally, the GPIB relies on direct memory access to the PC. In this way, the board and PC can communicate at 476 Kbytes per second and the systems can exchange up to a megabyte of data with a single function call.

GPIB is a powerful tool, especially where huge amounts of data must be moved around a system quickly.

It can also be used in a more general atmosphere and can link up to 15 printers, plotters, modems or other devices into a small network.

Though the GPIB may seem a panacea, it isn't because, like the RS-232 "standard," IEEE-488 has been used differently by different manufacturers. So, it can be confusing to see a device advertised as adhering to the 488 standard, only to find out the device's lines are used differently. True, the connector may be the same and the lines may also be called the same, but, if a manufacturer implements them in its own way, then simply calling it standard won't make it so. Instead, you'll have to patiently debug the interface until it coincides with others.

Fortunately, most manufacturers adhere to IEEE-488 as does the GP-100, so you should have little trouble.

High-speed data link

One of the items which made GPIB successful from the outset was its speed. The bus can potentially handle up to 1 megabyte of data per second, although data transfer rates of 1 to 10K are more common. With this type of throughput, it's possible to have real-time data input to a micro, mini or mainframe system, which is crucial in scientific, test and measurement of manufacturing applications. With this type of speed measurements can give real-time indications of what is happening and a system can quickly adjust.

For the technician, the GPIB's speed is attractive. With the PC interfaced with test equipment, you can have indications on the screen of what's happening in a part of a circuit and, as you change inputs, you can see how the rest of the circuit is affected.

Another reason for the success of this circuit is its configurability. Since 15 devices can be quickly attached and configured to work with the GPIB, a system's configuration can be adjusted to constantly-changing needs. If you need constant voltmeter and current readings from two points in a circuit and must also plot them, you can quickly add the needed devices to the circuit and you can record the results for future use. Plugging the new devices into the appropriate GPIB connectors should achieve this, provided, of course, the network adheres strictly to GPIB.

Since this bus is programmable, it is possible to transfer data directly from one device to another.

Data's everywhere

The data which moves through the bus appears at all points simultaneously and there's a need to keep things in order. Imagine devices which have no need of the data accessing and using it along with the device for which it was intended. It's a waste of system resources.

Each device has an address and only when the controller sends a message to that address does the device react. Until then, it listens for its address to be accessed. For example, if the printer is at address 8 and you send output to the printer, the controller—IBM-PC in this case—puts an address 8 on the bus and the printer comes to life. Devices that aren't at this address ignore the information, even though it appears at their connectors.

There are two types of addresses, talk and listen. A device doesn't know what it's next role will be or if it will take part in a function until it is addressed on the GPIB. The talk and listen addresses take care of that. For example, if a device sees its talk address then it knows it has to send data along the bus. A device which sees its listen address accessed knows it will have to accept data.

In action, the first piece of information a device receives is its listen address. This makes the device aware that it will be receiving information from the bus. Once it is listening, the controller can communicate with it, but, only after the computer-controller puts its talk address on the bus. In this way, the device knows which peripheral it will be communicating with.

Sometimes the device acting as the listener must indicate something to the controller, such as a paper jam or dead phone line and GPIB allows it. Of the 24 lines on the bus, only 8 are used for data, while the rest are reserved for grounding or special use. One of these is the Service Request line. It can be used by any device to indicate a problem has developed or a request must be made.

All the devices attached to the GPIB use the same SRQ line and since they do the controller must have a way of finding out which devices need attention.

There are three ways of handling this, the serial poll, in which each device is polled in turn by the controller; the parallel poll, in which all devices are polled concurrently, or the selective parallel poll, in which each data line is polled and once the line is found with the device that needs service, the controller polls all devices on that line serially.

Bus lines

The GPIB has 24 conductors, whose functions can be thought of in three groups. (See Fig. 1)

The first eight lines of the interface are the data bus. These lines are used to transfer data from one point or device to another. Since there are eight lines associated with the data bus, it can transmit one digital word or byte at a time (eight bits).

The handshaking or data byte transfer control lines enable various devices to handshake with one another. Without this function, there would be no need for the data bus, since the devices couldn't "talk." A talker device must know when a listener is ready to accept the next data byte. The Not Ready For Data line supplies this information to the talker.

The Data Valid line tells the listener whether the information it is receiving is important or just noise. That line tells the receiver that the data is good.

The other part of the GPIB's handshaking is performed by the Not Data Accepted line which tells the talker whether the listener has accepted the data.

Ultimate control, though, is provided by the five general interface management lines: Interface Clear (IFC) is a reset; Attention (ATN) is a master bus command from the controllr; SRQ is the special request line; Remote enable (REN) enables the controller to issue special commands to devices on the GPIB, finally End or Identify (EOI) is used an an end of message signal.

GPIB operates with a low-true logic convention. Because of the construction of this bus and the fact that everything is tied in in series, everything stays low until the last device in the series has accepted data. This means handshaking continues throughout the data transfer and waits for the slowest listener on the bus.

IBM interface

The GP-100 board and others use direct memory access, which speeds the data transfer process to and from the PC. For example, using input-output and handshaking routines and programming them results in a data transfer rate that will be below 100Kbytes per second. That is because the program must observe the handshaking protocol of the device with which it is communicating. Direct memory access, however, allows the GPIB board to place commands directly in the PC's memory and thus communications can be speeded to 476 Kbytes per second. To implement this, you must know where the transfer will occur, the number of bytes, and whether the data will be input our output.

Boards such as the GP-100 can also issue interrupts to your PC so events that happen along the GPIB can be trapped and monitored as they are detected. The PC services the board and bus as soon as the interrupt is implemented.

GPIB has become a standard which began out of a company's desire to tie its equipment together with some order and certainty. It allows the technician to tie his PC in with his test equipment for a computerized testing system. In the future it will become a necessity as things get more complicated. By then, only a computer will be able to keep up. So, it's wise to start early and use GPIB to its fullest.

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129	.38	.35	.29	199	.18	.15	.12
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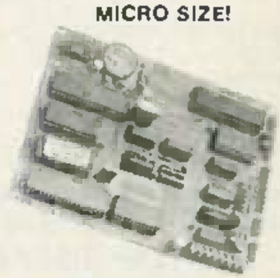

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ANTIQUE RADIOS

continued from page 81

Always complete alignment (and any other service!) before setting up the tuning buttons. If you only need to set the buttons, often that can be done without removing the chassis. Instructions for button-setting are often—but unfortunately not always—found on the back cover or inside the cabinet.

The Grunow and the Belmont are very similar in regard to servicing. Alignment must be done with the chassis removed, but the automatic-tuning adjustments can be done in-cabinet. However, the components used in each model differ greatly. For example, the tuning-capacitor plates in each gang of the Grunow are all the same size, so there is an extra padder in series with the oscillator coil to lower capacitance for the oscillator stage. The plates in different gangs of the Belmont, on the other hand, vary according to the needs of the different stages they are connected to.

Before attempting to align an antique radio, check the plates of the tuning capacitor for shorts. A scratching noise heard while rotating the tuning shaft is a good indication of shorted plates. The plates may be bent, or dust, coins, paper clips, etc., may be causing the short. You may be able to use a putty knife to straighten out bent plates.

Dust can be removed with a brush or a vacuum cleaner. If possible, the entire capacitor should be removed and washed.

Your restoration also includes the dial pointer. You should make it line up with the correct frequency. An automatic tuner makes a poor appearance if the pointer doesn't match up with the selected station.

Another problem with pushbutton sets is the pushbuttons themselves. The caps are often missing from them, and I have yet to find a suitable substitute. I'd like to hear your ideas.

That about wraps it up for this month; next time we'll discuss advances in early radio circuits. R-E

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STEREO AMP

continued from page 68

Switches S8 and S9 in the *Dubbing Select Circuit* operate similarly to the other switches in that section, except that they drive a 4013 "D" flip-flop, rather than an RS flip-flop built from gates. The RC networks connected to S8 and S9 debounce those switches. The outputs of those flip-flops are connected to the tape buffer circuit shown in Fig. 4.

The flip-flops in the *Dubbing Select Circuit* drive the A and B inputs of IC104 and IC204, triple SPDT analog switches that route the tape-recorder input and output signals to the appropriate places.

We should mention that the Q output of each flip-flop in the *Dubbing Select Circuit* controls the RESET input of the other flip-flop. That cross connection makes it necessary, when using the dubbing circuit, to turn off a circuit before turning on the opposite one. For example, if you're dubbing from Tape 2 to Tape 1 and want to reverse the operation, you'll have to press the 2–1 switch before pressing the 1–2 switch.

Next time, we'll finish up our discussion of the circuit's theory and then begin to build the unit. R-E

CLICK AND POP

continued from page 57

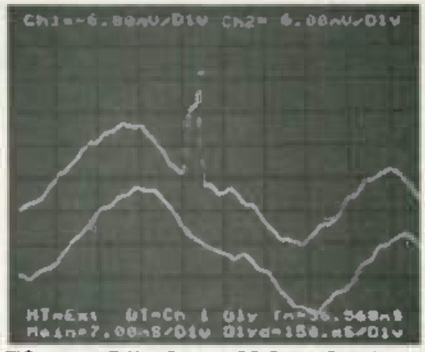

FIG. 11—THE UPPER TRACE SHOWS an input signal with a large scratch pulse; the lower trace shows how that scratch is removed, and how a smooth transition is made between the "from" and "to" portions of the waveform.

sound of both new and old record albums. A good record cleaner is probably the cheapest and most effective means of sound improvement. But beyond that, our Scratch Filter can provide such a dramatic improvement in sound that you'll wonder how you ever got along without it. The photo shown in Fig. 11 shows the kind of real-life performance you can expect from the device. Happy listening! R-E

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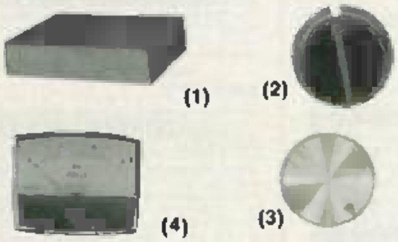

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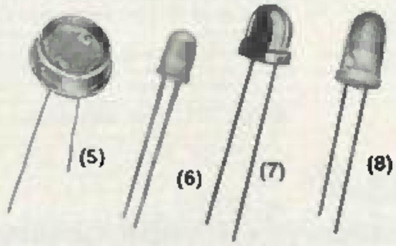

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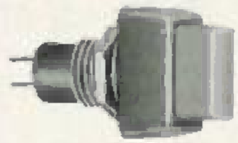

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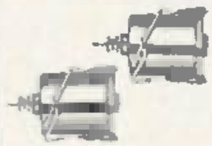

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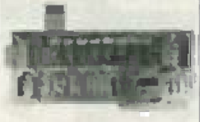

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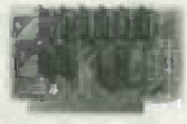

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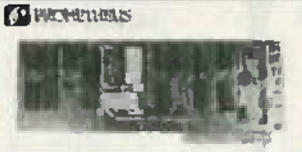

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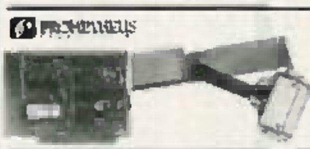

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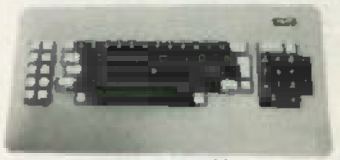

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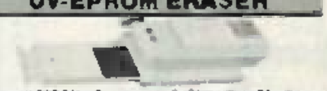

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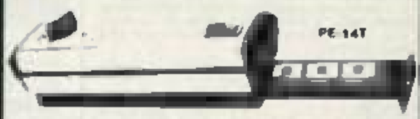

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74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.29	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.59	74LS259	1.29
74LS48	.69	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
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74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
74LS136	.39	74LS624	1.95
74LS138	.39	74LS640	.99
74LS139	.39	74LS645	.99
74LS145	.99	74LS669	1.29
74LS147	.99	74LS670	.89
74LS148	.89	74LS682	3.20
74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay) combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.99
74HC14	.79	74HC163	1.19
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.49
74HC32	.69	74HC245	1.49
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.89	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.99
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.89
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.49
74F08	.89	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.89	74F240	3.29	74F373	4.29
74F64	.89	74F244	3.29	74F374	4.29

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CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
4012	.25	4503	.49
4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	1.75
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C906	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74156	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.75
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.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	1.49
74S11	.35	74S196	1.49
74S20	.29	74S197	1.49
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.45	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.69
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

DATA ACQ / INTERFACE

DATA ACQ		INTERFACE	
ADC0800	15.55	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	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.69
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	1.49

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	Adj	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	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.18
28 PIN ST	.22	.18
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.45	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	4.79	XR2240	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	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
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	.45	MC4024	3.49
LM394H	4.60	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	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	2.80	75452	.39
NE592	.98	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

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

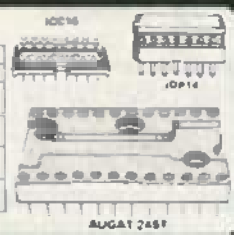
INTERSIL

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	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	...	.95	.95	...	...	...	1.75	...	2.95

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	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.29
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

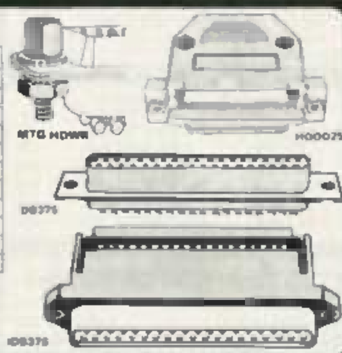
D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	3.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	...	1.95	2.65	...
	FEMALE	DBxxSR	1.25	1.55	...	2.00	2.75	...
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	...	3.89	5.60	...
	FEMALE	DBxxSWW	2.76	4.27	...	6.84	9.95	...
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	...	3.98	5.70	...
	FEMALE	IDBxxS	2.92	3.20	...	4.33	5.70	...
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	...	...
	GREY	HOODxx	.65	.65	...	.65	.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 ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	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

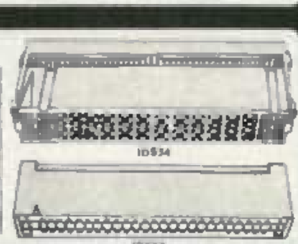
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.13
JUMBO YELLOW	T1¾	.14	.13
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

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	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	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	7.95	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	5.00	3.90

FOR ORDERING INSTRUCTIONS SEE D SUBMINIATURE ABOVE



SWITCHES

SPST	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
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 8 PIN DIP	1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	10'	COLOR CODED 1'	10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.35	3.20	.60	5.50
25	.48	4.00	.75	6.85
26	.48	4.10	.79	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER. ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

Dear Sirs:

I have dealt with JDR for years now, but I was recently lured away by other companies promising better services and prices. None of these companies were able to equal your service and low prices. I'm happy to say that I'm back to stay!

I think that when a company is able to serve it's customers so well, it deserves to be congratulated... I look forward to dealing with you in the future.

Yours truly, George Townsend

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XT COMPATIBLE MOTHERBOARD

$159.00

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- ALL IC's SOCKETED HIGHEST QUALITY PC BOARD
- ACCEPTS 2764 OR 27128 ROMS

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MODEL 190-9520
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- 16 TRUE COLORS
- 25 MHz BANDWIDTH
- RESOLUTION > 640 x 262
- .31mm DOT PITCH
- CABLE FOR IBM PC INCLUDED

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SAKATA
COMPOSITE COLOR
MODEL SC-100
- TOP RATED FOR APPLE
- 13" COMPOSITE VIDEO
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- INTERNAL AUDIO AMP
- ONE YEAR WARRANTY

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MONOCHROME
MODEL KLM-1211
- IBM COMPATIBLE TTL INPUT
- 12" NON GLARE SCREEN
- P39 GREEN PHOSPHORUS
- VERY HIGH RESOLUTION 25 MHz BANDWIDTH 1100 LINES (CENTER)

$99.95

20 Mb HARD DISK SYSTEM

INCLUDES ½ LENGTH HD CONTROLLER, CABLES, MOUNTING HARDWARE AND INSTRUCTIONS. ALL DRIVES ARE PRE-TESTED AND COME WITH A ONE YEAR WARRANTY.

SEAGATE ST-225

$489.00

BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

XT MOTHERBOARD	$159.95
PRO-BIOS	$29.95
256K RAM	$26.55
130 WATT POWER SUPPLY	$89.95
FLIP-TOP CASE	$49.95
DKM-2000 KEYBOARD	$79.95
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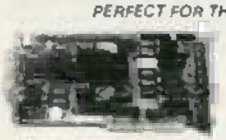

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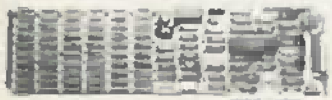

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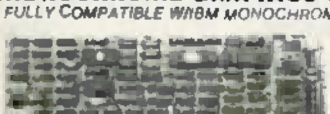

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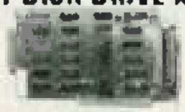

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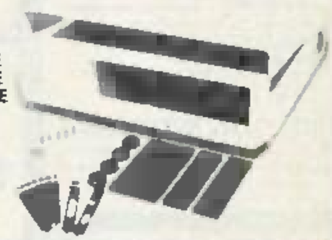

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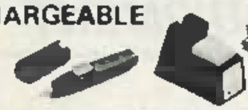

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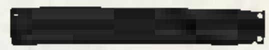
TA-2400A ELECTRONIC ECHO AND REVERBERATION AMPLIFIER

REMIX records yourself!



This unit combines the most advanced computer V.L.S.I. technique with high quality Japan Made component, so it has the following FEATURES:
It can generate various reflection and reverberation effect such as that in valley and music hall. It has a 3 section effect control which includes reverberation control, delay control and depth control. Special effect can be made in your record tapes by using this model. All kinds of infinit sound effect can be obtained by skillful use of this control. It has LED display to show reflection and reverberation.
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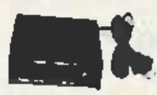
STEREO SIMULATOR

TA-3000



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TA-006	6W Mini Amplifier	Kit	$4.92
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TA-008	AC/DC SHOULDER AMPLIFIER	Ass	$48.00
TA-10	STEREO PRE AMPLIFIER WITH MAGNETIC MIC AMP	Kit	$6.00
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TA-202	20W AC/DC STEREO AMPLIFIER	Ass	$60.00
TA-300	30W Multi Purpose Single Channel Amp.	Kit	$11.07
TA-302	60W Stereo Power Booster	Kit	$50.00
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TA-322	60W IC Stereo Pre Amplifier & Power Amplifier	Kit	$29.50
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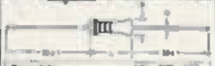

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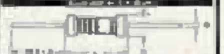

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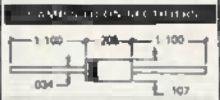

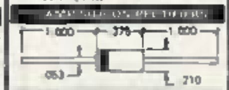

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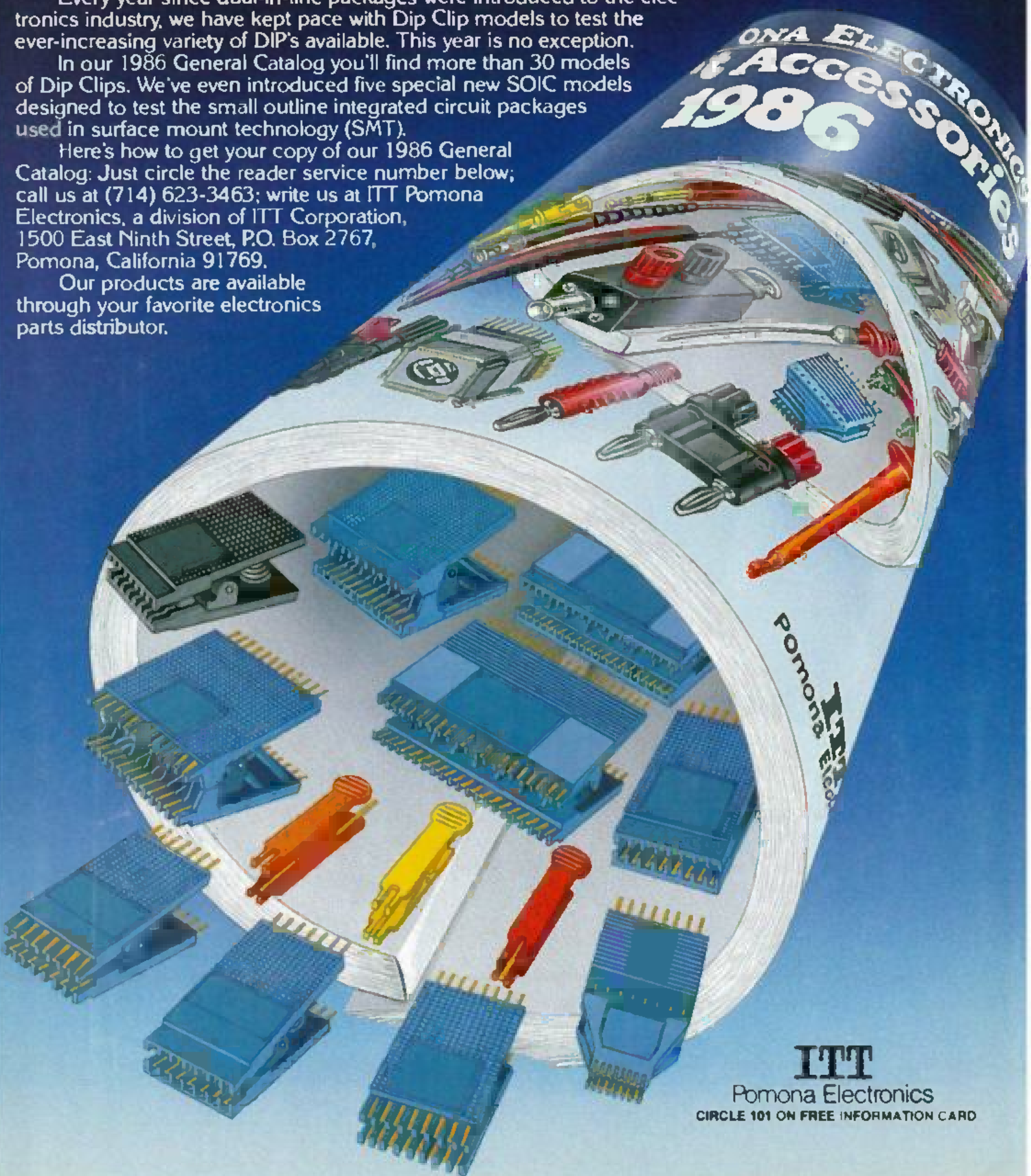

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