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Radio-Electronics

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THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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BOWLING-ALLEY GAME

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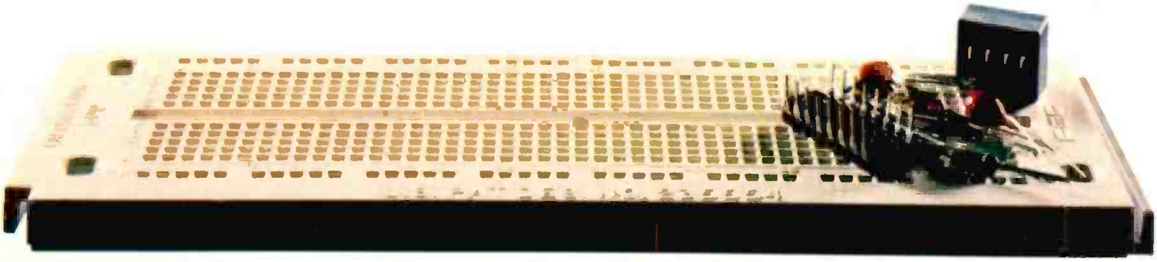
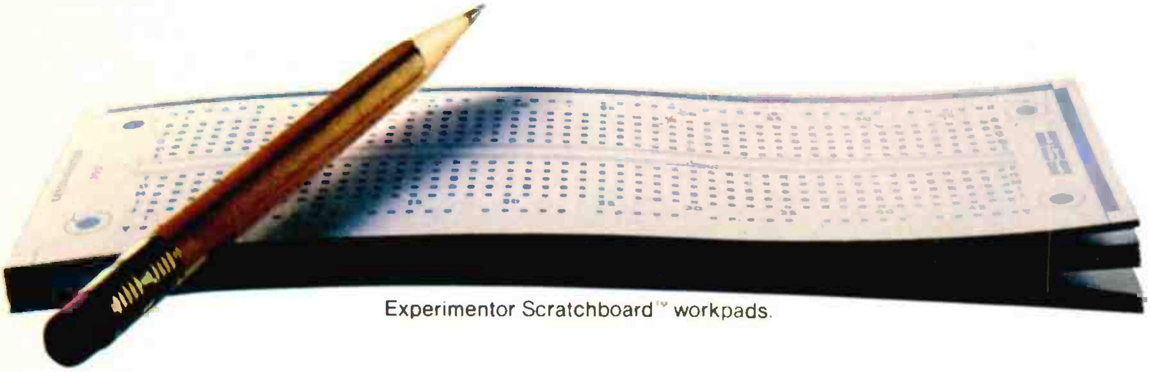


Experimentor solderless breadboard.



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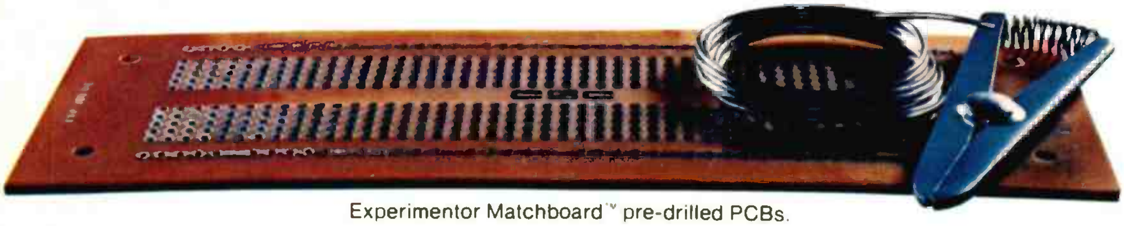

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CIRCLE 6 ON FREE INFORMATION CARD

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C1P: $349! A dramatic breakthrough in price and performance. Features OSI's ultra-fast BASIC-in-ROM, full graphics display capability, and large library of software on cassette and disk, including entertainment programs, personal finance, small business, and home applications. It's a complete programmable computer system ready to go. Just plug-in a video monitor or TV through an RF converter, and be up and running. 15K total memory including 8K BASIC and 4K RAM — expandable to 8K.

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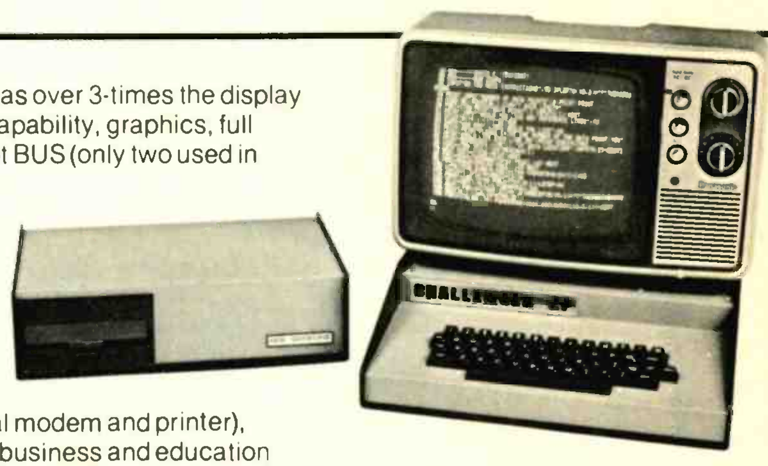

C2-4P: $598! The professional portable that has over 3-times the display capability of 1P's. Features 32 x 64 character display capability, graphics, full computer type keyboard, audio cassette port, and 4 slot BUS (only two used in base machine). It has 8K BASIC, 4K RAM, and can be expanded to 32K RAM, dual mini-floppies and a printer.

C2-4P MF: $1599! It's a big personal computing mini-floppy system at a special package price. Contains the famous C2-4P microcomputer with 20K static RAM, 5" mini-floppy unit for instant program and data loading, RS-232 circuitry (for optional modem and printer), and four diskettes featuring exciting games, personal, business and education applications.

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So simple a child can operate, the new CompuCruise combines latest computer technology with state-of-the-art reliability in a package which will not likely be available on new cars for years to come.

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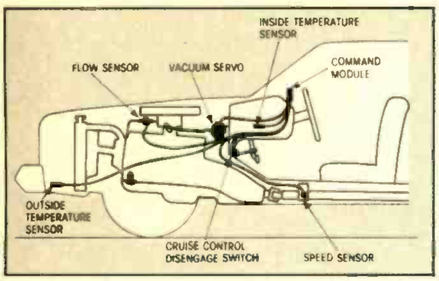
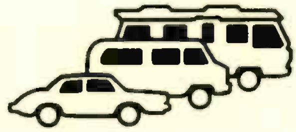


AIRLINE PILOTS COMPARE COMPUCRUISE$_{TM}$ TO SOPHISTICATED AVIONICS EQUIPMENT.

Similar to types of computers used on modern airliners, the CompuCruise slim panel-mounted control module contains a digital readout and back-lighted control buttons, both readily visible in the dark. By quickly learned systems of inquiry, the driver can elicit virtually any information relating to time, distance, fuel and performance of his vehicle.



There are a number of digital-type instruments on the market which can be purchased for your car, purporting to provide functional data on performance, but all are basically calculators, operating on fixed information provided by the driver.

CompuCruise is a true computer, operating from automatic data sensors which constantly react to changing conditions, automatically recomputing vital data every second. Each function operates independently, with data displayed and updated constantly until you change your request of the computer.

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Battery condition can be checked regularly, saving you from the potential embarassment of being stranded without warning.

TYPICAL DATA:

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YOUR COMPUCRUISE IS SMART! IF YOU PUSH THE WRONG BUTTON IT WILL LET YOU KNOW BY DISPLAYING "ERROR".

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You do-it-yourselfers can readily install the unit, but complete and detailed instructions are also included for the automotive service facility. CompuCruise units are fully operable on most foreign or American cars, trucks or RV's. At $199.95 the unit is only a few dollars more than the cost of cruise control alone on most vehicles, yet offers a whole new world of computerized management functions.

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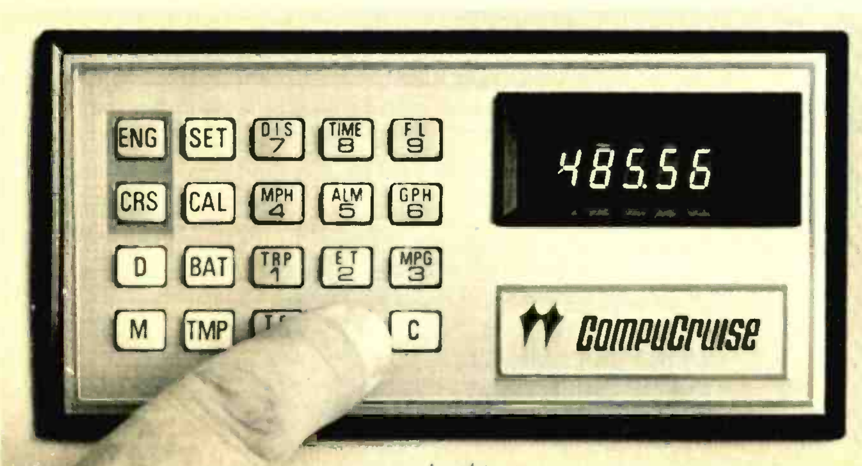
NOTE: Mountable on foreign or domestic vehicles including standard trans. **EXCEPT FOR DIESEL OR FUEL INJECTED ENGINES.**



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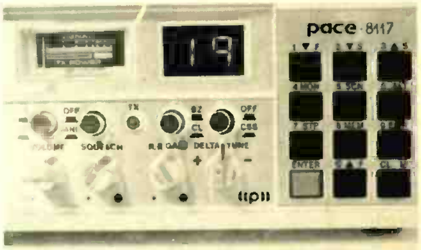
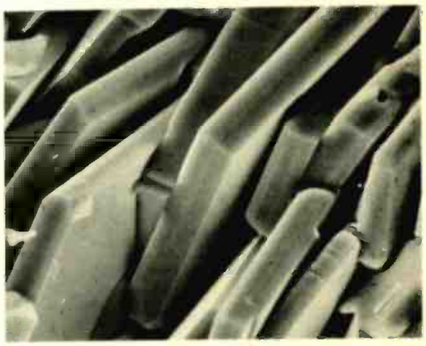
MAY 1979 Vol. 50 No. 5

ON THE COVER

A Time/Voltage Calibrator is a must if you have digital test equipment. It's the only way available to most of us to keep our test gear calibrated. Learn how to build your own calibrator. Story starts on page 35.



PACE 8117 is a computerized CB transceiver. For more data see our new Communications Corner on page 68.



TITANIUM DISULFIDE COMPOUND is used in new Exxon rechargeable lithium battery. Read the whole story starting on page 44.

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looking ahead

AM stereo: The battle for stereo on the standard broadcast band is taking some interesting new turns. Although the industry-wide National AM Stereo Radio Committee (NAMSRC) submitted field-test data to the FCC, the Commission seemed dissatisfied and asked for more broadcast testing and more information, with the indication that selection of a system would take longer than expected—if, indeed, the FCC decides to authorize AM stereo broadcasting at all. The second surprise was the choice by the ABC Radio Network of the Kahn-Hazeltine independent sideband (ISB) system as the one it feels "will best serve the interests of the broadcasters and the public." The ISB system, which carries left-channel information on the left sideband, right-channel on the right sideband, was not one of the systems tested by NAMSRC, although it is the oldest proposed system. ABC is currently testing the system on its New York station.

Teletext: EIA has established a special committee to evaluate various home video data systems and eventually establish standards for their use in the U.S. Several European countries already are using these systems, which present graphic data on home TV screens. Teletext systems display data broadcast during the vertical interval of the television picture. A second basic system, viewdata, is transmitted on telephone lines and provides the home user with access to a wide variety of material. Both systems can provide information on demand—such as weather forecasts, news, sports, stock market reports, highway information, etc., while viewdata eventually can serve as the home display terminal for a central computer.

Projection: Henry Kloss, who as founder and president of Advent Corporation was the father of home color projection television, has re-entered the business with a new projection TV system (he quit Advent in 1976). The "Novabeam" system, scheduled for marketing next fall, is based on a new Kloss-designed tube-and-lens system. Claims made for Novabeam are higher brightness, sharper resolution, lower cost than comparable three-tube two-piece television projectors now on the market.

Electronic gamesmanship: The toy business has discovered electronics with a vengeance, and things will never be quite the same. The major impact currently is in games, where even the familiar Scrabble is available in a handheld electronic version called *Sensor*. Although the first electronic games used the family TV set, toy manufacturers now have discovered they can accomplish many of the same effects without tying up the home video outlet. Many of the new handheld games were inspired by video games and include both visual displays and audio effects. While Mattel is the undisputed pioneer in the handheld game, the game that created the most talk at the recent New York Toy Fair was Milton Bradley's *Microvision*. This $50 unit is programmable, like a sophisticated TV game—and it has a screen, a two-inch-square liquid-crystal panel with 16 × 16 resolution. It can be used to play all of the familiar "TV games" plus new ones to come. How big is the pocket electronic game business? Just ask Mattel. It sold more than 2,000,000 of them last year.

Digital VTR: Television broadcasters are in a bit of a tizzy these days about videotape recorders. The "standard" four-head quad VTR, first introduced by Ampex in 1956, is an expensive two-inch-tape-gobbling monster and current technology has made possible its replacement by a far more economical one-inch helical-scan type of recorder that is superior in virtually every way. So naturally, broadcasters are beginning to replace their big quad recorders with the new standard helical unit—or are they? There's still a nagging worry that analog recording is obsolete and that digital VTR's represent the true wave of the future.

This is a real problem for the VTR manufacturers, who want to sell recorders now without encouraging a wait-for-digital attitude but who still want to impress potential customers that they're up to date on digital technology. Britain's Independent Broadcasting Authority demonstrated a digital recorder at a recent industry conference, impressing broadcast engineers and putting pressure on VTR leader Ampex. So at a major digital recording seminar sponsored by the Society of Motion Picture and Television Engineers, Ampex felt it was necessary to present something concrete along with its technical papers, without discouraging broadcasters from buying the latest in analog recorders. What Ampex did was take one of its four-head broadcast recorders, modify it for eight heads (and about twice the tape usage) and demonstrate perhaps the best digitally recorded video pictures ever shown. At the same time, it warned broadcasters that a practical, commercial digital recorder was still five to seven years away. It remains to be seen whether broadcasters will buy the new generation of helical-scan analogs or patch up their old quad machines and hold out for the start of the digital age.

Longitudinal scan: The home videocassette recorder business is also faced with a problem in standards and formats, but digital recording doesn't enter the picture. In the consumer field, the issue may become helical vs. longitudinal scan. Longitudinal recording, of the type used in audio, was attempted for video in the 1950's and abandoned. Now it promises to make a comeback in portable recorders, thanks to new tape transport systems. BASF is building a factory in California to turn out its multitrack LVR (longitudinal video recorder) which uses 8-mm tape in a portable format. Eastman Kodak, which is actively developing video recorders, is believed to be working on a longitudinal format. Toshiba recently demonstrated a longitudinal-scan system using half-inch tape with 220 video tracks in an endless-loop cartridge. The company gave no indication of when it would produce the unit, if ever, but pointed out it has one-third fewer mechanical parts than the Sony-developed Beta format. The simplicity of longitudinal systems is based on the use of a fixed head instead of the revolving-head system used in helical-scan recorders.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

How to listen to Moscow, Russia...Moscow, Idaho and your good buddy, Max Moscow.*

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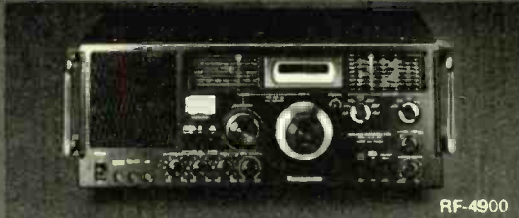

RF-4900

A fluorescent all-band readout in the RF-2900 (shown above) and the deluxe RF-4900 makes it easy to find thousands of overseas and domestic short wave transmissions as well as AM, FM and CB. The Panasonic fluorescent digital display is accurate to within 1 kHz. That's accuracy!

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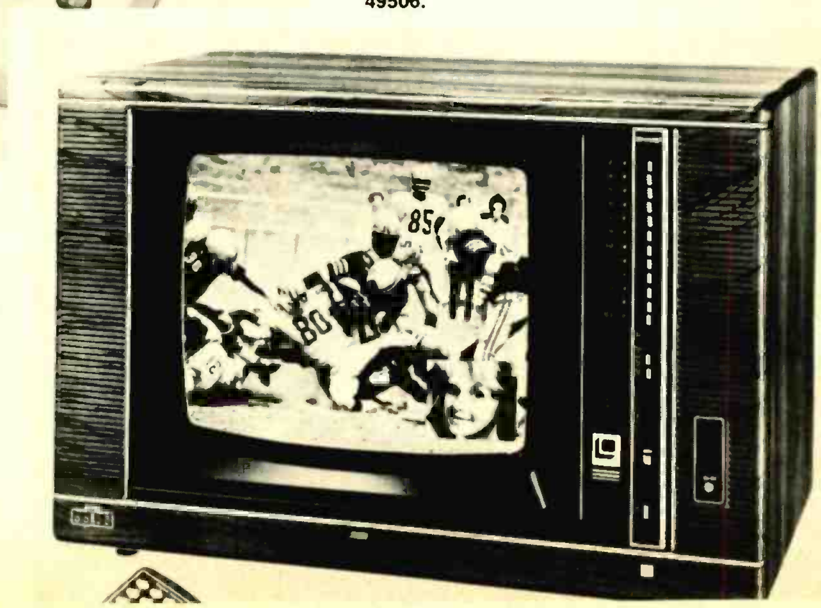
CIRCLE 34 ON FREE INFORMATION CARD

what's news

RCA CELEBRATES ITS 50 MILLIONTH TV SET in 32 years. Here, Jack K. Sauter, RCA marketing vice president, displays on the left the 19-inch *ColorTrak* receiver produced in 1978 and costing $570. On the right is the first TV set produced by RCA 32 years ago—a 10-inch black-and-white model, which sold in 1946 for $375.

COMUS C-6 DIET COMPUTER is a microprocessor-based instrument used to determine an individual's proper caloric needs to keep in shape. Keyboard data entry uses the word "SHAPE" (*S*ex, *H*eight, *A*ge, *P*ounds and *E*xercise), to compute the correct daily caloric intake based on metabolism, daily exercise (in 5 code categories) and diet. The unit is handheld, portable and powered by a 9-volt battery; it also doubles as a 4-function calculator with floating decimal (so you can figure out cost-per-serving). The *Comus C-6* comes in an off-white plastic case; it features an 8-digit red LED display and provides 2K bytes of ROM and 128 bytes of RAM. The entire package consists of the computer, instructions, calorie counter and exercise-level table. Selling for a suggested retail price of $34.95, and it is manufactured by Comus, Inc., 4550 Cascade Rd., Grand Rapids, MI 49506.



DUAL-VISION TV RECEIVER is manufactured by Sharp Electronics, who calls it the "TV of the Future." In the *model 17D50*, the 17-inch screen can display a 4-inch superimposed black-and-white picture in either the upper or lower corner of the screen, or it can eliminate it entirely. These pictures are also switchable, with the superimposed image becoming the main display and vice versa. The set also contains the following features: electronic varactor tuning; a 17-button/18-function capability; filter; a two-way/two-speaker system; a 75-ohm CATV connector; plus color-adjust, channel-hold and channel-lock controls. The picture tube used is Sharp's *Lynatron Plus High Focus* tube.

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RESISTANCE (6 LOW POWER RANGES): 0.1Ω to 20MΩ; Accuracy: ±0.5% rdg ±0.5% f.s. (±1.5% rdg on 20MΩ range); input protected to 120VAC all ranges.
DC CURRENT (6 RANGES): .01mA to 100mA; Accuracy: ±1.0% rdg ±0.5% f.s.
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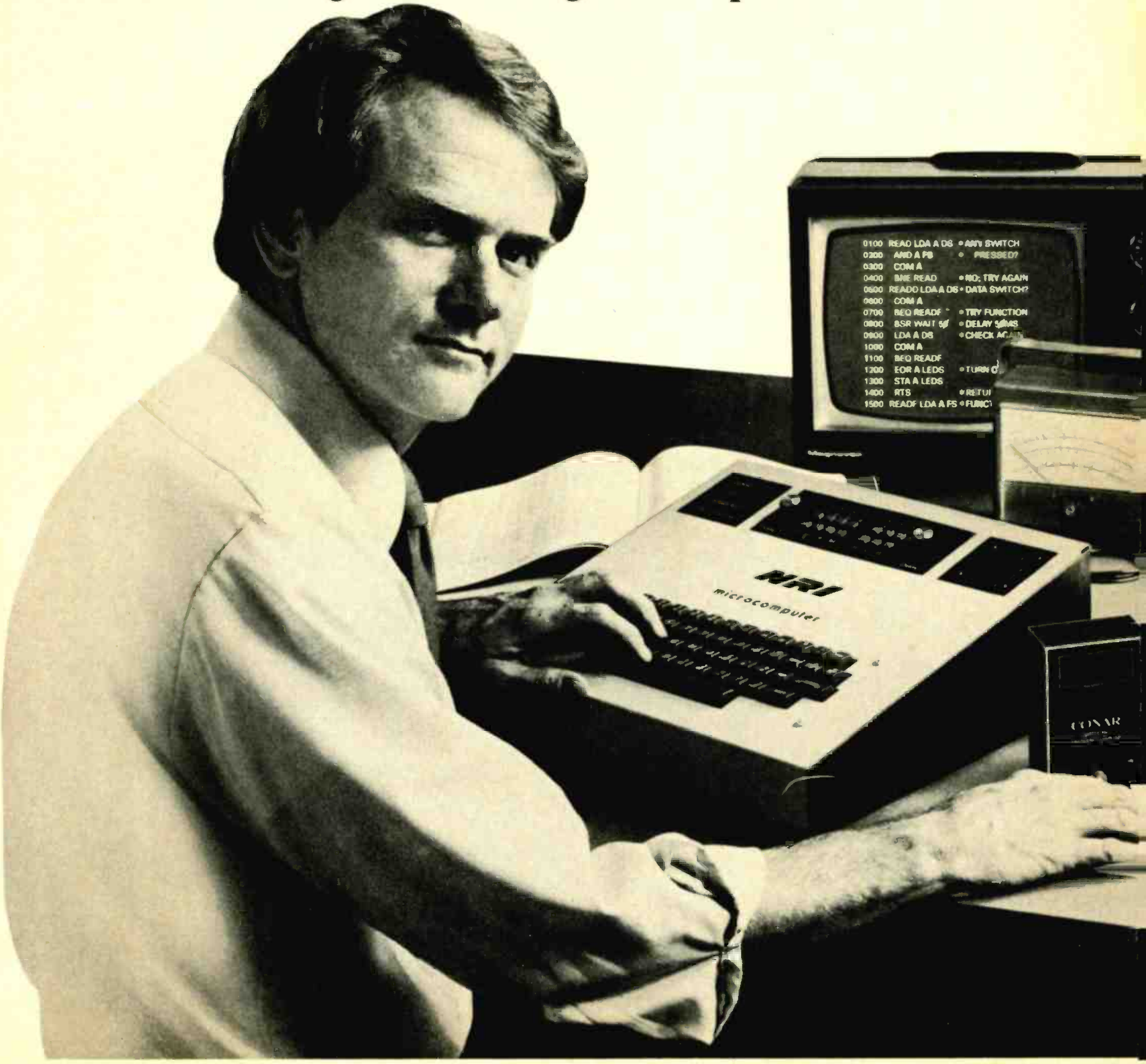

The microprocessor, that amazing little chip which shrinks electronic circuitry to microscopic size, has changed the world of the computer with dramatic speed. Now, big-performance computers are here in compact sizes...priced to make them practical for thousands of medium and small businesses, even homeowners and hobbyists.

Microcomputers are already being put to work on jobs like inventory control, payrolls, cost analysis, billing, and more. In homes, they're able to handle budgets and tax records, control environmental systems, index recipes, even play sophisticated games. And hobbyists across the country are expanding the state of the art while developing their own programs.

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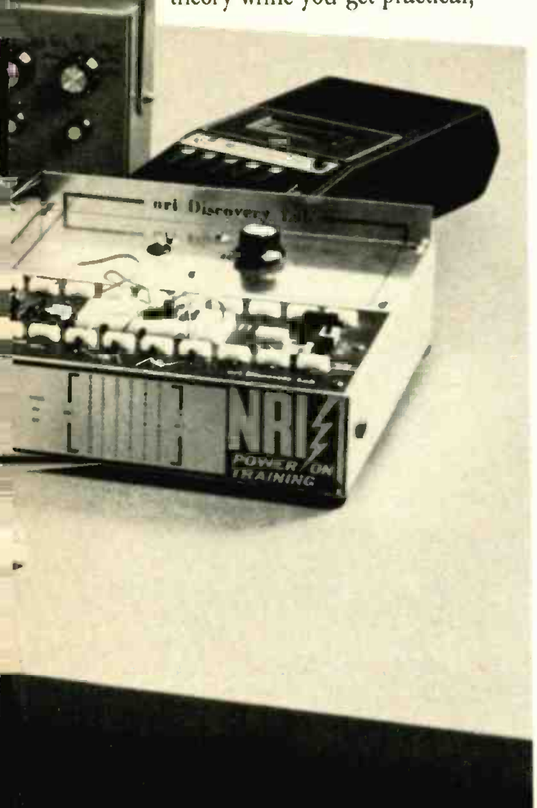

"hands-on" experience working with the NRI Discovery Lab®, assembling test instruments you keep, and even building your own fully functional microcomputer.

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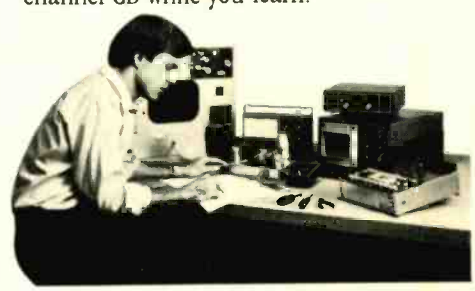
Even the servicing of home entertainment equipment has taken quantum jumps forward. NRI keeps you right up with the latest, with training in stereo, video tape and disc players, and the latest TVs. You even build your own 25" diagonal color TV, the only one complete with built-in digital clock, varactor tuning, and computer control that lets you program an entire evening's entertainment. In our complete communications course, you learn to service two-way radio, microwave transmitters, radar, AM and FM transmitters, CB radio, paging equipment, and more. And you build your own 2-meter transceiver or 40-channel CB while you learn.



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Send the postage-paid card today for your personal copy of the NRI electronics course catalog. It shows all the equipment, training kits, and complete lesson plans for these and many other courses. There's no obligation of any kind and no salesman will ever bother you. Find out how you can learn new skills, keep up with technology, advance your future with training for new opportunities. Get in on the ground floor now! If card has been removed, write to:

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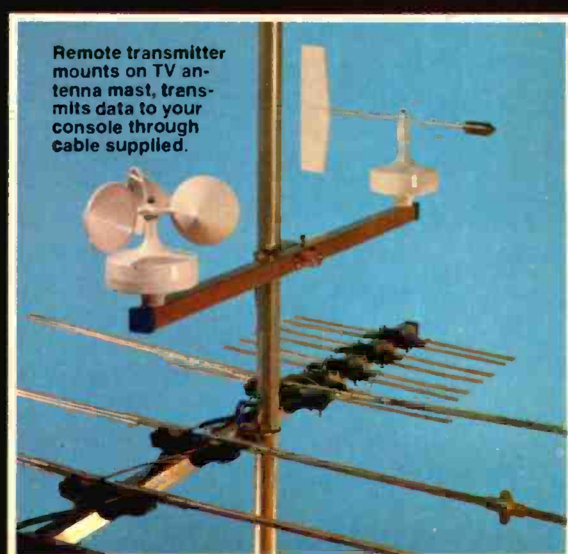
Fingertip control of all microprocessor calculations; data readout in bright LED digits from solid oiled walnut console.

Aerospace-designed transmitter!

Its wind speed and direction instruments are among the most sophisticated available. Rather than relying on friction-causing reed switches or other mechanical devices, they utilize solid-state infra-red sensors, and transmissive optical encoding. It offers unprecedented accuracy and within one-tenth of a mile per hour!

The remote transmitter unit with its windcup and weathervane mounts easily on your TV antenna or other outdoor mast for years of dependable, trouble-free service! It's actually been wind-tunnel-tested for strength and durability.



Remote transmitter mounts on TV antenna mast, transmits data to your console through cable supplied.

CIRCLE 100 ON FREE INFORMATION CARD

THE Electronic Weatherman

New Heathkit Weather Computer

Now...with your own computerized weather station, you can have the *temperature* (indoors and out)...*wind speed and direction* ...the *wind chill factor*...the *barometric pressure*...the *time* and *date* ...plus much *more*...*right at your fingertips!*

There's nothing else like it available today! A personal weather computer that not only monitors the current weather data, but also computes significant changes and stores wanted data in its memory! So now, for the first time, you'll have all the weather information you need for your personal and business planning!

Unique digital data display

The handsome solid oiled walnut computer console features large, bright, LED numerals, displaying up-to-the-second data on the time (AM, PM or 24 hour format) and date; indoor and outdoor temperatures (in your choice of Fahrenheit or Celsius); wind speed (in miles per hour, kilometers per hour or knots) and direction on a 16-point compass plus barometric pressure in millibars or inches of mercury.

The instrument's on-board microprocessor even calculates the wind chill factor at the touch of a button. It also stacks barometric pressure readings in memory, so it can compute the rate of rise or fall on command! The barometer readings are derived from a newly-developed piezo resistive silicon bridge transducer that senses the most minute changes in pressure. It's the first and only truly digital electronic barometer!

An electronic almanac!

The Weather Computer stores high and low temperatures as well as the time and date at which they were recorded. In addition, it records the highest wind gust speed and time, ready for instant recall. The data is stored in memory until you choose to clear it.

For serious weather research purposes, the instrument can be connected to a chart recorder for hard copy records. And, it can be interfaced with any compatible digital computer for even more sophisticated weather charting and forecasting. As a final thoughtful design touch, the instrument even makes provision for battery back-up to preserve the data stored in memory in case of power failure.

The Electronic Weatherman is a truly unique computerized weather instrument, offering capabilities never before available to the layman with a serious interest in the weather. For business or personal reasons, you'll find it an investment that can pay for itself many times over!

Easy-to-build kit form

If you want the fun (and savings) of building it yourself, you'll find the Heathkit Digital Weather Computer surprisingly easy to build, thanks to the fully-illustrated step-by-step assembly manual. Or, you can order yours assembled, ready to install and use.

The Heath Electronic Weatherman comes complete with remote transmitter unit, 100 feet of connecting cable and a solid oiled walnut console. Order yours now and be prepared for the weather, whatever comes!

For Fastest Service, Order by Phone CALL (616) 982-3411

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Schlumberger

HEATH COMPANY
Dept. 020-534
Benton Harbor
Michigan 49022

Gentlemen: Please send me...

☐ Heathkit Weather Computer Kit(s) (ID-4001) with 100′ of cable each (IDA-1290-2) @ $383.90 plus $3.95 shipping and handling each.

☐ Assembled Digital Weather Computer(s) with 100′ of cable each (IDW-4001) @ $595.00 plus $3.95 shipping and handling each.

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(Please Print)

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City__________ State__________ Zip__________

GX-360

Prices are mail order and effective through May 15, 1979.

editorial

Communications And You

We all communicate. You're reading this editorial. You talk to people on the telephone, you watch television, you write letters. And we all use equipment to aid us in our communications. This equipment can vary from the pencil to the computer.

The most commonly used communications equipment has electronic circuitry as its heart. It's a CB radio, a UHF/VHF radio, an amateur radio station, an all-wave receiver or a scanner and it is a hot item—an item many Radio-Electronics readers want to be kept up to date on.

Hearing this in your communications to us, we've added a new regular monthly column. It has been titled "Communications Corner." It will appear every month and is intended to be responsive to your needs. While no reader questions about communications will be answered directly, your comments about the column will be carefully considered as future columns are prepared.

I think you'll like it. Turn to page 68 now, and you can judge for yourself.

Larry Steckler

LARRY STECKLER
Editor

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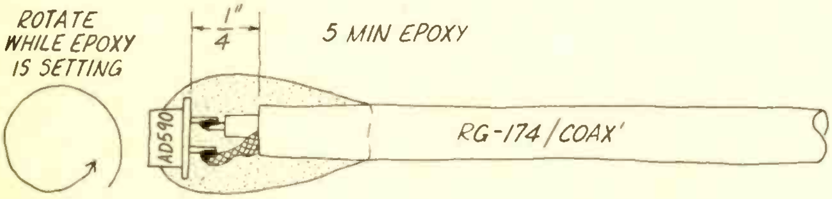
letters

T-100 THERMOMETERS

Optoelectronics, Inc., has now assembled a number of T-10Q thermometers and is satisfied with their performance, especially their accuracy. The linearity from 0°C to 100°C is typically .1° or .2°.



The company has decided to incorporate a change that will be included in all kits. It is recommended that a second 9-volt battery be added in series to boost the supply voltage to 18. This will insure that at least 4 volts is always across the sensor so that high Fahrenheit readings (> 150°F) can be produced. Battery life will be more than doubled because each battery can discharge down to 5 volts rather than the single battery discharging to 7½ volts. Battery life will be typically greater than 100 hours with carbon-zinc cells, and 300 to 400 hours with alkaline cells. A second battery snap will be included in all kits along with a piece of double-stick tape. The second battery fits nicely into the case without modification.

The company also recommends that the probe should be assembled as shown (see diagram) without using the nylon shell. However, the shell will be included with all the kits that are shipped.

BILL OWEN
Optoelectronics, Inc.
Fort Lauderdale, FL

WHERE ARE THE DESIGNERS?

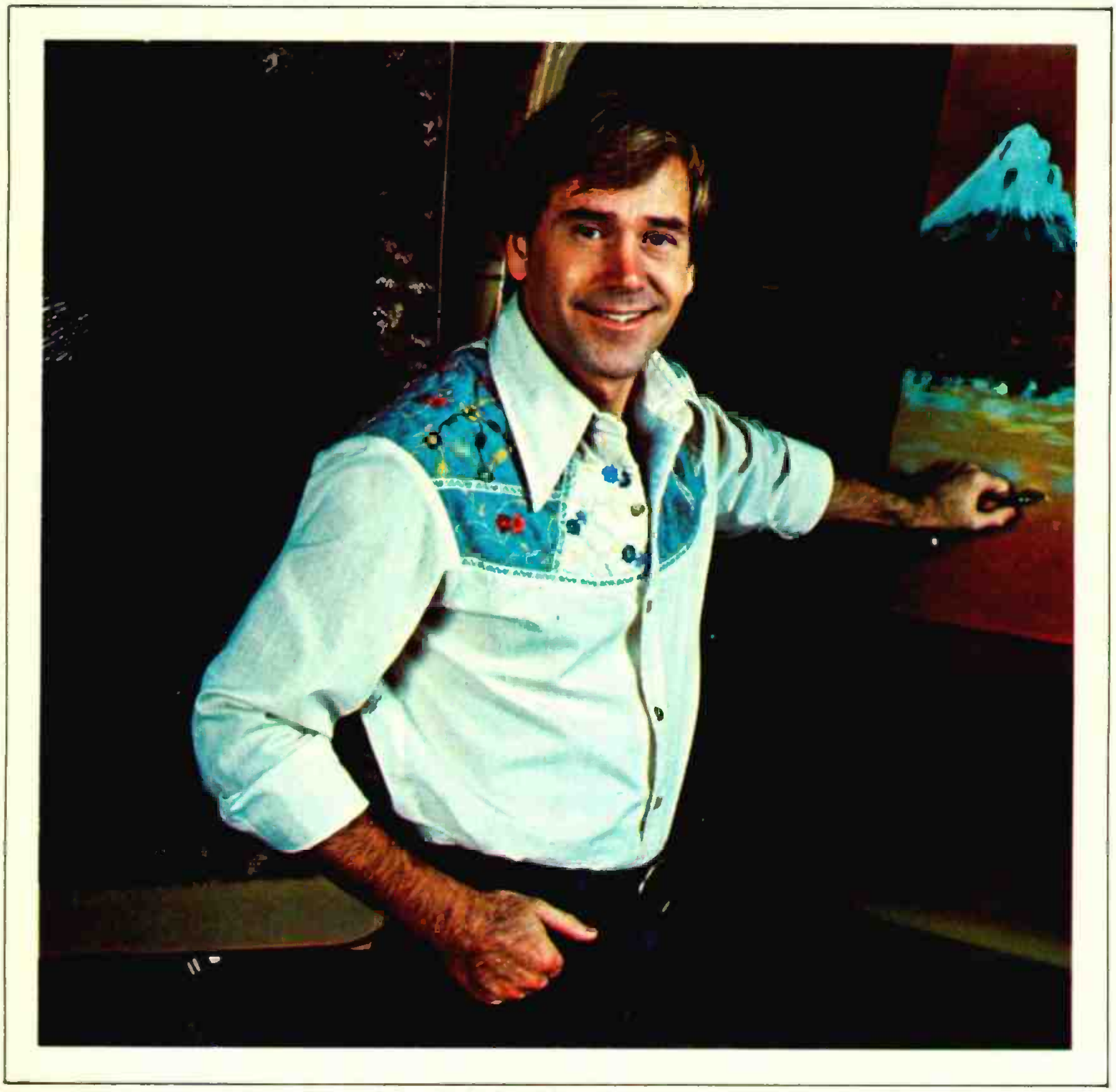
Before semiconductors, was the only true designer the one who designed new vacuum tubes?

As some philosophers point out, we seem to have gotten confused over the extent of design versus the intent of design. The intent hasn't changed, but advancing technology has allowed brand-new "extents" especially suitable to reliance on interchangeable parts available in mass quantity at super-low cost. The designer still designs, but he's charged with operating at a different level that today's tools and components make possible. This means that the economies of when to customize—always an expensive proposition—have changed, too, and the good designer adapts to that also, because it

continued on page 22

CIRCLE 42 ON FREE INFORMATION CARD

You gotta shop around.



When you do, you'll probably pick CIE. You can't afford to settle for less when it comes to something like electronics training that could affect your whole life.

When you shop around for tires, you look for a bargain. After all, if it's the same brand, better price—why not save money?

Education's different. There's no such thing as "same brand." No two schools are alike. And, once you've made your choice, the training you get stays with you for the rest of your life.

So, shop around for your training. Not for the bargain. For the best. Thorough, professional training to help give you pride and confidence.

* * *

If you talked to some of our graduates, chances are you'd find a lot of them shopped around for their training. They pretty much knew what was available. And they picked CIE as number one.

Why you should shop around yourself.

We hope you'll shop around. Because, frankly, CIE isn't for everyone.

There are other options for the hobbyist. If you're the ambitious type—with serious career goals in electronics—take a close look at what we've planned for you at CIE.

What you should look for first.

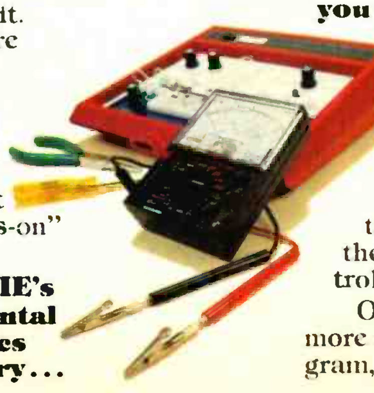
Part of what makes electronics so interesting is it's based on scientific discoveries—on ideas! So the first thing to look for is a program that starts with ideas and builds on them!

That's what happens with CIE's Auto-Programmed® Lessons. Each lesson takes one or two principles and helps you master them—before you start using them!

How practical is the training?

This is the next big important question. After all, your career will be built on what you can do—and on how well you do it.

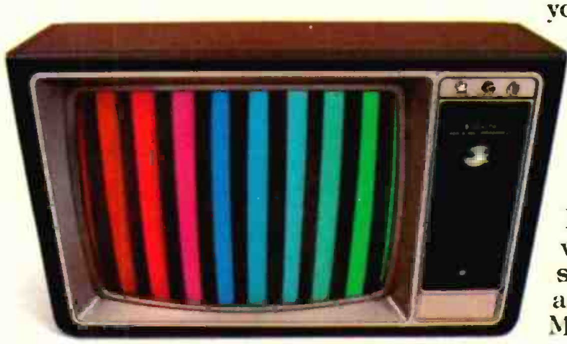
Here are ways some of CIE's troubleshooting programs help you get your "hands-on" training...



With CIE's Experimental Electronics Laboratory... you learn and review the basics—perform dozens of experiments. Plus, you use a 3-in-1 precision Multimeter to learn testing, checking, analyzing!

When you build your own 5 MHz Triggered-Sweep, Solid-State Oscilloscope you take your first real professional step. You use it as a doctor uses an X-ray machine—to "read" waveform patterns... lock them in... study, understand and interpret them!

When you get your Zenith 19-inch Diagonal Solid-State Color TV you



Pattern simulated.

apply your new skills to some real on-the-job-type troubleshooting! You learn to trace signal flow... locate malfunctions... restore perfect operating standards—just as with any sophisticated electronics equipment!

When you work with a completely Solid-State Color Bar Generator—actually a TV signal transmitter—you study up to ten different patterns on your TV screen... explore digital logic circuits... observe the action of a crystal-controlled oscillator!

Of course, CIE offers a more advanced training program, too. But the main point is simply this:

All this training takes effort. But you'll enjoy it. And it's a real plus for a troubleshooting career!

Do you prepare for your FCC License?

Avoid regrets later. Check this out before you enroll in any program.

For some troubleshooting jobs, you must have your FCC License. For others, employers often consider it a mark in your favor. Either way, it's government-certified proof of specific knowledge and skills!

More than half of CIE's courses prepare you for the government-administered FCC License exam. In continuing surveys, nearly 4 out of 5 CIE graduates who take the exam get their Licenses!

Shop around...but send for CIE's free school catalog first!

Mail the card. If it's gone, cut out and mail the coupon. If you prefer to write, mention the name and date of this magazine. We'll send you a copy of CIE's FREE school catalog—plus a complete package of independent home study information!

For your convenience, we'll try to have a representative contact you to answer your questions.

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☐ **YES...** I'm shopping around for the **right** kind of career training in electronics troubleshooting—and CIE sounds well worth looking into. Please send me my FREE CIE school catalog—including details about troubleshooting courses—plus my FREE package of home study information! RE-63

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continued from page 16

affords a whole new set of opportunities.

A related issue, and maybe not one you're concerned about, is that designers needn't be so skilled as in the past. That's true for the same products, and that's progress of a sort. But the super-designers are still there—in as limited quantity as ever—although they're working on difficult problems that couldn't even be approached with the old technology and not on matters that technology made easy to cope with. That's *important* progress because it means that the pyramid of achievement and knowledge by which we tend to view civilized development is moving up another layer as far as technology is concerned.

Finally, I would like to mention that the feature article in the June 1978 issue was about a product designed with integrated components and that had sufficient design novelty to be awarded a U.S. patent!
DENNIS E. HAMILTON
Penfield, NY

If everyone uses the IC's, who's left to design them! Does this mean that the future of the electronics industry is at the mercy of the IC designer? Does this mean that if I need only one of something I may not be able to build it? Plain and simple—is all future electronic design going to become dependent on a handful of engineers working for IC manufacturers?—Editor

TV ADAPTER CORRECTIONS

I must make some corrections to my letter which appeared in the August 1978 issue of **Radio-Electronics** (page 16) regarding the TV-to-stereo adapter.

In paragraph 3 regarding the sound detector takeoff in solid-state sets, a sentence reads, "the volume control immediately follows the sound detector in most cases. This, in turn, varies the gain of an amplifier stage. If so, audio does not appear on the volume control." This should read: "The volume control follows the sound detector in most cases, but in some sets, the volume control merely varies a DC voltage, which, in turn, varies the gain of an amplifier stage. In these cases, audio does not appear on the volume control, and must be found elsewhere."

I might add that most American-made sets using this DC volume control system use an IC for the sound detector/IF/audio amplifier functions; and pin 8 of this IC is the best place to pick off the audio. However, this may not always be the case, so to be sure, check with a scope or a signal tracer. Also, since the pin 8 output has about 5 to 6 VDC on it, make sure to use a blocking capacitor.

My apologies to the TV networks regarding my comments on their narrowband telephone lines. Both my letters (in May and August 1978 issues) were written in late December, 1977, before the AT&T switchover to multiplexed video-audio transmission links.
MICHAEL KILEY
Palos Heights, IL

equipment reports

Heath Model H17 Floppy-Disc System

CIRCLE 50 ON FREE INFORMATION CARD

OWNERS OF HEATH'S *MODEL H8* COMPUTER CAN now increase the versatility of their system with Heath's new *model H17* floppy-disc system. A floppy-disc system provides a quick method of program storage and retrieval. The advantages over a cassette system include loading and storage of programs in seconds rather than minutes, deleting and updating program and data files, cataloging of files, and more.

The Heath Company's Dept. 570-070, Benton Harbor, MI 49022) *H17* floppy-disc system consists of a factory-assembled control board that plugs into the *H8* bus and is connected via a ribbon cable to a Wangco *model 82* 5½-inch drive. The drive is housed in a cabinet that contains a power supply capable of powering a second drive. The cabinet also contains a cutout for an optional second drive.

Each 5½-inch hard-sectored disc is divided into 40 tracks, and each track is subdivided into 10 sectors for a total storage capacity of 102,400 bytes-per-disc. The *model 82* drives have a 30-ms track-to-track step-time specification, although some drives will operate much faster. Both drive units in my system operate reliably at a track-to-track step time of 8 ms. As Heath carefully points out, the track-to-track step time is not the same as the random-sector access time, which is the actual time required for the read/write head of the drive to get to a sector once it is requested. A track-to-track step time of 8 ms translates into an *average* track-to-track step time of 104 ms. Since the disc rotates (at 300 rpm), there is an additional average time of 100 ms for the sector to come under the read/write head. So, the average random-sector access time is 204 ms. Once a sector on the disc is accessed, data is transferred between the drive and the controller board one bit at a time at a serial rate of 16,000 bits-per-second. To reference this speed, the *H17* will load Extended Benton Harbor BASIC in about 2 seconds. Heath's standard 1200 baud cassette interface requires about 2 minutes.

Software

Software is required for a floppy-disc system to function. This software is called an operating system, and Heath supplies its own brand called HDOS. The operating system handles such functions as controlling the drive motor, positioning the read/write head, locating specific data on the surface of the floppy disc, creating files, transferring data, etc. It also provides communication with the user via command instructions.

After initially applying power to the system, HDOS must be "booted." Booting is the process of loading only those segments of HDOS that will enable the system to function. For example, one such portion, called the monitor, decodes the various commands and transfers control to the appropriate software segment to carry out the command. After the command is executed control returns to the monitor. Various other segments of HDOS are loaded into the *H8* when necessary.

When HDOS is booted, the monitor program is automatically located in the upper address space of the *H8* memory and occupies 2.4K. The other segments of HDOS are located in the lower address space of memory and occupy approximately 9K. Therefore, HDOS requires a total of approximately 12K RAM to operate. If you plan on using a BASIC interpreter, then you will need additional memory to support the BASIC, plus whatever "user" memory you require for your programs.

To boot HDOS, simply set the *H8* program counter to 030 000 using the octal keypad on the *H8* front panel and execute GO. HDOS will respond by printing ACTION? (BOOT) on the CRT terminal. To boot HDOS, simply type B on the terminal keyboard. After HDOS is loaded it will respond by identifying itself. It will then ask for the current date by printing DATE (DD-MM-YY)? After entering the current date and hitting the carriage return, HDOS is up and running. From now on, HDOS responds with a prompt character to indicate that it is ready to accept commands. There is a wide variety of commands available with HDOS. Among these commands is SYSGEN, which permits you to copy the minimal operating system onto a blank disc. You can use the COPY TO-FROM command to copy additional programs to this disc and store the original programs to this disc and store the original

continued on page 26

EQUIPMENT REPORTS
continued from page 24

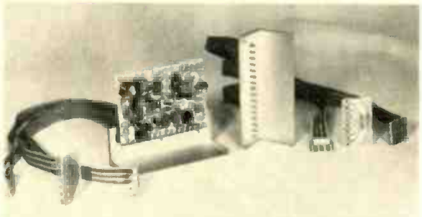
nal disc away for safekeeping. A PIP command (*P*eripheral *I*nterchange *P*rogram) is included and is used to copy a file from one disc drive or peripheral device to another. Other commands include SYSHELP, which lists all the valid system commands; DELETE, which erases specific files from the disc; RENAME, which changes the name of a specified file; CAT, which lists the files contained on the disc; and other commands.

Among the many commands and features of HDOS, one in particular struck me as being interesting and unusual. This is a diagnostic routine called TEST 17. After executing this command, you can check the rotational speed of the disc drives. The normalized drive speed is displayed on the LED's on the front panel of the *H8* as a decimal number, which should be as close to 1.000 as possible. Since the rotational speed tolerance is 1 percent, any number between 0.990 and 1.010 is acceptable. If it is out-of-tolerance, it can be trimmed by adjusting a pot on the drive assembly itself. Another test that can be performed under TEST 17 is a general checkout. Under this test, a specific bit pattern will be recorded on each sector of the disc and then read back. This test is automatically performed three times, and is intended to check the read/write head and the track seek mechanism. There is also a media check that locates all the bad sectors on the disc (if there are any) and a routine for minimizing the track seek time of the drive being tested.

Other commands are also available that are associated with the operation of the disc system. For example, if you have various BASIC programs already stored on cassette tape, you can use BASCON to convert these programs into files that can be stored on the disc. If you have text files stored on cassette tape, you can use TXTCON in a similar manner to convert these into disc files. A ONECOPY command is included that allows you to copy files from one disc to another in a system that has only one drive. In addition to HDOS, the software disc also contains BASIC, BUG-8, HASL-8 and TED-8.

Overall, HDOS is a versatile operating system. The *H17* disc system which sells for ($695.00 including software) will greatly increase the versatility of your *H8* system. **R-E**

Sylvania Module Extension Cable Kits



CIRCLE 141 ON FREE INFORMATION CARD

MANY YEARS AGO, WHEN SETS AND CIRCUITS (and I) were much simpler, I used extension cables a good deal. These cables let me get the chassis out onto the bench where I could actually get at it. When I started troubleshooting my first modular TV set, I thought it would be great if we had a set of extension cables so that we could get each module out where we could get at it . . . since many of us repair such modules, especially larger ones.

Evidently, someone was listening! Sylvania has come up with module-extension cable sets; one of these fits Zenith modules, the other, RCA modules. The Zenith cable set is called the *TV Module Extension Kit P/N KZ-2*. It will fit 19 Zenith chassis, including the 17EC45, 19EC45, 23EC45, and several others. This set consists of six cables and two special brackets (plus pins) and can be used with 10 different Zenith modules.

The instructions state: "Each Zenith module listed has an even number of pins (8, 12 or 16) on one end and an odd number (7, 11 or 15) on the other. Each bracket has two four-conductor cables and a larger one. One with 7 conductors, the other with 8. By selecting the right cables and plugs, any of these modules can be hooked up correctly." A complete instruction sheet comes with each set, listing the modules and chassis with which it can be used. A special data sheet is also included showing the Sylvania ECG part number semiconductor for the original component used in each module.

The RCA extension cable set is the *TV Module Extension Kit P/N KRX-5*, with five separate cables for use with the RCA *AccuColor* chassis from the *model CTC-41* through the *model CTC76*. Three of the cables have six contacts each, and the two remaining cables have 12 contacts. By choosing the right combination of contacts, any of the 15 modules listed in these chassis can be hooked up. Full hookup data and instructions are provided, as well as a list of ECG replacement semiconductors.

Both extension cable sets use flat multicon-
continued on page 32

See The Newest In Quality Electronics You

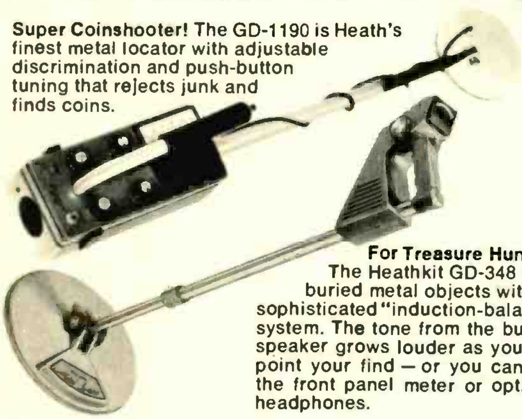
Custom Car Accessories like the Heathkit GC-1406 Digital Quartz Car Clock shown, or it's companion car clock with trip timer and stopwatch functions for the rally enthusiast, are easy and fun to build. And you have the quality and dependability in custom car accessories you can show-off with pride. Now you can choose one of these fine car clocks, a windshield wiper delay, a deluxe mobile siren and P.A. system, an ultrasonic Intrusion alarm, an electronic speed control or a cab-to-camper intercomm – all in money-saving kit form you can build, service and install yourself.

A Super-Accurate Digital Alarm. The ideal choice for a 'first kit' – with snooze feature, AM and PM indicator, 12 or 24 hr. format and pleasant green-blue digital display. Budget priced, too!

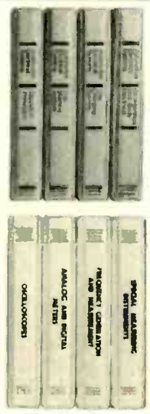
A Doorbell That Plays Your Favorite Tune! A fun way to greet guests with any 16-note tune you program – and you can even add remote speakers!

Low-Cost Home Security with this Heathkit GD-600 Photoelectric Lamp Switch. Turns your lamp on at dusk – off at daylight, for that 'lived-in' look when you're away from home.

Super Coinshooter! The GD-1190 is Heath's finest metal locator with adjustable discrimination and push-button tuning that rejects junk and finds coins.



For Treasure Hunters! The Heathkit GD-348 finds buried metal objects with it's sophisticated "induction-balance" system. The tone from the built-in speaker grows louder as you pinpoint your find – or you can use the front panel meter or optional headphones.



Learn To Service and Maintain Your Car's Electrical System with this newest Heathkit Automotive Electrical Continuing Education Program. Think of the money you'll save when you really understand how your car's electrical system works and how you can service it. This 4-part self-learning program takes you through electrical principles, starting and charging systems and accessories and body electrical...all at your own pace and at lowest cost.

Learn How To Use Electronic Test Instruments with this new Heathkit self-learning program. A progressive 4-part program using Heath's famous programmed instruction with audio and visual aids for maximum efficiency. Learn to use electronic meters, oscilloscopes, frequency generators and special measuring instruments.

Radio Control Gear You Can Depend On! From the leader in R/C development. See this new 8-channel, open gimbal transmitter with Heath's instant plug-In frequency change feature...all Heath firsts!...plus sensational savings on complete systems and R/C Starter Sets.

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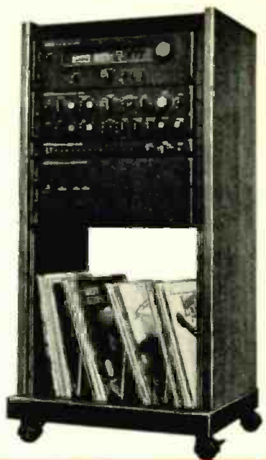

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EQUIPMENT REPORTS

continued from page 26

ductor cables, color-coded on one side and colored plain red on the other. This helps identify the position of the edge connector in the chassis socket. The terminal boards used for the socket end of these cables are made with what looks like a good grade of glass epoxy. Printed-circuit wiring on the other side of the board completes the circuit, and jumpers are added where used in the original socket that look as if they would stand up to hard use with no trouble.

I feel these extension module cable kits are a giant step forward in making our job just a little bit easier! The suggested retail prices for the extension cable sets are as follows: the Zenith *model KZ-2*, $49.50; the RCA *model KRX-5*, $54.50. The sets are available from Sylvania dealers and distributors. "Try 'em, you'll like 'em!" **R-E**

Microproducts Apple II Assembler/Editor

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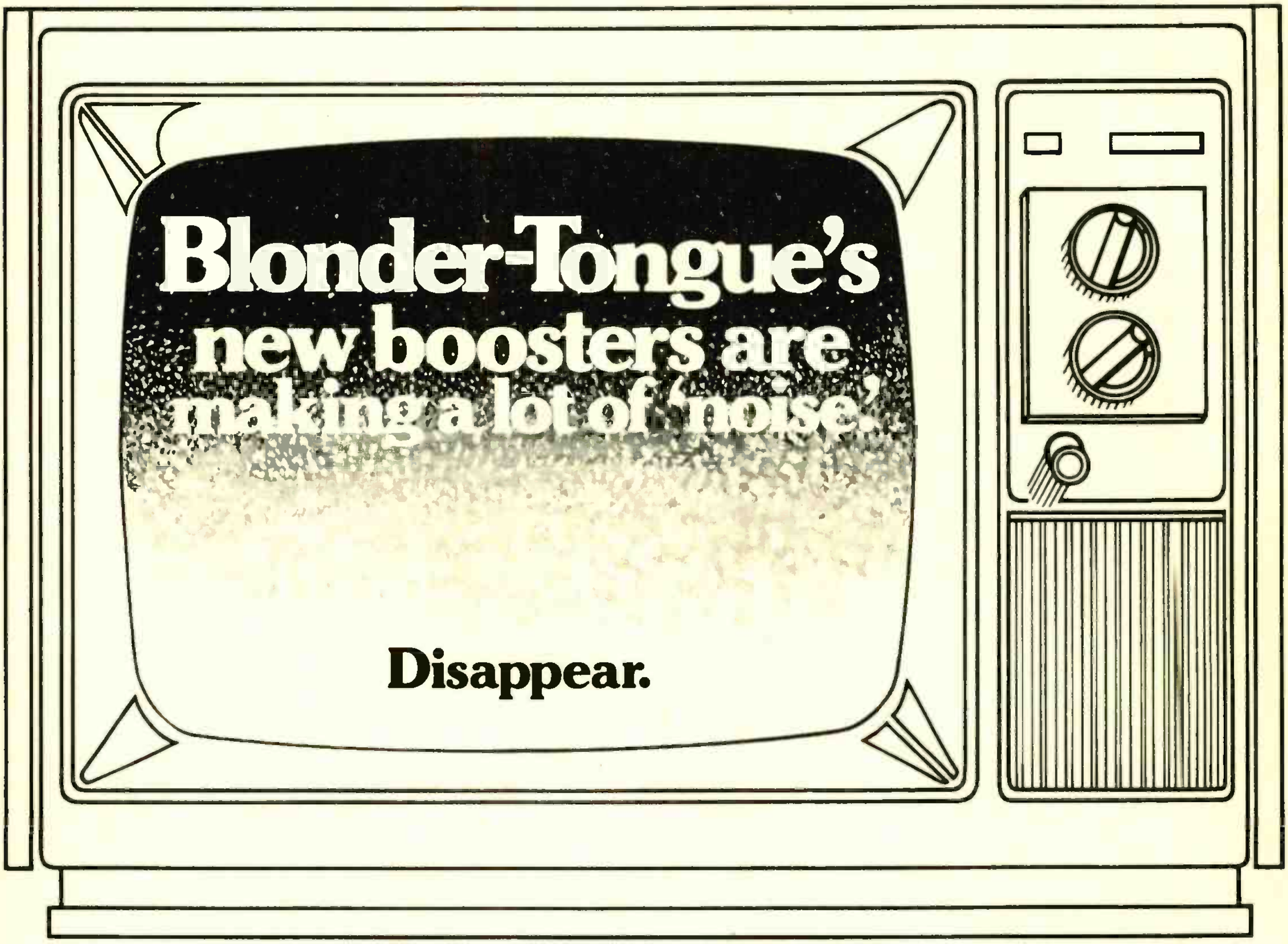
A CORESIDENT ASSEMBLER/TEXT EDITOR FOR the Apple II computer is now available from Microproducts (1024 17th Street, Hermosa Beach, CA 90254). This assembler is supplied on cassette tape, floppy-disc or EPROM, and features line renumbering, printer control and driver software for Microproducts' EPROM programmer. I used the disc-based assembler (Version 2.0), which also allows the program text files to be stored, retrieved and merged from the disc.

Writing in machine language yields fast and efficient programs. However, machine code is tedious and hard to debug. Even with a mini-assembler, such as the one in the Apple II, changing one line of a program usually necessitates a lot of machine code acrobatics. With a true assembler/editor such as the one described here, the program is written into a text file that can easily be read, documented, altered and debugged.

The Apple II assembler supports all standard 6502 mnemonics and address modes. Also included are six pseudo-op codes that allow you to originate variable codes as well as hexadecimal format and ASCII constants or tables. Labels can be 1 to 4 characters long, and the comment field handles up to 16 characters. Using this assembler makes writing machine-language programs almost as easy as using BASIC (well, maybe not quite). But with a little practice even the beginning computer user can break the "BASIC barrier."

I did find one bug that causes the assembler to generate false code—it does not always catch a BRANCH OUT OF RANGE error. Instead, it generates legitimate code, which can play havoc with your program and is very hard to debug. Fortunately, I also found the cure for this problem, and I notified Microproducts so that the company can correct any future units. (If anyone has an old version of this assembler and wishes to correct it, just send a self-addressed, stamped envelope to West Side Electronics, Dept. MP-F, P.O. Box 636, Chatsworth, CA 91311.)

The assembler on cassette tape (No. MP 78101-1) costs $19.95; on disc (No. MP 78101-3), $25.00; and on EPROM (No. MP 78101-2), $40.00 and you must supply the two 5-volt 2716 EPROM's. **R-E**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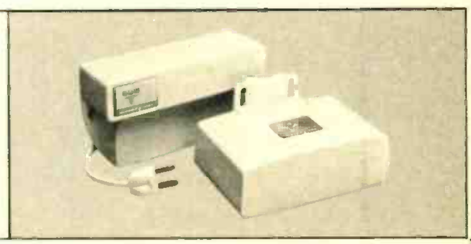

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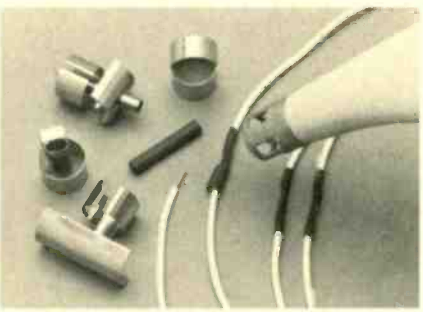

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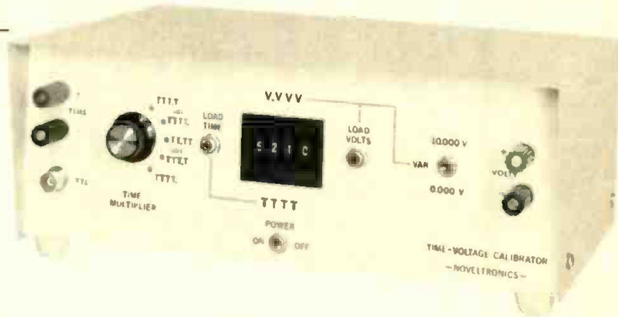
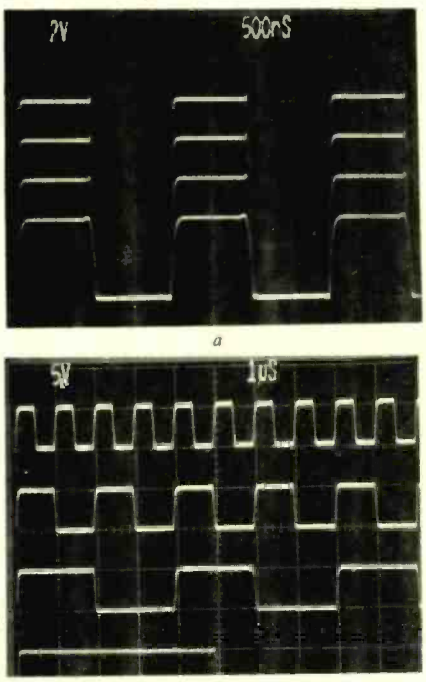


Time/Voltage Calibrator

Precision digital test equipment requires special test instruments to insure that calibrations are within specified tolerances. This calibrator supplies time and voltage references you'll need.

DOUG FARRAR

FOR YEARS LARGE COMPANIES HAVE ENjoyed the benefits of highly accurate digital test equipment because only they could afford the substantial initial capital outlay and the periodic maintenance and calibration required in using this equipment. Recently, however, advances in digital and linear-integrated-circuit technology have brought the cost of these test instruments down to a price affordable to even the hobbyist.



a

b

FIG. 1—MULTIPLE EXPOSURES of "time" outputs. At *a* programmed voltages are 4, 6, 8 and 10 with 2.0-μs period. At *b* we have 5-volt swings at 1, 2, 4 and 10 μs programmed periods.

However, there is a side to this story that is never mentioned: How is a hobbyist going to keep his new gear calibrated? In the days of 1% to 5% accuracy, the known voltage of a battery or the approximate resonant frequency of a crystal were adequate enough for calibration standards. Nowadays, a 3½-digit digital voltmeter (DVM) needs a 0.1%-voltage standard; newer scopes need 1% (or better) time standards. And even inexpensive frequency meters need .01% time standards.

Of course, you can routinely send an instrument to a calibration lab (as the manuals tell you to do!), but this could easily become more expensive than the cost of the unit itself. Even if you're willing to do that, you may not have such a lab near you. What's the hobbyist to do?

The Time-Voltage Calibrator described in this article can be the answer to your calibration problems, and could pay for itself many times over. This instrument has two separate sections for time and voltage, each controlled by a standard 4-digit thumbwheel-switch network. When you dial in the desired voltage and press the LOAD VOLTS pushbutton, a DC-voltage output is produced that is accurate to better than 0.1%. Dialing in the desired time and pressing the LOAD TIME pushbutton produces two time outputs with 0.005% accuracy. The first output is a standard TTL output with a duty cycle within 5 ns of 50%. The second time output has slower rise and falltimes than the first, but its voltage swing is highly accurate. The time period is controlled from the front panel, while the voltage

SPECIFICATIONS

VOLT SPECIFICATIONS

Range	0.000 to 10.000 volts in 1-mV steps
Total error	< ±0.1% of setting (untrimmed) < ±0.05% of setting (trimmed)
Settling time	stable to 1 mV within 15 seconds
Trim range	±20 mV

TIME SPECIFICATIONS

Range	000.0 to 999.9 μs in 0.1-μs steps
Multiplier	×1, ×10, ×100, ×1,000, ×10,000
Total error	<50 ppm (.005%) of setting (untrimmed) <5 ppm (.0005%) of setting (trimmed)
Trim range	±30 ppm, typical

	Time	TTL
V_{OL}	0 volts	<0.4 volts
V_{OH}	programmed by VOLTS section; approx. 4 volts (min.), +10 volts (max.), ±10 mV	>2.4 volts
Output impedance	<100 ohms (typ.)	normal TTL
Rise/falltimes	<50 ns (typ.)	<5 ns
Duty cycle	within 20 ns of 50%	within 5 ns of 50%

swing is between ground and whatever is dialed into the volts section (±10 mV). This last time output is very useful for calibrating oscilloscopes.

The maximum programmable output voltage is 10.000 in 1-mV steps. The time output is from 0.1 μs to 999.9 μs in 0.1-μs steps; but a multiplier switch can be used to multiply all these time increments by 10, 100, 1000, or 10,000, even while maintaining the 0.005% accuracy. This results in a maximum time output of 9.999 seconds. The scope photos in Fig. 1 show some of the waveforms obtainable with the Time and Voltage Calibrator.

The best part about the entire project is that it requires no calibration to meet these specifications! Using the components called out in the parts list, means you now have your own secondary time and voltage standards that are traceable to the National Bureau of Standards (NBS). But if you do have access to very accurate time- and voltage-measuring equipment, the calibrator can be trimmed to even tighter specs.

How it works

There are two almost separate sections to the calibrator: time (Fig. 2) and voltage (Fig. 3). Both sections are loaded with the thumbwheel-switch network, S1–S4 (Fig. 4). Two separate sets of latches (IC1–IC4 and IC5–IC8) latch the state of the thumbwheels when their respective LOAD switches (LOAD VOLTS, S6 and LOAD TIME, S7) are depressed and then released. So, after a value is loaded into either set of latches, the thumbwheels can be set to any other value.

Let's examine the time section first. The design goals for this circuitry were:

- Time increments of 0.1 μs;
- A squarewave output;
- A time range of 000.0 through 999.9 μs, with a time multiplier on top of this.

To accomplish the first two goals, a divide-by-n counter, where n is the thumbwheel-latch value, is clocked at a 20-MHz rate (50-ns time period), and

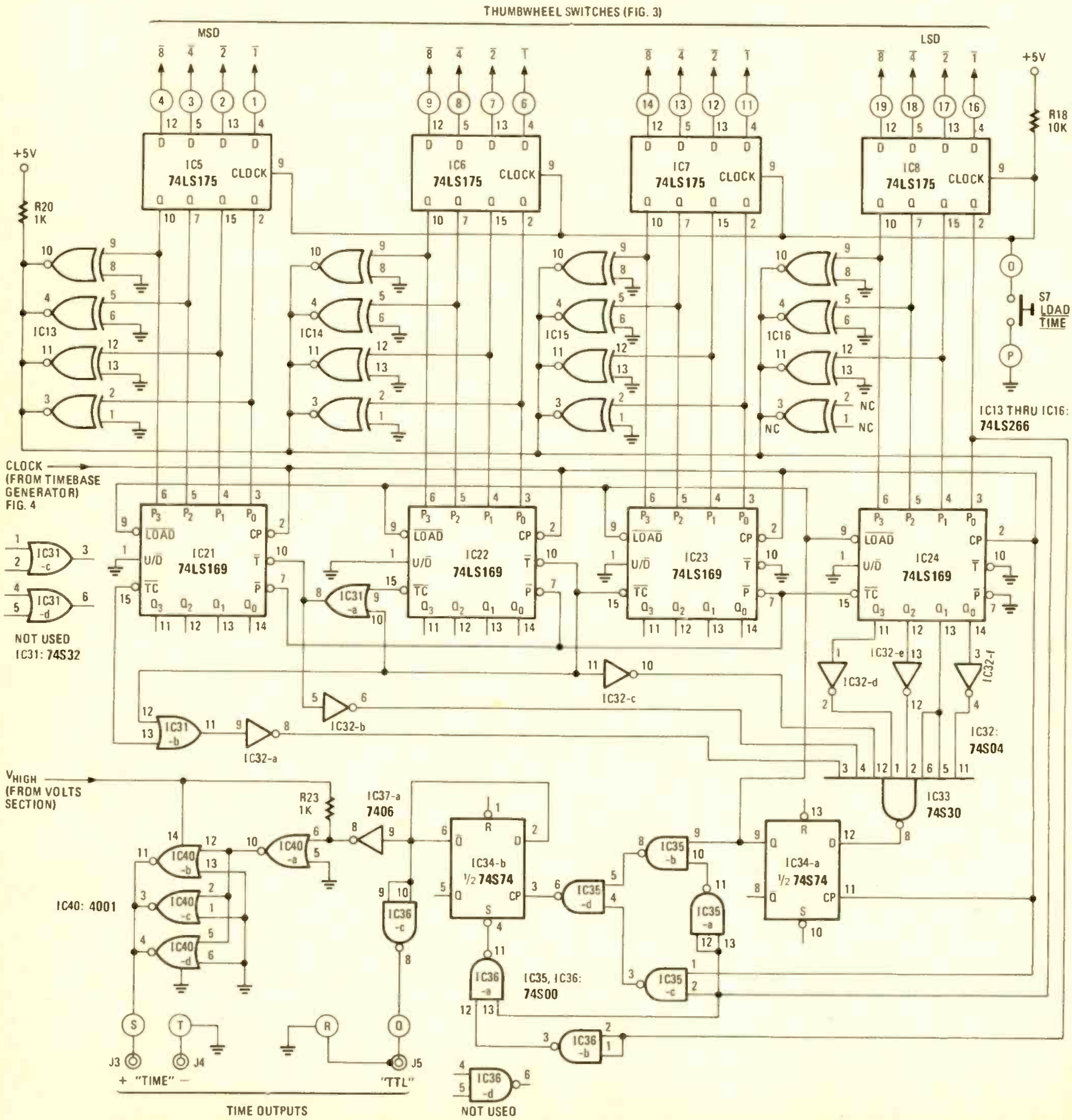


FIG. 2—THE TIME SECTION of the calibrator. Four thumbwheel switches select the time period of the waveforms at the TIME and TTL outputs when pushbutton S7 is depressed.

the counter output is divided by two to produce a squarewave with a time step of 2 × 50 ns = 100 ns (or 0.1 μs). The third and last design goal requires a four-decade counter network. By reducing the counter's clock frequency by 10, 100, 1000 and 10,000, the time output can be multiplied by a similar number.

Decade up/down counters IC21–IC24 are wired in the down-count mode, with IC21 being the most significant stage and IC24 the least significant. These IC's form a divide-by-n counter stage, where the value of n ranges from 2 to 9999. When the counter reaches a value of

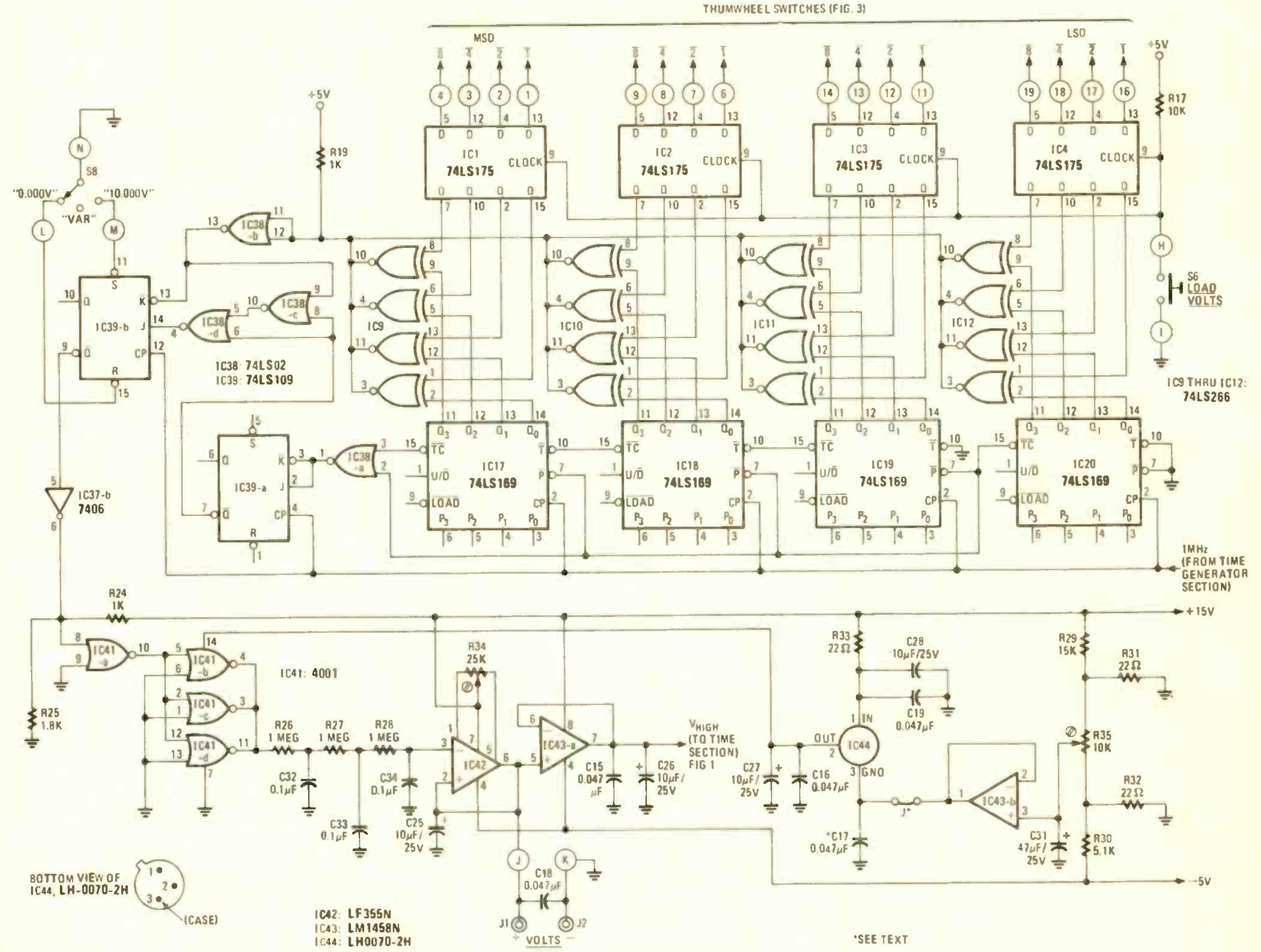


FIG. 3—THE VOLTAGE CALIBRATOR is based on a precision 10-volt reference that can be processed to deliver voltages down to 0 in 10-mV steps.

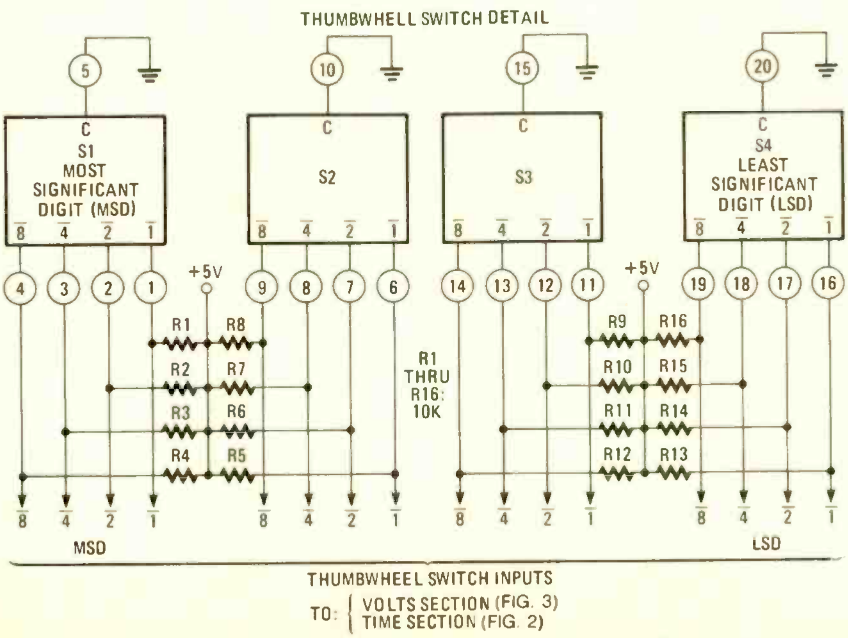


FIG. 4—THUMBWHEEL SWITCHES are BCD-complement types that provide the binary equivalent of analog numbers selected. Resistors R1 though R13 are pull-up resistors.

0002, all inputs to NAND gate IC33 go high, forcing the gate's output to a logic low level. This output drives the data input of the D-type flip-flop, IC34-a. On the next clock, IC34-a's output (Q) goes low, while the counter decrements to 0001. The output of IC34-a is connected to all four counters' synchronous parallel load inputs, so the counters are now prepared for a synchronous load on the next clock cycle, and will load the latched value of n from the thumbwheel switches at that time. The counter stage decrements in the following sequence:

n→(n − 1)→(n − 2) · · · 3→2→1→n · · ·

So loading the n-value produces a low output from IC34-a every n clock cycles. Dividing this signal with a divide-by-two flip-flop (IC34-b) produces the desired squarewave output, and every step in n is a 0.1-μs change in the resulting squarewave output.

Invariably, a value of 0000 or 0001 will be loaded into the time section. Since a divide-by-zero or a divide-by-one counter does not exist, the circuitry would produce 'an ambiguous output. To circumvent the problem, an open-collector exclusive-NOR network consisting of IC13–IC16 is used as a comparator to monitor the latches' loaded value. When a 0000 or a 0001 is loaded, the OR-tied output of the comparator gates goes high, signaling the logic that this special condition now exists. The comparator output drives IC35-c-2, IC35-a and IC36-a (IC35 is wired as a 1-of-2 multiplexer). When the comparator output is low, the multiplexer selects the divide-by-n output to be applied to the clock input of divide-by-two flip-flop IC34-b, as discussed above. But when the comparator output is high, the multiplexer selects the down-counters' clock input as the clocking signal to IC34-b. This produces a divide-by-2 squarewave of 20 MHz, or 10 MHz, which is a 0.1-μs period. But if a 0000 is loaded into the time thumbwheel latches, the input of NAND gate IC36-b is low, causing its output to go high. This means that both inputs to IC36-a are high, and the overriding asynchronous $\overline{SET}$ input to IC34-b is activated. The divide-by-two flip-flop output is now always low, regardless of the inputs on the synchronous inputs, producing a period of 0, as required.

The time-counter network can generate the correct squarewave for any value from 0 to 9999. All that remains to be done is to buffer the squarewave before applying the signal to the front panel. Buffer IC36-c inverts IC34-b's output, and is a standard TTL output (i.e., it has a precise time but no amplitude control). Open-collector buffer IC37-a drives CMOS buffer network IC40. This output swings between ground and its V_{DD} input (indicated as V_{HIGH} on the schematic diagram), which is a DC signal coming from the volts section (to be discussed shortly). While the rise and falltimes from buffer IC40 are slower than that of a TTL output, the amplitude and period are very accurate. However, reliable operation below about 4.5 volts cannot be expected.

Getting the time-counter network to operate at 20 MHz is not easy and requires more circuitry than a slower counter chain. Integrated circuit 31, IC32, IC33 and IC34 perform the necessary high-speed logic operations. It is important that these IC's be Schottky-type IC's, and not low-power Schottky or standard TTL types. Furthermore, if you believe in worst-case numbers, down-counters IC21–IC24 should be manufactured by either Fairchild, Motorola, or Raytheon, since the worst-case speed specifications of these companies are tighter than those of other makes. The "slower" devices may result in the counters not working with some n counts!

Up to this point, it has been assumed that the time counters work with a 20-MHz clock input. If a 2-MHz clock rate is used instead, each least-significant thumbwheel step would be 1.0 μs, rather

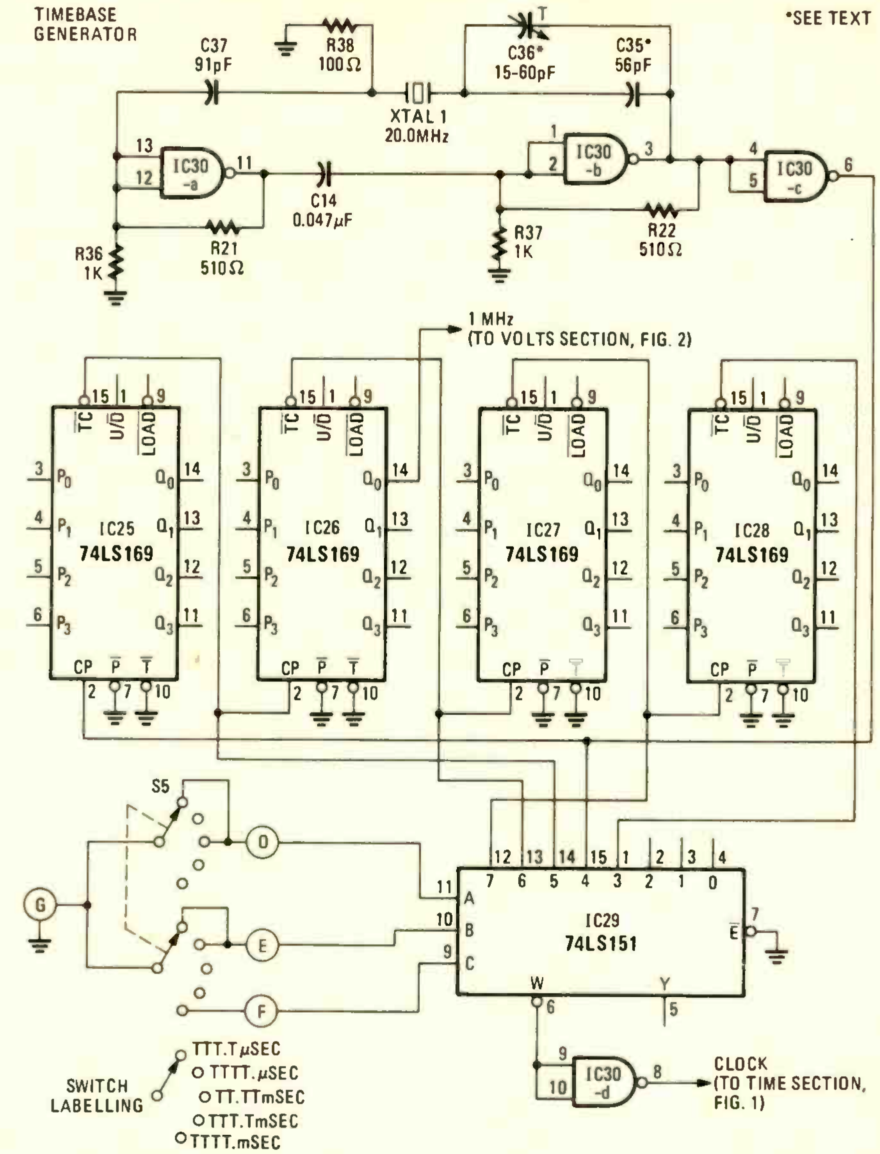


FIG. 5—DECADE COUNTERS in ripple configuration divide the 20-MHz clock frequency by a factor of 10 per counter.

than 0.1 μs. Furthermore, 200-kHz, 20-kHz and 2-kHz clock inputs would produce minimum steps of 10 μs, 0.1 ms and 1.0 ms, respectively. Generating these clock rates is a simple task, assuming that the 20-MHz frequency already exists. Decade counters IC25–IC28 (Fig. 5) are hooked up to divide the 20-MHz clock by factors of 10-per-counter.

The 20-MHz signal and the four counter outputs are connected to multiplexer IC29. Use of the multiplexer and TIME MULTIPLIER switch S5 allows front-panel "cold-switch" selection of a single clock to be applied to the time section. That is, a set of DC signals can select one AC signal to be applied to the time counters, thus avoiding the need to route the noise-producing AC signals to the chassis's front panel. The output of the multiplexer is buffered by IC30-d before being applied to the time calibrator's clock inputs.

The NAND gates, IC30-a and IC30-b, are the amplifying components of the crystal oscillator, whose frequency is set

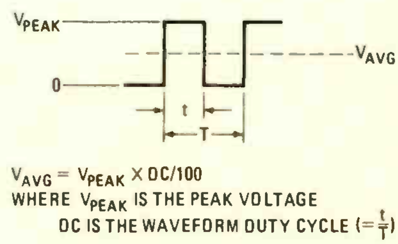


FIG. 6—CHARACTERISTICS of the squarewave that determines the average voltage.

by the 20.0-MHz crystal. The NAND gates introduce a small amount of loop delay that is compensated for by the paralleled capacitor combination of C35, trimmer C36, capacitor C37 and resistor R38. Resistors R21, R22, R36 and R37 bias the gates in their linear regions. The oscillator output is buffered by IC30-c before being applied to the multiplexer and countdown string.

The volts calibrator: how it works

Anyone who has designed an automobile dwellmeter will recognize the operational principle behind the programmable

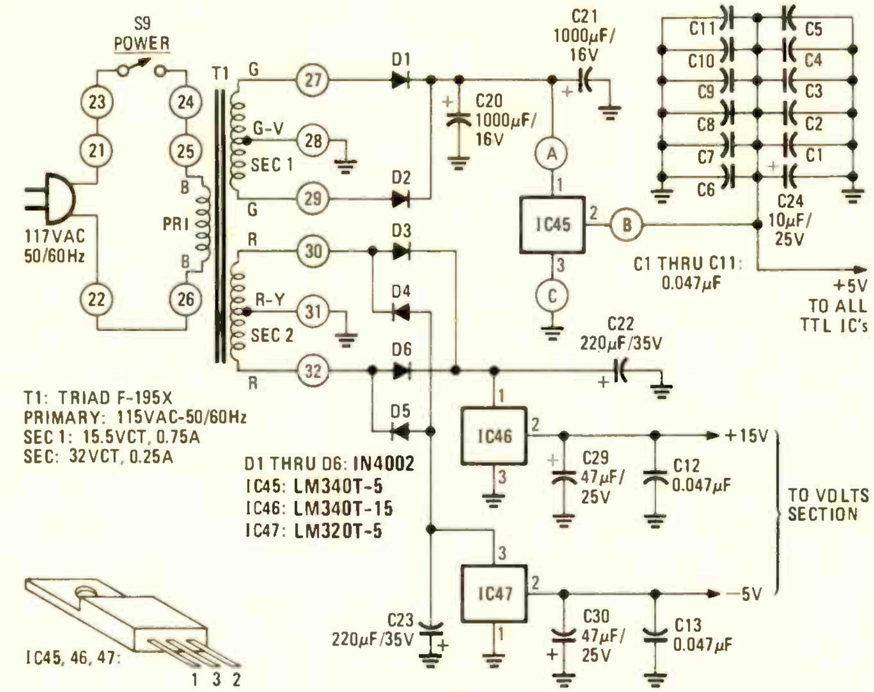


FIG. 7—POWER SUPPLY CIRCUIT. The power transformer with its two secondaries, supplies the IC voltage regulators that deliver the three regulated voltages used in the calibrator.

voltage generator. If a rectangular-wave voltage is allowed to swing between ground and some known voltage with some known duty-cycle, then the average voltage is given by the equations shown in Fig. 6.

So, with a duty-cycle of 0, the waveform never switches but remains at ground, and $V_{AVG} = 0$. A duty-cycle of 100 means that the waveform remains at V_{PEAK}, so $V_{AVG} = V_{PEAK}$. A duty-cycle at any point between the two extremes produces an average voltage between 0 and V_{PEAK}, as shown by the Fig. 6 equation.

How can this principle be used here? It's easy to generate an extremely accurate duty-cycle using standard digital technology. However, where do you obtain an accurate voltage source? Here comes linear IC technology to the rescue! National Semiconductor produces a linear IC voltage reference that is laser-trimmed to 10.000 volts. This IC comes in two accuracy grades: −1H is 10.000 volts ±10 mV (±0.1%), while −2H is ±5 mV (±0.05%). The latter value is specified here for the ultimate in untrimmed accuracy.

How do you generate an AC rectangular waveform that swings accurately between 0 and 10.000 volts; does it with the desired duty-cycle; and exhibits insignificant rise and falltimes between the two voltages? The answer is surprisingly simple: All CMOS circuits switch their outputs between ground and their supply voltage, V_{DD}. Because FET's behave in a resistive manner, there is no offset voltage at the outputs to contend with, as in TTL logic circuits. Thus, by applying the 10.000-volt reference to V_{DD} of a CMOS gate, and applying the specified duty-cycle to the gate's input, the desired signal conditioning appears at the CMOS output. All that remains to be done is to

continued on page 104

PARTS LIST

Resistors are 5%, ¼ watt unless otherwise noted
R1-R18—10,000 ohms
R19,R20,R23,R24,R36,R37—1000 ohms
R21, R22—510 ohms
R25—1800 ohms
R26-R28—1 megohm
R29—15,000 ohms
R30—5100 ohms
R31-R33—22 ohms
R34—25,000-ohm, PC-mount trimmer
R35—10,000-ohm, PC-mount trimmer
R38—100 ohms
Capacitors
C1-C19—0.047 µF, 25 volts, ceramic disc
C20, C21—1000 µF, 16 volts, radial electrolytic
C22, C23—220 µF, 35 volts, radial electrolytic
C24-C28—10 µF, 25 volts, radial electrolytic
C29-C31—47 µF, 25 volts, radial electrolytic
C32-C34—0.1 µF, 50 volts, Mylar
C35—56 pF (or 91 pF), 50 volts, mica (see text)
C36—15-60-pF trimmer (see text)
C37—91 pF, 50 volts, mica
Semiconductors
D1-D6—1N4002, 1A, 100-volt diode
IC1-IC8—74LS175, quad D-type flip-flop
IC9-IC16—74LS266, quad exclusive NOR gate
IC17-IC20—74LS169, 4-bit up-down decade-counter
IC21-IC28—74LS169 (Fairchild, Motorola or Raytheon, see text) 4-bit up-down counter
IC29—74LS151, 8-input multiplexer
IC30, IC35, IC36—74S00, quad 2-input NAND gate
IC31—74S32, quad 2-input OR gate
IC32—74S04, hex inverter
IC33—74S30, 8-input NAND gate
IC34—74S74, dual D-type flip-flop
IC37—7406, hex inverter, open-collector
IC38—74LS02, quad 2-input NOR gate
IC39—74LS109, dual J-$\overline{K}$ flip-flop
IC40, IC41—CD4001, quad 2-input CMOS NOR gate
IC42—LF355N (National) JFET op-amp
IC43—LM1458N (National) dual op-amp
IC44—LH0070-2H (National) 10-volt reference
IC45—LM340T-5 (National) 5-volt positive regulator
IC46—LM340T-15 (National) 15-volt positive regulator
IC47—LM320T-5 (National) 5-volt negative regulator
Miscellaneous
S1-S4—Thumbwheel switches, BCD-complement, Unimax SF-18 or equal (Unimax Switch Corp., Ives Rd., Wallingford, CT 06492)
S5—2-pole, 5-position rotary switch (CTS T-206 or equal)
S6, S7—Momentary, normally open switch
S8—SPDT, ON-OFF-ON switch
S9—SPST switch
J1-J4—5-way binding post
J5—BNC female, panel-mount connector
XTAL1—20.0-MHz quartz crystal, series-resonant, .005% or better tolerance, HC18/U holder
Thumbwheel switch end plates; line cord; strain relief; case (LMB #ME-7114); 4-40 X ½-in. hardware; knob; ½-in. aluminum strips; wire and coax; BNC receptacle and ground lug; PC board; and dry transfer letters.

The following components are available postpaid from Noveltronics, P.O. Box 4044, Mountain View, CA 94040:
CK-TVC: Complete kit of parts and hardware—PC board, special 2-color dry transfer chassis lettering sheet, and unpunched chassis, $150.
PK-TVC: Partial kit—complete thumbwheel switch assembly, LH0070-2H, transformer, crystal, case, special dry transfer lettering sheet, and PC board, $100.
PCB-TVC: Etched, drilled and silk-screened PC board, $25.

California residents add state and local taxes to the total order. Individual items are not available for sale. Orders paid by money order or bank-certified check can be discounted 5%, and guarantee shipment within 2 shipping days after receipt of order. Allow up to 2 weeks delay for personal check clearance time. No out-of-state P.O. boxes, please. Canadian and Mexican orders add 5% (non-discountable) of order, all other non-USA orders add 10% (non-discountable) to cover additional postage and handling. U.S. funds only.

BUILD THIS

BOWLING GAME

CHARLES L. STANFORD

If your gameroom is too small for that full-size bowling alley you've always wanted, here is an electronics-based bowling game for you to try.

BOWLING MAY BE ONE OF OUR EARLIEST sports, with origins dating back to the Egyptians of 5200 BC. Almost five million Americans bowl in sanctioned leagues, and over sixty million more bowl for recreation or exercise. However, it is hard to find a functional yet reasonably priced toy bowling game for the home. The game described in this article can be built to almost any size, uses materials that are easily obtainable and priced reasonably and is a faithful representation of the real thing.

Playing the game

Depending on the size of the alley you want to build, various objects can be selected as a "ball" or puck. I chose to size everything around a quarter (a twenty-five cent coin), but you could use a poker chip or any other circular opaque object. When the game is turned on and reset, all 10 display LED's are dark. If the "ball" slides down the alley and passes over several of the "pin" spots the photo-Darlington transistors embedded in the lane are blocked from light. This change in state is remembered by the internal CMOS bistable latches, and the display LED's indicate which pins would have been knocked down in a real game had the ball taken a similar path. For example, striking the 1 and 2 pins but missing the 3 pin is the same as hitting the "pocket" and it gives you a strike. Hitting the 1, 2 and 3 pins results in that nemesis of all bowlers, the 7–10 split. Other ball paths are similarly translated into the equivalent pin knockdown. If you get a "spare," (i.e., less than 10 pins are knocked down), the second ball is then thrown. Again, the gating tells the display which pins have been knocked down. For more realism, all the spares can be picked up except for the 7–10 split, which is unmakable. After a strike or the second ball, pressing the RESET pushbutton clears the display for the next bowler. Scoring is done exactly as in real bowling; you can obtain bowling score sheets from a local bowling establishment.

The circuit

The block diagram in Fig. 1 shows the sequence that occurs when a ball or puck such as a quarter passes over the pin area of the board. Each of the front seven pin locations has a photo-Darlington transistor inserted in a slot flush with the lane surface. Normal room lighting is sufficient to cause logic-level switching when the photosensitive area is covered by the ball. Each phototransistor (Fig. 2) is wired to its own bistable latch circuit, which "remembers" a pass of the ball by flipping states. These latches, in turn, feed a series of CMOS AND gates (Fig. 3), which are wired to detect various pin combinations. A total of 30 gates in 10 IC packages is connected to provide 21 separate and distinct outputs. While there is no way to show the effect of a hook ball or a pin bouncing off the side boards, every possibility of one or two balls going over the pin area is considered. See Table 1 for the various input combinations and the resultant displays.

Twenty-one of the outputs are diode-Or'ed into a diode matrix ROM (*R*ead *O*nly *M*emory) with seven horizontal-input lines and 10 vertical-output lines (see Fig. 4). The input lines each have connecting diodes at the appropriate junctions of the output lines to drive the 10 display LED's.

The power supply for this circuit (Fig. 5) is noncritical since switching speed is not important. Any handy holder for 4 C or D batteries will suffice. I omitted the batteries and used a 6-volt calculator battery eliminator from my junk box instead. Diode D1, capacitor C1 and resistor R1 provide the needed rectification and protection against reverse polarity and power surges. Note that both supplies can be installed if a shorting-type jack is used; standard dry cells can leak or explode if charging is attempted. A battery eliminator of from 4.5 to 12 volts can be used if LED current-limiting resistors R20–R29 are changed in value; the CMOS IC's will function on any DC supply between 3 and 15 volts.

Construction

Before starting construction, decide on the size of the ball. I chose a quarter, since the alley is a convenient size for table-top play and there is no danger of losing the ball and not easily finding another. The dimensions shown in Fig. 6 for constructing the lane, gutters and phototransistor holes are all determined by the diameter of a quarter. If a different size "ball," such as a poker chip, is chosen, all these dimensions must be multiplied by the ratio of the diameter of

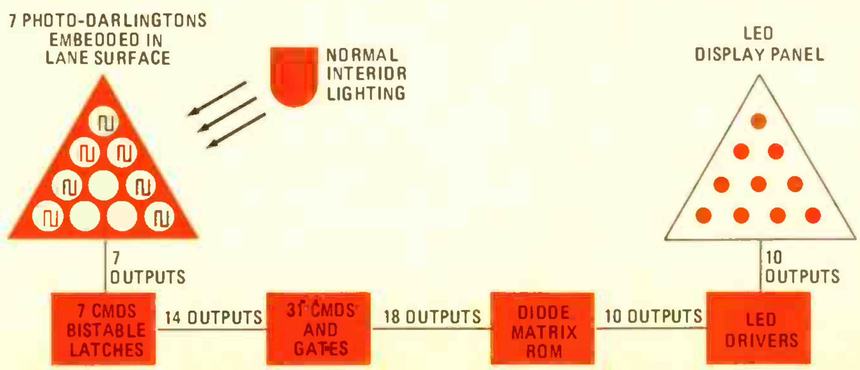


FIG. 1—BLOCK DIAGRAM of the bowling game. Action flows from pins at left to display at right.

the chosen ball to that of a quarter (this is approximately ¹⁵⁄₁₆ inch). In addition, you must be careful to shape the circuit board (see Fig. 7) so that it fits under the alley.

While an etched PC board could have been developed for this project, the labor and cost involved would have exceeded that of the rest of the components combined. This game, with its low-cost IC's and relatively straightforward schematic diagram, is a natural for wire-wrapping techniques. I went one step farther and used a modification of the IC bricklaying method (see "IC Bricklaying," **Radio-Electronics**, December 1977). The IC's were glued upside down to a sheet of ⅛-inch clear plastic, and the pins were direct-wired using a wiring pencil. Anyone trying this, however, must accept the risk of static damage to the sensitive CMOS IC's. A safer procedure is to use multilevel wire-wrap sockets on perforated board and connect the pins with several colors of 30-gauge Kynar-insulated wire.

First, insert the sockets in their relative locations, being careful to leave room for mounting the hardware and other components (see Fig. 7 for general guidelines and dimensions). At this point, it is generally easiest to wire the positive and ground leads on all IC's, using 22-gauge hookup wire and soldering them flush with the PC board. This both holds the sockets in place and provides a pin reference. Note the nonstandard connections of IC's 15 and 16. Now, install R1 and R2 through R8, C1, D1 and the 22-gauge wires that will later be connected to S1, J1 and B1 (if used). Finally, label each socket and mark the pin 1 locations on *both* sides of the board.

Wiring between the pins of IC's 1–14 will be easier to perform and trace if one wire-insulation color is used for all the number-designated pins (1, $\overline{1}$, 2, etc.) and another color is used for all lettered pins A through FF. Start by connecting all the pins of each designation together, as shown in Fig. 8. For example, $\overline{1}$ (which means "not one") is found at IC1 pins 2

TABLE 1—INPUT-OUTPUT CODES

Pin Code	Gate Combinations	Gate Output	Diode Matrix Input Lines	Diode Matrix Outputs 1 2 3 4 5 6 7 8 9 10
1 $\overline{2}$ 3	B (1 $\overline{2}$ 3)	B	11, 14, 16	1 1 1 1 1 1 1 1 1 1
1 2 $\overline{3}$	C (1 2 $\overline{3}$)	C	11, 14, 16	1 1 1 1 1 1 1 1 1 1
1 2 3 $\overline{4}$ $\overline{6}$ $\overline{7}$ $\overline{10}$	A (1 2 3) & E ($\overline{4}$ $\overline{6}$ $\overline{7}$ $\overline{10}$)	N	11	1 1 1 1 1 1 0 1 1 0
$\overline{1}$ 3 $\overline{4}$	H ($\overline{1}$ $\overline{4}$) & 3	U	12	0 0 1 0 1 1 0 1 1 1
$\overline{3}$ $\overline{4}$ 6 $\overline{7}$ 10	M ($\overline{3}$ $\overline{4}$) & 6 $\overline{7}$ 10	T	13	0 0 0 0 0 1 0 0 1 1
$\overline{1}$ $\overline{4}$ $\overline{6}$ 10	H & L ($\overline{6}$ 10)	V	14	0 0 0 0 0 0 0 0 0 1
$\overline{2}$ 4 $\overline{6}$ 7 $\overline{10}$	J ($\overline{2}$ 4) & G ($\overline{6}$ 7) & $\overline{10}$	P	15	0 0 0 1 0 0 1 1 0 0
$\overline{1}$ $\overline{4}$ $\overline{6}$ 7	H & G	W	16	0 0 0 0 0 0 1 0 0 0
1 2 3 10	A & 10	X	11, 14	1 1 1 1 1 1 0 1 1 1
1 2 3 6	A & 6	Y	11, 14	1 1 1 1 1 1 0 1 1 1
$\overline{1}$ 2 3	K ($\overline{1}$ 2) & 3	Z	12, 17	0 1 1 1 1 1 1 1 1 1
$\overline{2}$ 3 4 6	J & 3 6	Q	12, 15	0 0 1 1 1 1 1 1 1 1
$\overline{1}$ 3 $\overline{4}$ 7	H & 3 7	R	12, 16	0 0 1 0 1 1 1 1 1 1
2 $\overline{3}$ 4 6	F (2 $\overline{3}$ 4 6)	F	13, 17	0 1 0 1 1 1 1 1 1 1
$\overline{2}$ 4 6 7 10	J & D (6 7 10)	AA	13, 15	0 0 0 1 0 1 1 1 1 1
$\overline{1}$ 2 $\overline{6}$	K & $\overline{6}$	BB	17	0 1 0 1 1 0 1 1 1 0
$\overline{2}$ 4 $\overline{6}$ 7 10	J & G & 10	S	14, 15	0 0 0 1 0 0 1 1 0 1
1 2 3 4	A & 4	CC	11, 16	1 1 1 1 1 1 1 1 1 0
1 2 3 7	A & 7	DD	11, 16	1 1 1 1 1 1 1 1 1 0
$\overline{3}$ $\overline{4}$ 6 7 10	M ($\overline{3}$ $\overline{4}$) & D	EE	13, 16	0 0 0 0 0 1 1 0 1 1
$\overline{1}$ 2 $\overline{6}$ 10	K & L	FF	14, 17	0 1 0 1 1 0 1 1 1 1

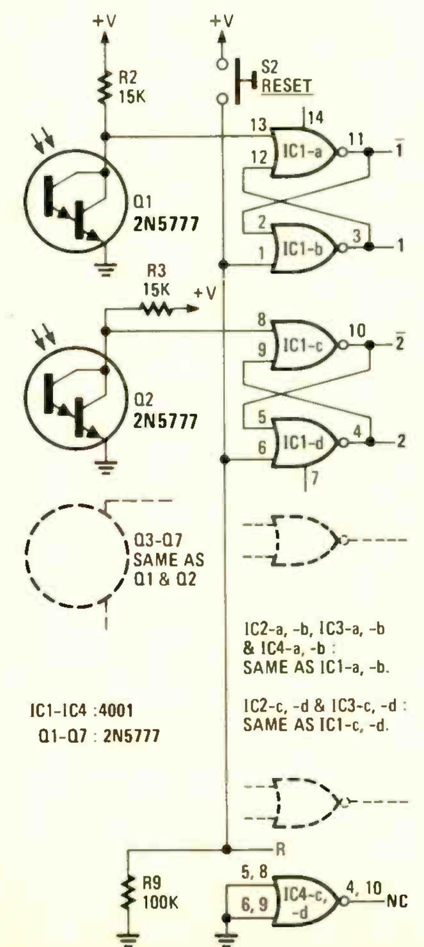


FIG. 2—DARLINGTON phototransistors Q–Q7 are wired to bistable latches using NOR gates.

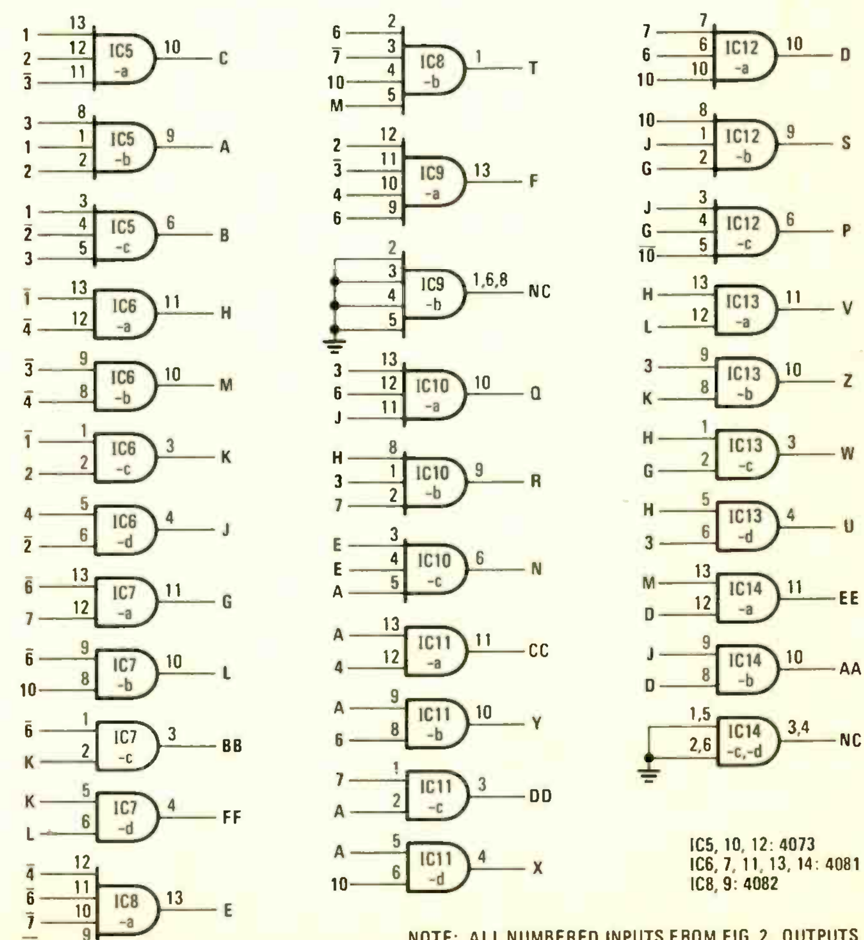
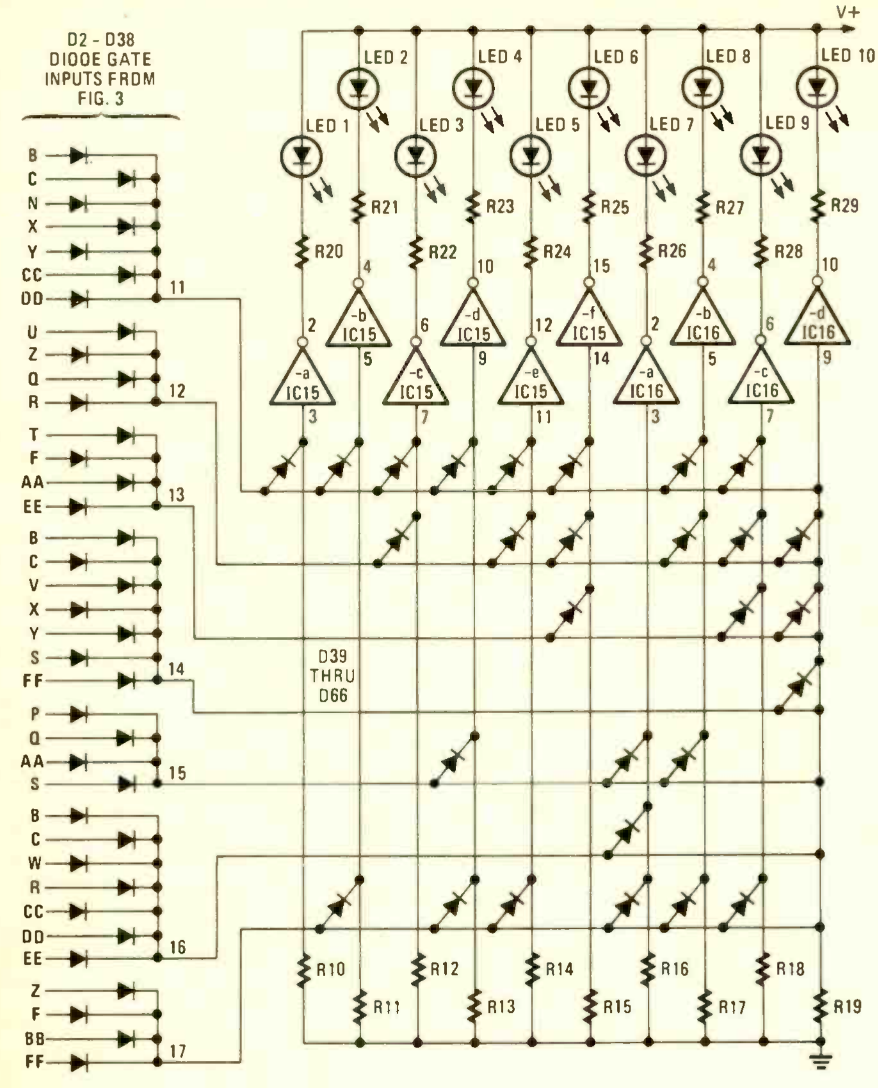


FIG. 3—THIRTY AND GATES provide 21 outputs generated by input from the phototransistors.



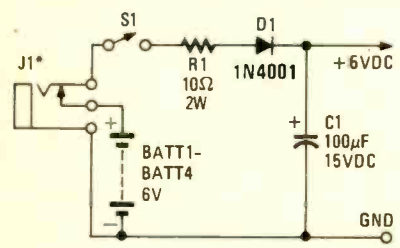
NOTES:

D2 - D66 = 1N914
R10 - R19 = 100K
R20 - R29 = 220 OHMS

IC15 = 4049
V+ : PIN 1.
GND : PIN 8.
NC : PINS 13 & 16.

IC16 = 4049
V+ : PIN 1.
GND : PINS 8, 11 & 14.
NC : PINS 12, 13, 15 & 16.

FIG. 4—DIODE OR GATES feed into a diode read-only-memory with seven horizontal input lines and ten vertical output lines. Ten invertersm fed by the output lines, control the LED indicators.



*SEE TEXT

FIG. 5—THE POWER SUPPLY. A 6-volt battery or four flashlight cells can be used away from AC lines. See text on AC input voltages.

and 11 and IC6 pins 1 and 13. Continue making pin connections until all numbered inputs have been checked off. Then, change wire colors and connect the pins with letter designations. Connect resistors R2–R8 to their respective leads on IC's 1 to 4 and to *V+* at the power supply. Also connect all the pins designated R to each other and to R9; ground the other end of R9.

The diode matrix and its inputs (see Fig. 4) come next. Diodes D2–D38 comprise a wired-OR circuit. Generally, the outputs of CMOS gates cannot be connected, since an off gate directly connected to an on gate would short the power-supply rails through the IC's. However, small-signal diodes can be used instead of additional gates to avoid this problem. Insert the bent leads of the diodes through the circuit board from the top with the anodes nearest the IC sockets. Then, connect the appropriate lettered outputs to their respective diodes.

Using a felt-tip pen, draw the horizontal matrix lines on the board and mark the locations of matrix diodes D39–D66. Insert the unbent anode leads through the board from the top. Run a piece of bare 22-gauge hookup wire from the cathodes of the groups of OR diodes across each line, wrapping once around each matrix diode. Solder snugly against the board so the diodes stand erect on the other side of the board. The 10 bias resistors, R10–R19, are similarly inserted from the top and wired in parallel to ground.

Now, turn the circuit board over and connect a wire up each of the 10 vertical lines of diodes, starting at the resistor. Thread these leads through the board and connect to their respective pins of IC's 15 and 16. Finally, connect the output pins of IC's 15 and 16 to resistors R20–R29.

Building the cabinet

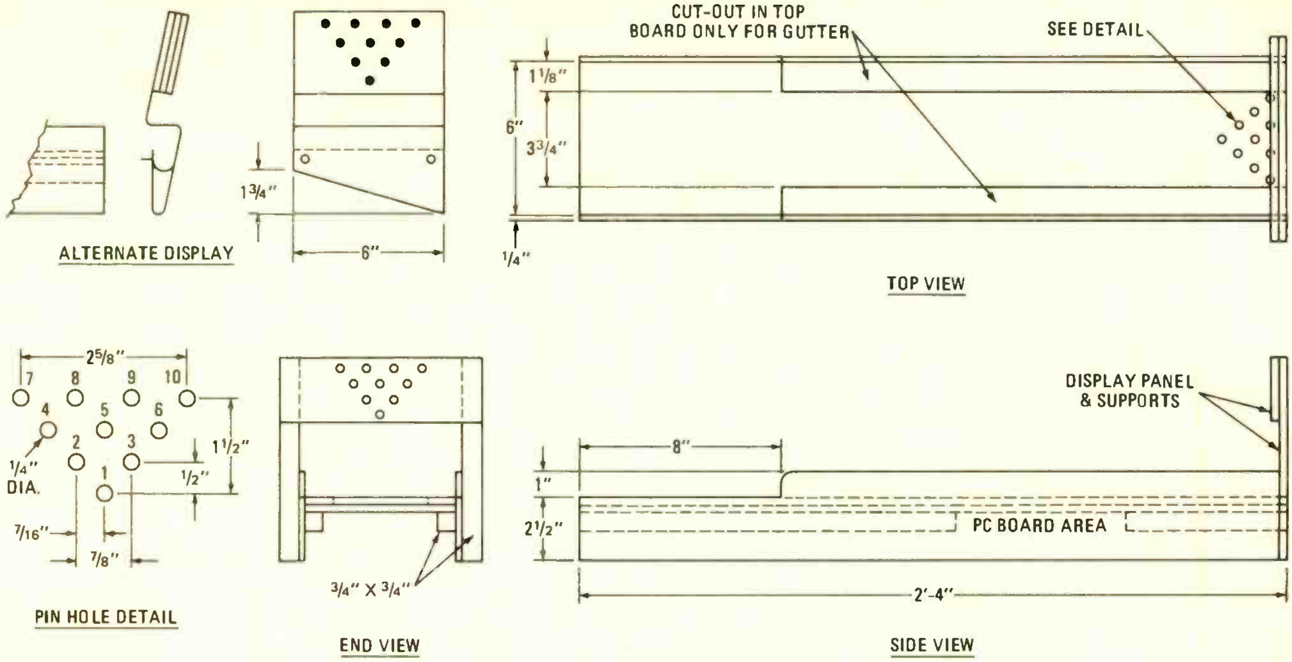
The construction of the alley is quite straightforward, requiring only simple hand tools, a few pieces of tempered *Masonite* or other smooth-surfaced board and some pine strips. First, cut both of the lane base pieces to the dimensions determined by the chosen ball size. Note that the T-shaped piece is the actual bowling surface and be careful not to mar or gouge it. Carefully mark and drill the photo-Darlington transistor mounting holes. Now, paint in a contrasting color the part of the bottom (rectangular) board that will be exposed as the gutters. Use black paint if a light shade of board is available, and white paint if you use dark *Masonite* or paneling. Do not paint the entire board because the glue will adhere better to bare wood or fiber. Next, glue the two pieces together.

When the lane is thoroughly dry, assemble it to the side boards using the ¾-inch or 1-inch-square corner braces and glue.

When all the glueing is complete and set, drill two very small holes (1/16 inch or less) through the bottom lane piece near the edge of each of the front seven transistor mounting holes. Snip off the base lead of photo-Darlington transistors

PARTS LIST

Resistors, ¼ watt, 10% unless otherwise noted
R1—10 ohms, 2 watts
R2–R8—15,000 ohms
R9–R19—100,000 ohms
R20–R29—220 ohms
C1—100 µF, 15 volts, electrolytic
D1—1N4001 or equal
D2–D66—1N914 small-signal diode
Q1–Q7—2N5777 photo-Darlington transistor
IC1–IC4—4001 quad 2-input NOR gate
IC5, IC10, IC12—4073 triple 3-input AND gate
IC6, IC7, IC11, IC13, IC14—quad 2-input AND gate
IC8, IC9—4082 dual 4-input AND gate
IC15, IC16—4049 inverting-type hex buffer/converters
LED1–LED10—jumbo red LED, Radio Shack 276-041 or equal
S1—SPST toggle or push-on/push-off switch
S2—SPST momentary pushbutton switch
J1—shorting-type phone jack, see text
BATT1–BATT4—size-C or size-D dry batteries, see text
Misc:
(14) 14-pin wire-wrap-type DIP sockets; (2) 16-pin DIP wire-wrap sockets; battery holder; perforated board; 22-gauge and 30-gauge wire; pressed board or *Masonite*, etc.



NOTE:
LED1-LED10 MOUNT IN PIN POSITIONS 1-10 RESPECTIVELY ON DISPLAY PANEL
PHOTOTRANSISTOR Q1 MOUNTS IN POSITION 1, Q2-P2, Q3-P3, Q4-P4, Q5-P6, Q6-P7, Q7-P10 ON ALLEY SURFACE

FIG. 6—SUGGESTED DIMENSIONS for the bowling alley. Pin hole spacings are for "ball" the size of a quarter. Alternate display mount has sloping "ball" return.

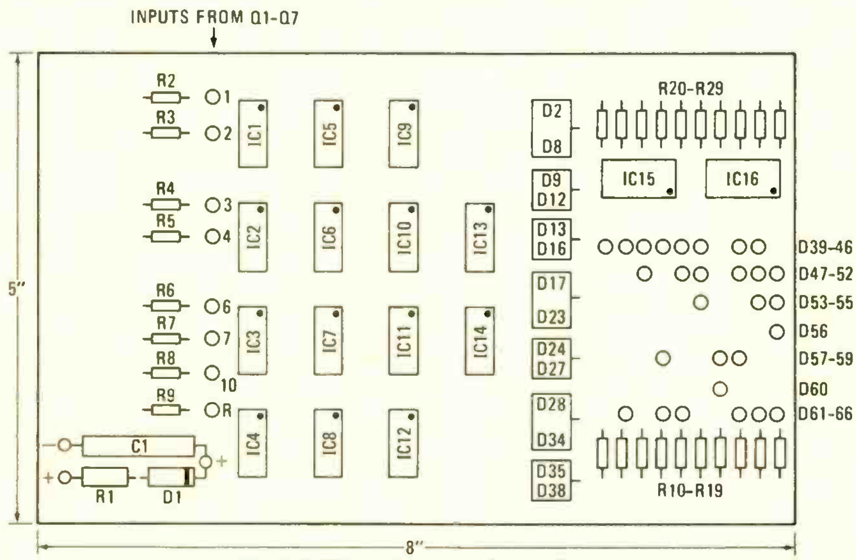
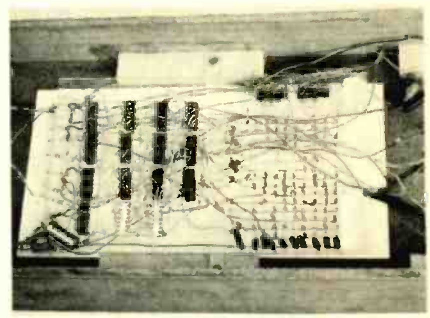


FIG. 7—HOW PARTS ARE POSITIONED on the circuit board. The transistors are cemented top-side-down so the pins are convenient for point-to-point wiring.



INTERIOR PHOTO showing circuit board of one version of the game. A PC board was not used because of circuit complexity.

Q1–Q7, carefully bend the other two leads as shown in Fig. 9, and insert them into the two small holes. Press down gently, making sure each transistor is slightly below the playing surface. Now, wire all the emitters in parallel and hook a separate lead to each collector. Leave these eight wires long enough so that they reach the eventual locations of R2–R8.

Constructing the display panel

The size of the display board is determined by the mounting method chosen. The simplest type of mounting is to attach the display panel to two vertical posts attached to the side frame pieces near the far end of the alley. In this case, the width of the panel will be the overall width of the alley plus the thicknesses of the vertical mounting posts (a ¾-inch width is recommended). The actual display area is composed of two pieces of ⅛-inch or 3/16-inch particle board or *Masonite*. Drill two small holes (a maximum of 1/16 inch) at the location of each LED in the front piece, then paint the panel flat black. Insert the LED leads, hold the LED's flush and carefully bend the leads flat on the back of the panel. Wire all the anodes in parallel with a piece of 22-gauge hookup wire that is long enough to reach from the display to the circuit board. Then, connect a similar length of 30-gauge Kynar wire to each of the cathodes. Group all the wires together at a bottom corner of the panel, and bolt or screw the back-panel cover in place. This will both hide the wires and hold the LED's in place. Now, carefully strip the necessary length of outer insulation off a piece of coax or other available wire of the proper size, and use it as a sheath for the eleven leads between the panel and the circuit board.

For a more professional look, drill the proper size holes in a piece of clear acrylic plastic and add it to the front of the panel. It will enhance the display brightness and give a finished appearance. I formed a convoluted shape out of clear plastic to form both a front panel and a sloping ball return.

Installation and testing

First, insert all the IC's into their proper sockets, observing polarity and CMOS-handling procedures. Then, screw the corners of the PC board to the mounting blocks and install power jack J1 and switches S1 and S2. If batteries are used, mount the battery holder. Finally, connect the display, power and switch leads. Be very careful to observe polarity at jack J1 and the battery holder. Unless the display wires are color-coded or tagged, they will have to be sorted out one

continued on page 106

WHAT'S NEW IN RECHARGEABLE BATTERIES

If we wanted rechargeable batteries to supply power to electronic equipment, we generally selected a NiCad or special alkaline type. Now, we can choose Lithium too

WALTER SALM

IF YOU USE BATTERIES (AND WHO doesn't), you're probably painfully aware of some of their limitations. Primary (nonrechargeable) batteries fill a definite need in our lives, but they have the distressing habit of becoming exhausted just when you need them the most.

The obvious answer to this has traditionally been the secondary (rechargeable) battery, and where electronic equipment is concerned, nickel-cadmium (NiCad) has been king for the last 10 to 15 years. But there are many forms of rechargeable batteries with specifications that vary widely. In addition to nickel-cadmium, there is the lead-acid type which is now being trimmed down from its large automobile size to small sealed units that are supposed to compete with nickel-cadmium. The sealed lead-acid type uses a sulfuric acid gel for its electrolyte, making it about as dry as other "dry" secondary batteries. It has the big advantage of a lower cost per watt-hour—less than ¼ as much as the nickel-cadmium type.

But the sealed lead-acid cell just hasn't caught on all that well with consumers. For one thing, the cell's nominal open-circuit potential of 2.0 volts means that it has little compatibility with the more traditional types of batteries used in consumer goods, such as appliances, radios, calculators and other devices. Remember, these devices were mainly designed to work with primary batteries that typically have a 1.5-volt open-circuit potential. The nickel-cadmium battery has been fairly interchangeable with them because of its 1.35 to 1.4-volt open-circuit rating. The slight difference in voltage is usually more than made up for by the NiCad's higher current discharge rate.

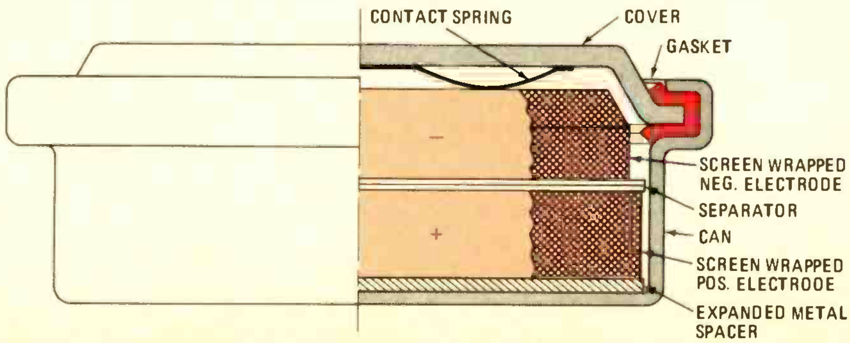
A closer look at the nickel-cadmium cell shows that it has a lot of built-in safeguards—and some important variables. When most secondary batteries recharge, a certain amount of waste-product gas is produced by the charging process. The lead-acid batteries used in the family chariot vent this gas through the small holes in the water filler plugs. Periodically, this type of battery must have water added to offset normal evaporation and water lost during the recharging process.

In the sealed nickel-cadmium battery, the gas produced is oxygen, which is handled by two techniques: providing enough internal air expansion space to accommodate this gas within the cell until it goes back into solution in the electrolyte during discharge; and by providing chemicals that would combine with and absorb excess oxygen to prevent pressure buildup. Generally though, as used by consumers, nickel-cadmium batteries do not vent gas when used with chargers recommended by the battery manufacturer.

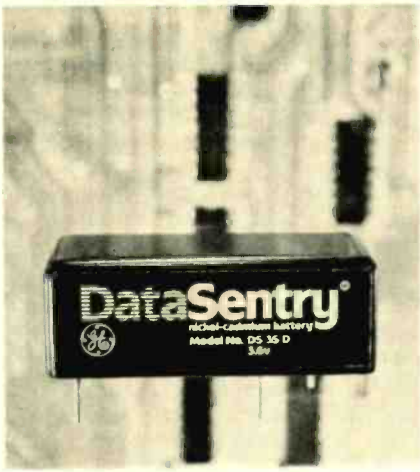
Most people think nothing of leaving a set of batteries plugged into the charger long beyond their recommended maximum charging period. It's quite familiar to notice the razor sitting on the shelf with red light still glowing a full 24 hours after it should have been unplugged. "Ohmygosh, how long has that been charging?" is the usual reaction.

Since one of the biggest abuses of NiCad's is overcharging (and overdischarging), most manufacturers now provide some kind of exhaust vent to prevent the ultimate catastrophe—an explosion or rupture due to overcharging, an event that rarely happens with consumer batteries but can occur in heavy-use industrial and commercial applications. There are basically two types of such vents—one-shot deals that effectively take the battery out of useful service, but prevent the explosion; and resealable vents that relieve pressure but maintain the battery's airtight integrity.

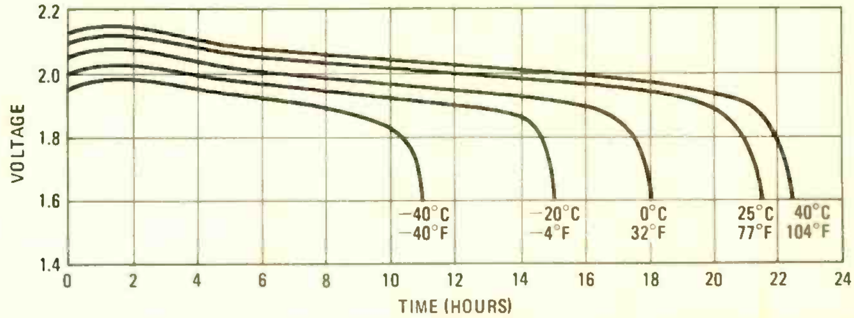
The secret of the resealable vent is that it opens only momentarily and then only when the internal gas pressure gets so high that the battery is in danger of rupturing. The vent opens, a puff of charging gas (oxygen) escapes, and the vent closes and reseals automatically. Actually, this vent can open and reseal many times during a heavy overcharge cycle,



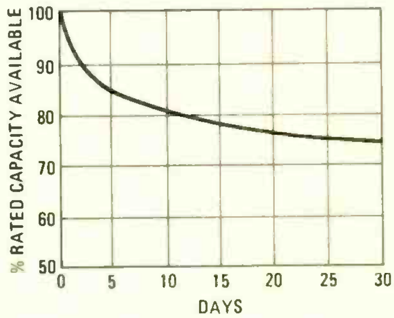
INTERNAL CONSTRUCTION of a sealed nickel-cadmium button cell.



NI-CAD IN A DIP from General Electric mounts directly on PC boards to provide standby power for logic circuits.



DISCHARGE CURVE for a sealed lead-acid 2.5 amp-hour D-size cell with a 125- mA current drain.



SELF-DISCHARGE CURVE of sealed nickel-cadmium cells in dry air.

and its presence greatly extends the life of the battery.

The non-resealable vents, while they avoid possible battery rupture, stay open once they break their seal, and the battery's electrolyte then proceeds to dry out fairly quickly.

The resealable vent is especially important in batteries used with quick-charge systems of 15 minutes or so.

Lead-acid in new dress

While it's fairly common to compare other rechargeable batteries with the venerable open-vented wet automotive lead-acid type, this old-time combination of materials has taken on new dress in recent years. The dry, sealed lead-acid battery has been on the scene for a couple of years now, and is gaining ground in many areas. Unfortunately, it still hasn't been able to displace the nickel-cadmium battery yet in its many consumer power applications.

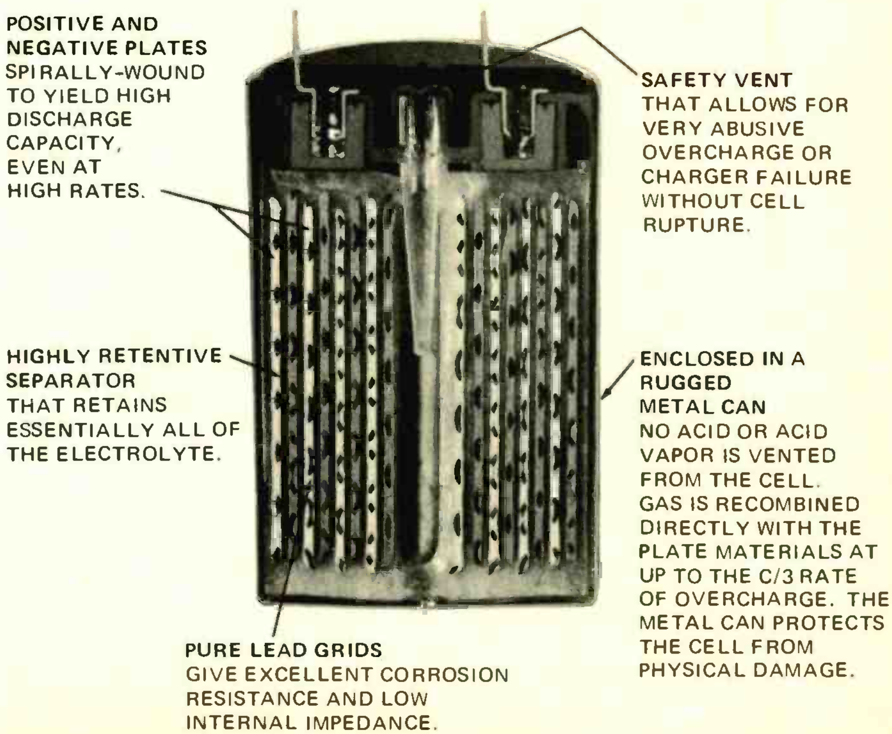
In its basic form, the dry lead-acid battery consists of two strips of lead separated by a porous glass-fiber strip. This sandwich is wound up into a cylindrical form and then baked to harden the lead paste. Once in the case, a very tiny amount of sulfuric acid is squirted in to become the electrolyte, and the whole thing is sealed up. There's no venting needed (except for instances of battery abuse), since the battery chemistry uses up free oxygen as soon as it forms during charging, and the battery will not overcharge.

Weight is somewhat of a problem when comparisons are made with NiCad types, but there is even more of an obstacle—the 2.0 volt open-circuit cell potential obviates any possible direct replacement use for conventional carbon-zinc or manganese-alkaline types. Manufacturers of this type of battery instead feel that energy-consuming appliances should be designed around the battery, instead of the other way around. And there is certainly some validity in this viewpoint.

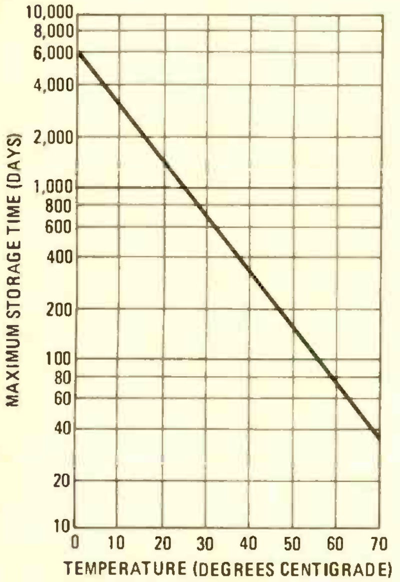
The discharge rate of both sealed-lead-acid batteries and nickel-cadmiums can be tailored to meet deep-discharge needs in certain applications. A favorite place for such batteries today is electric-start lawnmowers, motorcycles and other devices ordinarily started by handcranking.

Lead-acid batteries have also appeared as rechargeable lantern batteries (they're 6 volts, so the 2-volt nominal doesn't present a design problem) and in certain kinds of high-consumption power tools and appliances that are more conveniently used in a cordless version.

Lead-acid battery manufacturers state that these units can be recharged at least 200 times, and deliver full rated power each time. Full discharge doesn't shorten the battery life as it can do with some other types, and the battery doesn't leak off the charge as rapidly as NiCad's or conventional wet lead-acid batteries. NiCad's, on the other hand, are often guaranteed for at least 500 charge/discharge cycles, but can hold a full charge only for a week or so before leaking it off. As with



INTERNAL CONSTRUCTION of a typical sealed lead-acid cell.



STORAGE TIME vs. temperature for sealed lead-acid cells.

anything, you pay your money and you take your choice.

Lithium to the rescue

Remember the big splash over lithium primary batteries a couple of years ago? These batteries were going to be the power source of the future—they had such fantastic energy density. But as with many new technological developments, they had their design problems, which have been pretty much cleaned up by now.

Lithium's prodigious energy-storing properties have now come to the rechargeable battery. Two companies—Bell Laboratories and Exxon Research and Engineering Co.—have developed lithium secondary battery technologies that could well be the beginning of a minor revolution in energy sources. Bell's battery is called lithium-vanadium disulfide, while Exxon's is lithium-titanium disulfide. They both use certain special properties of metal-disulfide combinations to make the batteries work.

These materials belong to a class known as "layered compounds" and the compounds are typically only three molecules thick—two molecular thicknesses of sulfur bonded with a layer of metal molecules in between, sandwich-fashion. The next layer consists of another sulfur-metal-sulfur bond and so on.

TITANIUM DISULFIDE compound used in lithium cells produced by the Exxon Engineering and Research Company. This view of the compound with a X1000 magnification shows the layering effect. The between the layers is filled with lithium.

These layers are loosely bonded together like the pages in a book—with free space in between. A familiar layered material that comes to mind is mica, whose "pages" can be peeled apart rather easily.

In these layered compounds, the space between the layers is filled with lithium (full discharge state). When the battery is charged, the lithium migrates out from between the layers and is plated out as lithium metal. There is no reason for the lithium to move back between the layers until current is drawn from the battery. Thus, the battery retains its full charge.

Since the charge/discharge cycle doesn't involve any kind of chemical reaction, just a migration of lithium ions from one free space to another, there's no opportunity for any kind of chemical deterioration to occur. One scientist at Bell Labs described it as something like a sponge taking up water. The sponge may increase slightly in volume when all the spaces are filled, but it hasn't changed at all. The lithium ion migration into the space between layers acts much the same way.

Plastic separator

A further difference between the Bell and Exxon batteries is the plastic sheet separator used by Exxon. Here, the layered titanium disulfide is separated from a layer of metallic lithium by a porous plastic film. Once again, lithium ions migrate through the electrolyte mix, in this case a solution that's as dry as the paste in most "dry" batteries. Unlike the Bell battery, in which the layered compound is pressed or molded into a sponge-like shape, Exxon physically layers the material on a substrate, covers it with the plastic sheet, then covers it with a layer of lithium.

The other big difference between the two companies' approaches: Bell is licensing the manufacturing to other companies instead of producing batteries itself; Exxon is already in pilot production in a spanking-new plant and expects to have full-scale production underway soon. The new manufacturing subsidiary is part of Exxon Enterprises, Inc.

The new lithium rechargeables have several important features:

- Once charged, they can be stored indefinitely without leaking off any of the charge.
- No matter how many times the battery is cycled through charge/discharge, there is no chemical deterioration.
- Energy density is significantly higher than for other battery types—typically about two to five times as much as for comparable size nickel-cadmium batteries.

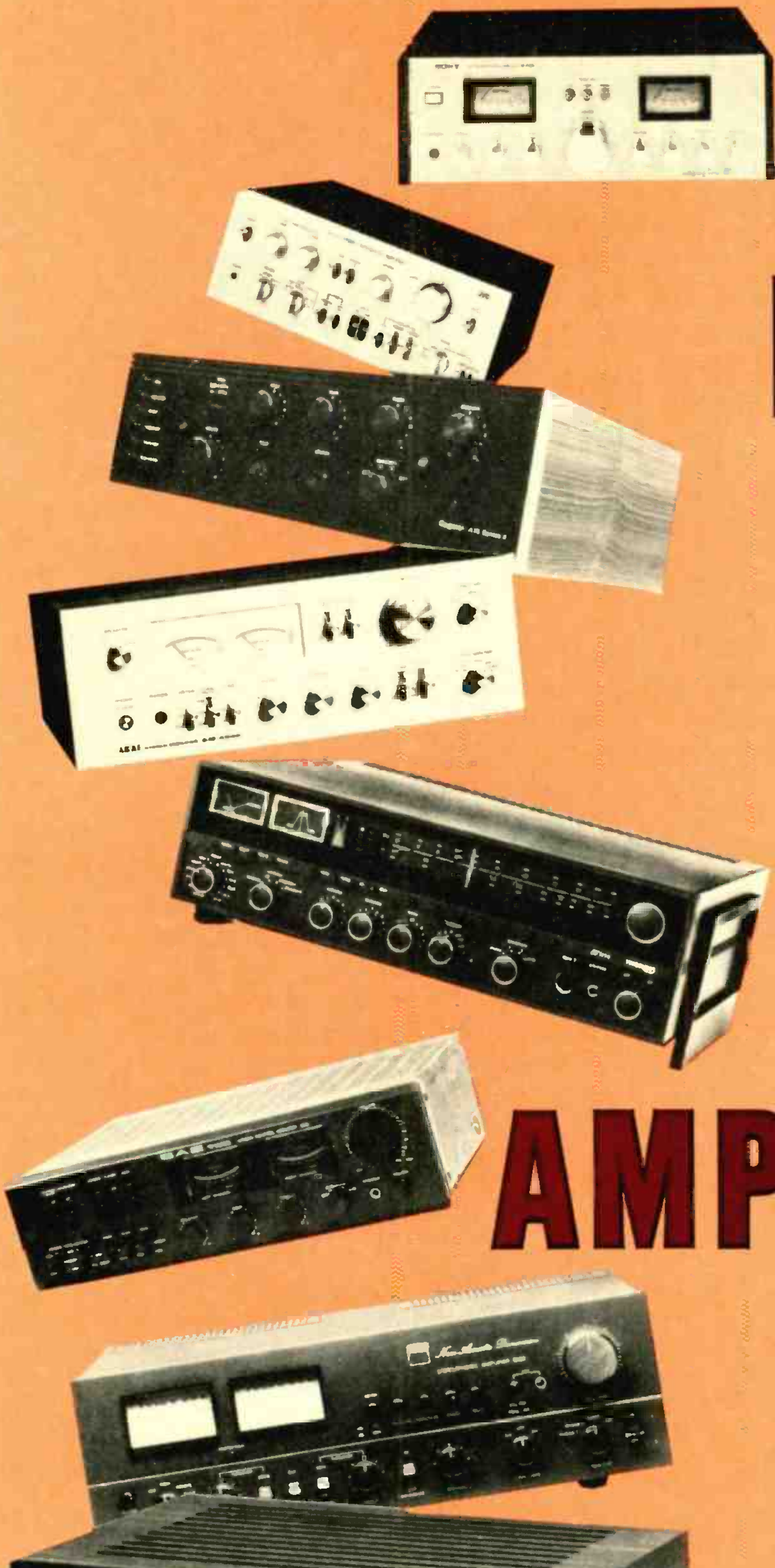
But that unlimited lifetime does have some qualifications. As one Exxon scientists put it, "Deep charging and discharging could have some adverse effects on battery lifetime. Actually, you can wreck *any* battery if you abuse it badly enough."

The frosting on the cake is a very practical application in a mind-blowing desk ornament proudly displayed by Exxon officials. Sealed into an acrylic plastic paperweight is an LCD digital watch movement, a lithium cell about the same diameter as the watch movement, and a tiny string of solar cells. The solar cells trickle-charge the battery, which keeps the watch running—indefinitely. Exxon believes that new products will be tailored to use these new batteries wired in permanently—just like so many transistors, resistors and capacitors. Since the battery will probably outlast whatever device it's powering, this doesn't sound like such a bad idea.

The one hitch is that the lithium rechargeables aren't directly interchangeable with batteries that have a nominal voltage of 1.5 volts; they can be designed for full-charge potential ranging from 2.1 to 2.4 volts per cell. The LCD watch desk ornament uses a tiny voltage-dropping resistor as a regulator to suit the voltage to existing watch circuits. But such "regulators" won't be needed with many products since they'll be designed with the lithium batteries in mind.

On the horizon, we'll probably soon see a whole new class of devices with permanent batteries. Overnight charging will become normal, while fast-charge systems will also undoubtedly be developed. It will be a boon for the person who can't afford to have a single day of downtime on his timepiece. It will be a godsend for the hearing-impaired whose hearing aids eat up expensive mercury batteries at a prodigious clip. The money saved on batteries will pay for a second hearing aid, so while one is being worn, the other can be hooked up to the charger.

The timetable is still a little fuzzy. But Exxon feels that the first product to feature its battery—probably a timepiece in the over-$100 range—could be ready for the market in a year or less. From there, the sky's the limit for the new "Forever Battery." **R-E**



BUYERS GUIDE TO HI-FI AMPLIFIERS

LEN FELDMAN

How To Select The BEST Amplifier For Your Hi-Fi

Although the fidelity and response of an audio system can be no better than that of its poorest component, the amplifier may be the very heart of the hi-fi setup. Use this guide to amplifier selection.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

THE AMPLIFIER OF A COMPONENT HIGH-FIDELITY SYSTEM may well be thought of as the "heart" of that system. All program source signals—whether they are from AM or FM broadcasts, phonograph records, tapes or TV—all pass through the amplifier before they are applied to the loudspeakers (or stereo headphones) for conversion back into audible sound.

When this article refers to a high-fidelity amplifier, we mean all the required amplification circuits, from the so-called preamplifier stages right on through to the power-output stages. In terms of high fidelity components, therefore, we might find the audio amplifier sections of a system contained in a single unit (a so-called integrated amplifier containing a preamplifier and a power amplifier); a two-unit system (a separate preamplifier/control unit and a so-called "basic" power amplifier); or even a subsection of a more all-encompassing component known as a stereo receiver (which, in addition to containing amplifier elements, also contains the FM tuner circuitry). Which of these three amplifier alternatives you choose for your system will depend upon your budget (usually, separate components end up costing more than an all-in-one receiver), the amount of space you have available for your components, and the degree of control flexibility and number of operating features you require.

Receivers, because of their compact size, generally offer a lower power output and fewer switches and controls than separate components. However, in recent years there has been a distinct tendency on the part of receiver manufacturers to offer higher and higher power outputs (the latest "record" set by one manufacturer is 250 watts-per-channel) as well as many, if not all, of the controls and switches normally found on separate components.

No matter which form of amplifier you elect to purchase, its performance specifications and the operating features you should be aware of are common to all types and can be discussed in similar terms. So, as we examine those specifications and features, we will use the term "amplifier" regardless of whether the unit is an all-in-one receiver or a separate component.

Phono preamplifier and equalizer

Signals delivered by such program sources as an FM or AM tuner or a tape deck are generally much greater in amplitude than those produced by the tiny phono pickup, or cartridge, mounted in the pickup arm of your record changer or turntable. The latter signals may have an amplitude of just a few millivolts. Accordingly, the phono signals must be amplified to a greater extent than the other high-level signals. The phono preamplifier section of an amplifier performs this task, raising the signal-amplitude level produced by the phono cartridge from a couple of millivolts to perhaps one-half volt or more.

The phono preamplifier section performs another important task—that of equalization. Modern phonograph discs are recorded with anything but a flat frequency response. Low bass frequencies are deliberately attenuated, while high treble frequencies are boosted or pre-emphasized. These frequency-response modifications are made to accommodate a greater amount of music per-disc-side and to improve the signal-to-noise ratio of the resulting disc by decreasing the audible surface noise heard during playback. But, to play back a record properly, all frequencies must be restored to their correct relative intensities. This is done by introducing the converse frequency-response characteristic in the preamplifier section. The process is known as RIAA equalization (RIAA stands for *R*ecord *I*ndustry *A*ssociation of *A*merica), and the same response curve is standard throughout the world. The RIAA playback response curve shown in Fig. 1 is the exact converse of the RIAA recording characteristic, so that the net effect of this two-part process is to restore flat response to the music we hear from phonograph records.

This response curve must be adhered to as accurately as possible, and, in quoting the frequency-response curve of a given preamplifier section, manufacturers generally use the following statement: "Frequency response, Phono: RIAA ±'so-many' dB." The lower the dB value, the more precise the equalization. Thus, "RIAA ±0.5 dB" represents a more accurate equalization (and, hence, a flatter playback response) than "RIAA ±1.5 dB."

Another phono-input specification is the input sensitivity. This specification, rather than being a measure of the quality of the preamplifier, is given to enable you to properly match the phonograph cartridge to the preamplifier. Stated in millivolts (mV), the specification indicates how much of a signal must be fed to the preamplifier's phono inputs so that, with the volume control turned all the way up, the preamplifier delivers its rated output voltage (or, in the case of an integrated amplifier or receiver, delivers its full rated power output).

Obviously, if a preamplifier requires a signal input of 4 mV and a cartridge is connected to it that nominally delivers a signal of only 1 or 2 mV when tracing record grooves, the cartridge will have difficulty driving the amplifier or preamplifier to its rated output. Most state-of-the-art preamplifiers intended for use with magnetic cartridges (the type preferred for high-fidelity use) have input sensitivities ranging from 2 to 3 mV, a value that closely matches the typical output of most phono cartridges.

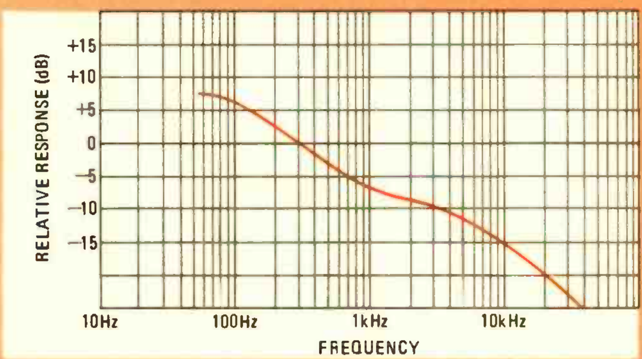


FIG. 1—RIAA PLAYBACK CURVE is the converse of the curve used during the recording process.

Recently, the Institute of High Fidelity (IHF), an American-based trade organization of high-fidelity component manufacturers, devised a new set of amplifier measurement standards. The new Standards (IHF-A-202, 1978) are an attempt to make amplifier measurement more uniform among manufacturers, so that when prospective purchasers compare specifications they can be sure that all the manufacturers' measurements are based upon the same reference points and can therefore be meaningfully compared.

One of the changes incorporated in these Standards concerns the measurement of input sensitivity of preamplifiers and amplifiers. The IHF felt that referencing phono-input sensitivity to the full rated output of an amplifier was not the best way to arrive at this specification. The reason will be clear if you consider the following example:

Suppose there are two amplifiers, one having a power-output rating of 10 watts-per-channel, the other with a power-output rating of 100 watts-per-channel. Suppose also that each manufacturer rates the phono sensitivity of these amplifiers as 2.0 mV (the voltage needed to drive the amplifier to its rated output). Clearly, the 100-watt-per-channel amplifier will *sound* much louder when driven with a 2-mV signal than the 10-watt-per-channel amplifier.

The IHF decided that it would be better to specify phono-input sensitivity (as well as the input sensitivity of other amplifier inputs) with reference to a constant, fixed *output* level of 1 watt, regardless of the amplifier's power rating.

Under these test conditions, the "new IHF" phono sensitivity of the 10-watt-per-channel amplifier would become 0.63 mV, while the phono sensitivity of the 100-watt-per-channel amplifier would be 0.20 mV. These results clearly indicate that if the *same* level of phono signal is applied to each amplifier, the 100-watt-per-channel amplifier will sound much louder, which is indeed the actual case.

Another important specification related to the preamplifier's phono input is known as "phono overload" or maximum phono-input level. Also stated in millivolts, this specification gives the maximum phono-input signal level that can be applied to the preamplifier before it produces audible distortion.

While average music signals imbedded in record grooves may cause a phono cartridge to produce a 2- or 3-mV signal, modern records have a great dynamic range and, during loud musical passages, cartridges may deliver much more voltage. Therefore, it is important that the preamplifier be able to handle higher signal levels without introducing distortion.

Phono S/N ratios

All electronic circuits generate some noise of their own. If the noise is very low compared with the signal being processed by the circuit, when the signal is finally reproduced with its added noise, the noise may be inaudible since it is so much lower in amplitude than the desired audio signal. In the case of very small phono-cartridge signals, the preamplifier stages must generate far less internal noise if that noise is to be inaudible after the extra phono-signal amplification. An all-important specification relating to the phono section is, therefore, the signal-to-noise (S/N) ratio.

Unfortunately, because not all manufacturers quote the S/N ratio in the same way, S/N specifications vary and cannot be easily compared with each other. The most conservative phono S/N specification references the residual hum and noise to the *rated* input sensitivity—i.e., how much lower the amplified noise and hum is compared with the amplified 2.0- or 3.0-mV phono-input signal.

On the other hand, some manufacturers refer the S/N figure to 10-mV input (a voltage value rarely produced by a cartridge tracing standard test record grooves). Clearly, the same amount of noise will be further removed or lower with respect to a 10-mV amplified phono signal than with a 2-mV or 3-mV signal, and the resulting S/N figure, quoted in dB (the higher the better), comes out anywhere from 10 dB to 14 dB higher than would be the case if it were referenced to the lower input signal level.

Often, certain weighting curves are inserted during phono hum-and-noise measurements. These curves tend to downplay the "hum" components of the resulting noise output, as well as the higher hiss frequencies of noise, on the theory that human hearing is less susceptible to these extreme frequencies than to middle-range musical frequencies. True as this theory may be, it nevertheless leads to still higher, or better, S/N figures when applied to amplifiers. Manufacturers who use this measurement technique will, at least, say so in quoting the results. Thus, the notation, "S/N, Phono (IHF "A" Weighted)," means that such weighting networks have been used in making the measurement, and these weighted measurements should not be compared with unweighted measurements quoted for another product.

The new IHF Amplifier Measurement Standard addresses the problem of the many ways in which amplifier manufacturers have been specifying S/N ratio (and the attendant confusion this creates in the mind of the prospective consumer). The audio engineers who devised and wrote the new standard reasoned that, in the first place, users are not likely to listen to amplifiers with the volume control turned all the way up (the setting of this control normally used to measure S/N ratios). A standard phono cartridge output level of 5 mV was set as the reference level against which signal-to-noise should be measured for all amplifiers.

The procedure, therefore, is to apply a fixed 5-mV signal to the phono inputs and to reduce the volume control on the amplifier until the *output* at the speaker terminals is equal to 1 watt (0.5 volt for separate preamplifiers that do not include power-amplifier circuitry). Next, the 5-mV signal is removed, a dummy load equivalent to the impedance of a phono cartridge is inserted into the phono-input jacks, and the noise level is measured on a meter and expressed in dB below the new input and output reference levels. The "A" weighting measurement is also used in the new technique.

There is no direct way to correlate the new IHF S/N measurements with older methods. On the one hand, the 5-mV input level will tend to make the dB values look higher, compared with readings obtained when lower input levels (such as 2 mV) were used, but the values will be lower if a manufacturer had previously used a 10-mV input level as a reference signal. On the other hand, the 1-watt *output* reference to which the volume control must now be set tends to make the dB values *lower*. The use of an "A" weighting network (if none was used in earlier S/N measurements) further complicates the relationship between the old and new readings. As soon as all manufacturers begin to use this new measurement technique, however, comparisons of the S/N ratio between competing amplifiers will be more meaningful in terms of actual perceived noise and hum; the higher dB values will, as usual, mean a *better* specification. During the transition period, some manufacturers may continue to quote their old S/N ratios as well as the new IHF measurements.

The final specification usually associated with the phono-input section of an amplifier is the input impedance. Usually, the input impedance will be 47,000 ohms or 50,000 ohms, a figure that is most nearly ideal for most phono cartridges. Some preamplifier sections may be equipped with a switch selector that permits you to choose other input impedances to match the specific cartridge requirements, such as those for playing quadriphonic (CD-4) records, which generally perform optimally with a 100,000-ohm impedance.

Amplifier control section

Figure 2 is a block diagram that shows the various sections of a complete audio amplifier. Earlier this article discussed the phono-preamplifier section. Only a single stereo amplifier channel is shown in Fig. 2, since the opposite channel of the stereo pair is identical. Note that connection points for high-level tuner or tape signals bypass the preamplifier section and go directly to the program selector switch. The signal selected by this switch is then fed to one or more tape monitor circuits that are nothing more than switchable circuit-interruption points in the signal chain.

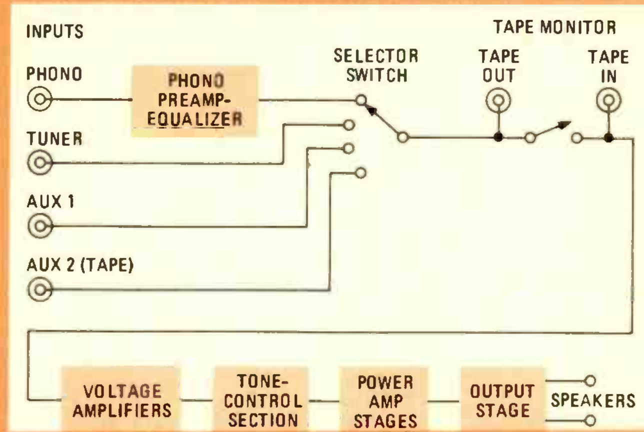


FIG. 2—BLOCK DIAGRAM of an amplifier.

Input and output jacks were originally devised as a connection point for tape decks—by connecting the amplifier's tape-out jack to the tape recorder input, and the tape-in or tape-play jack to the recorder's output, you can monitor the recorded results from three-headed tape machines a fraction of a second after the recording itself has been made. These input/output jacks are also useful as connection points for such audio accessories as graphic equalizers (they offer better tone control than more common bass and treble controls); noise reducers (Dolby decoders, or those using different noise-reduction designs); dynamic range expanders (they process music signals to restore an otherwise compressed dynamic music range); and even four-channel decoders. If you plan to expand your high-fidelity system to include a tape recorder and any of the above accessories, you should look for at least two separate tape-monitoring circuits on the amplifier you're considering.

Amplifier power

The most important question you will face in choosing an appropriate audio amplifier for your hi-fi system is: how much power output should the amplifier be able to produce? Much has been written about power requirements for audio systems, but here is a general guideline:

The louder you like your music, the more power you need. The larger the listening room, the greater the power requirement. The lower the efficiency of the speaker you select, the more power needed from the amplifier. The greatest variable of all is speaker efficiency. One type of speaker may require ten times as much power as another to deliver the same apparent loudness level. In fact, it is a good idea to choose speakers before any other component in your system. Then you can audition different amplifiers (or receivers) by hooking them up to your previously selected speakers to determine if the amplifier has sufficient power reserve to produce undistorted sound at your highest preferred listening levels.

Prior to November, 1974, many amplifier manufacturers specified the power-output ratings of their products in a variety of different ways, leading to all sorts of confusion regarding amplifier power ratings that was even worse than that associated with signal-to-noise ratios. After November, 1974, all amplifier manufacturers were required to state power ratings in very specific terms, as

AMPLIFIER CLASSES

AS YOU READ THROUGH THE BROCHURES supplied by various amplifier manufacturers you will probably come across terms such as "Class A," "Class AB," "Class B," etc. These terms all refer to the type of circuits used in the final power-output stages of audio amplifiers. There are many ways in which to arrange an amplifier's output stages, and these are identified by the "Class" notations. While it is possible to design good-sounding amplifiers in all classes, let's examine the difference between them.

In a Class-A amplifier, the transistor or transistors that supply power to the speaker load continuously conduct current, and that current value is essentially constant. In the absence of an audio signal, all the current (and power) is dissipated within the transistors themselves. When a signal appears, part of the power developed by the output stage is transferred to the speaker load. This arrangement is, therefore, highly inefficient, in that the same amount of power is drawn from the amplifier's power supply regardless of whether the amplifier is producing its maximum rated power, no power at all, or anything in between. Class-A amplifiers (what few exist these days) are therefore generally noted for their lower power-output ratings, and require unusually large heat-sink devices to dissipate the heat generated by the always fully on transistors. Class-A amplifiers are, however, capable of producing extremely low-distortion sound and are favored by those listeners to whom the unusually large energy consumption is of secondary importance.

A Class-B amplifier requires at least two output transistors. Each transistor is designed to amplify one-half of the alternating waveforms that constitute an audio signal. One transistor amplifies the positive-going wave, while the other transistor amplifies the negative-going half-cycle of each alternation. In the absense of all audio input signals, each transistor draws almost no current, and a Class-B amplifier, in the absence of input signals, runs extremely cool. As signal levels increase, current drawn from the power supply also increases until maximum power-output levels are reached. Thus, a Class-B amplifier is much more efficient than a Class-A unit. Class-B efficiency (at full power output) can reach as high as 65% or so (it is less than that at lower power levels), as opposed to the typically low 20% to 25% for a Class-A design.

While Class-B amplifiers can be designed to produce equally low distortion, special care must be taken in their design to make sure that no discontinuities in output take place as the signal is switched from one transistor to the other. Failure to observe proper design techniques can result in "notch distortion," or "crossover distortion," which is particularly annoying at low listening levels.

Class-C amplifiers are not normally used in audio amplifier circuits, but are reserved for radio receivers and transmitters. A Class C-amplifier conducts for less than one-half of each cycle, and depends upon the flywheel action of an associated resonant circuit to fill in the missing portion of the waveform. A Class-C amplifier is therefore practical to use where the same single frequency is to be amplified continuously, but is impractical for amplifying constantly varying complex audio signals.

The so-called Class-D amplifier is also known as a "switching amplifier," or "pulse-width modulation" amplifier. One or two manufacturers offer limited quantities of Class-D amplifiers, and a great deal of experimentation with this type of amplifier continues. In a Class-D amplifier, a very high-frequency series of pulses are modulated in their width by the audio signal. The output stages need to conduct for a short interval only to amplify the tips of these pulses, and when they do conduct, they are highly efficient—conducting as much as 90% to 95%. The high-frequency pulses associated with Class-D amplifiers (500 kHz or more) present special problems in the transistor switching speed and suitable transistor availability.

The recently developed Class-G amplifier uses a minimum of two pairs of output transistors. One pair is powered by a lower voltage supply than the other. When signal levels are relatively low, only the low-powered pair of transistors does the amplifying. When signals exceed the low-voltage supply amplitude, the other transistor pair, which operates from the higher voltage supply, takes over, while the first pair is simultaneously turned off. In this way, each pair of transistors is always operating over its most efficient range, and overall amplifier efficiency is greater with a Class-B design. Thus, less massive heat sinks are needed for the output transistors, and the complete amplifier or receiver is lighter in weight.

Somewhat similar to Class-G operation is the new and tentatively labeled Class-H amplifier. Only one set of output transistors is used, but these transistors are connected to two different power-supply voltages. The lower voltage powers the output devices for low-level signals, while the higher voltage takes over when the input signal amplitudes exceed the limits of the low-voltage supply. As in Class-G, this approach results in a more efficient use of the output transistors, and the audio signals themselves do not have to be switched from one device to another during the process.

dictated by a Federal Trade Commission rule. Even this standardized rating system, however, leads to certain ambiguities that should be clarified when comparing the power ratings of competing products.

The FCC rule says that a manufacturer must state the amplifier's ability to deliver *continuous* power with both channels operating. The stated power rating must be referenced to a given speaker impedance (since most amplifiers generally deliver higher power to 4-ohm speakers than to 8-ohm speakers). Furthermore, the manufacturer must state over what frequency range the amplifier can deliver its full rated power (since most amplifiers reproduce mid-frequencies somewhat better than extremely low bass or high treble tones). Finally, a statement must be made regarding the distortion level that the amplifier will produce at any power level up to its rated output level.

Thus, a typical power-output specification might read: "Power Output: 50 watts minimum continuous power into 8-ohm loads, at any frequency from 20 Hz to 20,000 Hz, with no more than 0.5% total harmonic distortion." Since the rule simply states that all these facts must be given (but does not specify minimum acceptable numbers), some degree of care is still required. For example, suppose amplifier A has a power rating of 100 watts-per-channel, 8-ohm loads, from 20 Hz to 20 kHz at no more than 1.0% distortion, while amplifier B is rated at the same 100 watts-per-channel, 8-ohm loads, 20 Hz to 20 kHz at no more than 0.3% distortion. Clearly, amplifier B is the better of the two. Or, suppose amplifier A is rated at 100 watts-per-channel, 8-ohm loads, from 20 Hz to 20 kHz, with no more than 0.2% distortion; amplifier B also carries a 100-watt rating, 8-ohm loads, from 40 Hz to 15 kHz at no more than 0.2% distortion. In this case, amplifier A is superior to amplifier B.

We have been using the word "distortion" without truly defining it. In fact, there are many forms of distortion that an amplifier can generate. Distortion is defined as any difference between the nature and composition of the signal input to the amplifier and the resulting output signal. The most common distortion is harmonic distortion. If, for example, a 400-Hz pure tone is fed to an amplifier, the output signal should contain an equally pure 400-Hz tone and nothing else. If multiples of that frequency show up in the output signal, such as 800 Hz, 1,200 Hz, 1,600 Hz, etc., the signal is said to contain harmonic distortion. While musical instruments produce complex harmonics or overtones, all of which should be faithfully reproduced by an amplifier, the amplifier should not generate its own harmonics, for these would change the overall musical timbre or coloration. Figures 3 and 4 show examples of amplifier-generated harmonic distortion. The upper trace of Fig. 3 shows that a single frequency or tone is reproduced by an amplifier with little or no distortion. The lower trace is a highly magnified representation of *only* the distortion components contained in the upper trace and appears as a virtual straight line (no distortion is present). If the same amplifier is

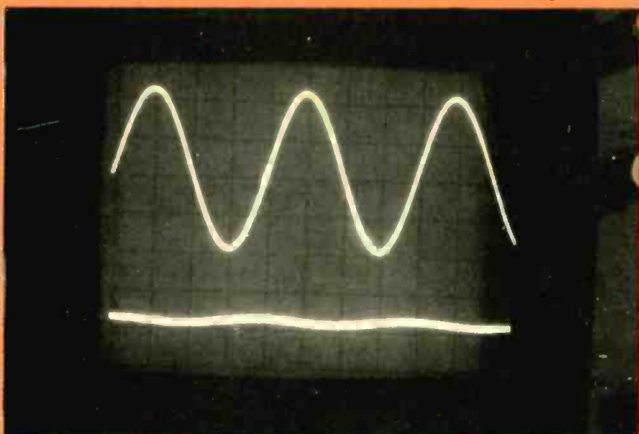


FIG. 3—HARMONIC DISTORTION CHARACTERISTICS. Upper trace shows output waveform. Lower trace shows only the harmonic components, which in this case is negligible.

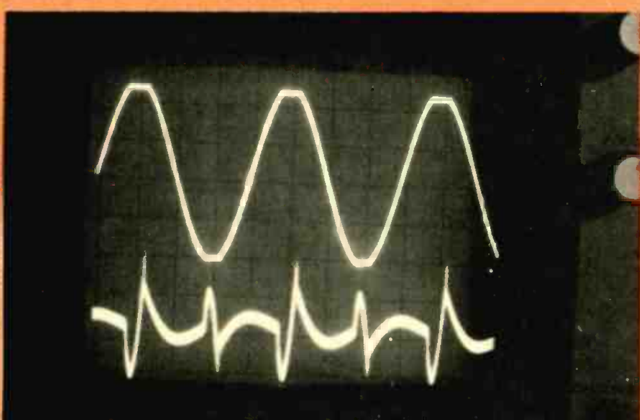


FIG. 4—AMPLIFIER CLIPPING produces harmonic distortion. Upper trace shows clipped output waveform; lower trace shows harmonic components.

driven beyond its power-output rating, the pure sinewave form will be clipped, as shown in Fig. 4. Under those circumstances, the distortion components (see the lower trace) are quite evident, and consist largely of third harmonic components. Harmonic distortion is specified in percent (%); and the lower the figure the better the amplification.

Another form of distortion that is usually specified is called IM (*I*ntermodulation *D*istortion). This type of distortion arises when a complex of frequencies is fed to the amplifier instead of a single tone. In a poorly designed amplifier, high and low frequencies may beat against each other, causing sum-and-difference frequencies between the two to appear in the output of the amplifier. Since such musically unrelated frequency components were not present in the original signal, their presence at the amplifier's output, even in small percentages, can be quite disturbing to a listener. The IM distortion is also specified in percent, and the lower the figure the better.

More subtle forms of amplifier distortion have recently been discovered, but since accepted measurement standards for measuring them have not yet been agreed upon, harmonic and IM distortion are the two types most commonly found in the specifications sheets.

Figure 5 shows the IM and harmonic distortion-versus-power-output characteristics for a typical high-quality amplifier. Note that both forms of distortion remain quite low until the maximum power output is reached, at which time they tend to climb rapidly. That is why it is important to operate an amplifier within its power rating. To try to pump more power from an amplifier into a speaker that requires more than the amplifier can deliver leads to horrendous distortion levels.

We mentioned earlier that frequency response is cited for the preamplifier section in adherence to the prescribed RIAA equalization curve. In the case of the high-level sections of the amplifier, frequency response is quoted directly in hertz, and a tolerance or maximum deviation from flat response is included. The specification, "Frequency response: 20 Hz to 20 kHz" has no real meaning

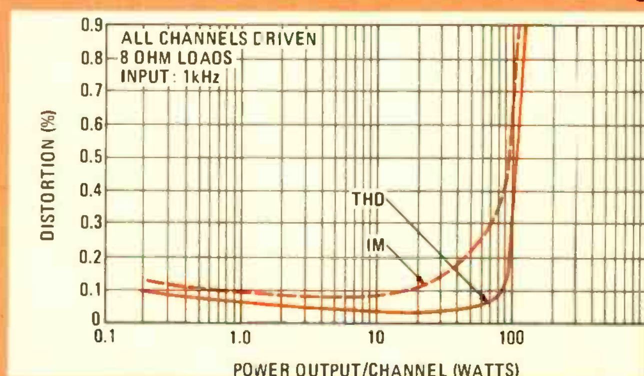


FIG. 5—HARMONIC AND IM distortion characteristics versus amplifier power output.

unless we also know the ±dB-tolerance associated with the response over that frequency range. A proper response statement would read: Frequency response: flat from 20 Hz to 20,000 Hz, ±0.5 dB, and this would be superior to one that stated: Frequency response: flat from 20 Hz to 20,000 Hz, ±2.0 dB.

Signal-to-noise ratios relative to the high-level inputs also appear in the specifications and are quoted in dB (with the higher values being better), and are ordinarily higher than those listed for the phono section.

The specification called damping factor is a measure of an amplifier's ability to control or suppress unwanted residual motion of the speaker cone caused by the mechanical inertia or by forces other than the driving audio signal itself. Stated as a simple number, higher damping factor values are better, although damping factors higher than 40 to 50 contribute no audible improvement to an amplifier's performance.

Front-Panel Controls and Features

Unlike low-fidelity "table radios," most high-fidelity amplifiers are equipped with separate power on/off switches. This arrangement permits setting the volume control at preferred points when turning the unit on and off. The balance control adjusts right- and left-channel listening levels so that they are equal (or, if you must sit closer to one speaker system than to another, the balance control can be used to adjust for that situation).

The need for tone controls, whether simple bass and treble controls or more elaborate types, often puzzles audio neophytes. If all the components in an audio system produce a uniform or flat frequency response, why do you require tone controls, which, after all, are designed to provide adjustments that alter the overall system response from that flat quality? It is true that amplifiers can be made to have a frequency response which is "ruler flat"; however, this does not necessarily apply to the loudspeaker system or even to the listening room (which, in a very real sense, is a system component). For this reason, and because different people prefer different tonal balance, tone controls are a very necessary feature.

Some amplifiers, in an attempt to cater to the audio purist who prefers not to use tone controls, offer a tone DEFEAT switch or pushbutton that bypasses the tone control circuits completely. The standard BASS and TREBLE controls offer a wide range of adjustment, usually beginning above or below mid-frequencies (around 400 Hz to 1 kHz), as shown in Fig. 6. One disadvantage to this control range is the fact that when you want to boost extreme low or high frequencies (to compensate for deficient speaker bass or ultra-high treble) you necessarily also affect the response of frequencies that are closer to the middle of the audio range. To counteract this effect, some manufacturers offer tone controls having multiple turnover (or pivot) points, as shown in Fig. 7. Still other amplifiers offer main- and sub-tone controls; the former effecting a wide frequency range, the latter boosting or attenuating only the extreme bass or treble range. Recently, some amplifiers have begun to include a mid-range tone control that acts upon the mid-frequency range similar to the way the bass and treble controls affect those frequencies. Fig. 8 shows the range typical of many mid-range tone controls.

A loudness switch is another control usually found on amplifier front panels. Studies of human hearing long ago confirmed that when we listen to music at lower-than-lifelike loudness levels, our hearing is less sensitive to extreme bass and treble frequencies than to mid-frequencies. Since in a home listening environment we often listen to music at "background" levels, reproduced music tends to sound thin and lacking in brilliance. To compensate for this effect, actuating the loudness control switch causes the amplifier to automatically boost the bass (and sometimes the treble) by an amount commensurate with the main volume-control setting. At high settings (where listening levels are presumably loud and therefore do not require compensation), no compensation is inserted, but as the volume is lowered, increased amounts of compensation are added automatically. Figure 9 shows the action of a volume/loudness control for different volume-control settings. This compensates for the fact that the loudness of any tone is a function, not only of its intensity, but also of its frequency.

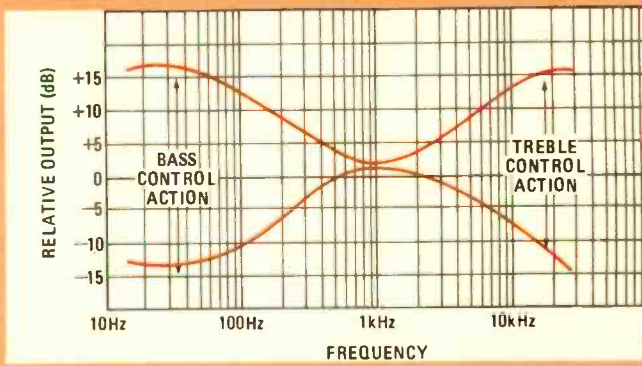


FIG. 6—TYPICAL RANGE of the bass and treble tone controls.

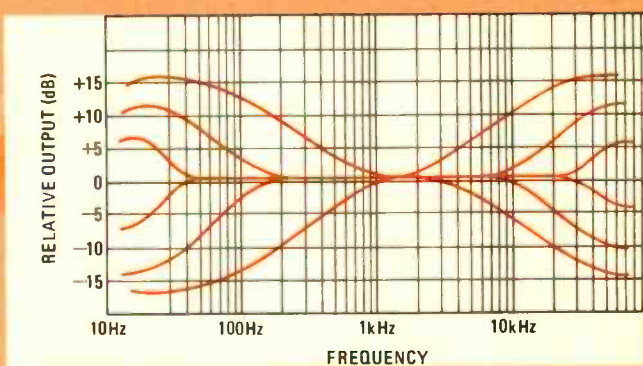


FIG. 7—ELABORATE TONE CONTROL circuitry include multiple user-selectable turnover frequencies.

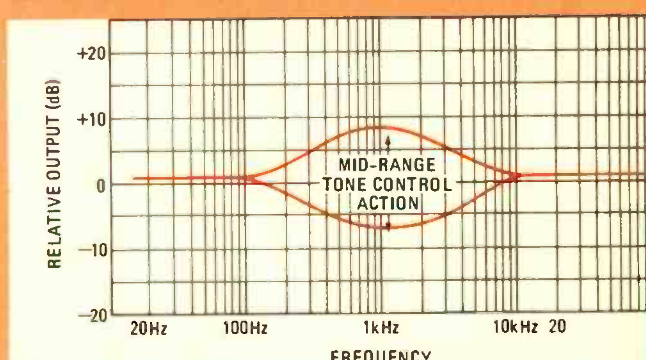


FIG. 8—MIDRANGE TONE CONTROL offers additional flexibility over standard bass and treble controls.

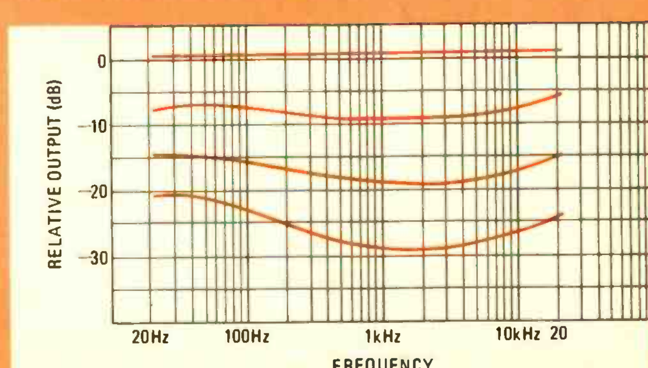


FIG. 9—LOUDNESS COMPENSATION decreases as the volume level is raised.

TABLE I
LOW-, MEDIUM- AND HIGH-PRICED AMPLIFIER SPECIFICATIONS AND RANGES

Specification	Low-cost	RANGES Mid-cost	High-priced
Harmonic distortion at rated output (%)	0.8–1.5	0.3–0.5	Less than 0.3
Harmonic distortion at 1-watt output (%)	0.2–0.5	0.05–0.1	Under 0.95
IM distortion at rated output (%)	1.0–2.0	0.3–1.0	Under 0.3
IM distortion at 1-watt output (%)	0.5–1.0	0.2–0.5	Under 0.2
Power bandwidth for full power (hz–kHz)	40–10	20–20	20–20 or better
Damping factor	10–15	15–30	30 or higher
Phono S/N, unweighted referred to input sensitivity (dB)	50–60	60–68	Above 68
Phono S/N, "A"-weighted, referred to 5-mV input & 1-watt (or 0.5 volt for preamplifiers) output, per new IHF Standards (dB)	60–65	65–75	Above 75
High-level input S/N, unweighted, referenced to full rated output (dB)	65–75	75–80	Above 80
High-level input S/N, "A"-weighted, referenced to 0.5-volt input and 1.0-watt (or 0.5-volt, for preamplifiers) output, per new IHF Standards (dB)	60–70	70–75	Above 75
Residual hum and noise referenced to full output, unweighted (dB)	75–85	85–95	Above 95
Residual hum and noise, "A"-weighted, referenced to 1-watt (or 0.5-volt for preamplifiers) output (dB)	70–80	80–90	Above 90
Phono frequency response (RIAA—dB)	±1.0–2.0	±0.5–1.0	±0.3 or less
High-level input frequency response (Hz–kHz, dB)	20–20, ±2.0	15 Hz–25 kHz, ±1	10–30, ±0.5 or better
Phono overload (mV)	50–70	80–100	Greater than 100

(NOTE: The power output of an amplifier is not an indication of its quality, but is dictated by price and design objectives.)

Another form of tone-altering control is the filter circuit. Low- and high-cut filter switches, often found on the front panels of amplifiers, attenuate frequencies above or below their respective cutoff points more steeply than regular bass and treble controls. Figure 10 shows a comparison between the action of tone controls and steep-cut filters. Such filters, if properly designed, are effective in reducing high-frequency hiss or noise, and in lessening the audible effect of lower-frequency turntable rumble without impinging too severely on the music.

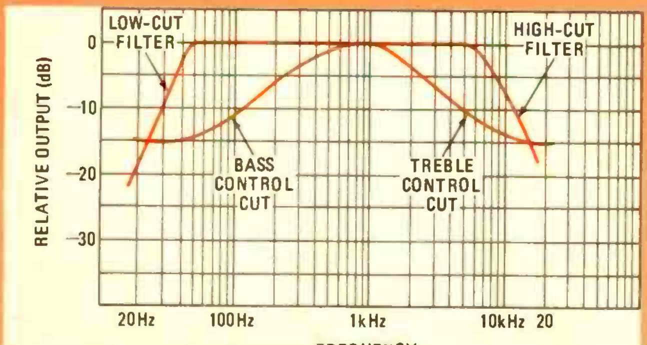


FIG.10—COMPARISON of tone control action and the effects of the high- and low-cut filters.

The final decision

Up to this point, a great many amplifier specifications have been examined and, indeed, published specs are important parameters for choosing this important hi-fi component. We would never suggest, however, that published specifications tell the whole story. There are still a great many audio amplifier characteristics that cannot be defined or measured—at least not with state-of-the-art instruments and techniques.

There is one ultrasensitive instrument you should use in making a final choice—your own ears. Compare specifications and pricing, of course, but in the last analysis let your ears serve as the final judge. Listen to several amplifiers in the price and power category which you seek. Use a wide variety of musical programs to make these subjective sound quality judgments. Listen at low and high levels—until you are sure that you have chosen the right amplifier for your own selected high-fidelity system.

As a final aid, a brief summary of the specifications we have discussed appear in Table I. The values shown in the table can serve as a general guide only and may not conform in all cases to what is available in the audio marketplace. We hope, however, that this summary helps get you started and wish you good listening. **R-E**

STEREO–AMPLIFIER ROUNDUP

MANUFACTURER	MODEL	PRICE	POWER OUTPUT CAPABILITY: 8Ω, @ 1kHz (W)	8Ω, @ 20Hz (W)	8Ω, @ 20kHz (W)	4Ω, @ 1kHz (W)	4Ω, @ 20Hz (W)	4Ω, @ 20kHz (W)	FREQUENCY LIMITS FOR RATED OUTPUT (Hz-kHz)	DYNAMIC HEADROOM (dB)	DISTORTION: HD @ RATED OUTPUT, 1kHz (%)	IM @ RATED OUTPUT (%)	HD @ 1W, 1kHz (%)	IM @ 1W (%)	DAMPING FACTOR 50Hz, 8Ω	PHONO PREAMPLIFIER: FREQUENCY RESPONSE (RIAA ±dB)	MAX INPUT BEFORE OVERLOAD (mV)	S/N RATIO "A"-WT'D RE. 1W OR 0.5V OUT FOR 5mV IN (dB)	HIGH-LEVEL INPUT: FREQUENCY RESPONSE (Hz-kHz, ±dB)	"A"-WT'D, RE. 0.5 OR 1W OUTPUT 0.5V INPUT (dB)	RESIDUAL NOISE "A"-WT'D, MIN VOLUME, RE. 1W OUTPUT (dB)	COMPONENT MATCHING: INPUT SENSITIVITY: HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	OUTPUT LEVEL: TAPE OUTPUTS @ RATED OUTPUT (mV)	HEADPHONE JACK @ RATED OUTPUT (mV OR mW)
AIWA	AA8700U	$ 550.00	75	75	75	85	85	85	20-20		0.02	0.02	0.01		>40[1] >60[2]	30Hz~15kHz ±0.2dB	280	83	5-100 +0, -3	110	0.3mV	150	150	150	1mW
DYNACO	SCA-50	$199K $299W	25	25	25				20-20		<0.25	<0.1	<0.25	<0.1	80	±1dB	100[2]	72[3]	15-45 ±0.5	89[3]	125[4]				
	2530	$ 749.00	100	100	100	200	200	200	20-20		<0.05	<0.2	<0.05	<0.2	80	±1dB	100[2]	80	10-50 ±0.5	85[3]	1.25[5]				
H. H. SCOTT	480A	$ 499.95	85W FTC @ .03% THD						20-20	2		.03		.03	100@ 1kHz	20-20 ±.5	250/ 500	84	20-20 ±0.5	88	90	16.3	0.27/ 0.54	150	750mV @8Ω
	460A	$ 429.95	70W FTC @ .04% THD						20-20	1.5		.04		.04	100@ 1kHz	20-20 ±.5	250/ 500	84	20-20 ±0.5	88	90	17.9	0.30/ 0.60	250	680mV @8Ω
	440A	$ 349.95	55W FTC @ .05% THD						20-20	1.5		.05		.05	100@ 1kHz	20-20 ±.5	180	79	20-20 ±0.5	83	85	20.2	0.37	150	600mV @8Ω
	420A	$ 249.95	40W FTC @ .08% THD						20-20	1.5		.08		.08	60@ 1kHz	20-20 ±.5	180	74	20-20 ±1	78	80	23.7	0.40	150	515mV @8Ω
HITACHI	HA3500	$ 200.00		30	30				20-20	1.4	0.05	0.03			30	±0.3	200	75				2.5		150	
	HA4500	$ 250.00		40	40				20-20	1.4	0.05	0.03			30	±0.3	200	75				2.5		150	
	HA5100	$ 450.00		50	50				5-20	1.75	0.02	0.008			60	±0.2	300	86	10-100 +0-2.5	100		2.5		150	
	HA7700	$ 600.00		65	65				5-20	1.75	0.02	0.008			60	±0.2	300	86	10-100 +0-2.5	100		2.5		150	

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MANUFACTURER	MODEL	PRICE	POWER OUTPUT CAPABILITY: 8Ω, @ 1kHz (W)	8Ω, @ 20Hz (W)	8Ω, @ 20kHz (W)	4Ω, @ 1kHz (W)	4Ω, @ 20Hz (W)	4Ω, @ 20kHz (W)	FREQUENCY LIMITS FOR RATED OUTPUT (Hz-kHz)	DYNAMIC HEADROOM (dB)	DISTORTION: HD @ RATED OUTPUT, 1kHz (%)	IM @ RATED OUTPUT (%)	HD @ 1W, 1kHz (%)	IM @ 1W (%)	DAMPING FACTOR 50Hz, 8Ω	PHONO PREAMPLIFIER: FREQUENCY RESPONSE (RIAA ±dB)	MAX INPUT BEFORE OVERLOAD (mV)	S/N RATIO "A"-WT'D RE. 1W OR 0.5V OUT FOR 5mV IN (dB)	HIGH-LEVEL INPUT: FREQUENCY RESPONSE (Hz-kHz, ±dB)	"A"-WT'D, RE. 0.5 OR 1W OUTPUT 0.5V INPUT (dB)	RESIDUAL NOISE "A"-WT'D, MIN VOLUME, RE. 1W OUTPUT (dB)	HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	COMPONENT MATCHING: INPUT SENSITIVITY: HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	TAPE OUTPUTS @ RATED OUTPUT (mV)	OUTPUT LEVEL: HEADPHONE JACK @ RATED OUTPUT (mV OR mW)
JVC US JVC CORP	JA-S77	$ 429.95	70	65	65	90			20-20		0.005	0.01	0.005		50	0.2	280	87	3-100 +0, -1	112		2.5	200	200	
	JA-S55	$ 339.95	65	60	60	70			20-20		0.005	0.01	0.02		50	0.3	230	87	5-100 +0, -1	112		2.5	200	200	
	JA-S44	$ 339.95	48	45	45	60			20-20		0.005	0.01	0.02		30	0.3	200	86	5-100 +0, -2	108		2.5	160	160	
	JA-S22	$ 239.95	43	40	40	50			20-20		0.01	0.01	0.02		30	0.3	200	86	5-100 +0, -2	108		2.5	160	160	
	A-M1	$ 599.95		50	50				20-20		0.009				30	0.3	200	88		112		2.5	150	150	
	A-S7	$ 229.95		50	50				20-20			0.05			50	0.5	200	86		107		2.5			
	A-S5	$ 179.95		30	30				20-20			0.08			50	0.5	150	81		102		2.5			
	A-S3	$ 149.95		20	20				20-20			0.08			30	0.5	150	78		102		2.5			
NEW ACOUSTIC DIMENSION	3030	$ 220.00	40	40	40	50	50	50	20-20	2.2	<.09	<.09	<.02	<.02	50	±0.3	190	>74	±0.5	>80[6]		150[7]			
	3045	$ 295.00	60	60	60	80	80	80	20-20	2.2	<.05	<.05	<.02	<.02	75	±0.3	200	>76	±0.5	>80[6]		150[7]			
	3060	$ 380.00	80	80	80	120	120	120	20-20	2.2	<.03	<.03	<.02	<.02	100	±0.3	200	>76	±0.5	>80[6]		150[7]			
	3080	$ 465.00	130	130	130	160	160	160	20-20	2.5	<.03	<.03	<.02	<.02	120	±0.3	200	>76	±0.5	>80[6]		150[7]			
NIKKO	NA-590	$ 209.95	35	35	35	50	50	50	20-20	1.00	0.05	0.05	0.05	0.05	60	1	138	82	10-50 ±0.5	90	90	2.3[8]	150	140	25mW
	NA-690	$ 249.95	50	45	45	55	55	55	20-20	1.07	0.04	0.04	0.04	0.03	60	±0.2	210	85	20-20 ±0.5	100	100	2.3[8]	150	150	25mW
	NA-890	$ 349.95	75	70	70	80	80	80	20-20	0.84	0.04	0.04	0.03	0.03	60	±0.2	220	85	10-20 ±0.5	100	100	2.3[8]	150	150	70mW
OPTONICA	SM3201	$ 250.00	45	40	40				20-20		0.19	0.1	0.15	0.1	>40[2]	0.3	240	82[9]	10-80 +1, -3	85[10]	65	23.7	23.7	150	630mV
	SM3205	$ 250.00	45	40	40				20-20		0.19	0.1	0.15	0.1	>40[2]	0.3	240	82[9]	10-80 +1, -3	85[10]	65	23.7	23.7	150	630mV
	SM3636	$ 320.00	65	60	60				20-20		0.09	0.1	0.09	0.1	>45[2]	0.25	240	86[9]	10-70 ±1.5	90[10]	70	23.7	23.7	150	630mV
	SM4646	$ 460.00	85	80	80				20-20		0.08	0.1	0.09	0.1	>45[2]	0.18	370	86[9]	10-80 ±1.5	90[10]	82	23.7	23.7	150	770mV

MANUFACTURER	MODEL	PRICE	POWER OUTPUT CAPABILITY: 8Ω @ 1kHz (W)	8Ω @ 20Hz (W)	8Ω @ 20kHz (W)	4Ω @ 1kHz (W)	4Ω @ 20Hz (W)	4Ω @ 20kHz (W)	FREQUENCY LIMITS FOR RATED OUTPUT (Hz-kHz)	DYNAMIC HEADROOM (dB)	DISTORTION: HD @ RATED OUTPUT, 1kHz (%)	IM @ RATED OUTPUT (%)	HD @ 1W, 1kHz (%)	IM @ 1W (%)	DAMPING FACTOR 50Hz, 8Ω	PHONO PREAMPLIFIER: FREQUENCY RESPONSE (RIAA ±dB)	MAX INPUT BEFORE OVERLOAD (mV)	S/N RATIO "A"-WT'D RE. 1W OR 0.5V OUT FOR 5mV IN (dB)	HIGH-LEVEL INPUT: FREQUENCY RESPONSE (Hz-kHz, ±dB)	"A"-WT'D, RE. 0.5 OR 1W OUTPUT 0.5V INPUT (dB)	RESIDUAL NOISE "A"-WT'D, MIN VOLUME, RE. 1W OUTPUT (dB)	COMPONENT MATCHING: INPUT SENSITIVITY: HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	HI LEVEL, RE. 1W OT 0.5V OUTPUT (mV)	OUTPUT LEVEL: TAPE OUTPUTS @ RATED OUTPUT (mV)	HEADPHONE JACK @ RATED OUTPUT (mV OR mW)
PIONEER	SA-9800	$ 750.00	100	100	100	120	120	120	10-50		0.005	0.002	0.004	0.002	55[12]	±0.2[11]	250	90[13]	5-100 +0, -1		110[14]	.5		150	
	SA-8800	$ 550.00	80	80	80	100	100	100	10-50		0.005	0.002	0.004	0.002	55[12]	±0.2[11]	250	90[13]	5-100 +0, -1		110[14]	.5		150	
	SA-7800	$ 450.00	65	65	65	80	80	80	10-50,000		0.009	0.003	0.007	0.003	55[12]	±0.2	200	87[13]	5-100 +0, -1		110[14]	.5		150	
	SA-7700	$ 375.00	60	60	60				20-20,000		0.04	0.04	0.03	0.02	40[12]	±0.2	180	86[13]	20-40 ±2		95[14]	.5		150	
	SA-6700	$ 250.00	40	40	40				20-20,000		0.05	0.05	0.03	0.02	30[12]	±0.3	180	78[13]	20-40 ±2		95[14]	.5		150	
RADIO SHACK	SA-1001	$ 179.95	35	35	35	52	52	56	20-20		.014	0.5[24]	.025			±1.0	150		20-20 ±1.5		0.5mV	25	0.36	150	0.4mV
	SA-2001	$ 279.95	60	60	60	78	78	76	20-20		.04	0.1[25]	.035			±1.0	180		20-20		0.5mV	25	0.19	200	0.37mV
ROGERS	A 75	$ 520.00	55	45	50	45	36	40	30-30		0.08	0.08	0.005	0.006	30	±2	>80	–70				2.7,4.0 63.0,90.0	180	180	20
SAE	2922	$ 850.00	100	100	100				20-20		0.05	0.05			150	±0.25	150	84	20-20 ±0.25	85.6		60		60	
	3022	$ 700.00	100	100	100				20-20		0.05	0.05			150	±0.25	150	81	20-20 ±0.25	75.6		60		60	
	3031	$ 550.00	50	50	50				20-20		0.05	0.05			150	±0.25	150	81	20-20 ±0.25	75.6		60		60	
	SAE TWO C3A	$ 325.00	50	50	50				20-20		0.05	0.05			30	±0.25	150	79	20-20 ±0.25	70		60		60	
SANSUI	AU-X1	$1450.00	160	160	160				5-20		0.007	0.007	0.007	0.007	100	0.2	330	97	5-500 +0, –3	110		200			
	AU-919	$ 800.00	110	110	110				5-20		0.008	0.008	0.008	0.008	100	0.2	320	96	5-100 +0, –3	110		150			
	AU-717	$ 550.00	85	85	85				10-20		0.015	0.015	0.015	0.015	60	0.2	350	86	5-100 +0, –3	110		150			
	AU-417	$ 395.00	65	65	65				20-20		0.02	0.02	0.02	0.02	60	0.2	300	86	5-100 +0, –3	110		150			
	AU-317	$ 350.00	50	50	50				20-20		0.03	0.03	0.03	0.03	70	0.2	200	83	5-70 +0, –1.8	110		150			
	AU-217II	$ 230.00	40	40	40				20-20		0.06	0.06	0.06	0.06	80	0.5	200	82	10-50 ±0.5	105		150			
	AU-117II	$ 190.00	50	50	50				20-20		0.17	0.17	0.17	0.17	50	0.5	160	82	10-40 +0.5, –2	105		150			

MANUFACTURER	MODEL	PRICE	POWER OUTPUT CAPABILITY: 8Ω, @ 1kHz (W)	8Ω, @ 20Hz (W)	8Ω, @ 20kHz (W)	4Ω, @ 1kHz (W)	4Ω, @ 20kHz (W)	4Ω, @ 20Hz (W)	FREQUENCY LIMITS FOR RATED OUTPUT (Hz-kHz)	DYNAMIC HEADROOM (dB)	HD @ RATED OUTPUT, 1kHz (%)	DISTORTION: IM @ RATED OUTPUT (%)	HD @ 1W, 1kHz (%)	IM @ 1W (%)	DAMPING FACTOR 50Hz, 8Ω	PHONO PREAMPLIFIER: FREQUENCY RESPONSE (RIAA ±dB)	MAX INPUT BEFORE OVERLOAD (mV)	S/N RATIO "A"-WT'D RE. 1W OR 0.5V OUT FOR 5mV IN (dB)	HIGH-LEVEL INPUT: FREQUENCY RESPONSE (Hz-kHz, ±dB)	"A"-WT'D, RE. 0.5 OR 1W OUTPUT 0.5V INPUT (dB)	RESIDUAL NOISE "A"-WT'D, MIN VOLUME, RE. 1W OUTPUT (dB)	HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	COMPONENT MATCHING: INPUT SENSITIVITY: HI LEVEL, RE. 1W OR 0.5V OUTPUT (mV)	TAPE OUTPUTS @ RATED OUTPUT (mV)	OUTPUT LEVEL: HEADPHONE JACK @ RATED OUTPUT (mV OR mW)
SERIES 20	A-27	$1300.00		120	120		180	180	5-30	1.8	0.012	0.006	0.008	0.005	170	±0.2	300	90[15]	100[23]			8.33	500	150	
SONY	TA-F6B	$ 610.00	100	100	100				20-20	.03	.03				50	±.2	250	91	2-150 +0, -1	105		150		150	
	TA-F5A	$ 350.00	70	70	70				20-20	.04	.01				40	±.2	250	91	3-70 +0, -1	100		150		150	
	TA-F3A	$ 240.00	50	50	50				20-20	.35	.5				30	±.5	250	81	10-60 +0, -3	95		150		150	
TECHNICS	SU-8099	$1000.00	115	115	115	170	150	150	20-20		0.007[16]	0.007	0.0025[17]		100[18]	±0.15	250	96[19]	20-20 +0, -0.1	110[20]	0.3mV[21]	200[22]	200	200	
	SU-8088	$ 600.00	85	80	80	95	90	90	20-20		0.01[16]	0.01	0.003[17]		50[18]	±0.2	250	96[19]	20-20 +0, -0.1	110[20]	0.3mV[21]	200[22]	200	200	
	SU-8077	$ 450.00	62	60	60	80	65	65	20-20		0.02[16]	0.02	0.003[17]		40[18]	±0.2	150	94[19]	20-20 +0, -0.1	108[20]	0.3mV[21]	200[22]	200	200	
	SU-8055	$ 300.00	50	47	47	56	48	48	20-20		0.02[16]	0.02	0.008[17]		36[18]	±0.5	150	86[19]	20-20 ±0.5	97[20]	0.6mV[21]	150[22]	150	150	
	SU-8044	$ 260.00	40	38	38	46	40	40	20-20		0.02[16]	0.02	0.008[17]		32[18]	±0.8	150	86[19]	20-20 ±0.5	97[20]	0.6mV[21]	150[22]	150	150	
THORENS	AT410	$1195.00	50	50	50	55	55	55	20-20		<0.1		<0.05		<50	±0.5	70	<65	20-20 ±0.5	<65	<68	180	180	250	10V INTO 600Ω
	AT403	$ 895.00	30	30	30	35	35	35	20-20		<0.1		<0.05		<35	±0.5	70	<65	20-20 ±0.5	<65	<68	180		250	10V INTO 600Ω

NOTES:

1–AT 20Hz~20kHz
2–AT 1kHz
3–UNWEIGHTED
4–FOR 25W OUT
5–FOR 100W@8Ω
6–S/N RATIO
7–FOR RATED POWER
8–FOR PHONO INPUT
9–10mV IN
10–RATED POWER
11–20Hz-20kHz
12–MINIMUM 20-20kHz, 8Ω
13–REFERENCE TO 2.5mV INPUT PRODUCING 1.0V PRE-OUT AND RATED OUTPUT POWER
14–RE. 150mV INPUT PRODUCING 1.0V PRE-OUT AND RATED OUTPUT POWER
15–REF 120W, 205mV IN
16–THD AT RATED OUTPUT, 20Hz TO 20kHz
17–THD AT ½ POWER, 1kHz
18–DAMPING FACTOR AT 1kHz ACROSS 8 OHMS
19–S/N RATIO ("A" WEIGHTED) WITH 5mV INPUT
20–"A" WEIGHTED S/N RATIO AT RATED POWER
21–RESIDUAL NOISE, "A" WEIGHTED, IN mV
22–HIGH LEVEL INPUT SENSITIVITY FOR RATED OUTPUT. THE SAME FIGURE APPLIES TO AUX, TUNER AND TAPE POSITIONS
23–REF 120W, 150mV IN
24–AT 30 WATTS
25–AT 50 WATTS

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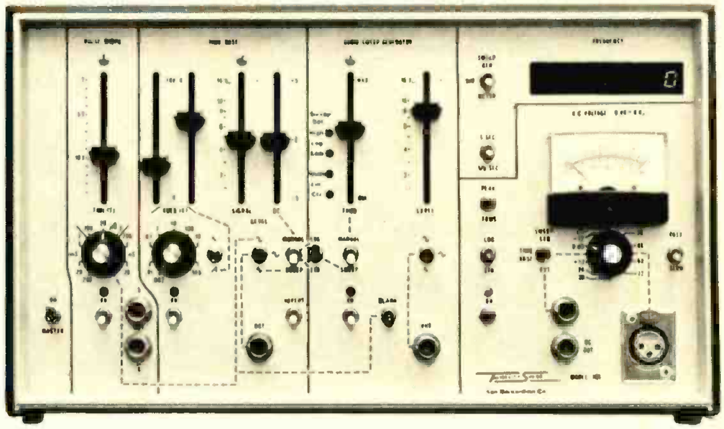
Audio Test Station



Part 4—This month we discuss in detail the theory of operation and the construction of the voltmeter and digital frequency meter that are essential to maximum usage of this audio test station.

RAY DAVISON

THIS MONTH, WE CONCLUDE THE CONSTRUCTION details of the Audio Test Station with the voltmeter and frequency counter sections.

Voltmeter section

The voltmeter circuit shown in Fig. 10 has two separate inputs. One is labelled EXT INPUT, which is a high-impedance low-gain input for line-level signals and the other is labelled MIKE INPUT, which is a low-impedance, high-gain input for low-level low-impedance signals. The front panel connector for the MIKE INPUT (J6) is a standard XLR type. The mike input circuitry consists of IC601 and its associated components, which form a balanced-line receiver. Resistor R601 terminates the line and R603 and R602 set the gain of IC601. The gain as seen from pin 3 of J6 is 16. The gain of the + input of IC601 is 16 + 1 or 17. Therefore, R603 and R604 are added to form a voltage divider so the overall gain of a signal applied at J6 pin 2 is the same as for a signal applied at J6 pin 3. This satisfies the basic purpose for having a balanced transmission line, namely common-mode rejection.

The balanced transmission line reduces the effect of stray signals picked up by interconnecting cables. The most susceptible stray pickup point in sound systems is a microphone cable. It is not that the mike cable itself is more susceptible, but rather that the microphone supplies such a low-level signal that it is relatively easy to pick up enough of a stray signal to be audible when mixed and amplified with the mike signal. The stray signal is often induced into a mike cable when the cable is in the presence of an electric or magnetic field.

The mike input circuitry inverts the signal applied to J6 pin 3, while the signal applied to pin 2 is not inverted. The actual mike signal that is applied to J6 pin 3 is of equal magnitude and opposite polarity of that which is applied to pin 2. Op-amp IC601 inverts the negative signal at pin 3, and adds this to the positive signal at pin 2.

When stray signals that are induced into the cable arrive at J6 pins 2 and 3 in phase, the signal at pin 3 is inverted and added to that at pin 2. However, this is subtraction. The result is what is known as common-mode rejection. A signal that was common to both inputs is rejected.

This circuit is normally shown with the four resistors of high precision and fixed value. In this circuit the common-mode rejection is simply trimmed by R604. To do this, connect a signal simultaneously at J6 pins 2 and 3. A mid-frequency sine-wave at about a half a volt peak-to-peak is suitable. Set S17 to −72 dB, adjust R604 for minimum output from IC603. The signal at the output of IC603 should be about the same magnitude as the input signal. Note that the same signal applied to either input alone would have been amplified by about 4,000 or 72 dB. Therefore, since the signal was passed with a gain of approximately 1, the common-mode rejection ratio is the 72 dB that the signal would ordinarily have been amplified by.

We have used this type of mike preamp in sound systems with mike cable lengths of well over 100 feet without any apparent extraneous pickup. However, for sound system use, the 748 is much too noisy. This can be easily remedied though by replacing the 748 with something like TI's TL071. The two parts are pin-compatible, and the 5-PE compensation capacitors used for the 748 can even be left in place when switching to the TL071. The difference in noise levels is dramatic.

A second-stage preamp consisting of IC602 is included. Having the preamp in two stages accomplishes a couple of things. First, the supply voltages are rather close to the maximum output voltage. A single amplifier with 48-dB gain and with an attenuator at the output would clip at signal amplitudes intended for the low-gain attenuator setting. In fact a signal which yields full scale on the −30-dB setting causes IC602 to clip.

Another reason for cascading is that the overall bandwidth is increased. This allows two common op-amps to be used in place of a single high-frequency unit.

Switch S16 selects one of three high-level inputs. The sweep generator and timebase pickup points are on the inboard side of the fuse that is used in conjunction with the output overvoltage sensors. Therefore, if there is no output from the sweep generator or timebase but its level can be read on the meter, it indicates a blown fuse. Capacitor C603 blocks any DC component present at S16. Resistors R610 through R615 form the actual input attenuator. Consider for the moment just this resistor string and S17. There is stray capacitance between every node of that resistor string and every other node. The result is a very complex R–C filter. At low frequencies, it is a simple voltage divider whose transfer function can be easily determined by simple arithmetic. Higher frequencies, however, travel from node to node in a manner that is quite difficult to predict accurately.

Capacitors C604 through C609 are added as an attempt to swamp out the internodal stray capacitance. This is

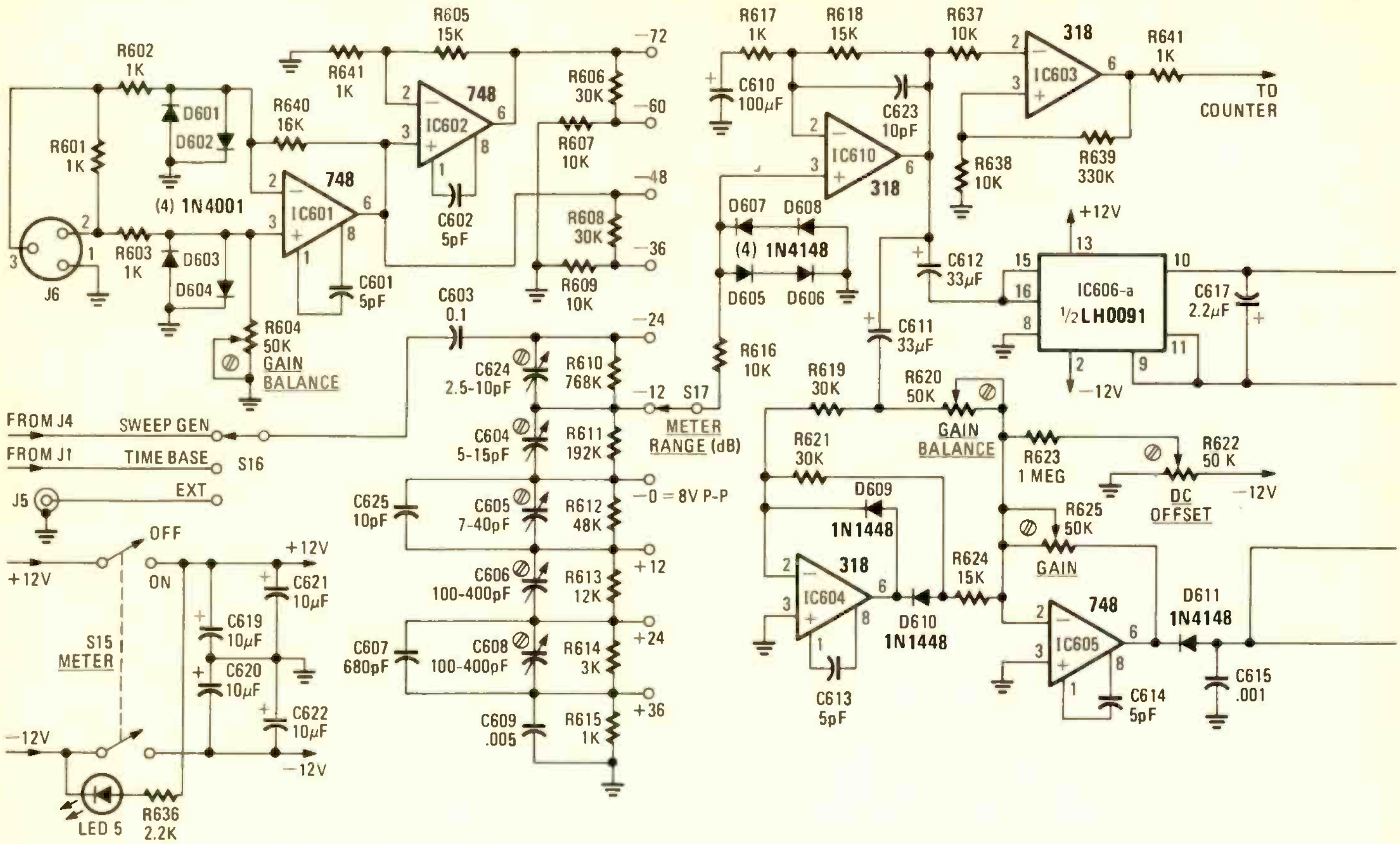


FIG. 10—SCHEMATIC DIAGRAM of the voltmeter. Its input circuitry uses frequency compensation. The separate preamp is for low-level inputs. The 1.5K resistor near the meter is R643, not R635.

called attenuator compensation. For purposes of simple compensation, the absolute capacitance values are relatively unimportant except that they must properly relate proportionately to the resistors that they are parallel with and the stray capacitances they are combining with. However, it is generally desirable to keep these capacitors small so as to minimize the total capacitance seen from the input.

If this were the input attenuator to an oscilloscope where waveform purity is of great importance, a low capacitance switch would be necessary. This is typically a large open-frame type with relatively large intercontact spacing. In this system, the problem is somewhat intensified by the use of a miniature switch where all nodes are in very close proximity. However, it is quite satisfactory up to at least 100 kHz. which should satisfy the needs of the system.

To adjust the compensating capacitors, monitor the output of IC603 with a scope. Apply a 10–15-kHz squarewave to the input and move S17 through each of the relevant positions. Adjust the capacitor immediately below the selected switch position for best squarewave response. Initial calibration of the attenuator will require several trials to bring the trimmers into proper relationship with each other. Once the adjustment is made with a squarewave input, a sinewave can be applied and swept from 10 kHz to 100 kHz to verify the overall response. Some fine tuning may be helpful at this time.

Assuming the sinewave from the timebase would be used for this last check, recall that the timebase begins a noticeable rolloff around 100 kHz. So be sure that any compensation adjustments made with the sinewave input are not compensating for timebase rolloff.

An additional gain stage and attenuator buffer consisting of IC603 is provided. Diodes D605 through D608 provide protection against excessive voltage applied to the external input. With S17 in the −24-dB position, IC603 is connected essentially straight to the external input. The diodes conduct at about 1 volt and are capable of 50 milliamps. Resistor R616 is intended to limit the diode current to a safe level. However, R616 cannot be arbitrarily large since it combines with the capacitance at the input of IC603 to form a low-pass filter. Since the diodes can handle 50 milliamps, 500V can be applied without damaging them. However, the power-handling capability of R616 must be considered at a fraction of that voltage level. If R616 is a half-watt resistor, it will tolerate 70 volts. The resistor can tolerate larger voltage levels than that for short periods of time. Since even a much smaller level will cause the meter to peg, if the operator is attentive, a 10K half-watt resistor should be adequate.

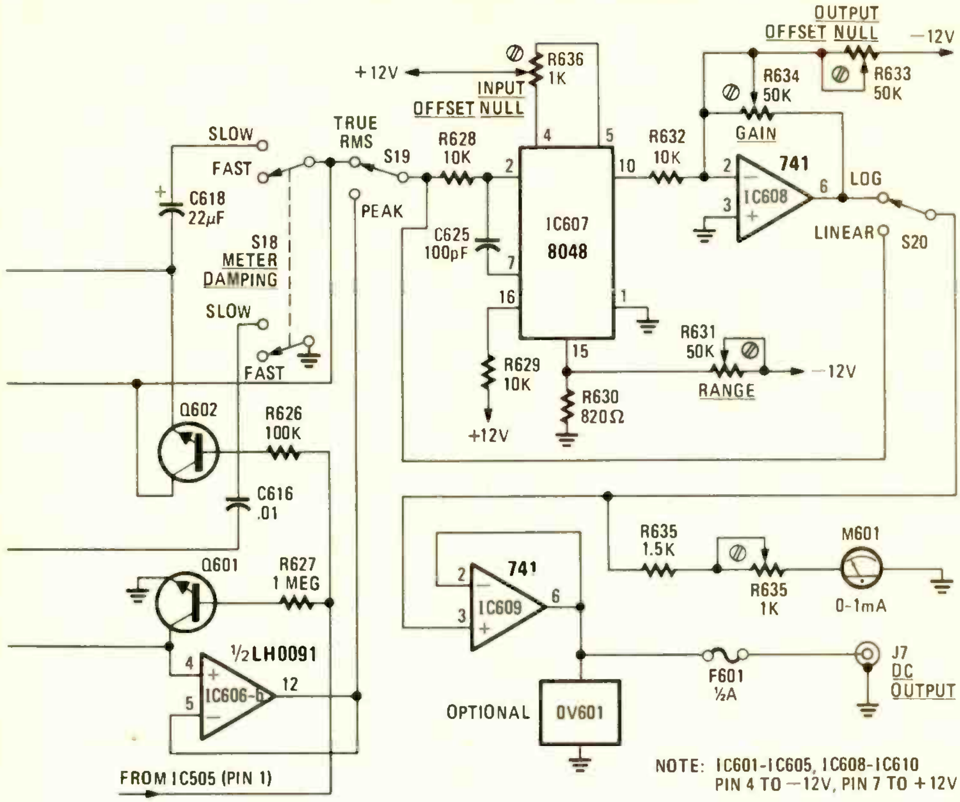
However, for insured safety R16 can be replaced with a positive temperature coefficient thermistor of approximately 10,000 ohms cold resistance. Such a device is a self-protecting resistor, since as excessive power causes it to heat, its resistance increases, which decreases the power and hence the heating effect. Also, keep in mind that R616 is of no particular value and need only be large enough to protect the diodes and small enough not to degrade high-frequency performance.

IC610 is a comparator with hysteresis. A zero-crossing dejector is formed by applying a signal through an isolation resistor to the negative input. Applying positive feedback causes the detection point to shift, which results in a circuit that ignores signals smaller than the detection levels.

This circuit preconditions the voltmeter signal before it is applied to the counter. For the circuit shown, the overall result is that the counter will count an input whose magnitude is 10% of the full-scale setting selected by S17.

IC604 through IC607 form the AC-to-DC converter. IC604 and IC605 are a full-wave rectifier. One-half of an applied waveform is inverted and added to the noninverted half. Resistor R630 adjusts the relative gain of the inverted and noninverted parts of this waveform. Trimmer R625 adjusts the overall gain of the rectified waveform.

Components D611, C615 and IC606 form a peak detector. When the signal from IC605 goes positive, diode D611 conducts charging C615. Capacitor C615 is small and hence charges as fast as the voltage from IC605 rises. When the output of IC605 passes a peak and starts to decrease, diode D611 cuts off and IC606 is left with charged C615 on its input.



Capacitor C615 discharges through the input of IC606. The rate at which C615 discharges is called the droop rate. Note that when D611 is cut off, IC606 has no DC bias on the + input. This results in a negative offset from IC606 equal to 1 diode-drop. Trimmer R622 shifts the output of IC605 enough to compensate for this and hence zero the output of IC606.

Note that the three diodes in the circuit do not exhibit the 7/10-volt threshold normally associated with a diode. The threshold is reduced to a negligible level by the active circuitry with which the diodes are associated.

The result so far then is a full-wave peak detector that will track an increasing amplitude instantaneously and track a decreasing amplitude at a slower rate, this rate being determined by the capacitor, and hence the droop rate is rather arbitrary and is based on the system under test.

If the acoustics of a large reverberant room are being analyzed, standing waves can cause wide fluctuation in amplitude. Tracing these rapid fluctuations requires a fast droop rate and hence a small capacitor. On the other hand, a fast droop rate will tend to track individual waveforms of a low-frequency signal. Therefore, to provide for difference response time requirements, S18 is provided to switch in a parallel capacitor, C616.

Also recall from the generator sections that there is a blanking mode that switches off the output of the audio generator at the end of a sweep. The same trigger that switches off the output of the audio generator turns on Q601, which rapidly discharges the capacitor at the input of IC606. Therefore, a clean cutoff is provided at the end of a plot.

The same signal that is applied to the peak detector is also applied to IC607. This is a true RMS-to-DC converter. Capacitor C617 controls the amount of filtering of the DC output. Unlike the peak detector, the response of IC607 is equal regarding both increasing and decreasing signal levels. Again S18 provides for a variable response time by adding C618 in parallel. Also the blanking trigger turns on Q602 to rapidly zero the output at the end of a sweep.

IC607 is a linear-to-log converter. Voltage gain in dB is defined as 20 times the log of the linear voltage gain. There is a linear voltage at S19 that is zero for a zero level input and ranges up to 4 volts for either a 4-volt peak or RMS input. Since a true log function cannot be physically implemented because it is of infinite length, a decision must be made to use only part of the function and eliminate the region that extends below some practical limit.

To help select an appropriate range; note the effect of a log converter on a linear input signal. Input variations slightly above zero produce very large output variations. Therefore, such things as ripple from the peak detector would be greatly magnified at low levels. Eliminating the lower portion of the function produces a dead zone, for any input voltage below the cutoff point is ignored. The cutoff-point trade off is between low-level excessive sensitivity and total dynamic range, which is the remaining portion of the function. Thus, it was rather arbitrarily decided to cut off the function at minus 40 dB.

VOLTMETER PARTS LIST

Resistors, ¼ watt, 5% or better
R601, R603, R617, R641—1000 ohms
R604, R620, R622, R625, R631, R633, R634, R640—50,000 ohms, trimmer
R605, R624—15,000 ohms
R606-R608—30,000 ohms, ¼ watt, 1%
R607, R609—10,000 ohms, ¼ watt, 1%
R610—768,000 ohms, ¼ watt, 1%
R611—192,000 ohms, ¼ watt, 1%
R612—48,000 ohms, ¼ watt, 1%
R613—12,000 ohms, ¼ watt, 1%
R614—3000 ohms, ¼ watt, 1%
R615—1000 ohms, ¼ watt, 1%
R616, R628, R629, R632, R637, R638—10,000 ohms, ½ watt
R618, R621—30,000 ohms
R623, R627—1 megohm
R616—100,000 ohms
R630—820 ohms
R635, R636—1000 ohms, trimmer
R639—330,000 ohms
R642—2200 ohms
R643—1500 ohms
Capacitors
C601, C602, C613, C614—5 pF disc ceramic
C603—0.1 μF disc ceramic
C604—5—15 pF trimmer
C605—7—40 pF trimmer
C606, C608—100—400 pF trimmer
C607—680 pF disc ceramic
C609—.005 μF disc ceramic
C610—100 μF electrolytic, 16 volts or higher
C611, C612—33 μF, electrolytic, 16 volts or higher
C615—.001 μF disc ceramic
C616—0.01 μf disc ceramic
C617—2.2 μF electrolytic or tantalum
C618—22 μF electrolytic, 16 volts or higher
C619-C622—10 μf electrolytic, 16 volts or higher
C623—10 pF disc ceramic
C624—2.5—10 pF disc ceramic
C625—100 pF disc ceramic
C626—10 pF disc ceramic
Semiconductors
IC601, IC602, IC605—748
IC603, IC604, IC610—318
IC606—LH0091 (National)
IC607—8048 (Intersil)
IC608, IC609—741
D601-D604—1N4001
D609-D611—1N4148
Q601, Q602—TIS97
Miscellaneous
S15, S18—DPDT toggle switch
S16—SP3-position toggle switch
S17—SP10-position rotary switch
S19, S20—SPDT toggle switch
J6—3-terminal microphone connector
J7—BNC connector
M601—1-mA DC meter
OV601—LA10 overvoltage limiter (MCG Electronics)
F601—0.5-amp fuse

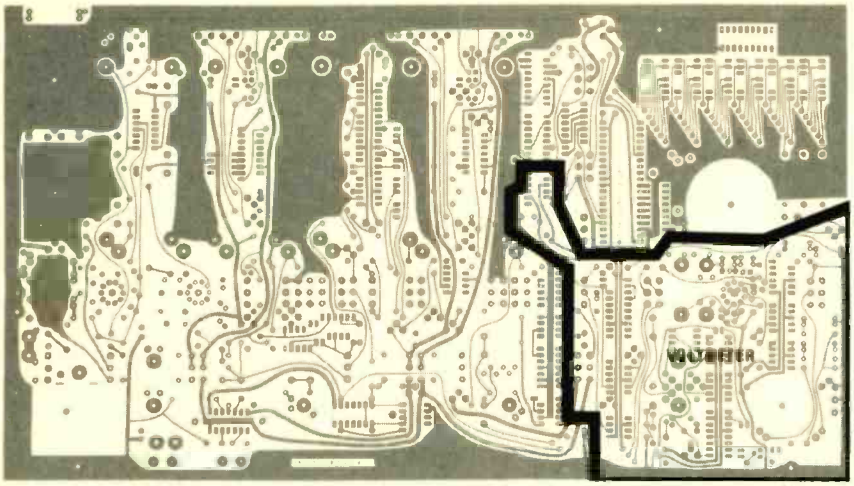


FIG. 11—FOIL PATTERN of the component side of the PC board overlayed with outlines of the area occupied by the voltmeter. The figure below shows the parts that are installed in this area.

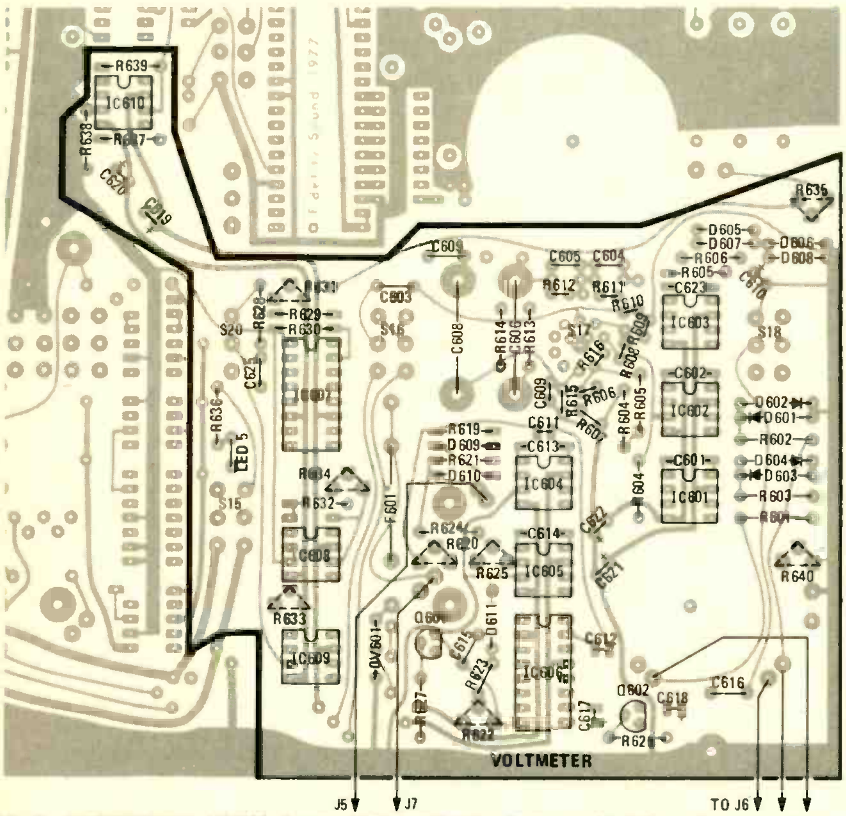


FIG. 12—COMPONENT LAYOUT diagram for the voltmeter. Parts used in this section are coded with numbers in the 600 series. See Fig. 10 for the schematic diagram.

The next task is to physically eliminate the lower portion of the function. To accomplish this, R631 applies a negative voltage to the inverting input of the output stage of IC607. This drives the log waveform up against a positive supply rail, which limits the transition or deflection. IC608 and its associated components provide proper polarity as well as gain and zero set.

Switch S20 selects the log signal, which was just described, or the linear signal, which is simply a bypass of the log converter. Resistor R635 converts the voltage signal to a current signal to drive the meter. A one-milliamp movement is quite satisfactory. Since audio measurements can sometimes be quite dynamic, it is preferable that the movement be critically damped.

IC609 is a very low-impedance output buffer. When connected in this manner, the impedance, looking back into the device, is that of the negative input, which is a virtual ground. IC609 is not really necessary but it does provide lower output impedance, isolation of the signal to the meter and better output protection than the circuit would have without it.

Overvoltage limiter OV601 limits the effect of the application of an external voltage; the same type optional unit is recommended here as was recommended for the other sections. Fuse F601 protects the overvoltage protector from excessive dissipation.

Assembly of this section is straightforward. Figure 11 shows the location of the voltmeter section with respect to the entire PC board and Fig. 12 shows the location of the components.

Counter section

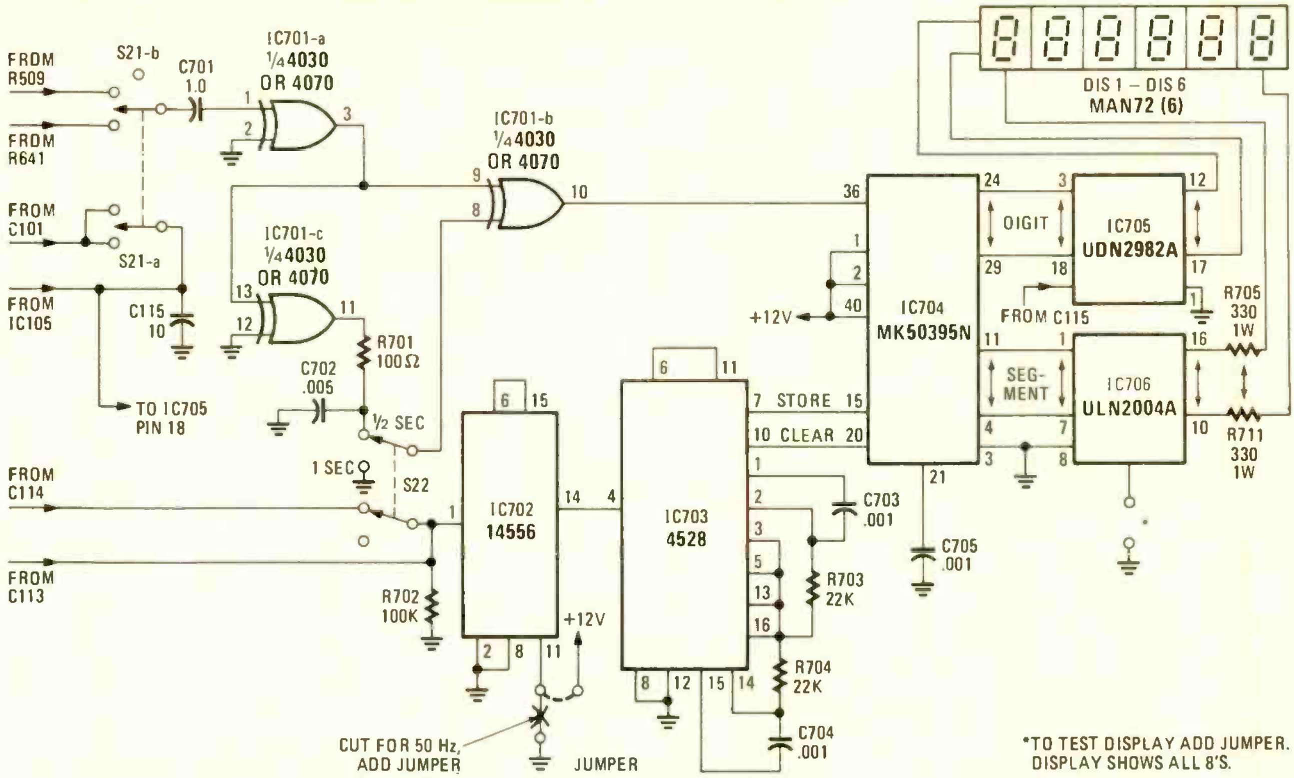
The schematic diagram of the frequency counter is shown in Fig. 13. Section b of S21 is the counter power switch; switch S21-a selects the signal to be counted. In one position the counter counts whatever signal is applied to the voltmeter. The voltmeter signal, however, can possibly be very low amplitude or altered in some way by the system under test so that it does not provide true and stable triggering of the counter. Therefore, S21-b can alternately select an internal signal from the audio sweep generator section. Stable counting of the sweep generator signal is thus always assured regardless of what happens to that signal as it is processed by the system under test.

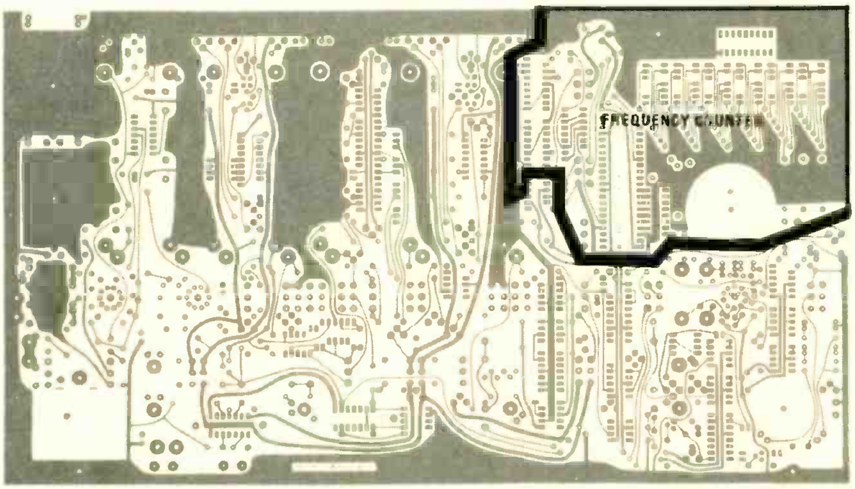
The counter timebase establishes the counting period or window. The counting circuit counts each cycle of the input waveform that occurs during the time the window is open. If the counting window is 1 second, the total number of cycles counted is the average frequency of the input signal during that second in Hz.

This system uses both 1-second and ½-second counting windows. The one-half second window is more useful for tracking a swept frequency.

The timebase, which establishes a counting window, is derived from the power line and selected by switch S22. Resistor R702 is a pull-down resistor for the input of counter IC702. With pin 11 connected to ground, IC702 divides by 60. With pin 11 connected to V+ (which for the counter section is 12V), it divides by 50. On the circuit board, pin 11 is connected to ground. To convert the unit to a 50-cycle power line, it is only necessary to cut a circuit on the back side of the board and install a short bus wire jumper between two pads, which are provided for this purpose. Cutting the circuit disconnects pin 11 from ground. Adding the jumper connects pin 11 to V+. The output of IC702 then is a pulse train whose frequency is either 1 or 2 times the power-line frequency.

IC703 is a dual one-shot. For each input pulse, IC703 provides a negative going store pulse. This store pulse is about 10-μs wide. This time is determined by C703 and R703. As the store pulse terminates, it triggers the second one-shot, which produces a positive going clear pulse. The width of the clear pulse is determined by C704 and R704 and is also about 10 μs. The counting window then is from the end of the clear pulse to the beginning of the next store pulse. These two pulses shorten the counting window by about 25 μs, inducing an error of 25 parts-per-million for a one-second update time or 50 parts-per-million for a half-second update. This error is insignificant in comparison to the normal power-line frequency variation. Line frequency er-





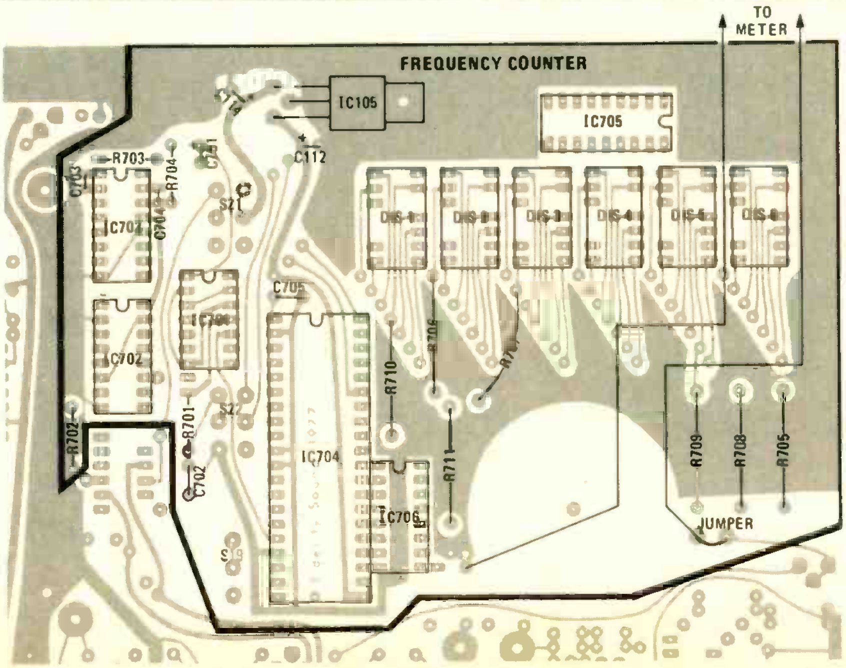


FIG. 13 (above)—THE SCHEMATIC of the digital frequency meter. FIG. 14 (left)—THE AREA OCCUPIED by the frequency meter. FIG. 15 (lower left)—LAYOUT OF PARTS in the frequency counter. IC105 at top center is a voltage regulator that is a part of the power supply.

COUNTER PARTS LIST

R701—100 ohms, ¼ watt, 5% or better
R702—100,000 ohms, ¼ watt, 5% or better
R703, R704—22,000 ohms, ¼ watt, 5% or better
R705-R711—330 ohms, 1 watt, 5% or better
C701—1 μF electrolytic, 16 volts or higher
C702—.005 μF disc ceramic
C703-C705—.001 μF disc ceramic
IC701—4030 or 4070
IC702—4566
IC703—4528
IC704—MK50395
IC705—UDN2982 (Sprague)
IC706—ULN2004 (Sprague)
DIS1-DIS6—MAN72 7-segment display
S21—DP3-position toggle switch
S22—DPDT toggle switch

The following are available from FSI, 1894 Commercenter W., No. 105. San Bernardino, CA 92408: Complete Kit, $495.00; cabinet and circuit board, $115.00. Set of semiconductors, $195.00; seven slide pots with knobs, $17.00, set of trimmers including four multiturn pots, $17.00.

California residents add state and local taxes as applicable.

rors are a fraction of a percent. The overall result is a timebase-caused error in the fourth or fifth significant figure of the displayed frequency.

IC701 is a quad exclusive OR gate connected as a frequency doubler. Gate *continued on page 105*

TROUBLESHOOTING CB Receivers

The receiver circuits in Citizens band transceivers can develop defects that affect range and performance. Here's a look at basic circuits and suitable test equipment.

FOREST BELT

THE SIGNALS NEEDED FOR CB RECEIVER servicing are not drastically different from those for FM two-way radios. Yet, because they are simpler, CB signal generators typically cost less than those designed for FM communications. Citizens band involves only a limited range of VHF signals—from 26.965 MHz to 27.405 MHz. You need IF (or high-IF) signals, usually, from 4 MHz to 12 MHz. Certain noise blankers take 21-MHz, 23-MHz and 25-MHz signals for correct alignment. And of course there's the 455-kHz IF that seems standard almost everywhere.

A CB generator uses AM modulation; and that's easy. However, there is one tricky concern: checking out the single-sideband function of AM/SSB receivers. Ordinary amplitude modulation doesn't suffice for that job. So, for SSB tests, you'll want your CB generator to have a *frequency-offset* feature. Various generators include this capability, but in different formats.

Basically, an overall alignment procedure follows the pattern for other communications receivers. There's no demodulator calibration for AM, nor any limiter stages. The first steps in an alignment procedure takes care of the 455-kHz IF stages.

The AM detector is a good—and usually convenient—place to connect your DC voltmeter as an alignment indicator. As the signal reaches the AM detector, the diode (or diodes) develops (by rectification) a DC component that is proportional to the carrier strength. This is often the same DC voltage used for the automatic gain control (AGC) of RF and IF stages, and in many CB receivers to control the squelch system.

Find the AM detector. Three common versions are shown in Fig. 1. Identify the detector output side on the circuit board; usually it's at the anode end of the series diode. This orientation makes the rectified DC negative with respect to ground. So the negative or black lead of your DC voltmeter clips to the detector output. The other (red) voltmeter lead goes to the negative power bus (note—only in a few chassis is this bus the same as chassis ground). If the diodes are wired with the cathode to the output side (Fig. 1-c), you'll have to reverse the voltmeter leads.

If a receiver has an S-meter, you can usually depend on it as an alignment indicator. Just make sure (using the schematic as a guide) that the S-meter senses signal strength *after* the last IF stage and not before. A few S-meters are driven directly by the AM detector or by a DC-driven AGC system; either of these systems is OK for alignment.

Set the signal generator for 455 kHz. Although accuracy is not so critical as for FM demodulator alignment; the frequency should be relatively close. And it must be stable—free of any significant drift. If you have any doubts, monitor the generator output with a frequency counter.

Feed the 455-kHz signal into the base of the mixer transistor just preceding the 455-kHz IF stages. Turn up the generator output just enough to show a noticeable DC meter reading at the AM detector. Do not turn it high enough to flatten out the indication. That is, if more input

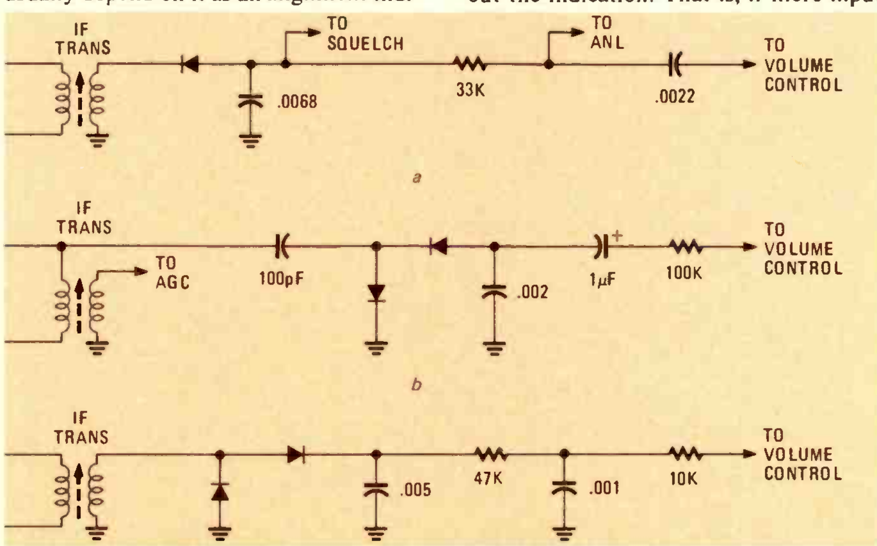
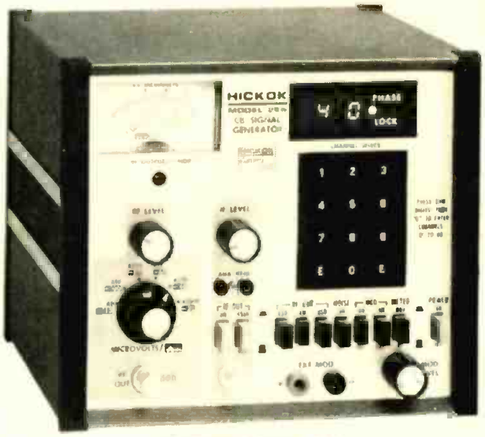


FIG. 1—MOST AM DETECTORS have diodes oriented for negative-going input, as shown in *a* and *b*. A few doubler detectors have diodes wired so that output is positive-going as in *c*.

SENCORE MODEL CB42



HICKOK MODEL 266

LEADER MODEL LSG-227

signal causes hardly any additional meter deflection, you've turned the generator output level too high.

Now adjust the mixer output coils and the 455-kHz IF transformers for a maximum DC reading. Where any core adjustment does not show a sharp peak, suspect trouble. The most likely culprits are: (1) a generator set for too much output; (2) a defective coil or slug; (3) an open decoupling capacitor for that winding; or (4) too much leakage from a transistor junction either before or after that coil. The cure for each should be obvious.

High-IF section

Some CB receivers do not have a 455-kHz IF. They use only one single-conversion mixer. The IF is in the megahertz range, just as it would be for a double-conversion mixer. In this case, however, the high-IF signal feeds the AM detector directly.

This design is most often found in AM/SSB receivers. The block diagram of Fig. 2 shows why. Signal insertion for SSB demodulation takes place at the same frequency used for SSB signal generation in the transmitter, so that the same oscillator is used. Hence, the receiver high-IF is chosen to match.

During AM operation, the same IF signal feeds an AM detector, with no need to heterodyne down to 455 kHz. The main advantage of the second conversion, which would be useless during SSB reception anyway, would be greater AM selectivity. However, today's crystal filters for high-IF stages have very steep skirts. Further bandwidth filtering is not absolutely necessary. A designer can choose an exceptionally sharp-sided high-IF filter, and get by without the extra mixer and extra IF section.

If you're dealing with a single-conversion receiver that has only the high-IF section, alignment procedure starts the same as for low-IF: Clip your DC voltmeter to the AM detector. (Never try to align in the SSB mode.) Feed the base of the mixer transistor with an accurate high-IF signal. Common frequencies are 7.8 MHz, 10.7 MHz and 12 MHz. Check the schematic or the service notes for the set you are aligning. The high-IF filter may have the frequency stamped on it. (This filter often does double duty as the SSB filter.)

Adjust the generator output as already described—enough for a DC reading at the AM detector, but not enough to saturate the RF or IF stages. Peak all the mixer and IF adjustments. As a trouble-finding aid, note any adjustments that peak too broadly.

In double-conversion sets, align the high-IF section after making sure the low-IF stages are OK. However, first verify that the second receive oscillator feeds the right frequency to the second mixer. The schematic usually gives the crystal frequency, but not always to fine enough accuracy. For example, a 7.8-MHz high-IF requires a 7.345-MHz crystal in the second conversion oscillator. The diagram could indicate only a 7.3-MHz frequency. Use your knowledge of heterodyning and a calculator to determine the exact frequency. Then, using your frequency counter, measure this frequency at the output of the oscillator.

You can use an alternative approach if your signal generator has digital dial-up accuracy. Use the high-accuracy generator for the 455-kHz alignment, as already described. Then, without changing the feed point, move the generator frequency to the high-IF. Keeping an eye on the DC voltmeter, raise and lower the frequency in 100-hertz steps. The highest DC voltmeter reading should coincide exactly with the high-IF design frequency.

If it doesn't, the crystal probably has

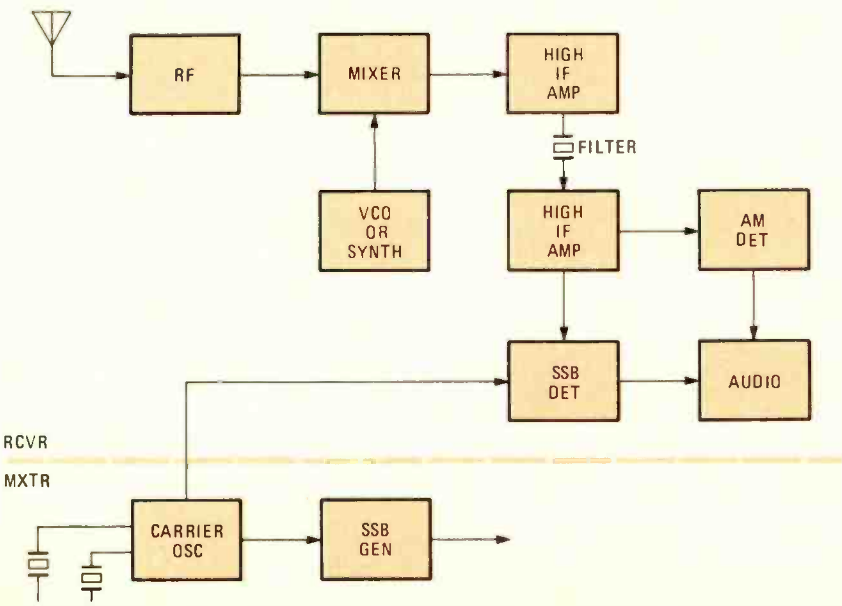


FIG. 2—MANY SSB RECEIVERS for CB convert (mix) only once, to the high intermediate frequency. Crystal or ceramic filter provides selectivity.

TABLE 1—CB SIGNAL GENERATORS

Mfr Brand	Model	Output (mV)	Accuracy (ppm)[1]	PLL	SSB offset	IF Signals Low (kHz)	High (MHz)	EIA NB test
B&K/ Precision	2040	100	5	✓	Var	455	—	Yes
Com-Ser[2]	CB-2700[2]	1	5	✓	—	30 up	to 12	No
Hickok	266	100	5	✓	± 1 kHz	455	1-20[3]	Yes
Leader	LSG-227	100	5	✓	Var & ± 1 kHz	455	—	Yes
Logi-Metrics	981[2]	20	2		—	—	—	No
Sencore	CB42[2]	100	5	✓	± 1 kHz	375 up	to 12	No
Time & Frequency Technology	767	300	5		Digital	100 up	to 12	Yes

Note: Var = Variable.
1. ppm = parts per million. 5 ppm equals 0.00005 percent.
2. Has features in addition to signal generator.
3. Needs external crystal for each high-IF frequency.

shifted frequency. The second oscillator circuit may contain a frequency adjustment, but many do not. A shift in frequency of more than 300 Hz from the center can degrade reception enough to justify replacing the crystal. Besides, the error will only grow worse.

A quick trick

The crystal-controlled nature of a CB receiver offers an excellent opportunity to save some alignment time. This time-saving procedure works best for single-conversion, whether the IF is 455 kHz or several megahertz. It also—usually—works OK for double-conversion, if you follow the procedure carefully.

You need a highly accurate signal generator, any of the phase-locked models (see Table 1) will have sufficient accuracy and stability. Once you're familiar with the CB models you work on most, you may like this shortcut.

Follow the procedure shown in the block diagram of Fig. 3. Coils have been added to show the adjustments you may encounter; some sets have fewer, some have more.

First thing you do is jump in with your frequency counter and verify the frequencies generated by the phase-locked loop (PLL) (or use a frequency synthesizer if the CB is an older model). Keep the transceiver's RF input connected to a dummy load during these measurements. This is to avoid any stray inputs that might confuse the frequency counter. A test point is usually provided for the counter near the mixer input. Check *all* channels.

Next, measure the frequency of the receive oscillator. It may be adjustable, so you can set the frequency precisely. If the set is a single-sideband model, look for another oscillator or two in the same vicinity. Set these oscillators while you're at it. A test point or test points nearby accommodate the frequency counter. Certain elaborate CB models have three or four oscillators, for various modes. Measure the frequencies of them all, switching to the appropriate modes of transceiver operation. Correct any that are adjustable. Install a new crystal anywhere the error exceeds a couple of hundred kilohertz.

Feed an accurate generator signal right into the front end (remove the dummy load). Set the generator for Channel 21. (Use Channel 13 in 23-channel sets.) No modulation is needed from the generator. Connect your DC voltmeter at the AM detector, as already described. Set the receiver for Channel 21, and select the AM mode. Turn up the generator output so that a reading is obtained on the meter.

Since you've already determined that all conversion oscillators and the phase-locked loop (or synthesizer) are on-frequency, you can now peak all the IF and RF adjustments for maximum DC at the AM detector. If the reading goes too high with the peaks too broad, reduce the generator output somewhat.

The beauty of this procedure, once you know where to find the oscillator and PLL (or synthesizer) test points, is its simplicity and speed. It is also *thorough*. If there's a problem in the oscillator or the PLL, it appears during your frequency-counter tests. (Note—of course, the frequency counter must have enough sensitivity to measure oscillators directly. Oscillators in CB sets usually have an output range from 20 mV to 50 mV RMS.)

You complete RF and IF alignment both with one connection of your signal generator, which saves time. And, naturally, any weaknesses or oscillations in those stages become evident as you adjust.

Unwanted oscillations in the RF or IF stages appear generally as an uncontrollably high DC reading at the AM detector. Often, this appears as you peak an adjustment, and is usually because somebody detuned the stages to cure the squawk or distortion. The true cure is substituting a new decoupling capacitor, a new coil assembly, or (rarely) a transistor with less inter-element capacitance.

Selectivity filters

You can check the bandwidth filters in CB sets in much the same way as in FM

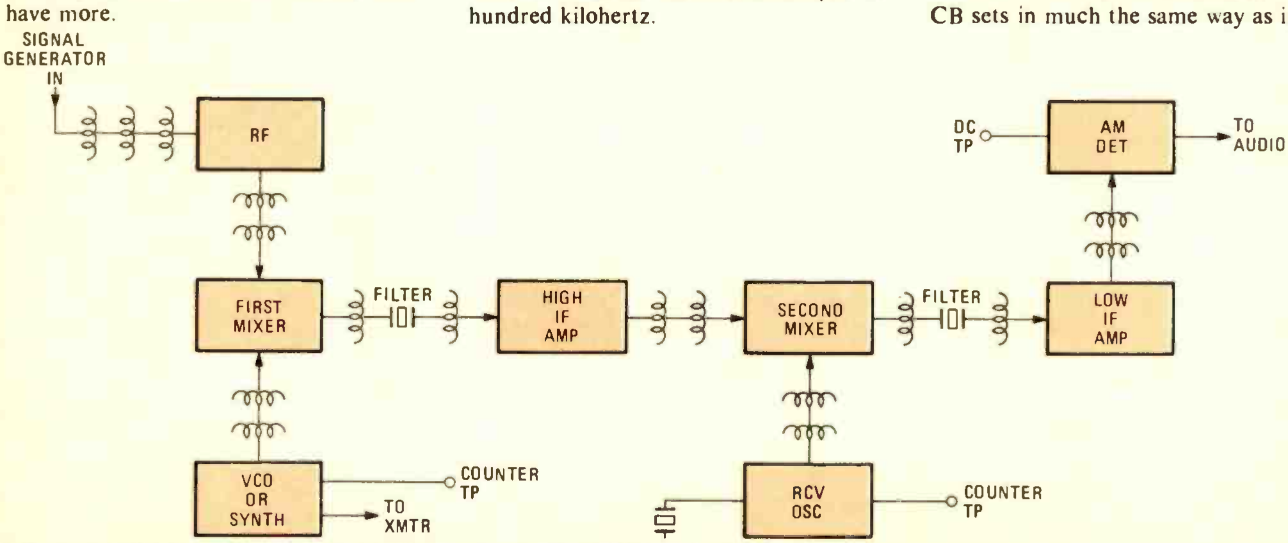


FIG. 3—CHECK OSCILLATORS FIRST with a frequency counter, and you can align with an accurate RF signal fed into the front end.

two-way receivers. But there is a handier evaluation, using the same test setup as for RF alignment.

The generator signal feeds into the antenna jack. The receiver and generator both operate on Channel 21 (or Channel 13). Keep the DC voltmeter at the detector output. However, here are two differences: Turn the generator output up to 50,000 μV, and add 30 percent modulation. Yes, the RF and IF stages will be saturated, the AGC will be fully operative, and the DC meter reading will be at its peak. Set the volume for comfortable listening.

Leaving the receiver set to Channel 21, change the generator frequency to Channel 20, which is 27.205 MHz. You'll note a drastic reduction in sound from the speaker, and in the DC meter reading. Turn up the volume enough to hear *some* sound, even if it's just noise with very little demodulated sound. Adjust the generator output, if there's enough, for a measurable DC meter reading.

Next, switch the generator frequency to Channel 22, or 27.225 MHz. The DC meter reading and the recovered sound should be the same as they were when you fed in Channel 20. If there is much difference, the alignment is faulty or the filter is off-center. Since a complete alignment procedure was performed before you made this test and you made sure all coils peak properly, the defect is likely to be in the filter.

You probably recognize what you're doing in this quick test—assessing *adjacent-channel rejection*. You can measure actual decibels of rejection. This test gives only an approximation. In a properly operating CB receiver, sound recovered under adjacent-channel conditions should drop to weak sound with some noise in the speaker. That signal drop represents about 50 dB of rejection, which is roughly equivalent to reducing the generator signal from 50 mV to 0.5 μV (on-channel).

Measuring adjacent-channel rejection takes only enough (or more) time to connect an audio voltmeter across the speaker. Set the generator to Channel 21, the output to 1 μV and modulation to 30 percent. Set the receiver to Channel 21, and adjust the volume control to give an audio output of 1.5 volts RMS. That's your reference audio level.

Switch the generator to Channel 20. Increase the generator RF signal, in decade steps, until the audio output meter again reads 1.5 volts RMS or close to it. Each RF increase by a factor of 10 represents 10 dB of adjacent-channel rejection. For example, if the adjacent-channel audio output comes up to 1.5 volts RMS again when the RF signal from the generator is increased from 1 μV to 1000 μV, the adjacent-channel rejection is 30 dB. If it takes 10,000 μV, the rejection is 40 dB. A 100,000-μV signal means 50 dB of rejection. The average modern CB receiver shows a rejection of 40 dB or so.

With this approach, you can assume the selectivity filter is faulty if (1) adjacent-channel rejection is less than 20 dB, or (2) if rejection values above and below the receiver channel are more than 10 dB apart. This judgment presumes that you have finished troubleshooting and aligning the RF and IF sections before testing adjacent-channel rejection.

The cure for a faulty filter is usually a new filter. If adjacent-channel rejection is balanced but poor, check carefully the input and output loading of the suspected filter. This includes the transistor preceding the filter and following it, plus the decoupling capacitors in the base or collector circuits of those transistors. New filters are somewhat expensive in some models, so you want to be as sure as you can.

Noise blankers

Manufacturers of specialized CB generators seem to have overlooked noise-blanker adjustments. They provide no signal for aligning the RF input coils. Inexpensive CB receivers of course have no noise blanker to consider. Some blankers sense pulse noise *after* the first mixer; any input coils tune to the high-IF. Others have untuned inputs, but several still incorporate a system similar to the one shown by the block diagram of Fig. 4, in which the coils are included to indicate their positions. An IC chip contains most of the blanker stages in newer CB receivers.

For alignment purposes, what concerns you mainly are the input coils. In Fig. 4, these coils are shown to peak at 21 MHz. However, some set designers choose 23 MHz or 25 MHz. A significant part of the objective is rejection of 27-MHz signals. But the blanker system needs the gain these stages afford at their own RF frequencies. This gain assures efficient pickup of ignition-noise pulses, because automotive-noise RF energy is strong in the 20–30-MHz frequency range.

In the absence of noise pulses, such as when an unmodulated RF test signal is used, the pulse-detector diode acts similar to an AM detector. That is, it produces a DC voltage that is proportional to RF signal strength.

Connect your DC voltmeter at the diode output; an IC usually has a test point for this connection. Feed just enough signal into the antenna jack (at the listed blanker-coil frequency) to cause a meter reading, and peak the RF coils.

That's all there is to it. Accuracy isn't critical, but you use a stable signal source because even small frequency changes could lead to a broadening of blanker response.

SSB tests

When you've aligned and tested a CB receiver for AM operation, you've already covered almost everything in the RF and IF stages that could interfere with SSB reception. Any symptom present in SSB only indicates a demodulator or mode-switching fault. The SSB demodulator normally is the same circuit as the SSB modulator. Servicing it as a transmit function proves easier than troubleshooting its receive function. So, if the complaint is an SSB "receive-only" symptom, mode-switching seems about all that's left.

To corroborate your evaluations of receiver operation after you've finished all AM alignment and assessment, you can test SSB reception with your CB signal generator. Here's the way to do it, quick and easy if your generator has the right controls.

What does "right controls" mean? It means you must be able to offset the channel carrier by 1 kHz (1000 Hz), accurately. You see this easiest in a generator with digital frequency knobs. For example, for CB Channel 21 at 27.215 MHz, the frequency reading on a 500-MHz signal generator that has a 7-digit dial would be 027.2150 MHz. To raise the frequency (the upper sideband) by 1 kHz, change the dial to read 027.2160 MHz. For the lower sideband, set the dial at 027.2140 MHz. Use no modulation, just RF.

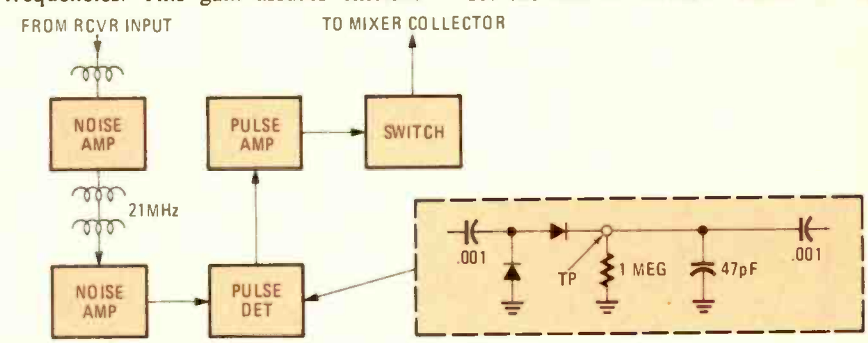


FIG. 4—MANY NOISE BLANKERS do not have tuned circuits; those that do should be aligned properly for optimum performance.

Set the receiver for AM at first. With the generator frequency set to channel center (027.2150 MHz), you should hear no sound in the speaker. Set the receiver for LSB operation, and set the signal generator for 027.2140 MHz. You should hear a 1000-Hz tone, and a frequency counter across the speaker should

continued on page 79

communications corner

A new monthly column devoted to the latest developments in the communications field.

HERB FRIEDMAN, COMMUNICATIONS EDITOR

WELCOME TO "COMMUNICATIONS CORNER," a new monthly column devoted exclusively to the latest developments in the field of communications as they affect CB, SWL, VHF/UHF radio, amateur radio—and whatever else comes along as a result of new technologies.

Just a few short years ago, each of these individual branches in the field of communications would have been considered separately and covered by separate articles and feature stories. But because of the "crossover" factor, whereby a modern technological development for one branch finds instant application to other branches under the umbrella labelled "communications," a better picture of what's happening today and what will happen tomorrow is attained by combining all aspects of consumer communications into a single column.

We will try to describe not only the latest developments in general and specific communications, but how they are actually applied to the various pieces of equipment the average consumer, hobbyist and technician will find.

In many instances, we will introduce you to the "leading edge of the state of the art," although this leading edge could often be nothing more than a 30-year-old idea updated with modern devices, (such as the substitution of transistors for vacuum tubes). We plan (with cooperation from the manufacturers) to introduce you to new uses for old ideas, old uses for new ideas, and, of course, new uses for new ideas as they affect the world of communications.

To give you an idea of what to expect in future months, we're now going to touch all the bases with some of the very latest developments in all fields of consumer communications. Later columns will go into the nitty-gritty of individual circuits.

Computerized CB

Heading the list in terms of interest (or at least my own interest) is computerized CB transceivers. We've all been hearing about computerized CB for at least the past 12 months. Originally, the BIG NEWS was that "the biggie" company in computers and calculators was on the verge of introducing a computerized CB. Many months (and a poor year for sales) later, the "biggie" has yet to introduce their model; but computerized CB has now been introduced by Robyn and Pathcom (among others), with more to follow.

Actually, the computerization of CB is really receiver-oriented. There are variations, of course, but the basic idea is a microprocessor that permits the user to program a specific group of channels to be scanned for activity (busy channel) or lack of activity (clear channel). Alternately, the computer can be programmed to scan all channels, or it could be programmed for operation on one channel with frequent checks of an alternate channel. (For example, Pathcom's *Pace 8117* can be programmed to monitor a second channel once every 10 seconds for ½ second.)

While you cannot scan with the transmitter keyed, the transmitter usually follows the receiver in a computerized transceiver; so if the receiver stops on a channel during a scan, the transmitter is similarly tuned to the same channel. One main feature of the computer is that it prevents operation on unauthorized frequencies. For example, if you attempted to program the *Pace 8117* for Channel 51 or even a 3-digit channel, as for example Channel 123, the computer says "tilt" to itself and defaults to Channel 19.

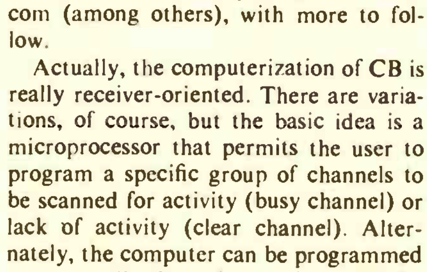


FIG. 1

The *Pace 8117*'s touch-pad, used for both channel entry and microprocessor programming, is shown in Fig. 1. This touch-pad is more or less typical of a computerized CB keyboard, and in later columns we'll cover touch-pad programming.

VHF/UHF

For several years, the more expensive VHF/UHF scanning monitor radios have allowed the user to digitally program a group of desired frequencies. Although somewhat more expensive then crystal-controlled scanners, the programmable scanners permitted the user to easily follow the special services—in particular the police—as they moved around the public-service bands. Usually, it took a not-very-accurate frequency list or handbook and some local undercover work to discover where the local safety services were moving as they hopscotched around the low VHF (30—50 MHz), high VHF (146—174 MHz) UHF (450—500 MHz) and the "T" (*T*elevision—unassigned low UHF television channels) bands. But for every need there's an invention, and this year's is the "searching scanner." Microprocessor-controlled searching scanners, such as those manufactured by Radio Shack and Bearcat, allow you to program high- and low-frequency limits, which are then continuously scanned until an active frequency is located. Some of the more sophisticated models, such as the Bearcat *model 250*, keep a running count of each active frequency; and at the end of a given time period, you can read back total activity to determine which frequencies in your immediate locality are most used.

And, finally, there's a searching scanner for the aviation enthusiast, the Regency *model ACT-T-720A* Digital Flight Scan. This scanner covers airport and aviation frequencies from 108 MHz to 136 MHz. Like the VHF/UHF monitor radios, the *model ACT-T-720A* can be directly programmed to a desired frequency, or can be programmed to search a selected range of frequencies.

Amateur radio

After having spent many years in the doldrums in terms of both membership and equipment, amateur radio, the oldest of electronically oriented hobbies, has been given new life by modern technology. From new all-band VHF mobile antennas, to broadband-tuned transmitters and receivers, to an ever-expanding two-meter FM band, and, finally, to digi-

continued on page 74

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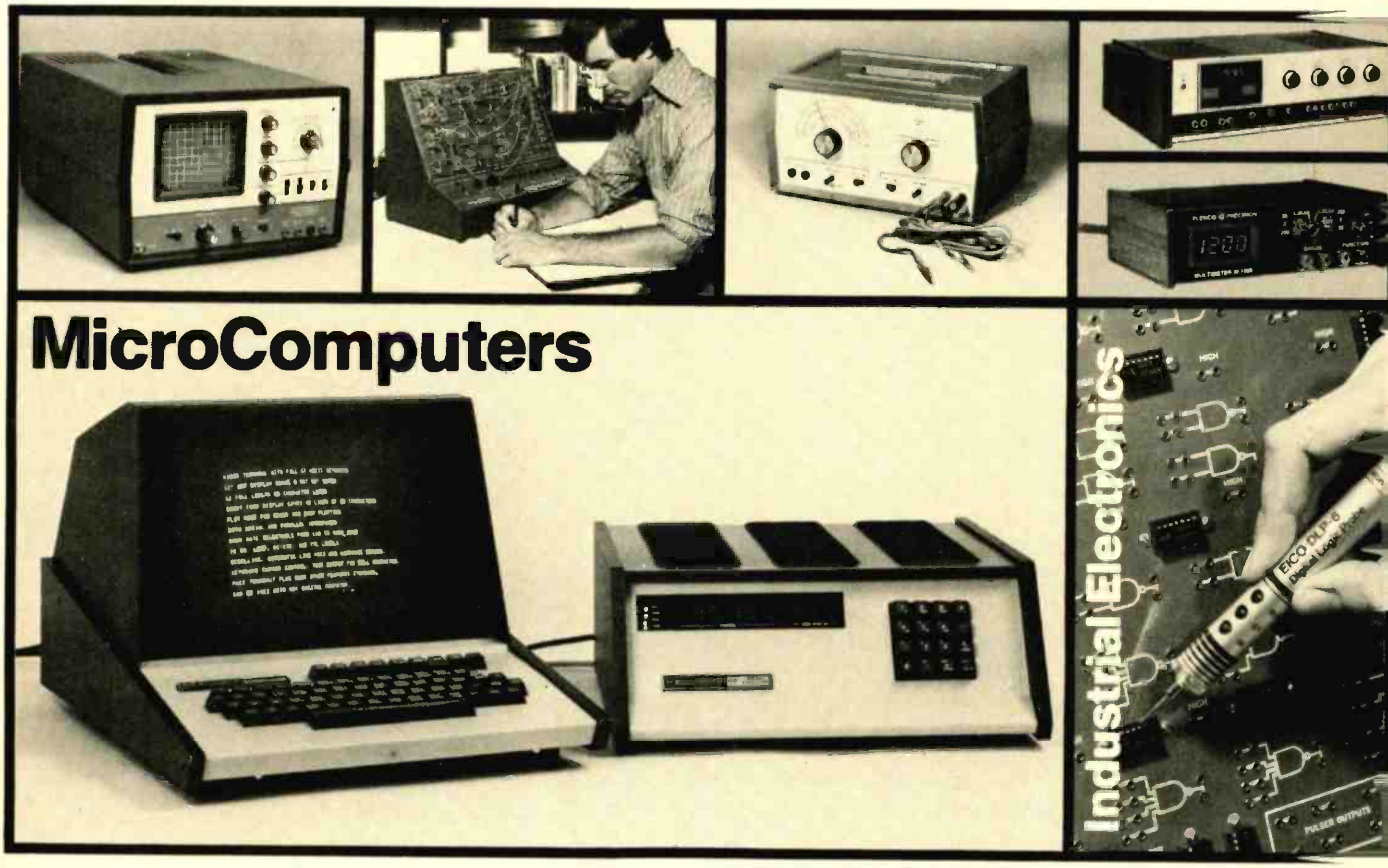

The world of electronics is daily becoming more challenging. Technology is growing more specialized, and the importance of digital systems increases every day. Test instruments, home entertainment units and industrial control systems are all going digital. And now, NTS training programs include a wider choice of solid-state and digital equipment than ever before offered in any home study course: Advanced NTS/Heath digital color TV (25" diagonal with optional programming capability), NTS/Heath microcomputer, digital test equipment, digital stereo receiver (70 watts per channel), NTS compu-trainer, plus much more state-of-the-art equipment to make your training exciting and relevant.

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Whether you are looking for training in Consumer, Commercial, or Industrial electronics, NTS offers fourteen courses, some basic, many advanced, in several areas of electronics. An all-new full-color NTS catalog shows you what each course covers,

COMMUNICATIONS CORNER

continued from page 68

tal readout and synthesis of VHF and UHF equipment, probably more technological excitement is going on in ham radio now than in all other electronic hobbies combined, other than personal computing. We'll cover many of the latest ham radio developments in detail in the coming months. Right now, let's look at digital-frequency readouts.

Digital readout

The price of a digital readout has decreased drastically. Everything from bathroom scales to set-back home thermostats has a counter-driven digital readout. It's, therefore, not surprising that much of the recently introduced Ham gear also contains digital readouts. No more interpolating the position of cursors, or "in-between" 1-kHz calibrations, a digital readout now indicates precisely—usually by 100 Hz—the center frequency of a receiver or transmitter. Actually, the procedure isn't difficult since all it involves is a frequency counter connected to the local oscillator or VCO. An offset applied to the counter programs it to display the frequency directly, for example, 21.275.3 MHz. This is a lot easier than the digitally synthesized tuning (programmable frequency selection) used in some gold-plated-special receivers.

We'll cover both digital readout and synthesized tuning in amateur gear in greater detail in future columns.

SWL

Finally, let's see what's happening in shortwave listening (SWL). For almost the entire history of broadcasting, SWL receiver dial calibration was a hit-or-miss affair. With very rare exceptions, the dial calibrations barely came near the correct frequency, let alone right on it.

Those SWL enthusiasts who were fortunate to know about the Barlow-Wadley receiver (and parted with several hundred dollars for it) were fortunate to end up with one of the very few noncommercial, nonmilitary receivers that could be preset to a frequency and actually be on the button when the power switch was turned on.

The Barlow-Wadley circuit is unique: It uses two VHF crystal-referenced oscillators—one fixed, the other variable. Because the operating frequency is around 50 MHz and because the reference frequency is 1 MHz, an unswitched tuning knob can step the tuning in quartz-referenced (drift-free), 1-MHz steps from almost 0 Hz to any desired frequency, usually 30 MHz. The output of the two oscillators (in the 1 MHz–3 MHz range, depending on design) is then tuned by a dial calibrated from 0–1 MHz in 1-kHz or 5-kHz increments. In short, this is a beautiful system with a drift-free dial calibration that provides accurate tuning on the first try.

The original Barlow-Wadley receiver was a small battery-portable unit that outperformed many of the "gold-plated boat anchors" we then called *communications receivers*.

If you wonder what a Barlow-Wadley circuit would be like using the latest digital readout, you can see for yourself at your local Radio Shack store in the form of the *DX-300* Quartz-Synthesized Communications Receiver (see front-view photograph Fig. 2).

FIG. 2

Using the Barlow-Wadley conversion format in a triple-conversion receiver, the *model DX-300* features a digital readout directly in MHz and kHz, to a 1-kHz dial accuracy. The rated frequency range

continued on page 76

COMMUNICATIONS CORNER

continued from page 74

is 10 kHz (or 10,000 Hz) to 30 MHz, with provision for a coaxial cable connecting to a dipole or a beam (with an SO-239 connector), longwire or a supplied telescopic whip antenna.

Station tuning is accomplished through two concentric knobs. One knob steps the tuning through 1-MHz increments from 0—30 MHz. The other knob provides continuous tuning, though the readout is calibrated in 1-kHz increments. A fine *tuning* control provides a very small tuning shift for use during SSB reception (this control is a clarifier). The RF preselector control has six bands, its own tuning adjustment and its own scrolling dial so the user can peak the preselector tuning to a desired segment of any frequency band. Both the preselector control and the MHz tuning control handle final signal peaking (common in Barlow-Wadley circuits).

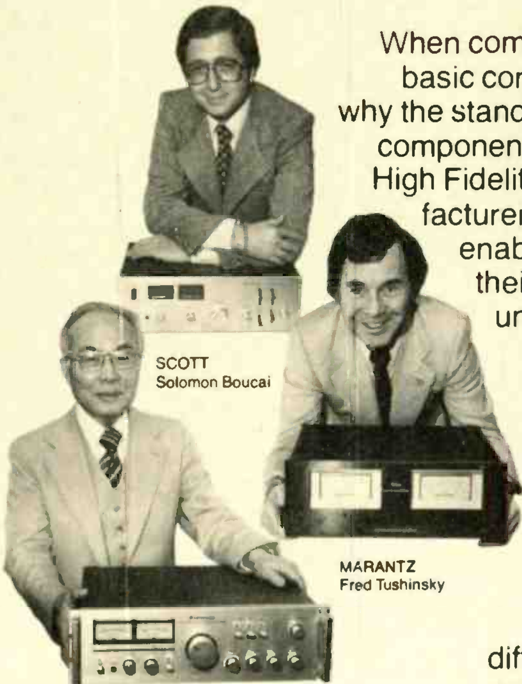
The end result is precision tuning at a hobbyist's price, plus the frequency coverage below the broadcast band, which is uncommon in SWL receivers. Other features include 120 VAC/12 VDC battery operations; AM, LSB, USB and CW reception; a three-step audio selectivity; 20-dB and 40-dB antenna input attenuators; a *standby* control; an S-meter, and more.

This discussion of the *model DX-300* receiver wraps up the first column. In the months ahead we hope to keep you up to date on the very latest developments in consumer communications. Sometimes we'll just give you the highlights of several items; other times we'll provide more in-depth coverage.

Unless we hear from you, however, we'll only be guessing at what subjects and equipment meet your particular needs. So take a few moments out to drop us a short note (a postcard is best), and let us know exactly what interests you most in the field of consumer communications. **R-E**

"No matter what the project he's working on is supposed to be—it ends up being a light dimmer."

Even competitors agree.



SCOTT
Solomon Boucai

MARANTZ
Fred Tushinsky

KENWOOD
Bill Kasuga

THRESHOLD
Nelson Pass

US JVC
George Meyer

YAMAHA
Stewart Greenberg

PHILIPS
Gerald Orbach

SAE
Malcolm Schneer

When competitive companies agree on a basic concept, it must be sound. That's why the standards for measuring high fidelity components developed by the Institute of High Fidelity are so widely used by manufacturers. These helpful guidelines enable manufacturers to present their product specifications in a uniform way. As a result, you can rapidly compare hi-fi components because everyone's "audio watts," "microvolts," and "dBs" mean the same thing. They help you and your audio dealer talk on the same wavelength when you're discussing the difference between hi-fi and not so hi-fi products.

IHF measurement standards are now in effect for tuners, amplifiers, and headsets. Additional standards are now being developed for speakers, tape recorders, turntables and cartridges. Look for them in manufacturers' literature and in retail advertising. Then you can buy real high fidelity with complete confidence. Institute of High Fidelity, Inc., 489 Fifth Avenue, New York, N.Y. 10017

IHF

TECHNICS
Jeff Berkowitz

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PHASE LINEAR
Bob Morrill

PIONEER
Bernie Mitchell

NIKKO AUDIO
John Schroeder

HITACHI
Jerry Henricks

SONY
Frank Leonardi

Shown above are just a few of the many manufacturers using IHF measurement standards

new lit

More information on new lit is available from the manufacturers of items identified by a Free Information number. Use the Free Information Card inside the back cover of this issue.

VIDEOTAPE MAGAZINE, *The Videophile,* is a bimonthly magazine containing information and articles on what's new in the world of VCR's and videotape. In addition to the feature articles, the departments include videotape and book reviews, VCR news and views, a humor section, letters to the editor, and many more. Subscription rates: 6 issues/year, $10 (Third Class); $16 (First Class).—**The Videophile,** 2003 Apalachee Parkway, Tallahassee, FL 32301.

CIRCLE 149 ON FREE INFORMATION CARD

WIRE AND CABLE CATALOG provides 96 pages of information on complete wire and cable line, including audio, CATV, intercom, mike, power and TV cables. The following new types of cable are described: computer, control, *Teflon* covered coax, booster and ribbon cables. The catalog also includes conduit-capacity charts, a metric conversion chart and technical data on solid and stranded copper wire.—**Columbia Electronic Cables,** 11 Cove St., New Bedford, MA 02744.

CIRCLE 150 ON FREE INFORMATION CARD

ELECTRONICS CATALOG, 99 pages describing hundreds of discounted items—from adapters to wire-wrap accessories. Includes such equipment as analyzers and testers; meters; color-bar generators; breadboarding materials; transistors; electronic tools; hi-fi equipment; CB's and accessories; service manuals; and troubleshooting guides. A handy order form and postal rate chart are contained in the back. Catalog price: $1.—**Edlie Electronics, Inc.,** 2700 Hempstead Turnpike, Levittown, NY 11756.

TEST INSTRUMENTS/BREADBOARDS, *Professional Products Catalog.* Catalog contains 32 pages of solderless breadboard equipment and test instruments, ranging from simple sockets and IC clips to lab-quality pulse and function generators, and CSC logical analysis test kits plus accessories. All products are illustrated and come with complete specifications.—**Continental Specialties Corp.,** 70 Fulton Terrace, New Haven, CT 06509.

CIRCLE 151 ON FREE INFORMATION CARD

CATV COAX CABLE GUIDE, *EL-10-78,* lists 20 pages of 59/U-type and 6/U-type drop cable plus converter and accessory cable. Several shielding methods are described, including using *Duobond* and *Duobond II* bonded foil, *Duofoil* foil-film laminate and copper and aluminum braid. Physical and electrical specs are provided along with attenuation ratings. The catalog also contains a description of the *SEED* (*S*hielding *E*ffectiveness *E*valuation *D*evice) for analyzing shield efficiency. Other sections include procedures in braid-coverage calculation, plus a comparison of the performance of bonded versus laminated shielding.—**Belden Corp.,** 2000 S. Batavia Ave., Geneva, IL 60134. **R-E**

CIRCLE 152 ON FREE INFORMATION CARD

CB RECEIVERS
continued from page 67

read 1000 Hz. Set the receiver for USB operation, and the signal generator for 027.2160 MHz. Again, the frequency counter should indicate 1000 Hz. Any imbalance signifies trouble, probably in the SSB demodulator.

Some CB signal generators make this procedure easy. The USB/LSB switches accomplish an exact 1-kHz frequency shift on whatever channel the generator has been set for.

Other models have a frequency-shift control for sideband tests, but it may not be precisely calibrated for 1-kHz offset. In these sets, upper and lower directions are usually switched, so that one setting of the variable knob still gives equal offsets. You adjust one sideband, either upper or lower, for a 1000-Hz count at the speaker, then switch to the other to verify demodulator balance.

As you may have guessed by now, you can use almost any communications service generator for CB alignment and diagnosis. Special CB test generators such as those described in this article simplify many procedures. In addition, certain generators contain features that widen their versatility. Consider all the features, plus all your needs, before you buy one. **R-E**

HOBBY CORNER

Here's a BFO circuit for shortwave receivers that helps clarify reception.

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

THE MAILBAG HAS BEEN VERY INTERESTING lately. There are a number of reader questions that I will share with you just as soon as we finish discussing our new subject first:

Beat-frequency oscillator (BFO)

Have you ever wondered about that "duck talk" you run into on your SWL receiver (that's single-sideband of course)? And what about the puffing sounds you hear when receiving continuous-wave (CW) code?

If you want to make sense out of those sounds, you will have to add a beat-frequency oscillator (BFO) to your receiver. Both SSB and CW require a steady signal in the receiver in order to be intelligible. The BFO described this month can be used with the shortwave receiver on your desk or your multiband portable receiver.

Several months ago we discussed crystal-controlled oscillators; and we stated that these could be used as a BFO with the proper crystal installed. This month's BFO circuit has several advantages over the crystal circuit. First, its components are less costly. Second, the device is smaller. Third, it can be tuned for maximum effectiveness.

This BFO is designed for use with any receiver having an intermediate frequency (IF) range of from about 400 kHz to 500 kHz. As the most common IF is 455 kHz, this BFO will work with most receivers. If your receiver has a different IF simply use an appropriate IF transformer in the BFO circuit.

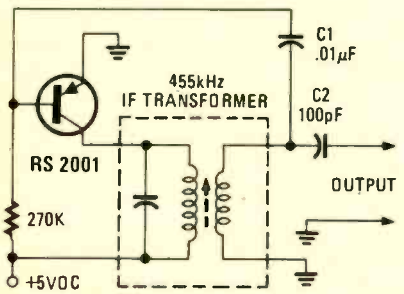

FIG. 1

Figure 1 shows the BFO circuit. You'll note that it requires few parts. Most NPN switching transistors will oscillate well, but if you use something other than the Radio Shack RS2001 shown in the diagram, you may have to vary the bias resistor. The applied voltage can vary over a wide range but it should be stable.

In order to save space, use a subminiature IF transformer (buy it or "steal" it from an old radio). The impedance is not critical, since we tried several in this circuit and all worked equally well. Just be sure that the one you use has a built-in capacitor on the primary side because the transistor has to have a tuned circuit or nothing will happen. Subminiature oscillator coils come in the same kind of containers but they have no internal capacitor.

If your BFO does not oscillate, exchange *either* the input *or* output leads of the transformer; do not change both sides. Capacitor C1 provides feedback to sustain the oscillation. You may want to experiment with its value.

Capacitor C2 serves two functions: It isolates the BFO operating voltage (+5 volts) from the receiver yet allows the 455-kHz signal to pass. Changes in its value will vary the strength of the signal applied to the receiver.

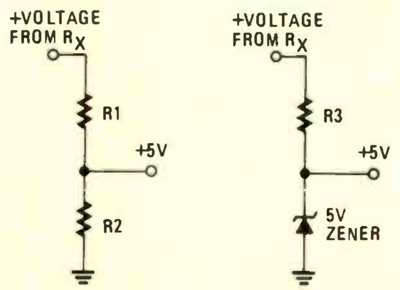

FIG. 2

The BFO is built on a small (2 cm × 4 cm) piece of perforated board. The operating voltage can be supplied by a couple of flashlight batteries. However, when the BFO is installed in a receiver, the best practice is to use one of the circuits shown in Fig. 2 to obtain power from the receiver and save battery space.

The values for R1, R2 and R3 will depend upon the value of the voltage "stolen" from the receiver. You can compute the necessary values using Ohm's law (E = I × R). However, trial-and-error experimentation will also do the job. In any case, use larger resistor values in order to draw just a few milliamps from the receiver. You should install a switch in the power line so that you can disable the BFO when you want to listen to AM stations.

Connecting the BFO to the receiver will undoubtedly require some manipulation for it to reach maximum effectiveness. Of course, we can't give exact instructions for all radios, but here are some general guidelines.

Getting the BFO to "inject" the right amount of signal into the receiver's IF is quite important. Too much BFO signal swamps or even blocks out incoming signals. Too little BFO signal won't do the job either. The amount of injection or signal BFO will be determined by the size of the coupling capacitor (C2 in Fig. 1), and by where in the IF chain you make the connection. Vary both of these if necessary to get the right amount of signal.

With the BFO connected but turned *off*, tune in a moderately strong broadcast station. Use the S-meter, tuning indicator and/or the quality and volume of sound to be sure that the receiver is tuned to the exact station frequency. Now, turn the BFO *on*, and you should hear a beat note or whistle. If not, turn the slug in the BFO transformer until you do hear one.

Next, adjust the slug to give a beat-note frequency of about 800 Hz. Then, adjust the coupling capacitor and/or the connection point until the note or whistle sounds about as loud as the broadcast-station signal.

That is all you have to do if you are interested only in CW (code) reception. However, if you also want to receive SSB signals, you must make additional adjustments. Single-sideband transmissions come in two varieties—upper and lower. With the present BFO adjustment, upper SSB signals may be strong and readable but lower SSB signals will be weaker and not readable (or vice versa).

In order to improve reception with stations using the weaker sideband transmission, you must turn the BFO slug to give a lower note, passing through zero and back up the other side. This is inconvenient when you are receiving different stations, so you must do one of two things:

The first option is to build a second BFO and tune it to the other side of zero beat. Then, you could simply switch from one BFO to the other. The second option is a compromise.

Oversimplification

In the November 1978 issue, we discussed parts substitution. At that time, I showed how to change the value of a potentiometer—specifically, how to make a 175K pot out of a 500K pot and a 270K resistor (see Fig. 3).

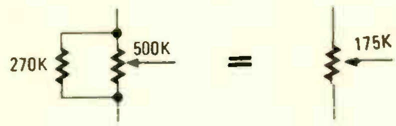

FIG. 3

Bill Clements, K4GMR, has pointed out to me that this is not always possible. It depends upon how the device is used. If it is used as a voltage divider (using all three terminals), the combination works like a single pot. Because most applications involve this type of use, you may never have noticed the exception.

However, when the combination is used as a two-terminal device, it does *not* function as a simple variable resistor. Place it into an audio tone-control circuit or into the R–C control circuit of a 555 timer, for example, and strange things may happen.

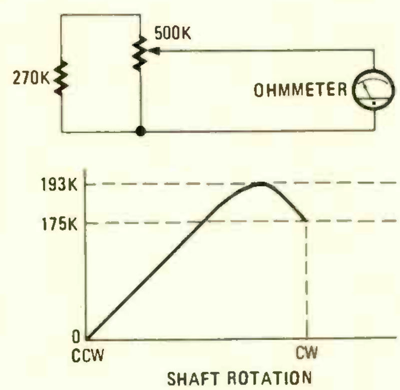

FIG. 4

In two-terminal use, with some values the resistance does not increase from zero to maximum as the arm is turned. The value may go from zero to a maximum, and then *down* to the value of the parallel combination!

Bill enclosed a complete mathematical analysis to show that the example given above varies from zero up to *193K* and then back down to 175K. Space won't permit including his analysis, but to check out his conclusion, you can give it the old breadboard test. The results will be something like those shown in Fig. 4.

I'll have to admit that a pot acting like

continued on page 84

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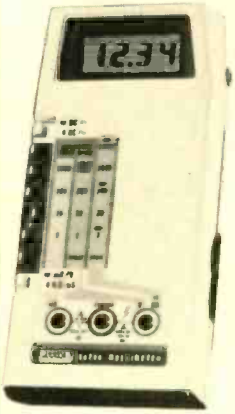

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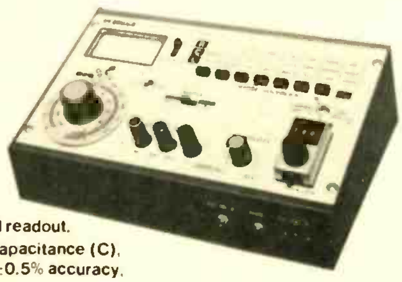

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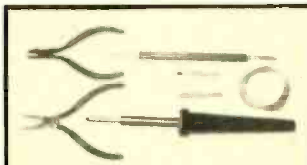

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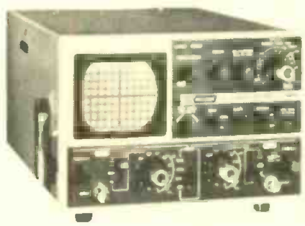

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continued from page 81

that could produce very confusing results in some circuits. I surely hope no one has pulled out his hair over one since last November! Many thanks to Bill Clements for calling this to our attention.

Reader circuit

Bill Cikas, Rockford, IL, sent in the very interesting circuit shown in Fig. 5. He calls it a "dual LED CMOS flasher," and suggests that it can be used as a crossing light on model railroad layouts. I am sure many other uses will occur to you as you watch the LED's light up alternately.

In this circuit, inverters IC1-a and IC1-b form a multivibrator and IC1-c is a buffer. Inverter IC1-d is connected so that its output is opposite that of IC1-c—when pin 6 is high, then pin 8 is low and vice versa. Because pins 6 and 8 are constantly changing state, first one LED and then the other is *on* since they are connected in reverse. The light seems to jump back and forth between the LED's.

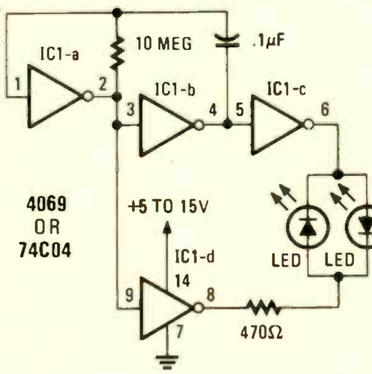

FIG. 5

The 470-ohm resistor protects the LED's by limiting the current through them. Depending upon the actual supply voltage used, the value of the resistor may have to be changed to obtain maximum light output without blowing the LED's.

You can change the switching rate by changing the value of the capacitor. However, don't make the rate too fast, or it will *appear* that both LED's are *on* all the time.

Thanks, Bill, for sharing your circuit with us.

Readers need help

Once again, readers are having problems. Most of you did very well answering the last questions, so put on the old thinking cap again and see what you can devise. Send along your answers and we'll share the best ones. Here are the problems:

Mr. Taggart of California wants to have wireless control of his TV sound from his chair across the room. He is willing to use a flashlight beam to do so. How would you turn the sound *on* and *off* or *up* and *down*?

Here are some suggestions: The pick-up might be a photoresistor, a phototransistor, a light-activated SCR, etc. The switch could be a relay, a triac, etc. The circuit could operate only when the light is on it, or go *on* and *off* with alternate light flashes. How about controlling the circuit with sound instead of light?

Mr. Taggart doesn't tell us *exactly* what he has in mind. Perhaps he wants quiet when the telephone rings. Or perhaps he objects when commercials seem too loud. If he wants to cut the sound *down* or *off*, there may be a better way to do this.

Can you devise something that modulates the sound *automatically*? How about running audio through an amplifier, then a rectifier and using that voltage to operate a relay when it reaches a preset level?

Here's another challenge for you: Mr. Prado (also of California) wants a circuit that will produce a sound (or whatever) to keep *mosquitos* away. (Now, just a minute—I thought there wasn't enough rain in sunny California to grow mosquitos!)

Mr. Cantley in Michigan wants a squelch circuit. He has one of those CB converters on his car radio, and says the CB comes in very well, but when no one is talking, the noise is driving him crazy.

Well, how about it? Can you help these readers? If so, send along the information to **Radio-Electronics** and you may see your circuit in a future issue. **R-E**

computer products

More information on computer products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside the back cover.

GAME SOFTWARE for 8K PET computer is available on cassette tape. The tape features 10 programs, including "Hangman II," "Pro Tic-Tac-Toe," Psychological Test," "Mystery Quiz," plus

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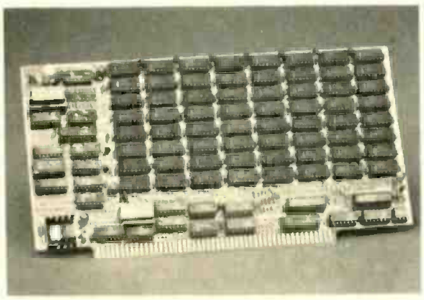
6 others. All programs use PET graphic capabilities. Tape No. 1 with 10 programs costs $5, postpaid.—**VIP Enterprises,** Box 17011, Salt Lake City, UT 84117.

MEMORY MODULES come in 32K, 48K, 64K and 128K-byte versions and are compatible with Xitan's ZPU-2 extended addressing capability, allowing up to 1 megabyte of RAM to reside on-line. Modules use 16-pin dynamic memory IC's.



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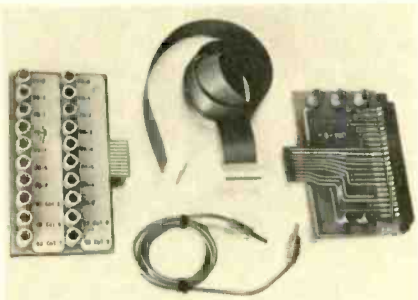
Timing is controlled by a precision digital delay line and the refresh rate is controlled to insure minimum power usage. All boards reside in non-memory mapped environment as a contiguous block, except for 128K version, which requires a memory-mapped environment. Suggested retail price for the *K-32* memory module, $799.—**Xitan, Inc.,** 1057 Main St., Hanson, MA 02341.

KIM ADAPTERS, *KIM-1 Interface Sets,* provide 20 I/O lines from KIM-1 computer to either standard terminal-strip breadboards or to TERC's Modular Breadboarding System (shown). The adapter connects directly to the KIM-1 applications connector and also provides convenient power, tape-recorder and TTY connections. Applications using these adapters have been developed including data-logging with display, signal generation, timing and nuclear instrument applications, using just the KIM computer, this adapter and breadboarded I/O circuits. Software, course material and breadboards also available. Adapters are available on a limited basis at cost as an educational service. Suggested retail prices: two-board set (shown), $60; single boards



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with terminal-strip adapter, $36.—**TERC Services,** 575 Technology Square, Cambridge, MA 02139.

MICROCOMPUTER, *models VDP-40, VDP-42, VDP-44,* is a complete system containing 8085 microprocessor, 32K/64K RAM, dual 5¼-inch floppy discs (MDOS), 9-inch CRT, keyboard and serial I/O. The *VDP-40, VDP-42, VDP-44* have a disc storage capacity of 180K, 400K and 780K bytes, respectively. A storage capacity of 780K

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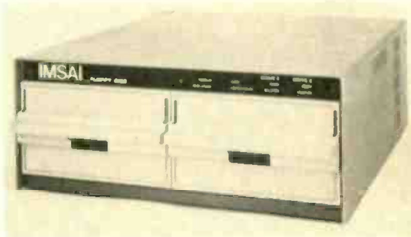
bytes is achieved by combining the IMDOS disc format with 77-track double-density mini-disc drives. The serial I/O can be used to drive line printer, modem or auxiliary terminal. Suggested retail prices: *model VDP-40,* $4495; *model VDP-42,* $4695; *model VDP-44,* $4995.—**IMSAI Manufacturing Corp.,** 14860 Wicks Blvd., San Leandro, CA 94577.

DUAL-DRIVE FLOPPY DISC SYSTEM, *model PCS-80/21* and *PCS-80/22,* features *CalComp model 142M* disc drives. System configurations are based on either IMSAI's DIO-C or FIF controller. Either controller will support up to 4 drives. The DIO-C controller will provide over 2.4 megabytes on-line storage. The DIO-C controller is compatible with all IMSAI 8080/8085 systems, and is supported by multi-disc operating system *Version 2.05.* FIF controller provides 256K bytes



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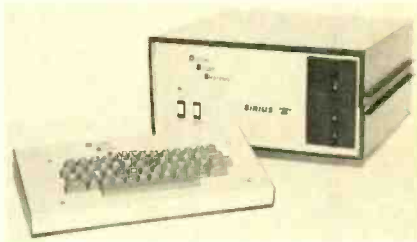
storage capacity-per-drive; is compatible with IMSAI's 1-8080 computer; and uses DMA for data transport.—**IMSAI Mfg. Corp.,** 14860 Wicks Blvd., San Leandro, CA 94577.

HOME COMPUTER *Sirius II,* contains Mostek Z80 and Fairchild 3870 microprocessors. Comes with 32,768 characters of read/write memory, RS-232 I/O interface, PROM board with 1000-character monitor (supplied), mini-floppy disc drive, 64-key alphanumeric/graphic keyboard



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and TV interface. Also included are a BASIC interpreter, monitor, and software (from home management to games). Additional hardware available includes RS-232 I/O, parallel I/O, and mini-floppy disc drives; plus add-on 16,384 byte RAM cards and A/D-D/A converters. Suggested retail price: $1850.—**Digital Sport Systems,** 7th and Elm Sts., West Liberty, IA 52776.

COMPUTER SOFTWARE, *Disc File Check Maintenance System,* is used on BFD-68 or MF-68 6800 systems. Ten-program disc performs all checking account maintenance operations, including tax records and is linked to a MENU program. The system also contains a master file directory, but allows user to backup his own files. A program disc and operating manual are provided. Suggested retail price: $49.95.—**Computerware Software Services,** 830 First St., Encinitas, CA 92024.

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computer corner

Direct Memory Access—a look at what it is and how it's used.

D. LARSEN, P. RONY, J. TITUS AND C. TITUS*

DIRECT MEMORY ACCESS (DMA) IS A TECHnique that allows a computer user to have direct access to individual memory locations without first having to go through the computer's central processing unit (CPU). The DMA interfacing technique has a number of uses, but few computer users completely understand it, and even fewer have fully implemented it for scientific data acquisition or control purposes.

A fairly elementary calculation shows that a simple software routine that inputs an 8-bit word and transfers it to a memory location will take many microseconds. Furthermore, if additional 8-bit words are to be taken and stored in some sort of a sequential file, additional software steps are needed for such "housekeeping" tasks as counting the number of words, incrementing the address pointer, etc. When these additional software steps are introduced into the test program, an 8-bit data word may only be acquired every 30 to 40 μs. In many cases, however, higher data-acquisition or data-transfer rates are required. Providing a direct access to the memory section of the computer is not a new idea. A DMA scheme was incorporated in Digital Equipment Corporation's popular PDP-8 minicomputer series. Additional hardware was required and interfacing was not particularly easy to do.

Most current microcomputers have a built-in DMA capability that is rarely considered. This capability allows microcomputers to be used in high-speed data-acquisition systems where the data-transfer rates are higher than those that can be achieved under program control. How is this possible?

Most microprocessor IC's, such as the 8080, Z-80 and 8085, have data-bus and address-bus outputs that are three-state. Three-state devices can pass normal logic 1 or logic 0 levels, and they can also be forced into a third logic state, in which their outputs appear to be very high-impedance loads on the bus. Thus, they no longer sink or source current and they are, in effect, disconnected from the bus. This third logic state allows external devices to obtain the use of the address and data bus lines when the computer's operations are suspended, and its outputs are removed from the bus lines. It is easy to control the microcomputer's bus signals to force them into this third state. The 8080 has a HOLD input. When this input is driven to a logic 1, it forces the 8080 to complete its current operation and then place its data-bus and address-bus outputs in their third state. A handshaking hold-acknowledge (HLDA) signal is output by the 8080 to indicate that it has actually placed these signals in the high-impedance state.

External devices that wish to make use of the address and data-bus lines are synchronized so that they will not attempt to use the bus lines until they receive the hold-acknowledge signal from the 8080. In general, these same devices have generated the bus-use request signal or hold signal that indicates to the 8080 that they want to use the buses. In many microcomputer systems, additional buffers are used between external devices and the address-bus and data-bus connections to the microprocessor IC itself. If this is the case, it is very important to make sure that these buffers sense the hold-acknowledge signal and place their respective outputs in the third state also. In the HOLD state, the CPU and its associated buffer circuitry must all be disconnected from the address and data buses.

External devices that are configured for DMA transfers generally have their own registers that provide address data, usually in 16-bit format. These address registers also have three-state outputs, which are normally disabled. They are enabled (or turned on) only when the 8080 is in the HOLD state. Then, they can use the address bus to address the particular memory location to or from which they wish to transfer data. The data path between the external device and the memory IC's has also been placed in the third state, so it also can be used for transferring data—in this case, the 8-bit value that will be transferred between the external device and the location being addressed by the external three-state address registers.

One other important detail must be discussed before the actual data transfer can take place. In most microcomputer systems, the reading-from and writing-to operations are controlled by two signals, memory-read ($\overline{\text{MEMR}}$ or $\overline{\text{MR}}$) and memory-write ($\overline{\text{MEMW}}$ or $\overline{\text{MW}}$). These signals may, or may not, be available with three-state outputs. In some systems, where a control-logic section has been constructed with discrete IC's, these two signals probably will not have three-state outputs. When a system controller IC has been used, the outputs are probably three-state devices. In either case, it is easy to gate an 8080-generated read or write pulse with the corresponding pulse generated by the microprocessor IC. In this way, either the external hardware, *or* the microprocessor can generate a read or

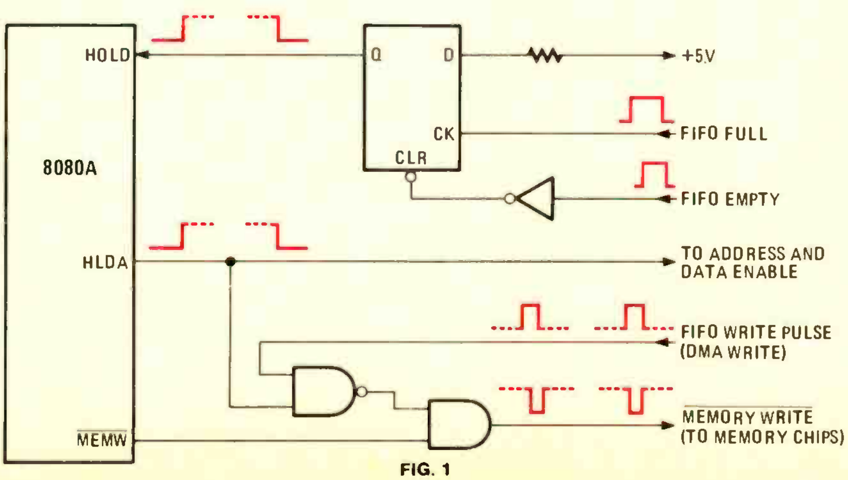

FIG. 1

*This article is reprinted courtesy American Laboratories. Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Both Mr. J. Titus and Dr. C. Titus are with Tychon, Inc.

a write signal. Since the 8080 processor does not operate or execute program steps while it is in the HOLD mode, it cannot generate a read or a write signal. By using the HLDA signal to enable the read and write signals generated by the external device, the proper signals will be generated by either the 8080 in the normal mode and by the external device in the HOLD mode.

While the DMA interface described thus far does not seem to be very useful, since it transfers only one 8-bit data word to a single location, it *does* illustrate the simplicity with which a DMA interface can be constructed. In most situations, however, a block of data will be transferred between the memory and an external device. Note that the transfer may be in either direction—i.e., from a high-speed data-acquisition device to the computer memory, or from the computer's memory to a high-speed data-storage device, such as a floppy disc.

In one application, a series of SN74193 programmable up-down counters were used to provide the 16-bit address information during the DMA transfer, and a first-in/first-out (FIFO) buffer memory was used to provide a block of data to the microcomputer's memory. Some simple control logic generated a write pulse (MEMW) and then incremented the address (count) present at the SN74193

continued on page 92

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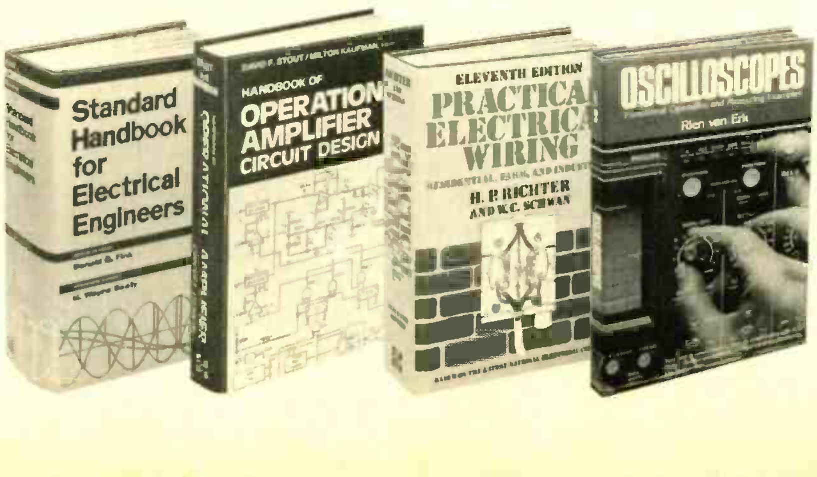

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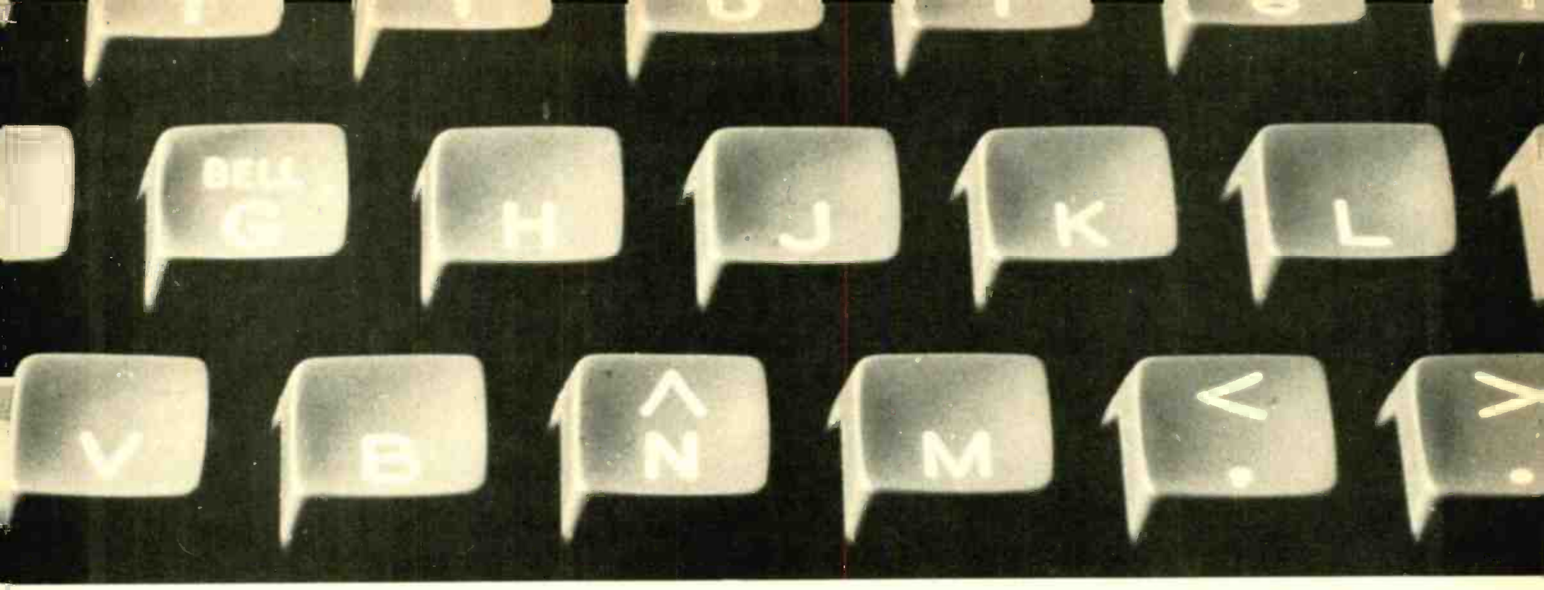
continued from page 87

counters. A series of switches allowed presetting the starting address at which the block of data was to be stored. Once a complete block of data was accumulated in the 256-byte long FIFO memory, external circuitry was used to detect the FIFO FULL condition, and to initiate the request for the use of the bus, asserting the HOLD line to the 8080. When the 8080 acknowledged the HOLD mode with the HLDA signal, the data was transferred from the FIFO memory to the microcomputer's main read/write memory at a rate of 500K bytes-per-second, or one byte every 2 μs. This data-transfer rate could have been increased at least fourfold, but it was unnecessary in this particular case.

Figure 1 is the block diagram of the interface that was used to control the DMA data transfers.

The DMA interfacing technique is also used in front-panel control circuits. Control panels are often provided on microcomputers so that memory locations can be addressed and the user can examine their content. The user may elect to "deposit" new data in one or more memory locations, again through via a front panel. A simple front-panel control system is easily constructed using the DMA technique,

continued on page 96



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state of solid state

The mysterious I²L logic process revealed. Plus new semiconductor announcements. **KARL SAVON**, SEMICONDUCTOR EDITOR

AS NEW INTEGRATED-CIRCUIT TECHniques evolve, terms are invented to go with them. Integrated Injection Logic (I^2L) is one such term that, at first hearing, is enough to frighten anyone off. But I^2L turns out to be not as ominous as it sounds, and, in fact, is a neat, valuable technique that leads to compact, moderate-speed logic applications. Another attraction of I^2L is that the injector voltage (the highest voltage with the IC) is only about 0.75. The result is a very low power dissipation per gate.

The processing steps leading to a finished I^2L circuit are nearly identical to those used to build conventional monolithic bipolar IC's, even to the extent that bipolar and I^2L circuitry can be combined on the same monolithic substrate. Therefore, let's start by reviewing the conventional bipolar IC process.

Figure 1 shows the cross-section of a conventional integrated NPN transistor. The process of building this transistor starts with slicing a thin wafer of silicon from an ingot. After the wafer has been polished to a mirror finish, a layer of silicon dioxide is formed by heat and oxygen on the wafer surface. Throughout the process, windows are etched through the oxide layer to allow the selective diffusing of defined areas. Photomasks are used to superimpose a pattern of photoresist material on top of the oxide. The areas that are not covered with resist are unprotected and are removed by acid. The initial wafer material forms the P-type substrate shown at the bottom of Fig. 1.

The next series of steps involves diffusing N+ pockets. These low-resistance pockets are covered by the layer described in the next step, which is also referred to as the buried layer.

An epitaxial layer is grown on top of the substrate into which the remaining diffusions will go. To isolate the transistors from each other, their epi (or collector) areas must be separated. The P+-isolation regions are diffused into the epi layer, dividing it into islands.

The transistor bases are then formed with a P-diffusion into the subregions of the collectors. This identical diffusion step also forms resistors, with their characteristic resistivity of around 200 ohms-per-square. Then, N+ emitter and collector contacts are added and openings are formed for contacting the aluminum interconnecting metal that follows in the next stop.

Metallization is formed by wiring that connects the various IC devices in their predetermined pattern. It is deposited on the surface and alloyed to the semiconductor material under the contact openings.

Finishing the passivation, bonding and packaging steps complete the multistep procedure.

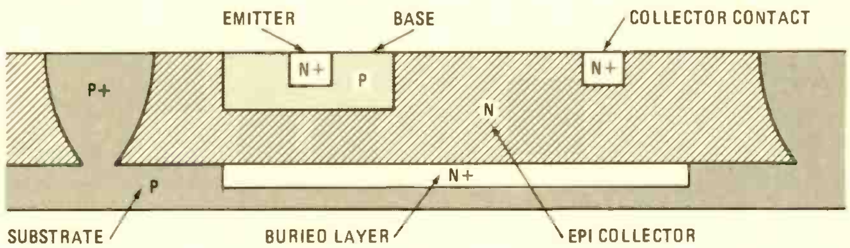

FIG. 1

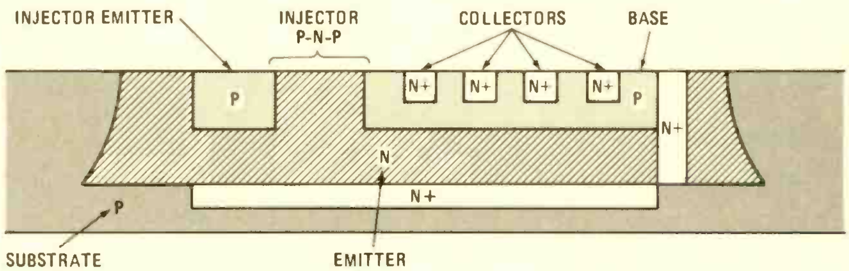

FIG. 2

Figure 1 shows that NPN bipolar transistors have two semiconductor junctions—the base-to-emitter junction between the emitter N+ and base P-regions, and the collector-base junction between the P-base and N-collector regions. In normal transistor operation, the base-to-emitter junction is forward-biased and the base-collector junction is reverse-biased.

The junction between the N collector and P substrate is reverse-biased and forms a nonconductive diode that is the actual isolation mechanism between transistors. The substrate is usually grounded, and the transistor elements are biased at or above ground, thus inhibiting the substrate-collector diodes.

What happens if the collector and emitter functions are reversed? If the collector is connected in place of the emitter in a circuit and vice versa, this inverted transistor still acts as a transistor. However, the nonsymmetrical geometrical layout causes the inverted beta (current-gain) to be lower than the noninverted beta, as well as some other parameter differences. However, especially configured digital circuits, the inverted transistor performs satisfactorily.

The inverted transistor is the "trick" to I^2L. If the noninverted N+ emitter regions are used as collectors and the N-collector region is grounded, many transistors can be built into a single isolated region, as shown in Fig. 2.

Figure 3 shows a single I^2L transistor stage that consists of an inverted transistor and a base-current source. The current source is the so-called injector, which is actually a PNP transistor. All the PNP emitters on the IC are connected to a common input pin, and sometimes form a long P-diffusion up and down the IC. The pin is connected through an external resistor to a more positive voltage source determining the total current drain of the IC. Each individual PNP transistor then supplies a portion of the total injector current to its particular NPN base. In Fig. 2, note the PNP injector transistor formed by the junction

between the injector emitter and the N region, and the junction between the N region and the base of the NPN.

The current sources serve as high impedances to the driving collectors. This very efficient arrangement allows compact use of the IC area because of the numerous devices contained in a single N-isolated area compared with the noninverted single transistor-per-collector isolation ratio. In addition, because of the injector PNP current sources, there is a complete absence of resistors in this logic scheme.

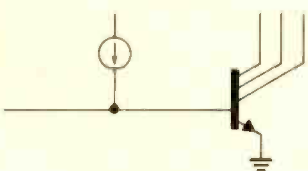

FIG. 3

The deep N+ region shown at the extreme right of Fig. 2 does not have a counterpart in the conventional transistor shown in Fig. 1. This area is a guard band that prevents parasitic currents from flowing to the wrong places.

We can now see how inverted transistors are used to implement a typical logic function. Figure 4 shows how output currents from several collectors are summed by simply connecting them together at the base of a transistor. Along with the inverter transistor, this connection creates a wired NAND gate. If currents i1, i2 and i3 are all 0, current source I1 turns on Q4 and its output voltage is 0.

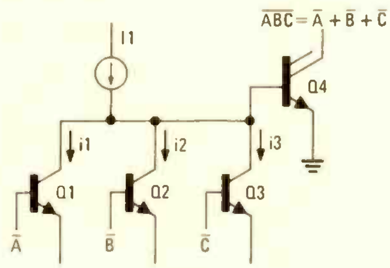

FIG. 4

If any of the three input currents is nonzero, Q4 is turned off and its collector swings high. In other words, current i1, i2 or i3 switches Q4's collector low. Using inverter transistors Q1, Q2 and Q3 creates an AND function. Assume the inputs to the transistors are A, B and C. Their collector currents are summed at the base of Q4, which swings high only when the three driving transistors are off—this is the AND function. You'll also observe that the NAND function, $\overline{ABC}$, is equivalent to $\overline{A} + \overline{B} + \overline{C}$.

Ignition circuit

Motorola's MC3333 *Vari-Dwell* ignition circuit uses a flux-averaging sensor instead of automotive points. The addition of the MJ10012, a Darlington driver transistor, to supply the high-energy ignition coil plus some resistors and capacitors complete the ignition system. The circuit operates from battery voltages from 4 to 24. Dwelltime and overvoltage shutdown are externally programmable.

Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036.

New power devices

The RCA 9113 NPN power-transistor series is designed for high-voltage switching applications. Its specific uses are for switch-mode power supplies, inverters, converters, pulse-width-modulated regulators and motor controls. These transistors are rated to 400 volts V_{CEO} and have switching speeds in the range of 1 μs. RCA Solid State Division, Box 3200, Somerville, NJ 08876.

Hitachi has developed complementary power audio-equipment MOSFET's that it expects to market at the end of the year as the *models HS8401* and *HS8402*.

Newly developed technology such as ion implantation adds the high-voltage and high gain necessary in power amps. The company claims these devices have greater frequency response and reliability compared with conventional power transistors. Their high-speed switching capability reduces distortion and dissipation to a greater degree than bipolar transistors. **R-E**

COMPUTER CORNER

continued from page 92

since a 16-bit three-state buffer can be used to supply the address and eight indicators can be used to show the state of each bit in the memory location addressed. Eight logic switches are used to load new data into a location and two control switches, EXAMINE and DEPOSIT, are configured to generate the memory-read and memory-write control pulses, respectively. Additional features can be added to such a simple control circuit to automatically increment or decrement the 16-bit memory address, etc.

There are, however, some words of caution that must be noted when considering the use of DMA. The 8080 microprocessors are locked out of performing any program steps while they are in the HOLD state.

Some microprocessors such as the MC6800 series require that DMA-based devices regularly relinquish control of the bus. The three-state control (TSC) line in 6800-based systems can only be asserted for periods of 5 μs at a time. Similarly, in systems that use dynamic read/write memory devices, the address and data buses cannot be used continuously by DMA-based devices for more than 1 ms or so. **R-E**

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service clinic

Fast-recovery diodes and DC power supplies can cause many troubleshooting headaches. **JACK DARR,** SERVICE EDITOR

I'VE USED THE MATERIAL IN THIS COLUMN before. This concerns two items that have been discussed at length. Still, I keep getting far too many letters from technicians who obviously have not gotten the word. So, I'm going to run it by again and hope that we will be able to reach a few more people who can use the information.

Fast-recovery diodes

The first item concerns the fast-recovery diode. This diode is a special type that turns off very rapidly. So, this is the type we must *always* use as a replacement in any kind of DC power supply that is fed by horizontal-frequency pulses (i.e., a flyback-derived DC supply). Conventional silicon diodes are sinewave diodes and work fine for a 60-Hz sinewave or pulse. However, when these standard types are used in a flyback-derived power supply, the input is a very sharp high-frequency pulse, and conventional diodes simply will not turn off fast enough. So they draw a very high reverse current. If you've changed a diode and the new one blows up in about 25 to 30 seconds, look out! This is the typical symptom of using the wrong type of diode.

Use a fast-acting diode in *all sets* using flyback-derived power supplies even the Quasar *Electronic Power Supply* that operates at 15,750 Hz, and is synchronized by flyback pulses. Unless you are absolutely *sure* that the AC power supply to the diode is a 60-Hz sinewave, it is best to use a fast-recovery diode. Incidentally, a fast-recovery diode works on a 60-Hz supply, but not the reverse—It's a one-way street.

In checking any transistor replacement guide, you'll find lots of fast-recovery diode types listed. Every manufacturer has at least one, and some have five or six types. Typical specs for these diodes show a recovery time of O.5 μs. Even on a very sharp pulse, a fast-recovery diode turns off completely and does not draw reverse current.

DC power supplies

The second item for discussion is a kind of dual problem in itself that has also drawn a lot of mail. For many years, I (along with many others) have been hollering "Check the B+!" (And this goes back as far as radio days!) It's *still* the *very first step* that should be taken in any kind of electronic troubleshooting. The reasoning is simple: If the B+ DC voltage supply is off, nothing will work until that is fixed. Also, statistically speaking, DC power supplies cause the most trouble of any section of the TV set.

So, when starting your analysis of a problem, make *sure* that all the DC power supplies are in the ballpark. In a solid-state color TV set, there may be four or five such supplies and they are all critical. Any trouble in here can cause all kinds of problems.

Secondly, there are two circuits in solid-state TV sets that interact—the DC voltage regulators, of which there may be several; and (linked with these) the numerous shut-down circuits. These circuits can kill everything if the high voltage or the low DC voltages exceed normal levels. If a voltage regulator is not working properly, the DC voltage rises, the shutdown fires and out it goes.

So, voltage regulators should always be checked for correct output. Most regulators are held to very tight tolerances. If the schematic calls for +69.5 volts, you'd better not get a reading less than +69 volts or more than +70 volts. If the regulators are using a pass transistor that is either leaky or shorted, the output voltage will rise to the supply level. Instead of +69.5 volts, you may read +90 volts or more. This voltage will trigger the shutdown circuit. If it doesn't the high voltage can go up to amazing levels, and a perfectly good horizontal-output transistor can be destroyed.

A simple test for this is to plug the set into a Variac. Monitor the DC voltage supply at a key point. Bring the line voltage up until the DC voltage reads exactly what it is supposed to—+69.5 volts or whatever the schematic calls for. In a lot of cases, you may find that the set starts working very well; I have. If this happens and the input voltage is quite a bit *below* normal, this is a very good hint that one of the voltage regulators is not working. If so, the problem is in the DC voltage regulator and nowhere else.

Ordinarily, these circuits are fairly simple to check. Look for shorted or leaky pass transistors, shorted or leaky drivers, error amps, and especially in one of the Zener diodes that are used as clamps in the regulator circuits. If the voltage across a Zener diode is not correct to within ±5%, check it or change it.

I hope that this reminder will get the message across to some who didn't get it the first time around. It saves a lot of time and trouble! **R-E**

service questions

HIGH VOLTAGE DOWN

A model TAC-3310 Toshiba has turned into a tough nut. A couple of new tubes, including a new horizontal output, cured the original problems, but the picture is still too dark, and the high voltage is only 11 to 13 kilovolts depending on the brightness-control setting. Nothing is smoking. The boost is low. I'm checking it on a test rig. The grid waveform on HOT is OK; so is the analyst plate drive.—R. T., Louisville, KY.

My reply to this problem began with some general suggestions. Then I wrote him, "Something's nudging me! You're using this on a test rig; your boost is low, etc. *Maybe* the horizontal yoke winding of the test rig doesn't quite match this set! If so, you would get these kinds of symptoms."

(Feedback: "Bingo! That was a good nudge. I used extension cables, hooked the Toshiba set to its own yoke/CRT, and everything fell into place. The high voltage and boost went up, the brightness was OK, and so on. I happened to notice that when the 21JZ6 screen went up to +105 volts, on the test jig it was also quite a bit lower.")

ODD COLOR PROBLEM

I get good color bars and a good vectorscope pattern on this Zenith model 25MC30. But . . . if I hook the set up to an antenna, there's no color at all! I thought of using alignment, but this seems unnecessary with the good color bars and vectorscope output. What goes?—J. U., Beaverton, OR.

I hate to say it but there's only one thing *left* that could be causing this. With the results you're getting from test signals, it could be there are problems in the *color-killer*. Check the grid voltage on the second bandpass amplifier; the schematic shows this as −30 volts, which signifies no signal or "killed" bias.

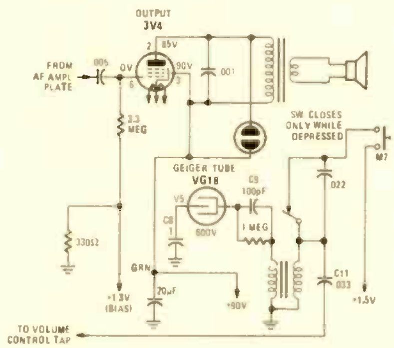
One thing used to cause us some odd problems—the 6JU8 quad-diode tube. This is used as the automatic frequency phase control and the killer detector. These tubes developed odd-ball leakages that upset things for three feet in all directions. Try a new 6JU8 first. (You're right. In no way is this an alignment problem!)

RADIO WITH A GEIGER COUNTER?

I've got something I'll bet you never heard of before. It's an old portable Sylvania radio, but it also has a built-in Geiger counter! The set is working but I can't get anything out of the counter. There is high voltage on the G/M tube, though.—J. D., Charleston, WV.

You're right, I *have* never heard of this one before. However, I do have a schematic on it (Sams Photofact 345-17). The partial schematic shows how it works.

When switch M7 closes, a pulse of current flows through the transformer. This charges up C8–C9 to a high voltage



for the counter tube. When the tube fires, the "clock" seems to be coupled back through C11 to the bottom end of the volume-control circuit. The neon lamp may be used as a charge indicator or as a peak limiter to keep excessively high pulses from damaging the output tube.

HORIZONTAL SYNC

I can't stop the picture from sliding sideways in this Admiral 11H chassis. Checking the AFC circuit, tubes (including AFC diodes), etc. didn't help. The hold control can stop the picture momentarily, but when it is stopped a vertical white line appears in the center of the picture. The vertical hold is good. Any help would be appreciated!—J. T., Ocala, FL.

Normally I'd say there's no sync getting to the AFC diodes, but you've got that white line in the picture. You may have some feedback through the B+ line due to a bad filter capacitor. Scope all the B+ lines for any signals; these cause feedback and all kinds of weird problems.

(Feedback: "Thanks! Capacitor C2A, the 80-μF section of a multiple filter, was leaky. I replaced it and now it works.")

CATHODE CURRENT RUNS HOT

The 6KM6 horizontal-output tube cathode current in this RCA chassis CTC-27XAD runs 450 mA and there's no output. The grid voltage reads −35, and the screen grid voltage reads +185. I can't get that current down.—H. J., New York, NY.

I can tell you one thing: a +185 voltage on the screen grid is much too high and can cause the cathode current to go way up. Find out why this happens. I have seen sets where the screen-dropping resistor had burned up and dropped in value. The only other thing that could cause the screen voltage to go so high would be an open contact on the screen in the socket. If this is the case, however, the cathode current drops to about 45 or 50 mA! Your drive seems to be normal, but the high screen voltage is not.

MORE BRADFORD FLYBACKS

Like a lot of Service Clinic readers, I also need a Bradford flyback transformer for a 1143B31 chassis and the part number is 334P03402. Can your crystal ball help?—D. B., FPO, NY.

The crystal ball didn't help, but after looking in some catalogs for similar part numbers, I dug up what certainly looks good. At least, the part number is exactly the same—it's a Mistubishi (MGA). Look up an MGA CH-120 chassis in Sams Photofact 1176. You can probably order one from MGA Melco Sales, Inc., 3030 N. Victoria, Compton, CA 90221.

SLOW WARMUP

This Zenith model 14N28 takes about 1 to 2 minutes to reach full height. The width is OK, but the picture lacks about 3 inches at the bottom of the screen; it then slowly builds up until the screen is full. I've checked out everything I can think of in the vertical circuits, and the waveforms look normal. I tried coolant spray on the circuit; no luck. I'm overlooking something, but don't know what.—J. S., Prospect Heights, IL.

If your picture comes on in-sync and it remains stable, the chances are this is not a problem in the vertical circuitry itself. It is probably something in the *supply* voltage to it.

There is a small thermistor in the deflection yoke that is supposed to be 1.0-megohm cold and drop to an unknown value. In any case, this thermistor feeds the boost voltage to the *plate* of the input half of the vertical oscillator. Take the back cover of the deflection yoke off and look for this; it's a small disc-type component. You can replace it with a Workman GM 1-meg thermistor. R-E

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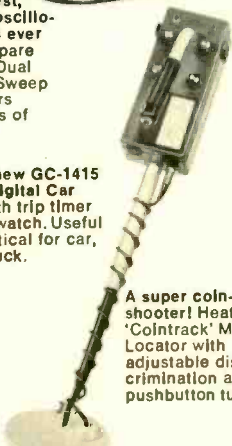

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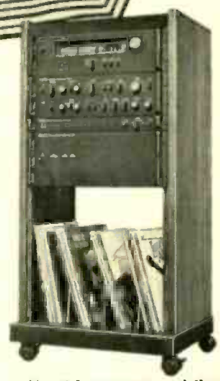

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DIGITAL MULTIMETER, *model RMS-350 Volksmeter,* is a battery-operated, 4-digit instrument designed to fit into a tool box. It measures true RMS AC from 1 mV to 750 volts; resistance from 1 ohm to 10 megohms; DC from 1 mV to 1000 volts and AC/DC current from 1 μA to 1 A.

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Features include LCD readout, automatic polarity, overload indication and overload protection, plus a 10-megohm input impedance. The *model RMS-350* measures 1.9 H×2.7 W×4-inches D. Optional accessories available include batteries and charger, a probe, carrying case and tiltstand case. Price: $189.—**Non-Linear Systems, Inc.**, Box N, Del Mar, CA 92014.

CCTV SURVEILLANCE CAMERA, *model ITC-44,* is available with choice of pickup tubes, including vidicon, separate-mesh vidicon, or silicon-target vidicon. With a ⅔-inch vidicon tube, only 1.2 foot-candles are needed from a standard 89% reflectance object; with the silicon-target vidicon tube,

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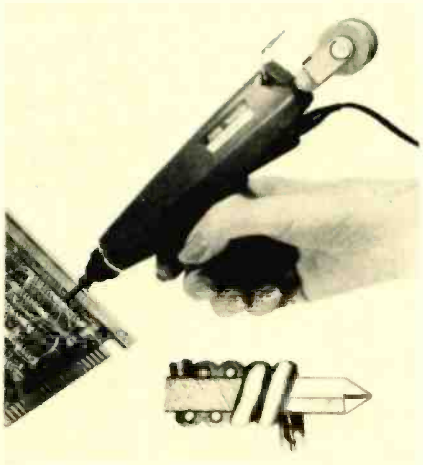
the minimum sensitivity is 0.01 foot-candle. The response range is 1000:1, and it can provide a horizontal resolution of 550 lines (with separate mesh vidicon). With gamma correction off, the S/N ratio is better than 44 dB; the video bandwidth, 6 MHz or better; and the deflection distortion, less than 2%. The *model ITC 44* operates from 117 VAC line; the economy *model ITC-44A* operates from 24 VAC. The unit is housed in an ABS plastic case, with internal RF shielding, weighs 5 lb., and carries a suggested retail price of $250.—**Ikegami Electronics (USA) Inc.**, 37 Brook Ave., Maywood, NJ 07607.

WIRE-WRAP TOOL, *model P184-4T1,* uses high abrasion-resistant polyurethane nylon *Tefzel* insulated wire to eliminate measuring. The tool uses the *model P184 Slit-N-Wrap* bit to feed wire from a spool on the shaft. This permits continuous wire-routing in a daisy-chain fashion. The *Slit-N-Wrap* bit can also be used with the *model P184-4T* NiCad-powered pencil-type motor. The *Tefzel* wire is available in 50-foot spools, with red, green, white or yellow insulation. Also available are 120-foot spools of uninsulated copper wire.



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Suggested retail prices: *model P184-4T1,* $89; *model P184-4T,* $80; *model P184 bit,* $29.50; *Tefzel*-insulated wire, $4.18/package of two 50-foot spools.—**Vector Electronic Co., Inc.**, 12460 Gladstone Ave., Sylmar, CA 91342. **R-E**

DIGITAL AUTOMOTIVE INSTRUMENTS, *Indy-Cators model DC-17301* clock/timer, *model DC-17304* MPG computer and *model DC-17306*

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tachometer, all feature 4-digit fluorescent display, require only 3-wire connection (hardware included). The *model DC-17301* (shown) clock/timer shows time of day in hours/minutes to 12 hours, or can be used as an elapsed-time counter to read minutes/seconds to 59:59, or hours/minutes to 99:59. Operates on 10–17 VDC and draws only nominal 2 watts. The *model DC-17304* MPG computer displays average miles-per-gallon since first fillup, total miles driven, total gallons purchased and total miles-per-gallon between fillups. *Model DC-1730* tachometer features continuous RPM count, with 1% accuracy full-scale, and automatic memory feature to display preset RPM number. Price: $39.95.—**Digital Concepts Corp.**, 249 Route 46, Saddle Brook, NJ 07662.

100-WATT REFLECTOR LAMP, *model 1300 Dremelite,* can be bench- or table-mounted for do-it-yourself projects and hobbies. Offers 360° rotation angle and a 45-inch arm reach. Addition-

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al features include insulator reflector and porcelain socket. The *model 1300* is available in white-only, baked enamel finish, and operates from a 100- 115-volt, 60-Hz AC source. Options include adjustable clamps and screwdown mounts for additional mounting angles. Suggested retail price, $39.95.—**Dremel, Div. Emerson Electric Co.**, 4915 21st St., Racine, WI 53406.

SOLDER SPOOL HOLDER, *Solder Mate,* prevents solder wire from unraveling. Portable metal

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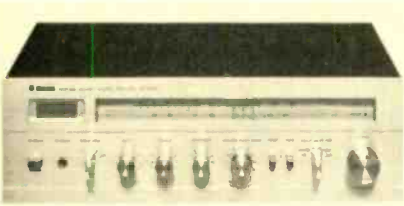
holder permits easy withdrawal of solder; holder is loaded by dropping spool into place and feeding solder through dispenser hole. Suggested retail price, $4.95.—**Efficiency Products Corp.**, 2 Kennedy Dr., North Chelmsford, MA 01863. **R-E**

stereo products

More information on stereo products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside the back cover.

AM/FM STEREO RECEIVER, *model CR-220,* provides 15 watts-per-channel RMS into 8 ohms from 20 Hz to 20 kHz, with no more than 0.05% THD. Front-panel controls include power on-off switch, bass and treble switches, variable-loud-



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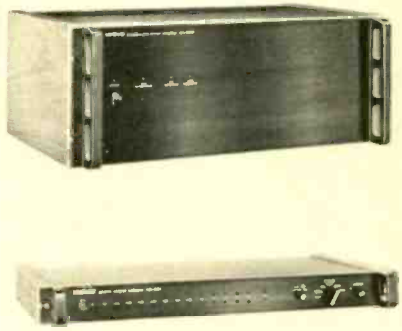
ness switch, tuning switch, and phone jack. Performance specifications for the *model CR-220* are: for the amplifier—phono input sensitivity, 2 mV at 1 kHz; phono S/N ratio, 90 dB. For the FM section—alternate channel selectivity, 60 dB; capture ratio, 1.5 dB; 50-dB quieting, 17.3 dBf (mono), 39.2 dBf (stereo); frequency response, 30 Hz–15 kHz +1, −3 dB; S/N ratio, 70 dB (mono), 65 dB (stereo; AM suppression, 52 dB. The AM section provides an alternate channel selectivity of 20 dB and an IHF sensitivity of 18 μV/m. The *model CR-220* measures 435 × 144 × 326.5 mm and weighs 7.6 kg. Suggested retail price: $220.—**Yamaha International Corp.,** 6600 Orangethorpe Ave., Buena Park, CA 90622.

STEREO COMPONENTS, the *model AA-1600* amplifier and the *model AD-1701* graphic output indicator, are rack-mountable components. The *model AA-1600* delivers 125 watts-per-channel (minimum RMS) into 8 ohms, 20 Hz through 20 kHz, at less than 0.05% THD. Other features include a delay switch, thermal circuit breaker and high-temperature LED indicator. The amplifier can also be installed in optional oak-finish *model AEA-1800-1* case.

The *model AD-1701* output indicator has two rows of fifteen LED's for graphic output display, peak-hold circuit and peak/average switch.



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Prices: *model AA-1600,* $359.95; *model AD-1701,* $189.95; *model AEA-1800-1,* $27.95.—**Heath Co.,** Dept. 570-070, Benton Harbor, MI 49022.

R-E

TIME/VOLTAGE CALIBRATOR
continued from page 39

apply the waveform to a low-pass filter to generate the average DC voltage and then buffer it.

The voltage-calibrator section (Fig. 3) resembles the time section somewhat, but the two circuits are different. Thumbwheel-switch latches IC1–IC4 feed exclusive-NOR inputs. Again, the exclusive-NOR network IC9–IC12 is used as a comparator, but this time it compares the thumbwheel-latch contents to the counter output. When both values agree, the OR-tied output is pulled high by resistor R19. Decade-counters IC17–IC20 are wired as up-counters. For this application, they free-run, starting from 0000, count to 9999, then start over again. Although the clock frequency's accuracy is unimportant in this application, a rather exact 1-MHz signal that is tapped from the 20-MHz timebase count-down section (IC26 pin 14) is used as the volts section's counter clock.

The TTL portion of the volts section must provide a programmable duty-cycle from 0 to 100%, inclusive, in .01 increments (with a 4-decade total). If a flip-flop can be set to 0 when the four decade-counters are at 0000 and then flipped back to 1 when the counter reaches the desired thumbwheel value, this achieves a programmable duty-cycle; the higher the thumbwheel setting the longer the flip-flop stays at 0. Since the counter-clock frequency is 1 MHz, the programmable duty-cycle output has a frequency of 100 Hz.

The duty-cycle flip-flop described above is J-$\overline{K}$ flip-flop IC39-b. When the counter network reaches 9999, the outputs of counters IC17 and IC20 are low, forcing the output of NOR gate IC38-a high. On the next clock pulse, the counters advance to 0000, and the output of J-$\overline{K}$ flip-flop IC39-a goes low for one clock cycle. Assuming that the exclusive-NOR comparator output is low at this time (that is, the thumbwheel latches are loaded with a nonzero value), the output of inverter IC38-b is high, forcing the output of IC38-c low. Therefore, inputs J and $\overline{K}$ to IC39-b are high; so on the next clock input, the duty-cycle flip-flop's output, $\overline{Q}$, goes low and the counter network increments to 0001. This is the first step of the duty-cycle generation.

The J and $\overline{K}$ inputs of IC39-b are held low and high, respectively, when there is no comparator equal output, or when the counter state is nonzero. This is the hold mode, so the duty-cycle flip-flop maintains its state until there is a change on its inputs.

When the counters and the thumbwheel latches agree in value, the comparator output goes high and the output of inverter IC38-b goes low. The output of IC39-a is high for all counts except .0000, so both the J and $\overline{K}$ inputs to IC39-b are low. On the next clock cycle, the flip-flop output is set back to a 1 and remains there until the counters again reach 0000, when the cycle repeats.

The counter sequence and the duty-cycle flip-flop's output proceed as follows:

Counter:
9999→0→1→2 ··· n→(n + 1) ··· 9999→0→1
Duty-Cycle Flip-Flop (IC39-b pin 9)
1→1→0→0 ··· 0→1 ··· 1→0

Thus, the output stays low for (n + 1) − 1 = n times out of 10,000 counts, so the thumbwheel setting directly loads the correct duty-cycle.

In the event that the thumbwheel latches contain 0000, the outputs of IC38-b and IC39-a go low simultaneously. This forces the output of IC38-c high, which, in turn, forces the output of IC38-d low. Then, IC39-b is constantly loading and then holding a 1 (i.e., the flip-flop output is a DC voltage, with a level corresponding to a 0% duty-cycle, as required).

By using the asynchronous $\overline{\text{SET}}$ and $\overline{\text{RESET}}$ inputs of flip-flop IC39-b, the duty-cycle logic can be overridden. The $\overline{\text{SET}}$ input forces the flip-flop output low (duty-cycle = 100%), and the $\overline{\text{RESET}}$ input forces a high output (duty-cycle = 0%). Switch S8 provides the logic signal. When switch S8 is in its center OFF position, the duty-cycle logic performs as described. This switch allows the user to select between the two voltage extremes and any other preloaded value.

The output of the duty-cycle flip-flop is fed to IC37-b, which converts its TTL-compatible voltage swing to a CMOS-compatible voltage. Resistors R24 and R25 limit the maximum voltage input to the CMOS gate to slightly less than 10. The NOR gate IC41 is the CMOS driver. Its V_{DD} supply lead is connected to the output of IC44, the precision voltage reference. Thus, the precision TTL-generated duty-cycle is voltage-level-shifted by parallel-connected NOR gates IC41-b, IC41-c, and IC41-d to produce the time and voltage requirement described earlier in this section.

A low-pass filter consisting of R26–C32, R27–C33 and R28–C34 produces a DC output whose value is equal to the desired voltage setting. The low-pass filter has a time constant of several seconds, so it takes about 10 seconds for the DC-output value to stabilize. Operational amplifier IC42 has a high-impedance JFET input that will not significantly load the low-pass filter's output. It is connected as a voltage-follower, guaranteeing a low-impedance output at PC board locations J and K. Trimmer resistor R34 nulls the op-amp's input-offset voltage and gives the operator a precise 0-volt setting.

Voltage-follower IC43-a has its input connected to the programmable voltage output. Its output, called "V_{HIGH}", feeds the V_{DD} lead of CMOS gate IC40 in the time section shown in Fig. 1. Thus, whatever value is loaded in the volts section will be the voltage-high output of the time calibrator's 50% waveform.

A low-output-impedance, ±20-mV voltage generator is composed of resistors R29–R32, trimmer R35, capacitors C17 and C31, and voltage-follower IC43-b. The output is used as the ground return for the 10-volt reference IC. Since the precision output is measured with respect to its ground leg, offsetting ground by ±20 mV (with R35) also offsets the output by an equal amount. If you don't trim the volts-calibrator section, most of this section can be omitted.

Thumbwheel switches S1–S4 (Fig. 4) are coded as BCD-complement, meaning that a 0 is a switch closure and a 1 is a switch open. Pull-up resistors R1–R16 pull any open switch node to 5 volts, but any switch closure will force a ground potential on that node. These two voltage levels are TTL-compatible, therefore they directly drive the latch inputs of the time and volts calibrator.

Three power-supply voltages are needed in the calibrator: +5, +15 and −5 volts. The first voltage powers all the TTL circuitry, and the second two voltages power the analog circuitry in the volts section. Transformer T1 (see Fig. 7) has two secondaries. Secondary 1 is full wave rectified by D1 and D2, filtered by C20 and C21 and regulated down to +5 volts by voltage regulator IC45. A bridge rectifier consisting of D3–D6 at secondary 2 provides both positive and negative voltages, which, in turn, are regulated down to +15 and −5 by IC46 and IC47. Separate secondaries in the power supply help minimize the possibility that the high-frequency voltage and current switching transients in the +5-volt power supply will appear in the analog section of the calibrator's time and volts outputs.

This concludes the theory of operation of the Time/Voltage Calibrator. Next month we will go into construction details and will present the PC board pattern and other pertinent information. **R-E**

AUDIO TEST STATION
continued from page 63

IC701-a is simply an isolator. With S22 in its lower position the timebase frequency is the same as the power-line frequency, which produces one window per second. At the same time pin 8 of IC701 is grounded, which yields an output pulse train of the same frequency as the input signal.

Gate IC701-c, R701 and C702 form the delay circuit. IC701-c provides both isolation and a small amount of delay and R701 and C702 provide additional delay. When S702 is in the one half-second update position, the input signal first arrives at pin 9 of gate A. Pin 8 is still low, the exclusive OR function is satisfied and pin 10 goes high. A short time later, the signal arrives at pin 8 and pin 10 goes low. Sometime later the input pulse ends. At this time, pin 9 goes low and pin 8 is still high. The exclusive OR is once again satisfied and pin 10 goes high again. A short time later the pulse at pin 8 also ends and pin 10 again goes low. The result is two narrow pulses for each single input pulse. The pulses occur at the beginning and end of the input pulse.

As the input frequency reaches about 300 kHz, the spacing betwen the two pulses reaches zero and the result is an output pulse the same frequency as the input. This is the only reason for having a one second update at all. That is, to extend the usefulness of the overall counter into this frequency range. If it was only to be used at lower frequencies, the one-second window need never be used.

IC704 is the actual counting element. When the clear input pin is low, IC704 counts the input at pin 36. When the store input pin is low, the number in the counter is transferred continuously to the display. When the clear input is high, the counter is reset. It starts over again at zero when the clear goes low. When the store input goes high, whatever number was last displayed remains displayed until the store goes low again. Since the store input only goes low for a brief period of time at the end of each counting window, the display shows the number the counter contained at the end of the previous window. Immediately after transferring the number present in the counter at the end of the period, the clear input goes high briefly, which initiates a new period.

The display is multiplexed. That is, only one digit is actually displayed at a time. IC705 provides power to the anode and IC706 provides ground for the cathode. Capacitor C705 establishes the scan frequency. IC704 through IC706 power each digit sequentially in seven segment format. If the LED's were continually powered, each number in the counter would flash sequentially on all six digits simultaneously. IC704 provides the digit scan through IC705. This simply powers each LED display sequentially. Therefore, a particular digit is only powered when the corresponding number from IC706 is to be displayed.

IC705 provides the voltage gain as well as a current gain. This allows IC704 to power the display from the unregulated supply. R705 and R701 provide current limiting for the displays.

Figure 14 shows the location of the Frequency Counter section and Fig. 15 shows the location of the components.

This wraps up the construction phase of the Audio Test Station. Next month we will go into calibration, tests and applications of this valuable addition to your bench. **R-E**

BOWLING GAME

continued from page 43

by one as they are attached to their respective resistors, R20–R29. Use a 6-volt supply with a 220-ohm resistor in series (or a 1.5-volt battery with a 100-ohm resistor) to individually light the LED's for identification. Attach the 22-gauge anode lead to the positive power supply. The RESET pushbutton, S2, connects to point "R" on IC's 1–4 and to the V+ line.

It is prudent to test the gating circuits before hooking up the photo-Darlington transistors. Apply power to the circuit and use test leads to connect each of the inputs to either ground or V+. Use a voltmeter or logic probe to follow each signal through the gates and into the diode matrix. If an error has been made, it can be traced and corrected in a matter of a few minutes. Try all the combinations shown in Table 1, checking each for the proper output.

Now, connect the photo-transistor leads to their appropriate points on IC's 1–4, apply a light source and selectively block each of the slots to make sure the voltage swing from light to dark is sufficient to trigger the CMOS latches. In general, the dark voltage at the junction

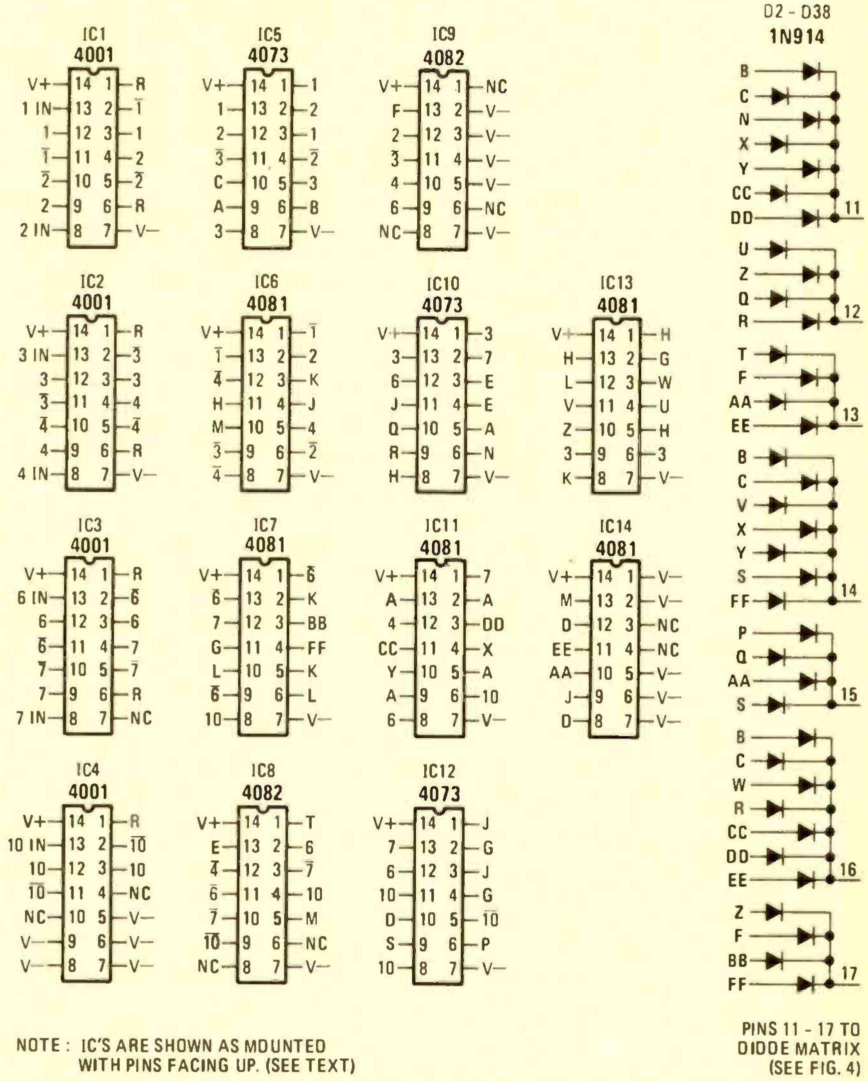

FIG. 8—WIRING GUIDE for the point-to-point connections between the IC's and the diode gates.

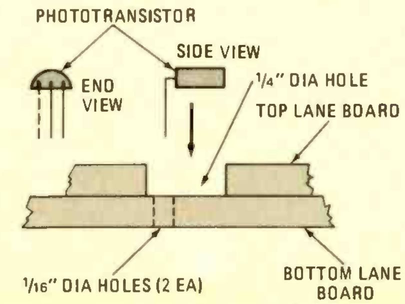

FIG. 9—HOW PHOTOTRANSISTORS are mounted. Be careful when bending pins.

of the collector, the resistor and the gate must be greater than 0.7 times the V+ voltage, and the lighted voltage should be less than 0.3 times the V+ voltage. If these voltages are too low, try decreasing the value of the pullup resistor. If they are too high, increase the value. If this doesn't work, replace the transistor. In tests of over 40 junk-box photo-Darlington transistors, 32 were usable with a pullup resistor value near 15K and with a 40-watt incandescent lamp 48 inches away. Normal room lighting is usually well above this level. **R-E**

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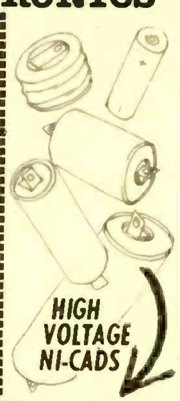

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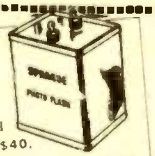

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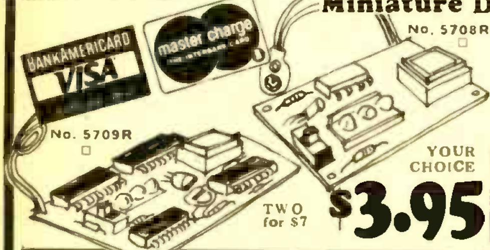

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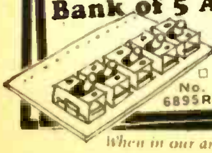

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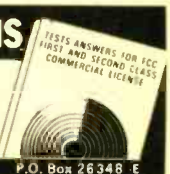

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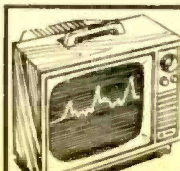

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2SA 525	.50	.64	.70
2SA 530	1.50	1.70	1.90
2SA 537A	1.50	1.70	1.90
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2SA 545	.45	.53	.59
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2SB 202	1.10	1.20	1.30
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2SB 530	3.20	3.40	3.70
2SB 531	1.80	2.00	2.25
2SB 536	1.00	1.20	1.30
2SB 537	1.00	1.20	1.30
2SB 539	3.20	3.40	3.70
2SB 541	3.20	3.40	3.70
2SB 554	5.00	6.00	6.60
2SB 556	3.20	3.40	3.70
2SB 557	2.10	2.50	2.80
2SB 561B	.35	.40	.45
2SB 564	.40	.53	.59
2SB 595	1.10	1.40	1.50
2SB 596	1.10	1.40	1.50
2SB 600	5.00	6.00	6.60
2SC 183	.40	.53	.59
2SC 184	.40	.53	.59
2SC 281	.30	.35	.40
2SC 283	.40	.53	.59
2SC 284	.80	.90	1.00
2SC 317	.40	.53	.59
2SC 352A	2.00	2.20	2.50
2SC 353A	1.40	1.60	1.80
2SC 367	.60	.70	.80
2SC 369	.30	.35	.40
2SC 370	.20	.27	.30
2SC 371	.30	.35	.40
2SC 372	.20	.27	.30
2SC 373	.20	.27	.30
2SC 374	.30	.35	.40
2SC 375	.30	.35	.40
2SC 377	.30	.35	.40
2SC 380	.20	.27	.30
2SC 381	.35	.40	.45
2SC 382	.35	.40	.45
2SC 383	.35	.40	.45
2SC 387A	.35	.40	.45
2SC 388A	.40	.53	.59
2SC 394	.20	.27	.30
2SC 403	.30	.35	.40
2SC 430	.50	.64	.70
2SC 454	.30	.35	.40
2SC 458	.20	.27	.30
2SC 460	.35	.40	.45
2SC 461	.35	.40	.45
2SC 478	.60	.70	.80
2SC 481	1.30	1.40	1.50
2SC 482	1.10	1.25	1.40
2SC 484	1.30	1.40	1.50
2SC 485	1.30	1.40	1.50
2SC 486	1.30	1.40	1.50
2SC 493	3.00	3.20	3.40
2SC 495	.45	.55	.60
2SC 496	.45	.55	.60
2SC 497	1.10	1.25	1.40
2SC 509	.35	.40	.45
2SC 510	1.30	1.40	1.50
2SC 515A	.80	.90	1.00
2SC 517	2.50	2.70	3.00
2SC 535	.30	.35	.40
2SC 536	.30	.35	.40
2SC 537	.30	.35	.40
2SC 627	1.30	1.45	1.60
2SC 631	.35	.40	.45
2SC 632A	.35	.40	.45
2SC 634A	.35	.40	.45
2SC 680	1.90	2.10	2.40
2SC 681A	3.00	3.25	3.50
2SC 684	.80	.90	1.00

TYPE	25-UP	10-24	1-9
2SC 693F	.20	.27	.30
2SC 696	1.00	1.20	1.30
2SC 708	1.30	1.45	1.60
2SC 710	.20	.27	.30
2SC 711	.20	.27	.30
2SC 712	.20	.27	.30
2SC 715	.30	.35	.40
2SC 717	.35	.40	.45
2SC 727	1.00	1.20	1.30
2SC 730	3.00	3.20	3.40
2SC 731	2.50	2.70	2.90
2SC 732	.20	.27	.30
2SC 733	.20	.27	.30
2SC 734	.20	.27	.30
2SC 735	.20	.27	.30
2SC 738	.20	.27	.30
2SC 756	1.50	1.80	2.00
2SC 756A	1.50	1.80	2.00
2SC 763	.35	.40	.45
2SC 772	.30	.35	.40
2SC 773	.35	.40	.45
2SC 774	1.00	1.20	1.30
2SC 775	1.40	1.60	1.80
2SC 776	2.00	2.20	2.50
2SC 777	3.00	3.25	3.50
2SC 778	2.90	3.20	3.40
2SC 781	1.90	2.10	2.40
2SC 783	2.10	2.50	2.80
2SC 784	.30	.35	.40
2SC 785	.35	.40	.45
2SC 789	.80	.90	1.00
2SC 790	.80	.90	1.00
2SC 793	2.00	2.20	2.50
2SC 799	2.00	2.20	2.50
2SC 828	.20	.27	.30
2SC 829	.20	.27	.30
2SC 830H	2.50	2.70	3.00
2SC 838	.35	.40	.45
2SC 839	.30	.35	.40
2SC 853	.70	.80	.90
2SC 867	3.20	3.40	3.70
2SC 867A	3.20	3.40	3.70
2SC 870	.35	.40	.45
2SC 871	.35	.40	.45
2SC 895	4.20	4.40	4.90
2SC 897	2.00	2.20	2.50
2SC 898	2.50	2.70	3.00
2SC 900	.20	.27	.30
2SC 923	.20	.27	.30
2SC 929	.20	.27	.30
2SC 930	.20	.27	.30
2SC 941	.20	.27	.30
2SC 943	.35	.40	.45
2SC 945	.20	.27	.30
2SC 959	1.00	1.20	1.30
2SC 971	.70	.80	.90
2SC 982	.70	.80	.90
2SC 983	.50	.64	.70
2SC 1000	.35	.40	.45
2SC 1012	1.20	1.40	1.50
2SC 1013	.50	.64	.70
2SC 1014	.50	.64	.70
2SC 1017	.80	.90	1.00
2SC 1018	.60	.70	.80
2SC 1030	1.80	2.10	2.40
2SC 1047	.35	.40	.45
2SC 1051	3.40	3.55	3.90
2SC 1060	.70	.80	.90
2SC 1061	.70	.80	.90
2SC 1076	30.00	35.00	39.00
2SC 1079	3.40	3.55	3.90
2SC 1080	3.40	3.55	3.90
2SC 1096	.45	.55	.60
2SC 1098	.50	.64	.70
2SC 1111	2.10	2.50	2.80
2SC 1114	4.20	4.40	4.90
2SC 1115	2.50	2.70	3.00
2SC 1116	3.20	3.40	3.70
2SC 1116A	3.40	3.55	3.90
2SC 1124	.80	.90	1.00
2SC 1127	.80	.90	1.00
2SC 1161	1.30	1.45	1.60
2SC 1162	.70	.80	.90
2SC 1166	.20	.27	.30
2SC 1167	3.80	4.00	4.40
2SC 1170B	3.80	4.00	4.40
2SC 1172B	3.20	3.60	3.95
2SC 1173	.50	.55	.60
2SC 1175	.35	.40	.45
2SC 1177	11.00	12.60	14.00
2SC 1189	1.00	1.10	1.20
2SC 1209	.30	.35	.40
2SC 1211D	.30	.35	.40
2SC 1212A	.80	.90	1.00
2SC 1213	.30	.35	.40
2SC 1215	.35	.40	.45
2SC 1222	.20	.27	.30
2SC 1226	.50	.55	.60

TYPE	25-UP	10-24	1-9
2SC 1226A	.50	.55	.60
2SC 1237	1.80	2.00	2.25
2SC 1239	2.20	2.70	2.90
2SC 1279	.50	.55	.60
2SC 1306	1.30	1.45	1.60
2SC 1307	1.90	2.10	2.40
2SC 1310	.20	.27	.30
2SC 1312	.20	.27	.30
2SC 1313G	.20	.27	.30
2SC 1316	4.20	4.40	4.90
2SC 1317	.20	.27	.30
2SC 1318	.35	.40	.45
2SC 1325A	6.50	6.90	7.60
2SC 1327	.20	.27	.30
2SC 1330	.50	.55	.60
2SC 1335	.50	.55	.60
2SC 1342	.45	.53	.59
2SC 1344	.45	.53	.59
2SC 1358	4.20	4.40	4.90
2SC 1359	.30	.35	.40
2SC 1360	.50	.55	.60
2SC 1362	.35	.40	.45
2SC 1364	.35	.40	.45
2SC 1377	3.20	3.40	3.70
2SC 1383	.30	.35	.40
2SC 1384	.35	.40	.45
2SC 1396	.45	.53	.59
2SC 1398	.70	.80	.90
2SC 1400	.35	.40	.45
2SC 1402	3.00	3.20	3.40
2SC 1403	3.20	3.40	3.70
2SC 1407	.50	.55	.60
2SC 1419	.60	.70	.80
2SC 1444	1.60	1.80	2.00
2SC 1445	2.50	2.70	2.90
2SC 1447	.60	.70	.80
2SC 1448	.70	.80	.90
2SC 1449	.60	.70	.80
2SC 1451	1.00	1.10	1.20
2SC 1454	3.20	3.40	3.70
2SC 1475	.80	.90	1.00
2SC 1478	.50	.55	.60
2SC 1509	.50	.55	.60
2SC 1567	.60	.70	.80
2SC 1567A	.60	.70	.80
2SC 1584	6.00	6.30	7.00
2SC 1586	6.50	6.90	7.60
2SC 1624	.60	.70	.80
2SC 1626	.60	.70	.80
2SC 1628	.60	.70	.80
2SC 1647	.70	.80	.90
2SC 1667	3.00	3.20	3.40
2SC 1669	.90	1.00	1.10
2SC 1674	.30	.35	.40
2SC 1675	.20	.27	.30
2SC 1678	1.10	1.25	1.40
2SC 1679	3.00	3.20	3.40
2SC 1681	.30	.35	.40
2SC 1682	.30	.35	.40
2SC 1684	.30	.35	.40
2SC 1687	.40	.45	.50
2SC 1688	.35	.40	.45
2SC 1708	.30	.35	.40
2SC 1728	.70	.80	.90
2SC 1730	.45	.53	.59
2SC 1756	.50	.55	.60
2SC 1760	.70	.80	.90
2SC 1816	1.50	1.75	1.95
2SC 1856	.45	.53	.59
2SC 1865	.45	.53	.59
2SC 1908	.30	.35	.40
2SC 1909	1.80	2.00	2.25
2SC 1945	4.50	5.00	5.60
2SC 1957	.60	.70	.80
2SC 1969	3.60	4.00	4.40
2SC 1973	.70	.80	.90
2SC 1975	1.30	1.70	1.90
2SC 1978	5.40	6.00	6.60
2SC 2028	.50	.64	.70
2SC 2029	1.50	1.80	2.00
2SC 2074	.80	.90	1.00
2SC 2076	.50	.64	.70
2SC 2091	.90	1.10	1.20
2SC 2092	1.80	2.00	2.25
2SC 2098	3.20	3.40	3.70
2SC 2166	1.40	1.60	1.80
2SD 72	.50	.64	.70
2SD 77	.35	.40	.45
2SD 90	1.30	1.45	1.60
2SD 91	1.30	1.45	1.60
2SD 92	1.30	1.45	1.60
2SD 93	1.60	1.80	2.00
2SD 118	2.90	3.20	3.40
2SD 130	1.10	1.25	1.40
2SD 187	.35	.40	.45
2SD 201	2.30	2.40	2.65
2SD 202	3.40	3.55	3.90
2SD 218	2.50	2.70	3.00

TYPE	25-UP	10-24	1-9
2SD 234	.60	.70	.80
2SD 235	.60	.70	.80
2SD 261	.35	.40	.45
2SD 287	2.50	2.70	2.90
2SD 300	4.50	5.00	5.60
2SD 313	.60	.70	.80
2SD 315	.60	.70	.80
2SD 325	.60	.70	.80
2SD 330	.60	.70	.80
2SD 350	3.80	4.00	4.40
2SD 380	5.20	5.40	5.95
2SD 381	.85	1.00	1.10
2SD 424	3.80	4.00	4.40
2SD 425	2.90	3.20	3.40
2SD 426	3.10	3.30	3.60
2SD 427	1.80	2.00	2.25
2SD 525	.90	1.10	1.20
2SD 526	.60	.70	.80
2SK 19BL	.50	.55	.60
3SK 22Y	1.40	1.60	1.80
3SK 39	.90	1.10	1.20
3SK 40	.90	1.10	1.20
3SK 41	1.30	1.45	1.60
3SK 45	1.30	1.45	1.60
AN 203	1.40	1.60	1.80
AN 214Q	1.50	1.70	1.90
AN 239	4.20	4.40	4.90
AN 247	2.50	2.70	3.00
AN 274	1.50	1.75	1.95
AN 313	3.00	3.20	3.40
AN 315	1.80	2.00	2.25
BA 511A	1.80	2.00	2.25
BA 521	1.90	2.10	2.40
HA 1151	1.50	1.75	1.95
HA 1156W	1.60	1.80	2.00
HA 1306W	2.00	2.20	2.50
HA 1339	2.50	2.70	3.00
HA 1339A	2.50	2.70	3.00
HA 1342A	2.50	2.70	3.00
HA 1366W	2.50	2.70	3.00
HA 1366WR	2.50	2.70	3.00
LA 4031P	1.80	2.00	2.25
LA 4032P	1.80	2.00	2.25
LA 4051P	1.80	2.00	2.25
LA 4400	1.90	2.10	2.40
LA 4400Y	2.00	2.20	2.50
LA 4420	2.00	2.20	2.50
LD 3001	2.00	2.20	2.50
M5 1513L	2.00	2.20	2.50
STK 011	3.80	4.00	4.40
STK 013	7.60	8.00	8.80
STK 015	4.20	4.40	4.90
STK 435	4.50	5.00	5.60
STK 439	7.90	8.00	8.80
TA 7045M	2.00	2.20	2.50
TA 7055P	2.00	2.20	2.50
TA 7061AP	.90	1.10	1.20
TA 7062P	1.10	1.25	1.40
TA 7203P	2.50	2.70	2.90
TA 7204P	2.00	2.20	2.50
TA 7205P	1.60	1.80	2.00
TA 7222P	3.40	3.55	3.90
TA 7310P	1.30	1.45	1.60
TBA 810SH	1.90	2.10	2.40
TC 5080P	5.00	5.20	5.80
TC 5081P	3.00	3.20	3.40
TC 5082P	3.40	3.55	3.90
UHIC 001	4.20	4.40	4.90
UHIC 002	4.20	4.40	4.90
UHIC 003	4.20	4.40	4.90
UHIC 004	4.20	4.40	4.90
UHIC 005	4.20	4.40	4.90
uPC 20C	2.10	2.50	2.80
uPC 563	1.90	2.10	2.40
uPC 575C2	1.30	1.45	1.60
uPC 576	1.90	2.10	2.40
uPC 592H	.70	.80	.90
uPC 1001H	1.90	2.10	2.40
uPC 1008C	4.20	4.40	4.90
uPC 1020H	1.90	2.10	2.40
uPC 1025	1.90	2.10	2.40
uPC 1154	2.00	2.20	2.50
uPC 1155	2.00	2.20	2.50
uPC 1156	1.90	2.10	2.40
uPD 861	8.00	8.40	9.50
uPD 857	8.00	8.40	9.50
uPD 858	6.00	6.30	7.00
PLL 01A	3.00	4.20	4.60
PLL 02A	5.00	5.20	5.90
PLL 03A	7.60	8.00	8.80
C-3001	1.30	1.45	1.60
2SC F8	2.20	2.70	2.90
4004	1.90	2.10	2.40
4005	2.00	2.20	2.50
SG 613	5.20	5.40	5.95
78L05	.90	1.00	1.10
MPS U31	1.50	1.70	1.90
SN 7400	.15	.17	.19

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SN7402N	.18	SN7473N	.35	SN74162N	1.95
SN7403N	.18	SN7474N	.35	SN74163N	.89
SN7404N	.18	SN7475N	.49	SN74164N	.89
SN7405N	.20	SN7476N	.35	SN74165N	.89
SN7406N	.29	SN7479N	5.00	SN74166N	1.25
SN7407N	.29	SN7480N	.50	SN74167N	1.95
SN7408N	.20	SN7482N	.99	SN74170N	1.59
SN7409N	.20	SN7483N	.59	SN74172N	6.00
SN7410N	.18	SN7485N	.79	SN74173N	1.25
SN7411N	.25	SN7486N	.35	SN74174N	.89
SN7412N	.25	SN7489N	1.75	SN74175N	.79
SN7413N	.40	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.59	SN74177N	.79
SN7416N	.25	SN7492N	.43	SN74179N	1.95
SN7417N	.25	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
SN7421N	.29	SN7495N	.65	SN74182N	.79
SN7422N	.39	SN7496N	.65	SN74184N	1.95
SN7423N	.25	SN7497N	3.00	SN74185N	1.95
SN7425N	.29	SN74100N	.89	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.59	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.20	SN74121N	.35	SN74192N	.79
SN7432N	.25	SN74122N	.39	SN74193N	.79
SN7437N	.25	SN74123N	.49	SN74194N	.89
SN7438N	.25	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.49	SN74141N	.79	SN74199N	1.49
SN7443N	.75	SN74142N	2.95	SN74S200	4.95
SN7444N	.75	SN74143N	2.95	SN74251N	1.79
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.69	SN74145N	.79	SN74283N	2.25
SN7447N	.59	SN74147N	1.95	SN74284N	3.95
SN7448N	.79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	.89	SN74365N	.69
SN7451N	.20	SN74151N	.59	SN74366N	.69
SN7453N	.20	SN74152N	.59	SN74367N	.69
SN7454N	.20	SN74153N	.59	SN74368N	.69
SN7459A	.25	SN74154N	.99	SN74390N	1.95
SN7460N	.20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

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CD4006	1.19	CD4035	.99	CD4076	1.39
CD4007	.25	CD4040	1.19	CD4081	.23
CD4009	.49	CD4041	1.25	CD4082	.23
CD4010	.49	CD4042	.99	CD4093	.99
CD4011	.23	CD4043	.89	CD4098	2.49
CD4012	.25	CD4044	.89	MC14409	14.95
CD4013	.39	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
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CD4018	.99	CD4051	1.19	MC14507	.99
CD4019	.49	CD4053	1.19	MC14562	14.50
CD4020	1.19	CD4056	2.95	MC14583	3.50
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	.23	CD4066	.79	CD4511	1.29
CD4024	.79	CD4068	.39	CD4515	2.95
CD4025	.23	CD4069	.45	CD4518	1.29
CD4026	2.25			CD4520	1.29
CD4027	.69			CD4566	2.25

74C00

74C00	.39	74C85	2.49	74C163	2.49
74C02	.39	74C90	1.95	74C164	2.49
74C04	.39	74C93	1.95	74C173	2.60
74C08	.49	74C95	1.95	74C192	2.49
74C10	.39	74C107	1.25	74C193	2.49
74C14	1.95	74C151	2.90	74C195	2.49
74C20	.39	74C154	3.00	74C922	5.95
74C30	.39	74C157	2.15	74C923	6.25
74C42	1.95	74C160	2.49	74C925	8.95
74C48	2.49	74C161	2.49	74C926	8.95
74C73	.89			80C95	1.50
74C74	.89			80C97	1.50

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78MG	1.75	LM340K-18	1.35	LM710N	.79
LM106H	.99	LM340K-24	1.35	LM711N	.39
LM300H	.80	LM340T-5	1.25	LM723N/H	.55
LM301CN/H	.35	LM340T-6	1.25	LM733N	1.00
LM302H	.75	LM340T-8	1.25	LM739N	1.19
LM304H	1.00	LM340T-12	1.25	LM741CN/H	.35
LM305H	.60	LM340T-15	1.25	LM741-14N	.39
LM307CN/H	.35	LM340T-18	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	.39
LM309H	1.10	LM358N	1.00	LM1310N	2.95
LM309K	1.25	LM370N	1.95	LM1458CN/H	.59
LM310CN	1.15	LM373N	3.25	MC1488N	1.39
LM311N/H	.90	LM377N	4.00	MC1489N	1.39
LM312H	1.95	LM380N	1.25	LM1496N	.95
LM317K	6.50	LM380CN	.99	LM1556V	1.75
LM318CN/H	1.50	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE501N	8.00	LM2901N	2.95
LM320K-5.2	1.35	NE510A	6.00	LM3053N	1.50
LM320K-12	1.35	NE529A	4.95	LM3065N	1.49
LM320K-15	1.35	NE531H/V	3.95	LM3900N(3401)	.49
LM320K-18	1.35	NE536T	6.00	LM3905N	.89
LM320K-24	1.35	NE540L	6.00	LM3909N	1.25
LM320T-5	1.25	NE544N	4.95	MC5558V	.59
LM320T-5.2	1.25	NE550N	1.30	8038B	4.95
LM320T-8	1.25	NE555V	.39	LM75450N	.49
LM320T-12	1.25	NE556N	.99	75451CN	.39
LM320T-15	1.25	NE560B	5.00	75452CN	.39
LM320T-18	1.25	NE561B	5.00	75453CN	.39
LM320T-24	1.25	NE562B	5.00	75454CN	.39
LM323K-5	5.95	NE565N/H	1.25	75491CN	.79
LM324N	1.80	NE566CN	1.75	75492CN	.89
LM339N	.99	NE567V/H	.99	75493N	.89
LM340K-5	1.35	NE570N	4.95	75494CN	.89
LM340K-6	1.35	LM703CN/H	.69	RC4136	1.25
LM340K-8	1.35	LM709N/H	.29	RC4151	2.85
LM340K-12	1.35			RC4194	5.95
LM340K-15	1.35			RC4195	4.49

74LS00TTL

74LS00	.23	74LS47	.69	74LS138	.69
74LS01	.23	74LS51	.23	74LS139	.69
74LS02	.23	74LS54	.23	74LS151	.69
74LS03	.23	74LS55	.23	74LS155	.69
74LS04	.29	74LS73	.35	74LS157	.69
74LS05	.29	74LS74	.35	74LS160	.89
74LS08	.29	74LS75	.49	74LS161	.89
74LS09	.29	74LS76	.35	74LS162	.89
74LS10	.23	74LS78	.39	74LS163	.89
74LS11	.60	74LS83	.75	74LS164	.99
74LS13	.49	74LS85	.99	74LS175	.79
74LS14	.99	74LS86	.35	74LS181	2.49
74LS15	.29	74LS90	.49	74LS190	.89
74LS20	.23	74LS92	.59	74LS191	.89
74LS21	.29	74LS93	.59	74LS192	.89
74LS22	.29	74LS95	.79	74LS193	.89
74LS26	.29	74LS96	.89	74LS194	.89
74LS27	.29	74LS107	.35	74LS195	.89
74LS28	.29	74LS109	.35	74LS253	.79
74LS30	.23	74LS112	.35	74LS257	.69
74LS32	.29	74LS123	.99	74LS258	1.39
74LS37	.35	74LS125	.69	74LS260	.55
74LS40	.29	74LS132	.79	74LS279	.59
74LS42	.69	74LS136	.39	74LS367	.59
				74LS368	.59
				74LS670	1.95

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- Full 1.5 amp at 5-10V output — Up to .5 amp at 15V output
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JE747 Jumbo 6 dgt. clock kit $29.95

DISCRETE LEDS

.200" dia.				.125" dia.		
XC556R	red	5/$1		XC209R	red	5/$1
XC556G	green	4/$1		XC209G	green	4/$1
XC556Y	yellow	4/$1		XC209Y	yellow	4/$1
XC556C	clear	4/$1				
.200" dia.				.185" dia.		
XC22R	red	5/$1		XC526R	red	5/$1
XC22G	green	4/$1		XC526G	green	4/$1
XC22Y	yellow	4/$1		XC526Y	yellow	4/$1
.170" dia.				XC526C	clear	4/$1
MV10B	red	4/$1		.190" dia.		
.085" dia.				XC111R	red	5/$1
MV50	red	6/$1		XC111G	green	4/$1
				XC111Y	yellow	4/$1
				XC111C	clear	4/$1

INFRA-RED LED
1/4"x1/4"x1/16" flat
5/$1

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LIQUID CRYSTAL DISPLAY
FIELD EFFECT

4 DIGIT — .5" CHARACTERS
THREE ENUNCIATORS
2.00" X 1.20" PACKAGE
INCLUDES CONNECTOR

T1001-Transmissive $7.95
T1001A-Reflective 8.25

DISPLAY LEDS

TYPE	POLARITY	HT	PRICE	TYPE	POLARITY	HT	PRICE
MAN 1	Common Anode-red	.270	2.95	MAN 6730	Common Anode-red ± 1	.560	.99
MAN 2	5 x 7 Dot Matrix-red	.300	4.95	MAN 6740	Common Cathode-red-D.D.	.560	.99
MAN 3	Common Cathode-red	.125	.25	MAN 6750	Common Cathode-red ± 1	.560	.99
MAN 4	Common Cathode-red	.187	1.95	MAN 6760	Common Anode-red	.560	.99
MAN 7G	Common Anode-green	.300	1.25	MAN 6780	Common Cathode-red	.560	.99
MAN 7Y	Common Anode-yellow	.300	.99	DL701	Common Anode-red ± 1	.300	.99
MAN 72	Common Anode-red	.300	.99	DL704	Common Cathode-red	.300	.99
MAN 74	Common Cathode-red	.300	1.25	DL707	Common Anode-red	.300	.99
MAN 82	Common Anode-yellow	.300	.99	DL728	Common Cathode-red	.500	1.49
MAN 84	Common Cathode-yellow	.300	.99	DL741	Common Anode-red	.600	1.25
MAN 3620	Common Anode-orange	.300	.99	DL746	Common Anode-red ± 1	.630	1.49
MAN 3630	Common Anode-orange ± 1	.300	.99	DL747	Common Anode-red	.600	1.49
MAN 3640	Common Cathode-orange	.300	.99	DL749	Common Cathode-red ± 1	.630	1.49
MAN 4610	Common Anode-orange	.300	.99	DL750	Common Cathode-red	.600	1.49
MAN 4640	Common Cathode-orange	.400	.99	DL338	Common Cathode-red	.110	.35
MAN 4710	Common Anode-red	.400	.99	FND70	Common Cathode	.250	.69
MAN 4730	Common Anode-red ± 1	.400	.99	FND358	Common Cathode ± 1	.357	.99
MAN 4740	Common Cathode-red	.400	.99	FND359	Common Cathode	.357	.75
MAN 4810	Common Anode-yellow	.400	.99	FND503	Common Cathode(FND500)	.500	.99
MAN 4840	Common Cathode-yellow	.400	.99	FND507	Common Anode (FND510)	.500	.99
MAN 6610	Common Anode-orange-D.D.	.560	.99	5082-7730	Common Anode-red	.300	1.30
MAN 6630	Common Anode-orange ± 1	.560	.99	HDSP-3400	Common Anode-red	.800	2.10
MAN 6640	Common Cathode-orange-D.D.	.560	.99	HDSP-3403	Common Cathode-red	.800	2.10
MAN 6650	Common Cathode-orange ± 1	.560	.99	5082-7300	4 x 7 sgl. Digit-RHDP	.600	19.95
MAN 6660	Common Anode-orange	.560	.99	5082-7302	4 x 7 Sgl. Digit-LHDP	.500	19.95
MAN 6680	Common Cathode-orange	.560	.99	5082-7304	Overrange character (±1)	.600	15.00
MAN 6710	Common Anode-red-D.D.	.560	.99	5082-7340	4 x 7 Sgl. Digit-Hexadecimal	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA3023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.49
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7 seg. CA. LED driver	

CLOCK CHIPS

MM5309	$4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
MM5841	9.95

MOTOROLA

MC1408L7	$4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin LP	$.17	.16	.15	22 pin LP	$ .37	.36	.35
14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

14 pin ST	$.27	.25	.24	28 pin ST	$ .99	.90	.81
16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
24 pin ST	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin SG	$.30	.27	.24	24 pin SG	$ .70	.63	.57
14 pin SG	.35	.32	.29	28 pin SG	1.10	1.00	.90
16 pin SG	.38	.35	.32	36 pin SG	1.65	1.40	1.26
18 pin SG	.52	.47	.43	40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

8 pin WW	$.39	.38	.31	22 pin WW	$ .95	.85	.75
10 pin WW	.45	.41	.37	24 pin WW	1.05	.95	.85
14 pin WW	.39	.38	.37	28 pin WW	1.40	1.25	1.10
16 pin WW	.43	.42	.41	36 pin WW	1.59	1.45	1.35
18 pin WW	.75	.68	.62	40 pin WW	1.75	1.55	1.40

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	50 PCS	$1.75
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	50 PCS	1.75
ASST. 3	5 ea.	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	50 PCS	1.75
ASST. 4	5 ea.	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	50 PCS	1.75
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	50 PCS	1.75
ASST. 6	5 ea.	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	50 PCS	1.75
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	50 PCS	1.75

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$9.95 ea.**

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TL074CN	Quad Low Noise bi-fet Op Amp	2.49
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TL496CP	Single Switching Regulator	1.75
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TIL308	.27" red num. display w/integ. logic chip	10.50
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Generates Complex Sounds
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XR205	$8.40	XR2206KA	14.95	XR2242CP	1.50
XR210	4.40	XR2206KB	19.95	XR2264	4.25
XR215	4.40	XR1800	3.20	XR2556	3.20
XR320	1.55	XR2206	4.40	XR2567	2.99
XR-L555	1.50	XR2207	3.85	XR3403	1.25
XR555	.39	XR2208	5.20	XR4136	1.25
XR556	.99	XR2209	1.75	XR4151	2.85
XR567CP	.99	XR2211	5.25	XR4194	4.95
XR567CT	1.25	XR2212	4.35	XR4202	3.60
XR1310P	1.30	XR2240	3.45	XR4212	2.05
XR1468CN	3.85			XR4558	.75
XR1488	1.39			XR4739	1.15
XR1489	1.39			XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400m	4/1.00	1N4002	100 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4003	200 PIV	1 AMP	12/1.00
1N752	5.6	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N753	6.2	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N757	9.0	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N759	12.0	400m	4/1.00	1N3600	50	200m	6/1.00
1N959	8.2	400m	4/1.00	1N4148	75	10m	15/1.00
1N965	15	400m	4/1.00	1N4154	35	10m	12/1.00
1N5232	5.6	500m	.28	1N4305	75	25m	15/1.00
1N5234	6.2	500m	.28	1N4734	5.6	1w	.28
1N5235	6.8	500m	.28	1N4735	6.2	1w	.28
1N5236	7.5	500m	.28	1N4736	6.8	1w	.28
1N5242	12	500m	.28	1N4738	8.2	1w	.28
1N5245	15	500m	.28	1N4742	12	1w	.28
1N456	25	40m	6/1.00	1N4744	15	1w	.28
1N458	150	7m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N485A	180	10m	5/1.00	1N1184	100 PIV	35 AMP	1.70
1N4001	50 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.70
				1N1186	200 PIV	35 AMP	1.80
				1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR(2N1849)	$1.95
C38M	35A @ 600V	SCR	1.95
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC	1.95

TRANSISTORS

C106B1	.50			2N3904	4/1.00
MPSA05	.30	2N3055	.89	2N3905	4/1.00
MPSA06	5/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	6/1.00	2N3392	5/1.00	2N4013	3/1.00
TIS98	6/1.00	2N3398	5/1.00	2N4123	6/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
40410	1.75	PN3568	4/1.00	PN4250	4/1.00
40673	1.75	PN3569	4/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3638A	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	MPS3702	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	2N3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	MPS3704	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	2N3705	5/1.00	2N5086	4/1.00
2N2369	5/1.00	MPS3705	5/1.00	2N5087	4/1.00
2N2369A	4/1.00	2N3706	5/1.00	2N5088	4/1.00
MPS2369	5/1.00	MPS3706	5/1.00	2N5089	4/1.00
2N2484	4/1.00	2N3707	5/1.00	2N5129	5/1.00
2N2906	4/1.00	2N3711	5/1.00	PN5134	5/1.00
2N2907	5/1.00	2N3724A	.65	PN5138	5/1.00
PN2907 Plastic	7/1.00	2N3725A	1.00	2N5139	5/1.00
2N2925	5/1.00	2N3772	2.25	2N5210	5/1.00
MJE2955	1.25	2N3823	1.00	2N5449	3/1.00
2N3053	2/1.00	2N3903	5/1.00	2N5951	3/1.00

CAPACITOR CORNER

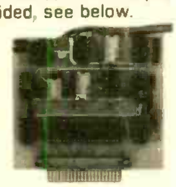
50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-99	100-		1-9	10-99	100-
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.14	.12	.09	1.0/16V	.15	.13	.10
4.7/25V	.15	.13	.10	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

CIRCLE 13 ON FREE INFORMATION CARD

TRS-80 E.S. SERIAL I/O

• Can input into basic • Can use LLIST and LPRINT to output, or output continuously • RS-232 compatible • Can be used with or without the expansion bus • On board switch selectable baud rates of 110, 150, 300, 600, 1200, 2400, parity or no parity odd or even, 5 to 8 data bits, and 1 or 2 stop bits. D.T.R. line • Requires +5, -12 VDC • Board only $19.95 Part No. 8010, with parts $59.95 Part No. 8010A, assembled $79.95 Part No. 8010 C. No connectors provided, see below.



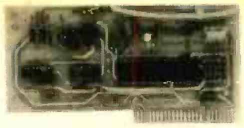
EIA/RS-232 connector Part No DB25P $6.00, with 9'. 8 conductor cable $10.95 Part No. DB25P9

3' ribbon cable with attached connectors to fit TRS-80 and our serial board $19.95 Part No. 3CAB40

MODEM ⁜

• Type 103 • Full or half duplex • Works up to 300 baud • Originate or Answer • No coils, only low cost components • TTL input and output-serial • Connect 8 Ω speaker and crystal mic. directly to board • Uses XR FSK demodulator • Requires +5 volts • Board only $7.60 Part No. 109, with parts $27.50 Part No. 109A

APPLE II ⁜ SERIAL I/O INTERFACE



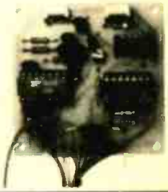
Baud rate is continuously adjustable from 0 to 30,000 • Plugs into any peripheral connector • Low current drain. RS-232 input and output • On board switch selectable 5 to 8 data bits, 1 or 2 stop bits, and parity or no parity either odd or even • Jumper selectable address • SOFTWARE • Input and Output routine from monitor or BASIC to teletype or other serial printer • Program for using an Apple II for a video or an intelligent terminal. Also can output in correspondence code to interface with some selectrics. • Also watches DTR • Board only $15.00 Part No. 2, with parts $42.00 Part No. 2A, assembled $62.00 Part No. 2C

T.V. TYPEWRITER

• Stand alone TVT • 32 char/line, 16 lines, modifications for 64 char/line included • Parallel ASCII (TTL) input • Video output • 1K on board memory • Output for computer controlled curser • Auto scroll • Non-destructive curser • Curser inputs: up, down, left, right, home, EOL, EOS • Scroll up, down • Requires +5 volts at 1.5 amps, and -12 volts at 30 mA • All 7400, TTL chips • Char. gen. 2513 • Upper case only • Board only $39.00 Part No. 106, with parts $145.00 Part No. 106A

TAPE ⁜ INTERFACE

• Play and record Kansas City Standard tapes • Converts a low cost tape recorder to a digital recorder • Works up to 1200 baud • Digital in and out are TTL-serial • Output of board connects to mic. in of recorder • Earphone of recorder connects to input on board • No coils • Requires +5 volts, low power drain • Board only $7.60 Part No. 111, with parts $27.50 Part No. 111A



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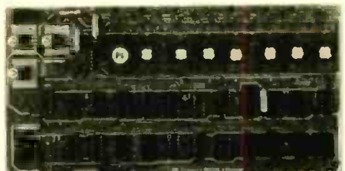
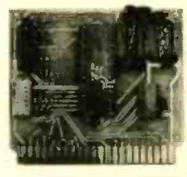
8K EPROM PIICEON

Saves programs on PROM permanently (until erased via UV light) up to 8K bytes. Programs may be directly run from the program saver such as fixed routines or assemblers. • S-100 bus compatible • Room for 8K bytes of EPROM non-volatile memory (2708's). • Onboard PROM programming • Address relocation of each 4K of memory to any 4K boundary within 64K • Power on jump and reset jump option for "turnkey" systems and computers without a front panel • Program saver software available • Solder mask both sides • Full silkscreen for easy assembly. Program saver software in 1 2708 EPROM $25. Bare board $35 including custom coil, board with parts but no EPROMS $139, with 4 EPROMS $179, with 8 EPROMS $219.



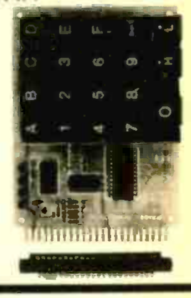
UART & BAUD RATE GENERATOR ⁜

• Converts serial to parallel and parallel to serial • Low cost on board baud rate generator • Baud rates: 110, 150, 300, 600, 1200, and 2400 • Low power drain +5 volts and -12 volts required • TTL compatible • All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity. • All connections go to a 44 pin gold plated edge connector • Board only $12.00 Part No. 101, with parts $35.00 Part No. 101A, 44 pin edge connector $4.00 Part No. 44P



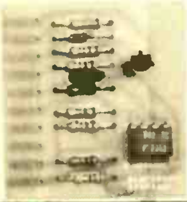
HEX ENCODED KEYBOARD E.S.

This HEX keyboard has 19 keys, 16 encoded with 3 user definable. The encoded TTL outputs, 8-4-2-1 and STROBE are debounced and available in true and complement form. Four onboard LEOs indicate the HEX code generated for each key depression. The board requires a single +5 volt supply. Board only $15.00 Part No. HEX-3, with parts $49.95 Part No. HEX-3A. 44 pin edge connector $4.00 Part No. 44P



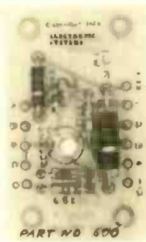
RS-232/ TTL ⁜ INTERFACE

• Converts TTL to RS-232, and converts RS-232 to TTL • Two separate circuits • Requires -12 and +12 volts • All connections go to a 10 pin gold plated edge connector • Board only $4.50 Part No. 232, with parts $7.00 Part No. 232A 10 Pin edge connector $3.00 Part No. 10P



RS-232/ TTY ⁜ INTERFACE

• Converts RS-232 to 20mA current loop, and 20mA current loop to RS-232 • Two separate circuits • Requires +12 and -12 volts • Board only $4.50 Part No. 600, with parts $7.00 Part No. 600A



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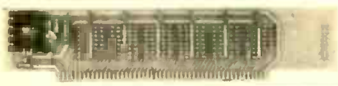
S-100 BUS ⁜ ACTIVE TERMINATOR

Board only $14.95 Part No. 900, with parts $24.95 Part No. 900A



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• Board supplies a regulated +5 volts at 3 amps., +12, -12, and -5 volts at 1 amp. • Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps. • Board only $12.50 Part No. 6085, with parts excluding transformers $42.50 Part No. 6085A

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⁜ Circuits designed by John Bell

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3.3	13	56	240	1000	4300	18K	75K	330K
3.6	15	62	270	1100	4700	20K	82K	360K
3.9	16	68	300	1200	5100	22K	91K	390K
4.3	18	75	330	1300	5600	24K	100K	430K
4.7	20	82	360	1500	6200	27K	110K	470K
5.1	22	91	390	1600	6800	30K	120K	510K
5.6	24	100	430	1800	7500	33K	130K	560K
6.2	27	110	470	2000	8200	36K	150K	620K
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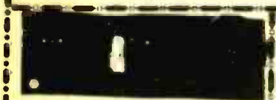

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32K Econoram IX™	Dig Grp	4 MHz	$649	N/A	N/A
32K Econoram X™	S-100	4 MHz	$599	$649	$789
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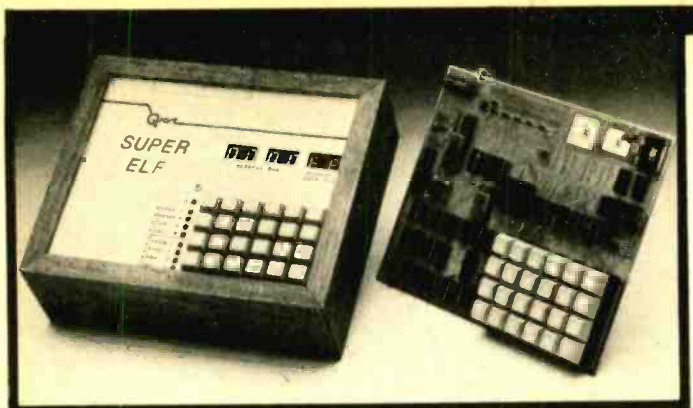

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Same day shipment. First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded with additional memory, Tiny Basic, ASCII Keyboards, video character generation, etc.**

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest address and data bus displays before, during and after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on nine LED indicator lamps.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high** and **low address**. There is a 44 pin standard connector for PC cards and a 50 pin connector for the **Quest Super Expansion Board**. Power supply and sockets for **all** IC's are included in the price plus a detailed 90 page instruction manual.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95. High address option $8.95. Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95. NiCad Battery Memory Saver Kit $6.95.** All kits and options also come completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year.

Tiny Basic for ANY 1802 System

Cassette $10.00. On ROM $38.00. Super Elf owners, 30% off. **Object code listing with manual $5.00. Object list, manual and paper tape $10.00. Original ELF Kit Board $14.95.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow **you** to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed**. EPROM can be used for the monitor and Tiny Basic or other purposes.

A 1K Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatible cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of monitor functions simply by calling them up.

Improvements and revisions are easily done with the monitor. If you have the **Super Expansion Board and Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports with full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. A Godbout 8K RAM board is available for $135.00. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $12.50 for easy connection between the **Super Elf** and the **Super Expansion Board.**

The Power Supply Kit for the Super Expansion Board is a 5 amp supply with multiple positive and negative voltages $29.95. Add $4.00 for shipping. Prepunched frame $5.00. Case $10.00. Add $1.50 for shipping.

INTEGRATED CIRCUITS

7400 TTL	
7400N	17
7402N	17
7404N	19
7409N	.23
7410N	17
7414N	.63
7420N	17
7422N	1.39
7430N	.20
7442N	50
7445N	.69
7447N	60
7448N	69
7450N	17
7474N	29
7475N	49
7485N	.88
7489N	2.00
7490N	43
7492N	43
7493N	43
7495N	69
74100N	90
74107N	29
74121N	.34
74123N	59
74125N	.39
74145N	.69
74150N	95
74151N	.69
74154N	1.00
74157N	.69
74161N	87
74162N	87
74163N	.87
74174N	.96
74175N	.90
74190N	1.15
74192N	.87
74193N	85
74221N	1.55
74298N	1.65
74365N	66
74366N	66
74367N	66

74LS00 TTL	
74LS00N	.25
74LS02N	25
74LS04N	25
74LS05N	25
74LS08N	25
74LS10N	25
74LS13N	.40
74LS14N	90
74LS20N	.25
74LS22N	.25
74LS28N	41
74LS30N	.25
74LS33N	.39
74LS38N	.30
74LS74N	.35
74LS75N	.47
74LS90N	.51
74LS93N	.51
74LS95N	1.89
74LS107N	.35
74LS112N	.35
74LS113N	.35
74LS132N	.72
74LS136N	.35
74LS151N	.87
74LS155N	.87
74LS157N	.67
74LS162N	.91
74LS163N	.91
74LS174N	.95
74LS190N	1.06
74LS221N	1.25
74LS258N	.67
74LS367N	.89

LINEAR	
CA3045	.90
CA3046	.67
CA3081	1.80
CA3082	1.90
CA3089	2.95
LM301AN/AH	.35
LM305H	.87
LM307N	.35
LM308N	.89
LM309H	1.15
LM309K	.95
LM311H/N	.90
LM317T/K	2.92
LM318	1.35
LM320K-5	1.20
LM323K-5	6.95
LM320K-12	1.35
LM320K-15	1.35
LM320T-5	1.35
LM320T-8	1.60
LM320T-12	1.60
LM320T-15	1.60
LM324N	1.15
LM339N	1.55
LM340K-5	1.35
LM340K-8	1.35
LM340K-12	1.35
LM340K-15	1.35
LM340K-24	1.35
LM340T-5	1.25
LM340T-8	1.25
LM340T-12	1.25
LM340T-15	1.25
LM340T-18	1.25
LM340T-24	1.25
LM343H	4.50
LM350	7.50
LM370	1.15
LM377	3.00
LM379	5.00
LM380N	1.00
LM381	1.60
LM382	1.60
LM703H	40
LM709H	28
LM723H/N	.50
LM733N	.67
LM741CH	.35
LM741N	.25
LM747H/N	62
LM748N	.35
LM1303N	.82
LM1304	1.10
LM1305	1.27
LM1307	2.00
LM1310	2.75
LM1458	.47
LM1800	1.75
LM1812	7.50
LM1889	3.00
LM2111	1.75
LM2902	1.50
LM3900N	60
LM3905	1.75
LM3909N	.61
MC1458V	50
NE540L	2.89
NE550N	65
NE555V	.43
NE556A	.79
NE565A	1.00
NE566V	1.50
NE567V	1.20
NE570B	5.00
NE571B	5.00
78L05	60
78L08	60
79L05	70
78M05	85
75108	1.75
75491CN	.50
75492CN	.55
75494CN	89

A to D CONVERTER	
8038B	4.50
8700CJ	13.95
8701CN	22.00
8750CJ	13.95
LD130	9.95
9400CJV/F	7.40
ICL7103	9.50
ICL7107	14.25

CMOS	
CD34001 Fair	.50
CD4000	.16
CD4001	.21
CD4002	.21
CD4006	1.10
CD4007	.21
CD4008	.79
CD4009	.39
CD4010	.39
CD4011	.21
CD4012	.21
CD4013	.36
CD4014	.86
CD4015	.86
CD4016	.36
CD4017	.94
CD4018	.94
CD4019	.21
CD4020	1.02
CD4021	1.02
CD4022	.86
CD4023	.21
CD4024	.75
CD4025	.21
CD4026	1.51
CD4027	.36
CD4028	.79
CD4029	1.02
CD4030	.21
CD4035	1.02
CD4040	1.02
CD4042	.71
CD4043	.63
CD4044	.63
CD4046	1.67
CD4049	.36
CD4050	.36
CD4051	1.13
CD4060	1.42
CD4066	.71
CD4068	.40
CD4069	.40
CD4070	.40
CD4071	.21
CD4072	.21
CD4073	.21
CD4075	.21
CD4076	1.75
CD4078	.40
CD4081	.21
CD4082	.21
CD4116	.47
CD4490	5.50
CD4507	1.00
CD4508	4.25
CD4510	1.02
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1.02
CD4520	1.02
CD4527	1.51
CD4528	.79
CD4553	3.50
CD4566	2.25
CD4583	4.50
CD4585	1.10
CD40192	3.00
74C00	28
74C04	33
74C10	28
74C14	2.10
74C20	28
74C30	28
74C48	1.95
74C74	75
74C76	1.40
74C90	1.15
74C93	1.40
74C154	3.00
74C160	1.44
74C175	1.35
74C192	1.65
74C221	2.00
74C905	3.00
74C906	.75
74C914	1.95
74C922	5.50
74C923	5.50
74C925	6.95
74C926	6.95
74C927	6.95

INTERFACE	
8095	65
8096	.65
8097	.65
8098	.65
8T09	1.25
8T10	4.50
8T13	3.00
8T20	5.50
8T23	3.10
8T24	3.50
8T25	3.20
8T26	1.69
8T28	2.75
8T97	1.69
8T98	1.69

MOS MEMORY RAM	
2101-1	3.95
2102-1	.95
2102AL-4	1.60
21F02	1.25
2104A-4	4.95
2107B	4.95
2111-1	3.75
2112-2	3.95
2114	8.50
4116	12.95
2513B	8.30
21L02-1	1.29
MM5262	.40
MM5280	3.00
MM5320	9.95
MM5330	5.94
PD411D-3	4.00
PD411D-4	5.00
P5101L	13.95
4200A	9.95
82S25	2.90
91L02A	1.50
HD0165-5	6.95
MM57100	4.50
GIAY38500-1	9.95
MCM6571A	9.95
9368	3.50
4100	10.00
416	16.00

CLOCKS	
MM5309	3.00
MM5311	3.60
MM5312	4.80
MM5313	3.60
MM5314	3.90
MM5315	4.00
MM5316	5.00
MM5318	3.60
MM5369	2.10
MM5841	14.45
MM5865	7.95
CT7001	5.80
CT7002	8.95
CT7010	8.95
CT7015	7.25
MM5375AA/N	3.90
MM5375AB/N	4.95
7205	16.50
7207	7.50
7208	15.95
7209	4.95
DS0026CN	3.75
DS0056CN	3.75
MM53104	2.50

MICROPROCESSOR	
6800	17.50
6802	24.95
8080A with data	8.95
8085	27.00
Z80A	19.75
8212	2.90
8214	8.00
8216	2.90
8224	2.90
8228	5.35
8251	8.50
8253	10.00
8255	9.25
8257	19.50
8259	19.50
CDP1802CD	19.95
CDP1802D	25.00
CDP1861	12.95
6820	9.95
6850	12.95
6502	12.50

IC SOCKETS

Solder Tin Low Profile

PIN	1 UP	PIN	1 UP
8	.15	22	.30
14	.18	24	.35
16	.20	28	.42
18	.27	36	.58
20	.29	40	.57

3 level wire wrap gold 14 pin .25
2 level 14 pin ww .20

WIRE WRAP LEVEL 3

PIN		PIN	
14	.25	24	.86
16	.33	28	1.00
18	.57	40	1.23

UART FIFO	
AY5-1013	5.50
AY5-1014	7.50
3341	6.95

PROM	
1702A	3.95
N82S23	2.95
N82S123	3.50
N82S126	3.75
N82S129	3.75
N82S131	3.75
N82S136	8.75
N82S137	8.75
2708	10.50
DM8577	2.90
8223	2.90
2716T1	29.50
2716 Intel	48.00

CRYSTALS	
1 MHz	4.50
2 MHz	4.50
4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3.90
20 MHz	3.90
32 MHz	3.90
32768 MHz	4.00
1.8432 MHz	4.50
3.5795 MHz	1.20
2.0100 MHz	1.95
2.097152 MHz	4.50
2.4576 MHz	4.50
3.2768 MHz	4.50
5.0688 MHz	4.50
5.185 MHz	4.50
5.7143 MHz	4.50
6.5536 MHz	4.50
14.31818 MHz	4.25
18.432 MHz	4.50
22.1184 MHz	4.50

CONNECTORS	
44 pin edge	2.75
100 pin edge	4.50
100 pin edge WW	5.25

KEYBOARD ENCODERS	
AY5-2376	$12.50
AY5-3600	13.50
74C922	5.50
74C923	5.50
HD0165-5	6.95

IC Test Clips	1	10
Red	.55	.47
Black	.55	.47

Keyer 8043 comp. w/spec./sock. 14.50

TRANSISTORS	
2N1893	.40
2N2222A	.18
2N2369	.30
2N2904A	.20
2N2907A	.25
2N3053	.40
2N3638	.25
2N3643	.25
2N3904	.18
2N3906	.18
2N3055	.69
2N4400	.25
2N4401	.75
2N4402	.20
TIP31	.60
TIP31A	1.00

D Connectors RS232

25 Pin Subminiatures

DB25P	2.95
DB25S	3.95
Cover	1.50
RS232 Complete Set	6.50
DE9P	1.50
DE9S	1.95
DA15P	2.10
DA15S	3.10

CLOCK MODULES Complete alarm clocks ready to hook up with transformer and switches. Very compact with .50" and .84" digits

MA1002A, C or E .50	8.95
102P3 Transformer	2.25
MA1010A, C or E .84	11.95
102P2 Transformer	2.25
Special transformer and six switches when purchased w/module	2.95
MA1003 car module .3" green fluor. display	15.95

RESISTORS ¼ watt 5%
10 per type .03 — 1000 per type .012
25 per type .025 — 350 piece pack
100 per type .015 — 5 per type 6.75

KEYBOARDS	
56 key ASCII keyboard kit	$67.50
Fully assembled	77.50
53 key ASCII keyboard kit	60.00
Fully assembled 70.00 Enclosure	14.95

LEDS	
Red TO18	.15
Green, Yellow TO18	.20
Jumbo Red	.20
Green, Orange, Yellow Jumbo	.25
Cliplite LED Mounting Clips	8/$1.25

(specify red, amber, green, yellow, clear)

CONTINENTAL SPECIALTIES in stock
Complete line of breadboard test equip.
MAX 100 8 digit Freq. Ctr. $128.95

OK WIRE WRAP TOOLS in stock
Portable Multimeter $18.00

DIGITAL THERMOMETER $48.50
Batt. oper. General purpose or medical 32 – 230 F. Disposable probe cover ±.2 accuracy. Comp. Assy. in compact case. Switches from F to C

COMPUTER BOARD KITS	
8K RAM Board Kit	$135.00
4K EPROM Kit	114.95
I/O Board Kit	44.50
Extender Board w/connector	12.50
16K EPROM board kit w/o PROMS	74.50
North Star Floppy Disk Kit	$665.00
Additional Drive Kit	415.00

SPECIAL PRODUCTS	
MM5865 Stopwatch Timer	9.00
PC board	7.50
Switches Mom. Pushbutton	.27
3 pos. slide	.25
Encoder HD0165-5	6.95
3 Digit Universal Counter Board Kit Operates 5–18 Volt DC to 5 MHz typ. .125" LED display	10.50
Voice actuated switch	.50
Paratronics 100A Logic Analyzer Kit	$224.00
Model 10 Trigger Expander Kit	$229.00
Model 150 Bus Grabber Kit	$369.00
Sinclair 3½ Digit Multimeter	$59.95
Clock Calendar Kit	$23.95

TRANSFORMERS	
6V 300 ma	3.25
12 Volt 300 ma transformer	1.25
12.6V CT 600 ma	3.75
12V 250 ma wall plug	2.95
12V CT 250 ma wall plug	3.50
24V CT 400 ma	3.95
10V 1.2 amp wall plug	4.85
12V 6 amp	12.95

DISPLAY LEDS			
MAN1	CA	.270	2.90
MAN3	CC	.125	.39
MAN72/74	CA/CA	.300	1.00
DL704	CC	.300	1.25
DL707/DL707R	CA	.300	1.00
DL727/728	CA/CC	.500	1.90
DL747/750	CA/CC	.600	1.95
DL750	CC	.600	1.95
FND359	CC	.357	.70
FND500/507	CC/CA	.500	1.35
FND503/510	CC/CA	.500	.90
FND800/807	CC/CA	.800	2.20
3 digit Bubble			.60
4 digit bubble			.80
DG8 Fluorescent			1.75
DG10 Fluorescent			1.75
5 digit 14 pin display			1.00
NSN69 9 digit display			.60
7520 Clairex photocells			.39
TIL311 Hex			9.50

COMPUTER GRADE CAPS			
1600	mfd	200V	4.50
2000	mfd	45V	2.50
3200		50V	2.50
5500		25V	2.50
5800		40V	3.00
6100		40V	3.00
6100		50V	3.00
7700		50V	2.50
8000		55V	2.50
9400		65V	3.00
10000		20V	2.50
12000		30V	3.50
35000		25V	5.00
55000		25V	5.00
82000		15V	6.00
60000		10V	6.00

Auto Clock Kit $15.95
DC clock with 4-.50" displays. Uses National MA-1012 module with alarm option. Includes light dimmer, crystal timebase PC boards. Fully regulated, comp. instructs. Add $3.95 for beautiful dark gray case. Best value anywhere.

RCA Cosmac VIP Kit $229.00
Video computer with games and graphics. Fully assem. and test. **$249.00**

Not a Cheap Clock Kit $14.95
Includes everything except case. 2-PC boards. 6-.50" LED Displays. 5314 clock chip, transformer, all components and full instructions. Orange displays also avail. **Same kit w/.80" displays.** Red only. **$21.95** Case **$11.75**

60 Hz Crystal Time Base Kit $4.40
Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy. Kit includes: PC board, IC, crystal, resistors, capacitors and trimmer.

Digital Temperature Meter Kit
Indoor and outdoor. Switches back and forth. Beautiful. .50" LED readouts. Nothing like it available. Needs no additional parts for complete, full operation. Will measure −100° to +200°F, tenths of a degree, air or liquid. Very accurate. **$39.95**
Beautiful woodgrain case w/bezel **$11.75**

NiCad Battery Fixer/Charger Kit
Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.25**

PROM Eraser
Will erase 25 PROMs in 15 minutes. Ultraviolet, assembled **$34.50**

Rockwell AIM 65 Computer
6502 based single board with full ASCII keyboard and 20 column thermal printer. 20 char. alphanumeric display, ROM monitor, fully expandable. $375.00. 4K Assembler $85.00, 8K Basic Interpreter $100.00. Power supply assembled in case $60.00.

Multi-voltage Computer Power Supply
8v 5 amp, ±18v .5 amp, 5v 1.5 amp, −5v .5 amp, 12v .5 amp, −12 option. ±5v, ±12v are regulated. Kit $29.95. Kit with punched frame $34.95. Woodgrain case $10.00.

Video Modulator Kit $8.95
Convert your TV set into a high quality monitor without affecting normal usage. Complete kit with full instructions.

2.5 MHz Frequency Counter Kit
Complete kit less case **$37.50**

30 MHz Frequency Counter Kit
Complete kit less case **$47.75**
Prescaler kit to 350 MHz **$19.95**

79 IC Update Master Manual $35.00
Complete IC data selector, 2500 pg. master reference guide. Over 50,000 cross references. Free update service through 1979. Domestic postage $3.50. Foreign $5.00. 1978 IC Master closeout $19.50.

Stopwatch Kit $26.95
Full six digit battery operated. 2–5 volts. 3.2768 MHz crystal accuracy. Times to 59 min., 59 sec., 99 1/100 sec. Times std., split and Taylor. 7205 chip, all components minus case. Full instructions.

Hickok 3½ Digit LCD Multimeter
Batt/AC oper. 0.1mv–1000v, 5 ranges, 0.5% accur. Resistance 6 low power ranges 0.1 ohm–20M ohm. DC curr. .01 to 100ma. Hand held, ½" LCD displays, auto zero, polarity, overrange. $74.95.

S-100 Computer Boards

8K Static RAM Kit	$135.00
16K Static RAM Kit	265.00
24K Static RAM Kit	423.00
32K Dynamic RAM Kit	310.00
64K Dynamic RAM Kit	470.00
8K/16K Eprom Kit (less PROMS)	$89.00
Video Interface Kit	$139.00
Motherboard $39. Extender Board	$8.99

TERMS: $5.00 min. order U.S. Funds. Calif residents add 6% tax. BankAmericard and Master Charge accepted. Shipping charges will be added on charge cards.

FREE: Send for your copy of our NEW 1979 QUEST CATALOG. Include 28¢ stamp.

CIRCLE 24 ON FREE INFORMATION CARD

THE MOST ADVANCED TIMEPIECE OF ITS KIND IN THE WORLD!

LCD Quartz Alarm Chronograph with calendar and dual time zone!! Watch is the same as Seiko but you pay a lot more for the name! Features:

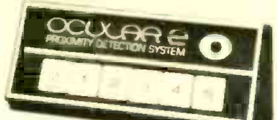
- 24 hour alarm
- Chronograph counts up to 12 hrs., 59 mins. 59.9 sec.
- Precision of chrono up to 1/10 sec indicated by 10 moving arrows!!
- Lap time (with chrono running uninterrupted)
- Time displays by LCD for hour, min, sec, day, date of the week and AM/PM.
- Calendar gives out date-day
- Dual time zone for any two cities of the world at your own choice.
- With light switch to allow you to see the time in the dark!

$65.50

ONE YEAR FULL WARRANTY!

DIGITAL AUTO SECURITY SYSTEM

4 DIGITS PERSONAL CODE!!



- proximity triggered
- voltage triggered
- mechanically triggered

3-WAY PROTECTION!

This alarm protects you and itself! Entering protected area will set it off, sounding your car horn or siren you add. Any change in voltage will also trigger the alarm into action. If cables within passenger compartment are cut, the unit protects itself by sounding the alarm.

SPECIAL $19.95

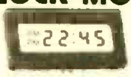
ALL UNITS FACTORY ASSEMBLED AND TESTED—NOT A KIT!

GREEN COLOR 0.6" LED ALARM CLOCK

- 24 hr. alarm
- 10 min. snooze time
- AM/PM Indicator
- Power interrupt Indication
- Green color 0.6" display
- 110V AC 60Hz input
- Factory assembled.

NOT A KIT $17.50 EACH

LCD CLOCK MODULE !



- 0.5" LCD 4 digits display
- X'tal controlled circuits
- D.C. powered (1.5V battery)
- 12 hr. or 24 hr. display
- 24 hr alarm set
- 60 min. countdown timer
- On board dual back up lights
- Dual time zone display
- Stop watch function

NIC1200 (12 hr) $24.50 EA.
NIC2400 (24 hr) $26.50 EA.

JUMBO 1" LED ALARM CLOCK MODULE

Assembled — not a kit!

Features:
- 1" 4 digits red LED display
- 12 hours real time format
- 24 hours alarm audio output (just add speaker)
- Power failure indicator
- Count down timer 59 mins.
- 12-16V AC 50/60 Hz input
- 10 min. snooze control

$8.50 EACH

#PCM 701

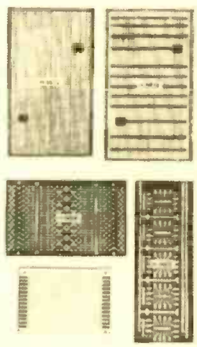
Transformer $1.75

TIMATRON RACK MOUNT TYPE CABINETS!

All are of aluminum and machine made to very high-precision quality with sleek, black anodized finish. Front panels come blank and undrilled to allow you to make panels of your own design. For large quantity orders Formula International will silkscreen print and drill panel holes at a minimal extra charge.

SIZE	PRICE
19" (W) x 2⅓" (H) x 12" (D)	$36.85
19" (W) x 4" (H) x 12" (D)	45.25
19" (W) x 8" (H) x 20" (D)	72.00
16" (W) x 2⅓" (H) x 8" (D)	26.50
16" (W) x 4" (H) x 8" (D)	33.45
9⅓" (W) x 2⅓" (H) x 12" (D)	33.45
9⅓" (W) x 4" (H) x 12" (D)	24.50
9⅓" (W) x 4" (H) x 8" (D)	30.25

UNIVERSAL PROTOBOARDS "CIRCUIT FIT"



All Boards are made of High Quality G10 Fiberglass and Phenolic. Pre-drilled in .042" diameter holes on 0.1" centers with tin plated copper eyelet and finger edge connectors (single sided) to allow any kind of standard components to fit board.

Part No.	Size	Holes	Price Fiberglass	Price Phenolic
U.S.P 723	2" x 2.8"	529	$ 1.27	$ .50
U.S.P 724	2.8" x 3.7"	750	2.42	.80
U.S.P 725	3.7" x 5.5"	1500	4.89	1.38
U.S.P 728	7" x 9.6"	6240	19.50	10.40
H-5612	3½" x 6"			1.70
H-5616	3½" x 6"			1.70
H-5606	3¼" x 5"			1.50
H-5602	2¼" x 6½"			1.50

NEW MARK III
9 Steps 4 Colors
LED VU

Stereo level indicator kit with arc-shape display panel!! This Mark III LED level indicator is a new design PC board with an arc-shape 4 colors LED display (change color from red, yellow, green and the peak output indicated by rose red). The power range is very large, from -30dB to +5dB. The Mark III indicator is applicable to 1 watt – 200 watts amplifier operating voltage is 3V – 9V DC at max 400 MA. The circuit uses 10 LEDs per channel. It is very easy to connect to the amplifier. Just hook up with the speaker output!

IN KIT FORM $18.50

HICKOK LX303 DIGITAL LCD MULTIMETER

- 3½ digits display
- 200 hours 9V battery life
- Auto zero; polarity; overrange indication
- 100MV DC F.S. sensitivity
- 19 ranges and functions
- D.C. volt: 0.1 MV to 1000 V
- A.C. volt: 0.1 V to 600 V
- Resistance: 0.1Ω to 20 MΩ
- D.C. current: 0.01 A to 100 MA

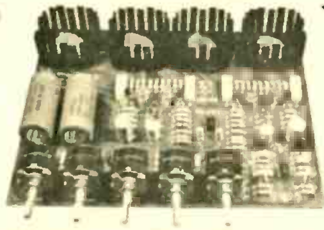
OUR PRICE $71.45

ELECTRONIC DUAL SPEAKER PROTECTOR

Cut off when circuit is shorted or overload to protect your amplifier as well as your speakers. A must for OCL circuits.

KIT FORM **$8.75 EA.**

60W + 60W STEREO AMPLIFIER



COMPLETED UNIT—NOT A KIT!

OCL pre amp. & power stereo amp. with bass, middle, treble 3-way tone control. Fully assembled and tested, ready to work. Total harmonic distortion less than 0.5% at full power. Output maximum is 60 watts per channel at 8 Ω. Power supply is 24 - 36V AC or DC. Complete unit

Assembled $49.50 ea.
Power transformer $ 8.50 ea.

ELECTRONIC WHEEL OF FORTUNE KIT

With 10 numbers split into black and white on dial. The LED turns when you hit the play switch, then it slows down and stops on one number. It sounds like a motor inside, but there is none. Lots of fun and easy to build. Kit comes with nice looking case, all electronic parts, P.C. Board and LEDs. Bettery not included.

$12.50

FM WIRELESS MIC KIT

It is not a pack of cigarettes. It is a new FM wireless mic kit! New design PC board fits into a plastic cigarette box (case included). Uses a condensor microphone to allow you to have a better response in sound pick-up. Transmits up to 350 ft.! With an LED indicator to signal the unit is on.

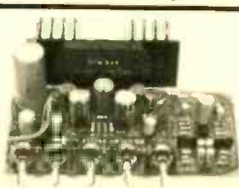
#FMM2 **KIT FORM $7.95**

GENERAL PURPOSE INSTRUMENT BOXES

All boxes are made of aluminum. Top is anodized black. Bottom is silver and comes with 4 rubber pedestals.

Part No.	Sizes	Price
FTA 421	4 1/8" (W) x 1 1/2" (H) x 2 7/8" (O)	$2.10 ea.
FTA 452	4" (W) x 2" (H) x 5" (O)	3.50 ea.
FTA 572	5 3/8" (W) x 2 3/4" (H) x 7" (O)	4.95 ea.

22W + 22W STEREO HYBRID AMPLIFIER KIT



It Works in 12V D.C. As Well! Kit includes 1 PC SANYO STK-024 stereo power amp. IC LM 1458 as pre amp, all other electronic parts, PC Board, all control pots and special heat sink for hybrid. Power transformer not included. It produces ultra hi-fi output up to 44 watts (22 watts per channel) yet gives out less than 0.1% total harmonic distortion between 100Mz and 10KHz.

$32.50 PER KIT

POWER TRANSFORMER $6.50 EACH

CIRCLE 9 ON FREE INFORMATION CARD

SUPER 15 WATT AUDIO AMP KIT

Uses STK-015 Hybrid Power Amp

Kit includes: STK-015 Hybrid IC, power supply with power transformer, front Amp with tone control, all electronic parts as well as PC Board. Less than 0.5% harmonic distortion at full power ½dB response from 20—100,000 Hz. This amplifier has QUASI—Complimentary class B output. Output max is watt (10 watt RMS) at 4Ω.

ONLY $23.50 each

FM WIRELESS MIC KIT

This new model FM wireless MIC kit uses 3 high freq. transistors, works in the FM range (88-108 MHz). It transmits the sound wave fidelity clearly over long distances (up to 250 ft.). Kit comes with all electronic parts, P.C Boa d and mini microphone!

$6.95 EACH KIT

WE FOUND THE CASE FOR THE FM MIC!

Small nice looking aluminum case size like a pack of cigarettes. It is an intercom Audio amp inside with a mic jack, a mini toggle sw on top, can be used for many projects. We give you the circuit data as well.

VERY SPECIAL PRICE 2 for $4.99

Sub-Mini Size CONDENSER MICROPHONE

$2.50 each

FET Transistor Built-In

MINI ELECTRONIC ORGAN KIT

PET-102 (25 KEYS)

The kit contains all electronic and mechanical parts, key boards, speaker, switches and PC Board as well as the wooden cabinet. Ideal for school project or gift to children interested in electronics. Uses 6V C size x 4 battery (not included).

$38.50

PROFESSIONAL CASE

for our 0-30V Power Supply. It is a nice looking metal cast case with giant 4" volt/amp meter; output blinding post and fuse holder, on/off switch and line cord! ONLY $21.50 EA.

CASE 030

FLUORESCENT LIGHT DRIVER KIT

12V DC POWERED

Lights up 8 ~ 15 Watt Fluorescent Light Tubes

Ideal for camper, outdoor Auto or Boat

Kit includes high voltage coil, power transistor, heat sink, all other electronic parts and PC Board, light tube not included!

WITH CASE ONLY $6.50 PER KIT

MANY SOUND DECISIONS!

Solid state sound indicator operating voltage 6V DC 30μA. Small size approximately ¾" X 1⅛".

Model EB2116 (Continuous)
Model EB2126 (Slow Pulse)
Model EB2136 (Fast Pulse)

$3.60 EACH

Continuous | Slow pulse | Fast pulse

POWER SUPPLY KIT

0-30V D.C. REGULATED

Uses UA723 and ZN3055 Power TR output can be adjusted from 0-30V, 2 AMP. Complete with PC board and all electronic parts.

0-30 POWER SUPPLY $10.50 each

Transformer for Power Supply, 2AMP 24V x 2 $8.50

12V DC MINI RELAY

6V	SPDT	2AMP	1.30
12V	SPDT	3AMP	1.60
12V	DPDT	2AMP	2.50
12V	4PDT	3AMP	3.50

5 AMP 5VDC

3 Terminals Positive Voltage Regulator Hard to find! Fairchild 78H05To-3 Package, Input 8.5 - 20V DC Output +5V DC 5AMP Load Regulation 1%.

Only $8.75 ea

HEAVY DUTY CLIP LEADS

10 pairs — 5 colors

Alligator clips on a 22" long lead. Ideal for any testing.

$2.20/pack

1Watt AUDIO AMP

All parts are pre assembled on a mini PC Board

Supply Voltage 6 ~ 9V D.C.

SPECIAL PRICE $1.95 ea.

ELECTRONIC SWITCH KIT

CONDENSER TYPE

Touch On Touch Off uses 7473 I.C. and 12V relay

$5.50 each

MINI-SIZED I.C. AM RADIO

Size smaller than a box of matches! Receives all AM stations

Batteries and ear phone included

Only $10.50

"FISHER" 30 WATT STEREO AMP

MAIN AMP (15W X 2)

Kit includes 2 pcs. Fisher PA 301 Hybrid IC all electronic parts with PC Board. Power supply : 16V DC (not included). Power band with (KF 1% : 3dB). Voltage gain 33dB. 20Hz — 20KHz.

Super Buy Only $18.50

ULTRA SONIC SWITCH KIT

Kit includes the Ultra Sonic Transducers, 2 PC Boards for transmitter and receiver. All electronic parts and instructions. Easy to build and a lot of uses such as remote control for TV, garage door, alarm system or counter. Unit operated by 9—12 DC.

$15.50

EECO THUMBWHEEL SWITCHES

BCD OUTPUT 0—9

10 positions 3 digits with end and each digit section is detatchable.

3 Digits only $5.00

5W AUDIO AMP KIT

2 LM 380 with Volume Control

Power Supply 6 ~ 18V DC

ONLY $6.00 EACH

TIMER KIT

Time Controlled from 1-100sec. Ideal to be used as timer delay unit for burglar alarm, photo service, and other purposes. Max. loading 110V, 2 AMP. Supply voltage 12-18V DC.

PT-60 ELECTRONIC IC TIMER $11.50 each

Sub Mini Size PANEL METER

500 UA

ONLY $1.20 ea

HARD TO FIND!!

12V 4PDT RELAY

3 Amp Contact

$3.50 Each

NUMERIC AND HEXADECIMAL LED DISPLAY WITH LOGIC

HP 5082 - 7300

- 4 x 7 Dot Matrix 0.4" Digit
- With On Board Decoder/ Driver and Memory.
- TTL Compatible
- BCD Input

SPECIAL $9.90 Each

ELECTRONIC ALARM SIREN

COMPLETE UNIT

Ideal for use as an Alarm Unit or hookup to your car back up to make a reverse indicator. Light Output up to 130dB

Voltage Supply 6 ~ 12V $7.50

AU—999

CDS LIGHT CONTROL SWITCH KIT

High Sensitivity Darlington Circuit, operated with a 9V D.C. supply to control lights or use it for burglar alarm, shooting game, visitor buzzer, product counting, flash-light slave unit or automatic door opener and many more. The potentiometer is to adjust the sensitivity and the relay in the circuit can handle up to 200 watts.

$4.50 ea. kit

TRANSFORMERS

ALL 117 VOLT INPUT

30V	4AMP	$7.50 EA.
36V CT	3AMP	$8.50 EA.
48V CT	3AMP	$8.50 EA.
24V CT	3AMP	$8.50 EA.
24V CT	0.8AMP	$1.80 EA.
12V CT	0.5AMP	$1.80 EA.
12V CT	120MA	$1.25 EA.

AC POWER SUPPLY

Wall Type Transformer

12V AC	Output	200MA	$2.75 EA.
16V CT AC	Output	100MA	$2.10 EA.
6V DC	Output	120MA	$1.90 EA.
12V DC	Output	100MA	$1.90 EA.

GIANT SIZE VU METER

1MA movement 3 1/2" scale length. Scale in VU -20db to +3db. Meter face 5 1/8" x 2 3/8" with a "smoke" plastic cover.

4"

5 1/8"

SPECIAL

$8.50 Each

SOUND ACTIVATED SWITCH

All parts completed on a PC Board. SCR will turn on relay, buzzer or trigger other circuit for 2 - 10 sec (adjustable). Ideal for use as door alarm, sound controlled toys and many other projects.

Supply voltage 4.5V ~ 9V D.C.

$1.75 ea./2 for $3.00

LINEAR SLIDE POT

500KΩ SINGLE

Metal Case 3" Long

2 FOR $1.20

TEXTOOL 40 PINS D.I.P. ZERO INSERTION TEST SOCKET

It is perfectly suited for both hand test and burn in requirements. All brand new parts. $8.75 ea.

PROFESSIONAL PANEL METERS

A. 0-50UA	8.50 ea
B. 0-30VDC	8.50 ea
C. 0-50VDC	8.50 ea
D. 0-3ADC	9.00 ea
E. 0-100VDC	9.00 ea

2"

2¾"

Type MU-52E

All meters white face with black scales. Plastic cover.

PUSH-BUTTON SWITCH

N/Open Contact

Color: Red, White, Blue, Green, Black. 3/$1.00

N/Close also Available 50¢ ea.

LARGE QTY. AVAILABLE

Rechargeable NI-CD Batteries Pak

6AA NI-CD in a flat pack gives you a total of 7.2V 450MA output

$5.25 PER PACK

I.C. TEST CLIPS

Same as the E Z clips With 20" Long Leads in Black and Red Colors

$2.75 per pair

SOLID STATE ELECTRONIC BUZZER

Mini size 1" x ¾" x ¾"

Supply voltage 1.5V 12V

Ideal for Alarm or Tone Indicator

$1.50 each

BATTERY POWERED FLUORESCENT LANTERN

FEATURES

- Circuitry designed for operation by high efficient, high power silicon transistor which enable illumination maintain in a standard level even the battery supply drops to a certain low voltage
- 9" 6W cool/daylight miniature flourescent tube
- 8 x 1.5V UM 1 (size D) dry cell battery
- Easy sliding door for changing batteries.
- Stainless reflector with wide angle increasing lumination of the lantern

$10.50 EACH
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Contacts	Price	Contacts	Price
8 PIN	.08	22 PIN	.22
14 PIN	.12	24 PIN	.24
16 PIN	.14	28 PIN	.28
18 PIN	.18	40 PIN	.40
20 PIN	.20		

GENERAL INSTRUMENT

1 Amp Rectifiers (Epoxy)

Part No.		Price
1N4001	50V	.029
1N4002	100V	.039
1N4002	200V	.045
1N4004	400V	.049
1N4005	600V	.055
1N4006	800V	.065
1N4007	1000V	.07

1.5 Amp Single Phase Silicon Bridge Rectifiers

Part No.		Price
W06M	600V	.34
W08M	800V	.39

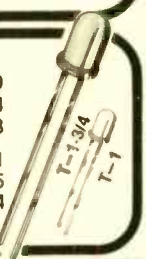
SWITCHING DIODES

Part No	Price
1N914 (100V 4NS)	.027
1N4148 (100V 4NS)	.027

L.E.D. LAMPS

LED209	T-1 3mm Red	.09
LED211	T-1 3mm Green	.14
LED212	T-1 3mm Yellow	.13
LED220	T-1-3/4 5mm Red	.11
LED222	T-1-3/4 5mm Green	.15
LED224	T-1-3/4 5mm Yellow	.14

MAJOR MANUFACTURER



CMOS I.C.'S

CD4000BE	.17	CD4042BE	.59	CD4515BE	$1.95
CD4001BE	.17	CD4043BE	.57	CD4516BE	.69
CD4002BE	.17	CD4044BE	.55	CD4518BE	.79
CD4006BE	.87	CD4046BE	.99	CD4519BE	.47
CD4007BE	.17	CD4049BE	.33	CD4520BE	.69
CD4008BE	.75	CD4050BE	.33	CD4522BE	.99
CD4009BE	.39	CD4051BE	.54	CD4526BE	.99
CD4010BE	.39	CD4052BE	.54	CD4527BE	$1.09
CD4011BE	.17	CD4053BE	.54	CD4528BE	.69
CD4012BE	.17	CD4060BE	.99	CD4531BE	.74
CD4013BE	.32	CD4066BE	.44	CD4532BE	$1.19
CD4014BE	.73	CD4068BE	.21	CD4539BE	.99
CD4015BE	.69	CD4069BE	.21	CD4543BE	$1.39
CD4016BE	.35	CD4070BE	.29	CD4555BE	.65
CD4017BE	.62	CD4071BE	.21	CD4556BE	.65
CD4018BE	.69	CD4072BE	.21	CD4581BE	$2.25
CD4019BE	.39	CD4073BE	.21	CD4582BE	.79
CD4020BE	.69	CD4075BE	.21	CD4584BE	.60
CD4021BE	.69	CD4076BE	.79	CD4585BE	.90
CD4022BE	.69	CD4077BE	.25	40014PC	.59
CD4023BE	.17	CD4078BE	.21	40085PC	$1.09
CD4024BE	.49	CD4081BE	.21	40097PC	.60
CD4025BE	.17	CD4082BE	.21	40098PC	.60
CD4026BE	$1.39	CD4085BE	.69	40160PC	.89
CD4027BE	.39	CD4086BE	.69	40161PC	.99
CD4028BE	.57	CD4093BE	.40	40162PC	.89
CD4029BE	.74	CD4104BE	$2.25	40163PC	.99
CD4030BE	.35	CD4502BE	.85	40174PC	.89
CD4033BE	$1.45	CD4508BE	$2.25	40175PC	.89
CD4034BE	$2.25	CD4510BE	.88	40192PC	$1.19
CD4035BE	.64	CD4511BE	.99	40193PC	$1.19
CD4040BE	.74	CD4512BE	.59	40194PC	$1.10
CD4041BE	.74	CD4514BE	$1.95	40195PC	$1.10

LINEAR I.C.'S

LM324N	.49	Quad Op Amp
LM339N	.49	Quad Comparator
LM555N-8	.29	Timer
LM556N-14	.59	Dual Timer
LM723CN	.34	Voltage Regulator
LM723CH	.39	Voltage Regulator
LM741CH	.37	Op Amp
LM741CN-8	.24	Op Amp
LM1458N-8	.39	Dual Op Amp

VOLTAGE REGULATORS

PART NO.	UNIT PRICE	DESCRIPTION
LM323K	~~$5.50~~ $4.95	3 Amp 5 Volt Regulator
78H05KC	$5.75	5 Amp 5 Volt Positive Regulator TO3
7800UC Series TO-220/LM340T	.79	Positive Voltage Regulators (Plastic) 1 Amp 5, 6, 8, 12, 15, 18, 24 Volts
78MOOHC Series TO-5/LM340H	$1.50	Positive Voltage Regulator 1/2 Amp 5, 6, 8, 12, 15, 18, 24 Volts
7800KC Series TO-3/LM340K	$1.60	Positive Voltage Regulator 1 Amp 5, 6, 8, 12, 15, 18, 24 Volts
78LOOAWC Series TO-92	.29	Positive Voltage Regulator 100 MA 2.6, 5, 6.2, 8.2, 12, 15 Volts
7900UC Series TO-220/LM320T	$1.10	Negative Voltage Regulator 1 Amp 5, 6, 8, 12, 15, 18, 24 Volts
79M00HC Series TO-5/LM320H	$1.50	Negative Voltage Regulator 1/2 Amp 5, 6, 8, 12, 15, 20, 24 Volts
7900KC Series TO-3/LM320K	$1.95	Negative Voltage Regulator 1 Amp 5, 6, 8, 12, 15, 18, 24 Volts
78MGT2C	$1.25	Dual In Line Adjustable 4 Terminal Positive Voltage Regulator
78GUI TO-220	$1.45	1 Amp Adjustable Positive Voltage Regulator
78S40PC	$2.50	Switching Regulator

All new major manufacturer production material offered.
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MICROPROCESSOR CHIPS

CPU's

Part No.	Price
8080A	~~5.95~~ 5.50
6800	~~8.95~~ 7.95

INTERFACE SUPPORT CIRCUITS

Part No.	Price	Part No.	Price
8212	1.98	8255	5.95
8214	~~4.95~~ 3.95	8257	9.95
8216	1.98	8259	14.95
8224	2.75		
8226	1.98	6810	~~3.95~~ 3.50
8228	4.75	6820	~~4.95~~ 3.95
8238	4.75	6821	~~4.95~~ 3.95
8251	~~5.95~~ 4.95	6850	~~5.95~~ 4.95
8253	14.95	6852	~~5.95~~ 4.95

MOS Static RAM's

Part No.	Price
2102LFPC 1K 350NS (Low Power)	$1.19
2102-1PC 1K 450NS	$.99
2114 4K (1K x 4) 300NS	$7.50
2114 4K (1K x 4) 450NS	$6.50

MOS Dynamic RAM's

Part No.	Price
4K 4027 4K (4K x 1) 300NS 16 PIN	$2.95
416-3 200NS	$9.95
416-5 300NS	$7.95

UART's

Part No.	Price
AY5-1013A	$4.95
AY3-1015	$5.95

1K CMOS RAM

Part No.	Price
5101 450NS (Low Power)	$4.95
5101 800NS	$3.95

Zilog

Z80-CPU	~~14.95~~ $13.60	Z80-CTC	$10.90
Z80A-CPU	~~24.95~~ $16.20	Z80A-CTC	$13.10
Z80-PIO	$10.90	Z80-DMA	~~46.00~~ $32.20
Z80A-PIO	$13.10	Z80-SIO/0	~~59.00~~ $45.00
		Z80A-SIO/0	~~68.00~~ $50.00
		Z80-SIO/1	~~59.00~~ $45.00
		Z80A-SIO/1	~~68.00~~ $50.00

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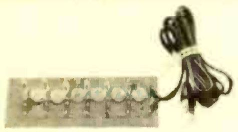


103 MINI-WINK NEON FLASHER. Random flash pattern. Interesting displays. 6 neon lamps. AC operated.

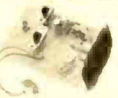
103	$2.95
103A (103 w/PCB)	4.60
103B (103 w/PCB, CASE)	6.85

110 ELECTRONIC WHOOPER SIREN. Powerful wailing sound. Dual oscillator circuit. Use with any alarm circuit. Battery not included.

110	$4.95
110A (110 w/PCB)	6.50
110B (110 w/PCB, CASE)	9.60

117 TUNABLE ELECTRONIC ORGAN. Tunable 7-note scale. Play sing-a-long favorites. Battery not included.

117	$6.95
117A (117 w/PCB)	8.90
117B (117 w/PCB, CASE)	12.00

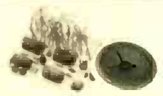


120 SIREN/CODE OSCILLATOR. Loud, piercing alarm. Practice Morse code. Battery not included.

120	$4.20
120A (120 w/PCB)	5.55
120B (120 w/PCB, CASE)	8.65

104 VARIABLE STROBE LIGHT. Great for parties and photography. Variable flash rate. AC operated.

104	$9.95
104A (104 w/PCB)	14.20
104B (104 w/PCB, CASE)	19.70



126 PROGRAMMABLE DOORBELL. Adjustable rate and pitch for 15 musical notes. Play favorite tunes. 6 IC's. Uses existing transformer and switch.

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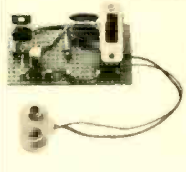
126A (126 w/PCB)	23.70
126B (126 w/PCB, CASE)	29.20

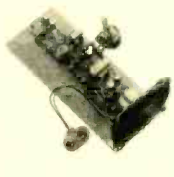
*Perforated Boards **NOT INCLUDED** w/100 Series*



109 AUTO/HOME BURGLAR ALARM. Use with car horn or models 110 or 124 sirens. Latching circuit. Battery not included.

109	$2.25
109A (109 w/PCB)	3.40
109B (109 w/PCB, CASE)	5.00

114 AUDIO AMPLIFIER. High sensitivity, high gain, use as intercom, PA amp, phone pick-up and others, push-pull output. Battery not included.



114	$6.35
114A (114 w/PCB)	8.90
114B (114 w/PCB, CASE)	12.00

102 6/9 VOLT SUPPLY. 100mA. Battery eliminator, dual range output switch, neon pilot lamp. AC operated.

102	$3.95
102A (102 w/PCB)	5.30
102B (102 w/PCB, CASE)	7.25

119 MOTOR SPEED CONTROL. Adjust motor speed to suit application. SCR controlled, use as light dimmer. AC operated.

119	$3.95
119A (119 w/PCB)	5.50
119B (119 w/PCB, CASE)	7.75

123 ELECTRONIC TIMER. Turns appliances on and off, adjustable control, 2 minutes to 1 hour. 1 IC, AC operated.

123	$8.95
123A (123 w/PCB)	11.40
123B (123 w/PCB, CASE)	13.65

540 BINARY CLOCK. Handcraft tomorrow's timepiece today. Watch constantly changing patterns of LED's as they display Binary Time. This unique clock project enhances the learning of Digital Logic and the Binary Coding System, as well as offering a beautifully styled conversation piece.

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*Perforated Boards **NOT INCLUDED** w/100 Series*

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124	$5.65
124A (124 w/PCB)	7.10
124B (124 w/PCB, CASE)	10.20

105 FISH CALLER. Clicking sound imitates distressed fish. Adjustable speed. Battery not included.

105	$2.95
105A (105 w/PCB)	4.10
105B (105 w/PCB, CASE)	5.70

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107A (107 w/PCB)	11.85
107B (107 w/PCB, CASE)	14.95

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118	$1.95
118A (118 w/PCB)	2.90
118B (118 w/PCB, CASE)	4.50

122 COMPUTER SOUND EFFECTS GENERATOR. Produces weird, spacey sounds. 4 IC's. Control tone, rate and blip or glide. Battery not included.

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122A (122 w/PCB)	19.40
122B (122 w/PCB, CASE)	24.90

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18-ST	18 Pin Solder Tab	.18
20-ST	20 Pin Solder Tab	.20
22-ST	22 Pin Solder Tab	.22
24-ST	24 Pin Solder Tab	.24
28-ST	28 Pin Solder Tab	.28
40-ST	40 Pin Solder Tab	.40
8-WW	8 Pin Wire Wrap	.24
14-WW	14 Pin Wire Wrap	.28
16-WW	16 Pin Wire Wrap	.30
18-WW	18 Pin Wire Wrap	.60
20-WW	20 Pin Wire Wrap	.70
22-WW	22 Pin Wire Wrap	.84
24-WW	24 Pin Wire Wrap	.96
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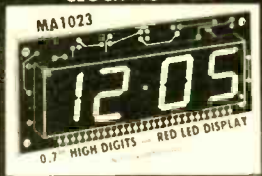

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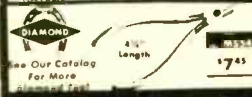

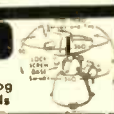

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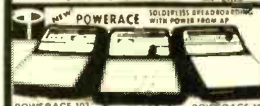

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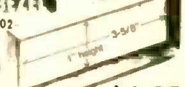

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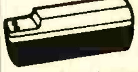

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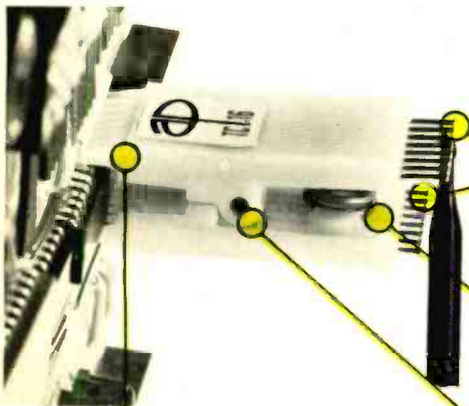

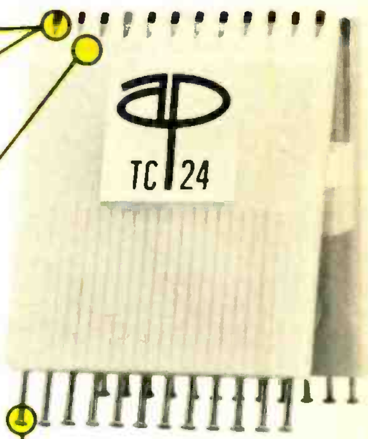

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