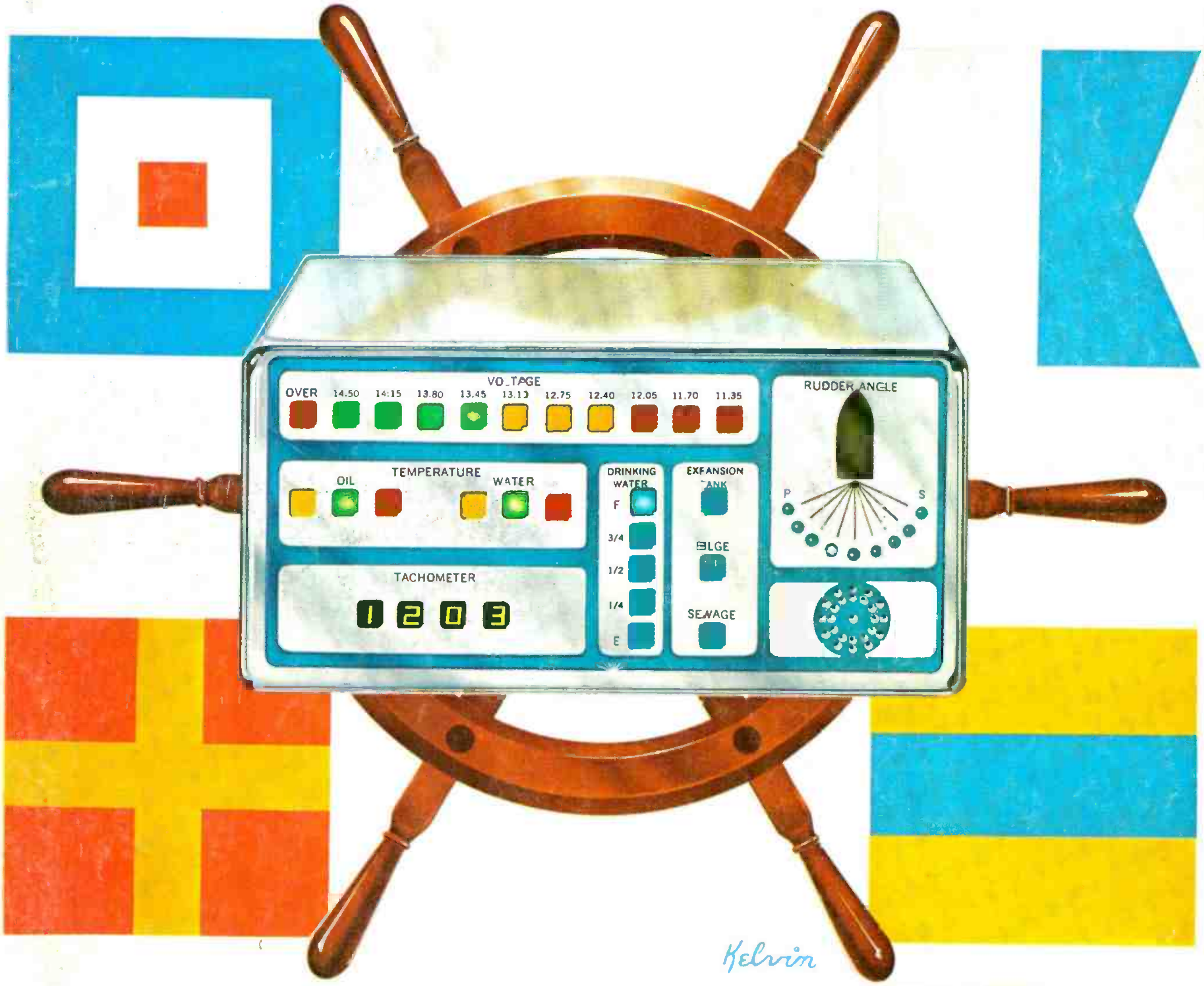
Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE JULY 1979/$1.25

A Universal Charger for Batteries
Build a $10 In-Circuit Transistor Tester
How to Use Decibels for Audio & R-F

Space-Age Electronic Projects for Boats



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Popular Electronics

Tested In This Issue

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Empir...
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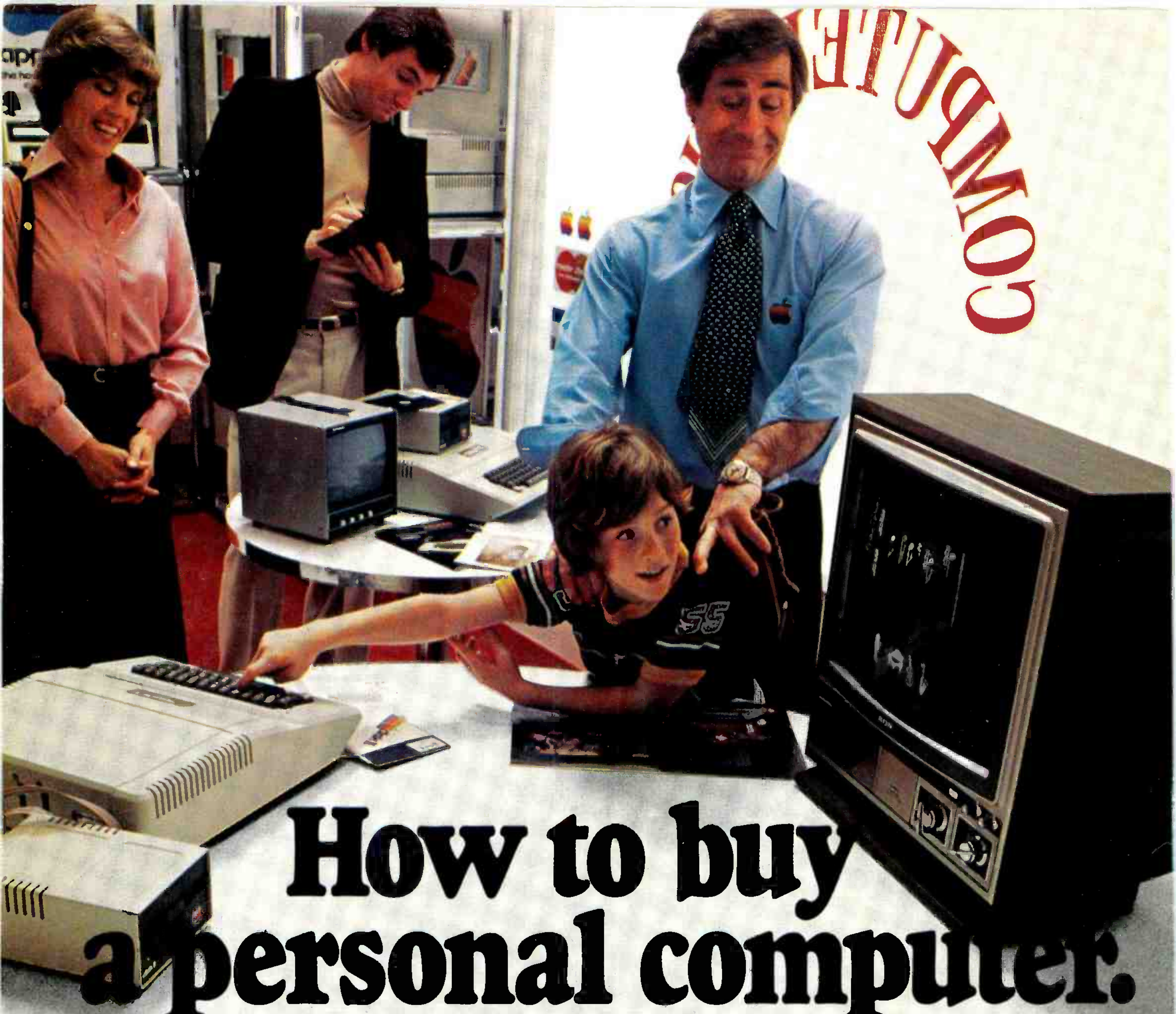
...e Receiver



How to buy a personal computer.

In California, a store owner charts sales on his Apple Computer. On weekends though, he totes Apple home to help plan family finances with his wife. And for the kids to explore the new world of personal computers.

A hobbyist in Michigan starts a local Apple Computer Club, to challenge other members to computer games of skill and to trade programs.

Innovative folks everywhere have discovered that the era of the personal computer has already begun—with Apple.

Educators and students use Apple in the classroom. Businessmen trust Apple with the books. Parents are making Apple the newest family pastime. And kids of all ages are finding how much fun computers can be, and have no time for TV once they've discovered Apple.

Visit your local computer store

The excitement starts in your local computer store. It's a friendly place, owned by one of your neighbors. He'll show you exactly what you can use a personal computer for.

What to look for

Your local computer store has several different brands to show you. So the salesman can recommend the one that best meets your needs. Chances are, it will be an Apple Computer. Apple is the one you can program yourself. So there's no limit to the things you can do. Most important, Apple's the one with more expansion capability. That means a lot. Because the more you use your Apple, the more uses you'll discover. So your best bet is a personal computer that can grow with you as your skill and involvement grow. Apple's the one.

It's your move

Grab a piece of the future for yourself. Visit your local computer store. We'll give you the address of the Apple dealer nearest you when you call our toll-free number. Then drop by and sink your teeth into an Apple.

800-538-9696. In California, **800-662-9238.**

CIRCLE NO. 6 ON FREE INFORMATION CARD

apple computer

Treasure Detector

A new computerized metal detector that actually selects treasure from trash may uncover America's long lost relics and precious metals.

The new breakthrough in metal detectors makes finding treasure much easier.

There's a lot of treasure right under our feet. There's also a lot of garbage.

And the problem with most metal detectors is that they're dumb. They can't tell treasure from trash.

The new Techna metal detector is different. It has both a sensing system and a brain that can tell the difference between a foil gum wrapper and a coin—between a bottle cap and a diamond ring.

The new breakthrough was made possible by the use of a "discriminator IC"—a computer-type integrated circuit that can compare the ferrous and non-ferrous relationships that distinguish treasure from trash.

There are discriminator-type metal detectors now on the market, but they cost between $170 and $400. And no matter what price you pay, the detector is usually difficult to operate.

The new Techna Discriminator represents several breakthroughs. First, it is inexpensive—only $69.95. Secondly, it uses a new (patent pending) phase compensation system of metal detection, whereas other discriminators use either the off-resonance or inverse discrimination principle.

This system utilizes a microprocessor circuit which replaces the conventional electronics, mode switch, and multiple tuners that added to the cost and weight of a discriminator unit.

Finally, the Discriminator is very easy to operate and understand. You simply set it to sense treasure, trash, or both and it automatically tunes itself and starts operating. Whenever you scan treasure, a loud speaker will emit a sound and you start digging.

DETECTORS ARE BIG BUSINESS

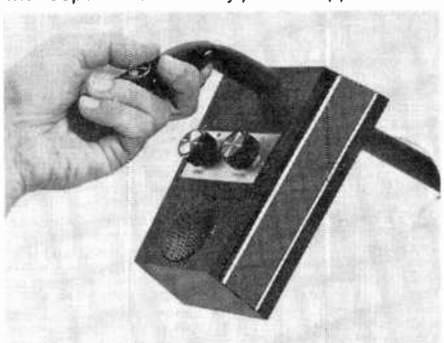
Metal detectors are big business. When we investigated the field, we discovered an entire new sport—treasure hunting. Treasure clubs exist and conduct contests. There's a national magazine and an association, and hundreds of thousands of units are in use every day.

Treasure hunting doesn't just mean looking for buried pirate chests. There's great interest now in discovering articles of historical significance such as old coins, military buttons, and old pistols.

Long ago when people distrusted banks, they buried their valuables somewhere on their property. If they died suddenly or became senile, their treasures were lost forever. Many treasure hunters are now visiting ghost towns or going through older sections of cities looking for both historic and valuable articles.

WORLD WAR II STARTED IT

Metal detectors first saw extensive use during World War II. Back then, they were called mine detectors and were used to uncover enemy land mines. They were heavy, often weighing hundreds of pounds, and had to be carried on the backs of soldiers along with separate and heavy power supplies.



The Techna Discriminator is light and easy to operate with only two controls to adjust.

The new Techna Discriminator is light. It weighs only 2½ pounds and is powered by two readily-available 9-volt batteries. As you glide the sensing head over the ground, the unit remains silent until it uncovers a precious metal or whatever type metal you are searching for. An electronic sound is emitted. Then just dig in the area of the sound.

If you already own an expensive metal detector, you know that most of your "discoveries" turn out to be bottle caps or gum wrappers. With the Techna, you discover just what's worth digging up. While others are digging up bottle caps, you're covering more ground faster and are more likely to discover something worthwhile.

BREAKTHROUGH PRICE

The fully computerized Techna Discriminator is available from JS&A for only $69.95 complete with batteries and all components. We suggest you order one just to try it out. Try it in your back yard. Take it to a sandy beach where many coins and jewelry are lost. See how the system can tell the difference between treasure and trash, and then after you have discovered the fun of treasure hunting and how advanced this new product really is, decide whether or not you wish to keep it.

If you feel the Techna Discriminator does not meet all your expectations for any reason, we will gladly accept the return of your unit within our 30 day trial period and even refund your $3.50 postage and handling. If you decide to keep your unit, you will own the world's most advanced metal detector. No competitive model even comes close.

Techna is America's largest manufacturer of metal detectors in the United States, and JS&A is America's largest single source of space-age products—further assurance that your modest investment is well protected.

Each Techna detector is backed by a solid one-year parts and labor limited warranty. We doubt if you'll ever have a problem with the unit because of its solid-state construction, but if service is ever indeed required, Techna's service-by-mail center will fix your unit and have it back to you quickly.

To order your Techna Discriminator detector, send your check for **$69.95** plus $3.50 for postage and handling (Illinois residents please add 5% sales tax) to the address shown below. Credit card buyers may call our toll-free number below. We will promptly send you your Techna detector with batteries, 90-day limited warranty, and instructions.

Why not join the legion of treasure hunters worldwide with the world's most advanced space-age metal detector. Order the Techna Discriminator metal detector at no obligation, today.

JS&A PRODUCTS THAT THINK®

Dept.PE One JS&A Plaza
Northbrook, Ill. 60062 (312) 564-7000
Call TOLL-FREE 800 323-6400
In Illinois Call .... (312) 564-7000

NEW! The world's only land, sea and air scanner!

We have received thousands of requests to have a scanner capable of monitoring aircraft, marine and all public service frequencies. The *Bearcat* 220 is one scanner which can monitor all public service bands *plus* the exciting aircraft band channels. In fact, the *Bearcat* 220 covers seven bands, Low VHF, High VHF, UHF, UHF-T, 2-meter and ¾ meter amateur and Aircraft. ***Only the incredible, new, no-crystal Bearcat** 220* Scanner tunes in all the real excitement of the entire AM aircraft band — plus every FM public service frequency — with pushbutton ease. Only the Bearcat 220 has a dual detector to scan *both* AM and FM transmissions in *one* scanner. Up to twenty channels may be scanned at once. Or frequencies can be arranged into two banks of ten frequencies each, allowing the listener to choose the bank of most interest. You can mix and monitor *any combination* of aircraft, marine or public service channels at the same time.

Not only does the new *Bearcat* 220 feature normal search operation, where frequency limits are set and the scanner searches between your programmed parameters, it also searches all marine or aircraft frequencies by pressing a single button. These frequencies are already stored in a read only memory (ROM) so no reprogramming is required.

The new *Bearcat* 220 is a crystalless synthesized scanner and features push button programming of desired frequencies. A decimal display indicates all channels, frequencies and operations that you have programmed into this computerized scanner. The lockout feature lets the listener skip frequencies not of current interest. When the handy priority feature is activated, the frequency on channel 1 is sampled every two seconds regardless of other scanner functions. This means you can listen to "maydays" from a jet in distress at 30,000 feet on 121.5 MHz., while at the same time monitor for other exciting transmissions. The listener can use a factory set automatic squelch position for easier operation, or manually tune the squelch for precision adjustment. In addition, the *Bearcat* 220 has connectors for external antenna, external speakers, and *both* AC/DC power.

MANY IMPORTANT FEATURES

Other important *Bearcat* 220 features include: direct channel access for going directly to a desired channel; patented selective scan delay so scanning on desired channels is delayed two seconds after the end of a transmission; and scan speed control which allows scanning and searching at 11 or 4 channels per second. Since the *Bearcat* 220 uses two AA size batteries to maintain channel memory for one year, if you remove the batteries, your scanner will *"self-destruct"* all programmed channels when power is removed, in case your scanner falls into enemy hands.

TEST A BEARCAT 220 FREE FOR 31 DAYS

Test any *Bearcat* brand scanner from Communications Electronics™ for 31 days before you decide to keep it. Check out the excellent specifications and reception quality of the *Bearcat* 220. If you decide to keep it, you'll own the most sophisticated and technologically advanced scanner available. If for any reason you are not completely satisfied, we insist that you return it in new condition with all enclosed parts in 31 days, for a courteous and prompt refund (less shipping charges and rebate credits).

COMPLETE NATIONAL SERVICE

With your *Bearcat* 220 scanner, we will send a complete set of simple operating instructions and a one-year limited warranty. If service is ever required on any *Bearcat* scanner purchased from Communications Electronics, just send you're receiver to one of our *approved* national service centers. When you purchase your scanner from Communications Electronics, you're buying from the world's **leader** in no-crystal, high technology scanners. *We've sold more synthesized scanners than any other company!* A detailed service manual for the *Bearcat* 220 should be available in October, 1979 for $15.00 postpaid.

MADE BY ELECTRA - QUALITY CHECKED BY CE

Since all *Bearcat* scanners sold by Communications Electronics™ are products of Electra Company, a Division of Masco Corporation of Indiana, you can be assured of the finest monitor radios available in the world. In addition, our Quality Control Department further audits the quality of every *Bearcat* model sold by us to insure the high reliability found in all *Bearcat* scanners. CE has given the *Bearcat* 220 our quality control rating #2, which is a better overall rating than the *Bearcat* 210 but not as good as the world famous *Bearcat* 250.

$20.00 REBATE! — SAVE EVEN MORE

The suggested list price of the *Bearcat* 220 is $379.95. Our normal price is $299.00. But...if you order before August 31, 1979, you will earn a $20.00 rebate. As long as your order is placed before August 31, 1979, you will qualify for our CE direct rebate even if delivery is after August 31st. See "the small print" for further details of our *Bearcat* rebate offer.

THE SMALL PRINT

All sales are subject to availability. Prices and specifications are subject to change without notice. No COD's please. Cashier's checks may be processed immediately and receive an order priority number. Personal checks require three weeks bank clearance. All orders will be shipped in the sequence received. The special rebate offer on the *Bearcat* 220 is good only when purchased from Communications Electronics,™ Scanner Distribution Center™ between June 1 and August 31, 1979. Communications Electronics proof of purchase invoice and special rebate coupon (enclosed with your order) must be postmarked within 20 days of our shipping date. Offer good in U.S.A. only. International shipments are welcome *without* rebate offer. Void where taxed or prohibited by law. Offer limited to one rebate per scanner. If returned for credit during our 31 day free trial, rebate and shipping costs will be deducted from refund. Resellers, companies, clubs and organizations (profit and non-profit) are not eligible for rebates. Allow 4-6 weeks after rebate request for check.

INCREASED PERFORMANCE ANTENNAS

If you want the utmost in performance from your *Bearcat* 220, it is essential that you use an external antenna. We have four base and mobile antennas specifically designed to receive all seven bands on your *Bearcat* 220 scanner. Order #A60 is a magnet mount mobile antenna. Order #A61 is a gutter clip mobile antenna. Order #A62 is a trunk-lip mobile antenna and #A70 is an all band base station antenna. All antennas are $25.00 postpaid in the continental United States.

Only $279.00 after rebate

Bearcat® 220 Specifications

Frequency Reception Range

Low VHF Band	32-50 MHz
Aircraft Band	118-136 MHz
2 meter amateur band	144-148 MHz
High VHF Band	148-174 MHz
¾ meter amateur band	420-450 MHz
UHF Band	450-470 MHz
UHF-T Band	470-512 MHz

Scanner Dimensions
27.0 cm Wide x 7.6 cm High x 19.4 cm Deep
(10⅝" Wide x 3" High x 7⅝" Deep)

Scanner Weight
3.18 Kilograms
(7 pounds)

Power Requirements
117 V ac, 60 Hz, 20 Watts
13.8 V dc, 9 Watts

Audio Output
At least 2.0 Watts rms, 8 ohms,
10% THD (maximum)

Antenna
Telescoping (supplied), Connector provided for external ant. 50-70 ohms

Scan/Search Speed
Selectable 11 or 4 channels per second

R.F. Sensitivity
0.4 microvolts 32-50 MHz.
0.4 microvolts 144-174 MHz.
0.8 microvolts 420-512 MHz.
(±5 KHz. deviation 12 dB SINAD)
1.0 microvolt for 10 dB S/N Aircraft

IF Selectivity
−55 dB @ +25 KHz.

Front Panel
Volume (ON/OFF), Display, Keyboard, Squelch (Auto. Squelch), Speaker

Rear Apron Connectors
External antenna, External speaker, 117 V ac and 12 V dc receptacles

Accessories
Vehicle mounting bracket and hardware, AC & DC power cords

Specifications are typical and subject to change.

BUY WITH CONFIDENCE

The *Bearcat* 220 is an extraordinary scanning instrument. It provides virtually any scanning function that the most professional monitor could require. From all the tense tower talk, to monitoring the pulse of all public service frequencies. To ***order the world's only land, sea and air scanner and get the fastest delivery***, send or phone your order directly to our Scanner Distribution Center.™ Mail orders to Communications Electronics,™ Box 1002, Ann Arbor, Michigan 48106 U.S.A. Send $299.00 plus $5.00 for U.P.S. U.S. shipping for each *Bearcat* 220 scanner. Your $20.00 rebate coupon will be packed with your scanner. U.P.S. air shipping is even faster and is $9.00 per scanner. Becuase this is the most fantastic scanner that CE has offered and due to the unprecedented demand for this high quality scanner, be prepared to allow between 6 to 12 weeks for delivery. If you have a Master Charge or Visa card, you may call anytime and place a credit card order. **Dial toll free 800-521-4414.** International orders are invited at slightly higher cost. If you are outside the U.S. or in Michigan, dial 313-994-4444. If you order by credit card, your account will be billed about 15 days before we are scheduled to ship your order. **Dealer inquiries invited.** All order lines at CE are staffed 24 hours.

Since this is our most exciting scanner we have ever offered, you must place your order today at no obligation to assure a prompt order confirmation and delivery.

When you follow the leader to real excitement, your journey ends at **Communications Electronics.™**

Autoprogramming,™ Scanner Distribution Center™ and CE logos are trademarks of Communications Electronics.
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Bearcat® 220 Features:

- **20 Channels/2 banks**—Scan up to 20 frequencies at the same time. Activate 10 channels at one keystroke.
- **7 Band Coverage**—Includes Low and High VHF bands, UHF, UHF-T, the entire 2 meter and ¾ meter amateur bands in addition to the aircraft band. With special programming techniques, this unit can monitor additional frequencies *not* published in factory specifications.
- **Automatic Search**—Seek and find new and exciting frequencies.
- **Communications Electronics™**—quality control approval rating #2. Our second highest quality grade for FCC certified technologically sophisticated monitoring equipment.
- **Self-Destruct**—Since the *Bearcat* 220 uses two AA size batteries to maintain channel memory, if you remove the batteries, your scanner will *electronically* erase all programmed channels, in case your scanner falls into enemy hands.
- **Scrambler/Tape Audio Output**—Top secret cryptographic messages may be received and decoded by connecting the *Bearcat* 220's external speaker jack to a correctly keyworded decrypting device, even if it utilizes the National Bureau of Standards, Data Encryption Standard.
- **Small Size**—The *Bearcat* 220's small physical size lends itself to government monitoring applications. When used with a battery power supply and a tape recorder, the *Bearcat* 220 may be easily concealed in an attache case for unattended, unobtrusive surveillance.
- **UL Listed/FCC Certified**—In addition to the #2 rating from Communications Electronics,™ the UL listing and FCC certification assures you of quality design and manufacture.
- **Aircraft Search**—Push *one* button to automatically search the entire aircraft band.
- **Marine Search**—Push one button to automatically search marine frequencies
- **Priority**—Samples programmed priority frequency on channel 1 every 2 seconds regardless of other scanner operations—important for professionals who must monitor a certain frequency.
- **Limit**—Sets the upper and lower frequencies of the user controlled search range.
- **Speed**—Choice of either 11 or 4 channels per second scan speed for closer monitoring of frequencies.
- **Automatic Lockout**—Locks out channels and "skips" frequencies not of current interest.
- **Selective Scan Delay**—Adds a two-second delay on desired channels to prevent missing transmissions when "calls" and "answers" are on the same frequency.
- **Simple Programming**—Simply punch in on the keyboard the frequency you wish to monitor.
- **Decimal Display**—The large decimal display shows channels and frequency as well as features selected.
- **Patented Track Tuning**—Receive frequencies across the full band without adjustment. Circuitry is automatically aligned to each frequency monitored.
- **Crystalless**—Without ever buying a crystal, you can select from all local frequencies by simply pushing a few buttons.
- **Automatic Squelch**—Factory-set squelch automatically blocks out unwanted noise.
- **Direct Channel Access**—Move directly to desired channel without stepping through all channels.
- **Deluxe Keyboard**—Makes frequency and feature selection easy for simply programming.
- **Space Age Circuitry**—Custom integrated circuits... a *Bearcat* tradition in scanning radios.
- **Rolling Zeros**—This *Bearcat* exclusive tells you which channels your scanner is monitoring.
- **AC/DC**—Operates at home, office or in your vehicle.

COMMUNICATIONS ELECTRONICS™

854 Phoenix ☐ Box 1002 ☐ Ann Arbor, Michigan 48106 U.S.A.
Call TOLL-FREE (800) 521-4414 or outside U.S.A. (313) 994-4444

This list is a sample of the many radio services that may be received on the Bearcat® 220 scanner:

Aeronautical Fixed
Aeronautical Mobiles
Air Controllers
Air Force
Aircraft Towers
Amateur
Amateur Satellite
Approach Control
Army
ATIS
Automobile Emergency
Broadcasting
Bureau of Indian Affairs
Bureau of Reclamation
Business
Citizens Band (Class A)
Civil Air Patrol
Coast Guard
Coastal Services
Conservation Services
Corps of Engineers
Customs
Department of Transportation
Domestic Public Land Mobile
Drug Enforcement Agencies
Earth Exploration Satellite
Energy Research
Environmental Protection Agency
Executive Branch
Federal Aviation Administration
Federal Bureau of Investigation
Federal Communications Commission
Federal Protective Service
Fire
Fishing Boats
Fixed Satellite
Fixed Stations
Flight Service Stations
Forest Products
Forest Service
Geodetic Servies
Government
Government Services Administretion
Highway Maintenance
Imigration and Naturalization
Intelligence Agencies
Land Mobile
Local Government
Manufactures
Marine Corps
Maritime Mobiles
Meterological Aids
Meterological Satellite
Military
Mobile Satellite
Mobile Stations
Mobile Telephone
Motion Picture
Motor Carrier
National Park Service
National Weather Service
Navy
NORAD
Oil and Energy Exploration
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Space Operations
Space Research
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We're first with the best.℠

CIRCLE NO. 1 ON FREE INFORMATION CARD

JULY 1979

Popular Electronics®

VOLUME 16, NUMBER 1

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

Feature Articles

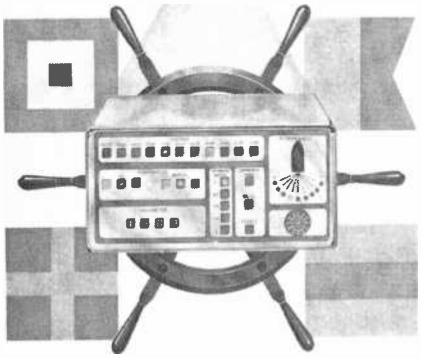
Construction Articles

Columns

Julian Hirsch Audio Reports

Electronic Product Test Reports

Departments



About the cover:

Useful electronic circuits can perform sensing, processing and displaying functions aboard your boat to make it safer and more convenient to operate.

Cover Art by George Kelvin

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Editorial

UNSUNG ELECTRONICS INVENTORS

Names of today's innovative developers of electronic devices and products are hardly household words. Where are the modern Edison's, Marconi's, de Forest's, et al? Buried in corporate research laboratories, where, in concert with teams of others and bolstered by many millions of dollars, they work in virtual anonymity. Unlike electronics "stars" of the past, they are not heads of our present-day corporations. Consequently, the corporation generally takes credit for new, outstanding developments. The only exception that comes quickly to mind is Bell Labs' famous trio which was credited with inventing the transistor—Bardeen, Brattain, and Shockley. These scientists earned a Nobel prize.

Isn't this shameful? After all, money isn't everything. So let's have a big "hurrah" for, say, Hans Camenzind. Hans who? Well, he's the guy who invented the ubiquitous 555 timer over at National Semiconductor. And how about a "rah, rah" for Bob Widlar for the 708 and 741 chips out of Fairchild. And a big hand for Texas Instruments' Jack Kilby who, in 1959, devised the idea of making component elements in one package by semiconductor processes (the result was what we call an integrated circuit). And a round of applause for Bob Noyce's innovative spearheading of the planar semiconductor while at Fairchild (he's now head of National Semi), which separated and interconnected circuit elements electrically. (This technique was patented by Kurt Lehovec at Sprague Electric.) Theo Staar of Belgium can take a bow, too, as he developed the standard cassette jointly with Philips.

There are some inventors around who received a few semipublic accolades, of course. Among them are John Kemeny, Dartmouth College's prez, who co-developed the computer language, BASIC; Marvin Camras, for his patent on binaural magnetic recording; and IBM's Kenneth Iverson, who developed APL—A Programming Language. (Note: Ray Dolby is president of his own company, Dolby Laboratories, so we won't count such a rare bird.)

Must someone win a Nobel Prize to be accorded at least a semblance of fame beyond that of his co-workers' circle? I'd certainly like to hear from readers who know of modern-day electronics developers who changed the course of the electronics field, but whose contributions are virtually unrecognized by electronics enthusiasts.

Art Salsberg

Don't take our word for it.

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."

Popular Electronics March, 1979

"(Their) new Challenger 1P weighs in at $279 and provides a remarkable amount of computing for this incredible price."

Kilobaud Microcomputing February, 1979

"Over the past four years we have taken delivery on over 25 computer systems. Only two have worked totally glitch free and without adjustment as they came out of the carton: The Tektronic 4051 (at $7,000 the most expensive computer we tested) and the Ohio Scientific Superboard II (at $279 the least expensive) . . . The Superboard II and companion C1P deserve your serious consideration."

Creative Computing January, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."

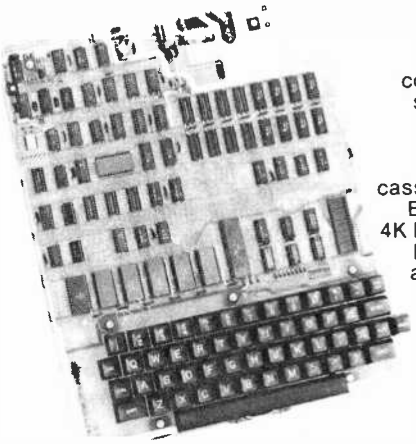
Interface Age April, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program . . . The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don't have to throw it away when you are ready to go on to more complex computer functions. Everything is there that you need; you simply build on to what you already have. You don't have to worry about trading off existing equipment to get the system that will really do what you want it to do. At $279, Superboard II is a tough act to follow."

Radio Electronics June, 1979

"The Superboard II is an excellent choice for the personal computer enthusiast on a budget."

Byte May, 1979



SUPERBOARD II
$279.00
The world's first complete computer system on a board including full keyboard, video display, audio cassette interface, 8K BASIC-in-ROM and 4K RAM. Expandable. Requires +5V at 3 amp power supply.

C1P $349.00
Complete with enclosure and power supply. All features of Superboard II. Easy to expand to more memory and floppy disk.

C1P MF $995.00
The first floppy disk based computer system the world has ever seen for under $1,000. 8K BASIC-in-ROM, 12K RAM. Expandable to 32K RAM.

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Letters

MINIWAVE NOTES

I thoroughly enjoyed "A Personal Microwave Communications System: The Mini-Wave" (October and November 1978 and January 1979). A few interesting things came to mind as I read it. An i-f of 100 MHz can be used if the experimenter is interested in just an audio link. Therefore, an ordinary FM receiver can be teamed up with the Gunnplexer. It may be necessary to insert a gain stage ahead of the FM receiver, however. It is also possible to use a 55.25- or 61.25-MHz i-f, which corresponds to TV channels 2 and 3, respectively. Once again, preamplification may have to precede the receiver. It might also be necessary to introduce afc.

For flawless video, you should strive for a 48-dB S/N. When dealing with an audio link, a lower S/N can be tolerated. We can, of course, reduce the bandwidth of the receiver and transmitter to improve S/N. In some cases, line-of-sight communication may not be possible. This problem can be circumvented by using buildings, water towers, and other structures as reflectors. Like all electromagnetic waves, microwaves can be made to bend when propagated through different media. 10.0-GHz tropo anyone? It is also interesting to notice the scattering effects microwaves exhibit under varying conditions. Thanks for the great article. See you on 10.2-GHz simplex! *—Carlton Davis, Newark, DE.*

OF °F AND °C

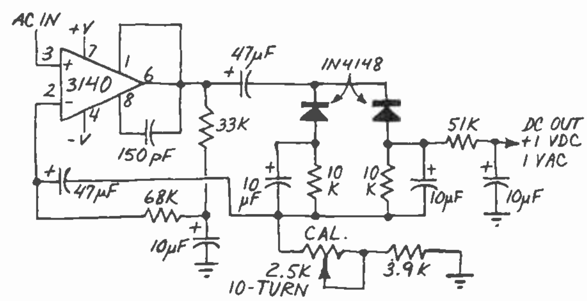
The °F equivalents of the °C temperature *rises* (not the temperature *points*) . in "The Importance of Power-Handling Capacity" (March 1979) are in error. A 20° C rise from, say, +20° C (+68° F) to + 40° C (104° F), for example is a 36° F rise—*not* 68° F, as would be obtained from a table of °C to °F equivalents. The extreme example of this would be to consult a table for a 0° C (no change) rise and concluding it is equal to a 32° F change. Therefore, the values of *rise* cited, 20°, 68°, 90°, 105°, and 155° C are equal to 36°, 122°, 162°, 189°, and 279° F, respectively. This is just a nit, however, when balanced against the high level of interest and information contained in the article. Keep up the good work. *—Lou Cortina, Pomona, CA.*

SWL BOOSTER

Just a short note to tell you how much I enjoy POPULAR ELECTRONICS. As an SWL, I particularly like Glenn Hauser's column and all articles on shortwave listening. *—Bob Lowe, Kingsburg, CA.*

IRONING OUT LINEARITY

I built the ac converter circuit featured in "Build A Multiple-Choice Digital Multimeter" (February 1979) to use as the front end of a dedicated digital panel meter. Linearity was too poor for use with a 3½-digit meter, however. After much experimenting, I came up with the revised circuit shown.



The 47-µF capacitors are not critical, but they should be fairly large and equal in value. The 1-µF capacitor on the output can be considerably reduced in value, especially at higher frequencies. This will help the output to settle faster. The CAL potentiometer should be a 10-turn precision device.

This circuit gives accurate ac conversions through a range of 10 mV to 2.0 volts, correct to three decimal places, verified by a calibrated 5-digit DMM. *—Joe Sharp, Orange, VA.*

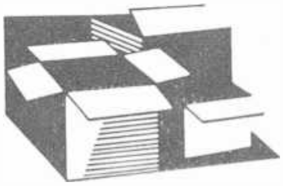
NOTES ON CRUISEALERT OPERATION

The "Cruisealert" (February 1979) operates properly on an automatic transmission at higher speeds, but the alarm will sound on each shift with a manual transmission if one is shifting properly. The alarm will also sound on an automatic transmission if the Cruisealert is set for a low speed. For a manual transmission with overdrive, the project would require constant adjustment, depending on the cruising gear chosen. The way it is designed, the Cruisealert would be best used as an RPM "red-line" alarm for manual transmissions. *—Ken W. Pavlicek, La Grange, IL.*

The Cruisealert was primarily intended for automatic transmissions (although it can certainly be used on manual transmissions), and for the speeds normally encountered on highways. It can also be adjusted to sound an alarm at the proper shift points for manual transmissions.

Out of Tune

"Automatic Garage Door Closer" (March 1979). On the schematic diagram, *C3* is shown as a 100-µF electrolytic capacitor, while in the Parts List its value is specified at 15 µF. There is no absolutely "correct" value for this capacitor. Its value can be anywhere between 15 and 100 µF, since its sole purpose is to safely bleed off the back emf from the relay's coil.



New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

Heath Small-Engine Tune-Up Meter

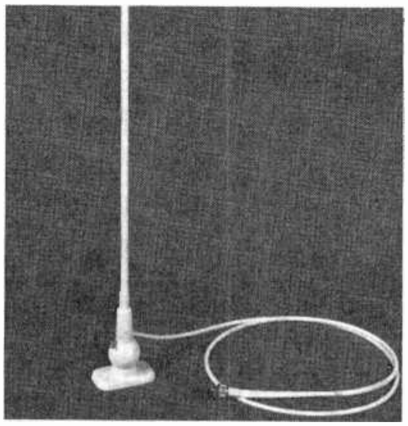
Heath's Model CM-2045 small-engine tune-up meter is designed for use on garden tractor, lawn mower, snow blower, motorcycle, snowmobile, outboard motors

and car engines with four or fewer cylinders. It can be used with all 2- and 4-cycle engines, including those from Briggs and Stratton. Test parameters include 0 to 20 volts dc, resistance to 100,000 ohms, engine RPM to 3000 and 15,000 full-scale, and dwell. The last is on four scales: 90° to 360° for one-cylinder engines, 40° to 180° for two cylinders, 30° to 120° for three cylinders, and 20° to 90° for four cylinders. Color coding is used on the meter for easy reading. A snap-on inductive pickup makes connection to the engine's spark-plug lead. Power is from three C cells (not included). $44.95.

CIRCLE NO. 90 ON FREE INFORMATION CARD

Small-Craft CB Antenna

A new marine CB antenna, designed especially for "bass boats" and other small craft, is available from Antenna Specialists Co. The 4' fiberglass whip is a half-wavelength design said to operate without the necessity of a ground plane. A rust-



proof plastic swivel-ball mount allows installation on sloping decks or on the side of a super-structure. It's supplied with all mounting hardware and 6' of coaxial cable terminating in a PL-259 connector. $29.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

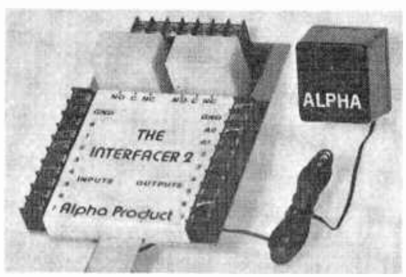
Crown Digital FM Tuner

The FM-1 tuner from Crown features a quartz-crystal referenced LSI digital controller, with numerical display of station frequency. In addition an analog indicator shows the approximate location of the station in the band. Frequencies for as many as five stations can be stored in memory, where they are retained even after power loss and can be called into active use at the touch of a button. Tuning can be done manually or by an automatic scanner that gives a seven-second preview of each station whose signal is sufficiently strong. Mono stations can be excluded from the search on command. Sensitivity for 50-dB quieting is rated at 36 dBf in stereo, with stereo THD 0.09% at 65 dBf, alternate channel selectivity of 75 dB in mono, and mono capture ratio of 2 dB.

CIRCLE NO. 91 ON FREE INFORMATION CARD

TRS-80 I/O Interface

Interfacer 2 from Alpha Product Co. is designed to allow the Radio Shack TRS-80 microcomputer to control and sense a variety of external devices. Of the eight outputs provided, two are SPDT relays and the others are TTL level. The eight inputs accept either contact closure or TTL level



logic signals. Two inputs are opto-isolated. Inputs and outputs of the Interfacer 2, which plug directly into the 40-pin edge connector on the rear of the TRS-80 interface, are controlled by level II Basic INP and OUT statements. $88. Address: Alpha Product Co., 85071 79th St., Woodhaven, NY 11421.

Dual Semiautomatic Turntable

The newly announced Dual 714Q single-play, semiautomatic turntable features a tonearm that has a specified effective mass of only 8 grams when equipped with the Ortofon ULM 60E cartridge designed especially for it. (Other cartridges can be used with the arm, but effective mass is

then higher.) The platter is directly coupled to the motor, whose speed is controlled by a quartz oscillator system that allows up to 11% variation in pitch on command. The turntable also incorporates a front-panel, solenoid-operated cue control, four-point gimbal tonearm suspension, lead-in groove sensing, and a spring-operated stylus force mechanism. It is supplied with base and dust cover, but without cartridge. $480.

CIRCLE NO. 92 ON FREE INFORMATION CARD

President AM Mobile CB Rig

"Thomas J" is President's top-of-the-line mobile AM CB transceiver. It features separate microphone-gain, r-f gain, tone, and delta-tune controls; digital numeric channel display; PA, blanker/anl-override, dimmer, and instant channel-9 access switches; and S/r-f/modulation/SWR meter. Specifications include: 4 watts r-f output; 0.5-μV or less sensitivity for 10 dB (S + N)/N; 60-dB spurious and adjacent-

channel rejection; and −65-dB or better spurious and harmonic suppression. The noise blanker is described as a full r-f type with manual override. Size is 8¾"D × 7⁵⁄₁₆"W × 2¾"H (22.2 × 18.6 × 7 cm) and weight is 5 lb (2.3 kg).

CIRCLE NO. 93 ON FREE INFORMATION CARD

Mini-mike for Pocket Recorder

Designed as an accessory for Pearlcorder D series Microcassette Recorders, the DM-1 Uni-Directional Microphone from Olympus Optical Co., Ltd. is said to provide the directivity needed to record in classrooms and theaters, for outdoor interviews, and at conferences. Like other units in the D System, the DM-1 screws to the base of the D Series recorder, which makes all necessary mechanical and electrical connections. In use, the telescopic boom is extended as far as necessary and the mike aimed at the desired source of sound. A wind screen is provided for outdoor use. $79.95.

CIRCLE NO. 94 ON FREE INFORMATION CARD

B&K-Precision Power Supply

A new lab power supply capable of functioning as three separate power supplies and featuring an automatic tracking circuit has been introduced by B&K-Precision.

The Model 1650 supply offers a 5-volt dc at 5-ampere and two separate (A and B) 25-volt dc at 0.5-ampere outputs. The automatic tracking circuit allows the B output to track voltage changes of the A supply. Tracking is controlled by means of a pulse-width-modulated proportional control signal. This design permits complete electrical isolation of both supplies in the tracking mode. Also featured are automatic current limiting and short-circuit protection on all ranges and outputs. All output connectors are color-coded six-way heavy-duty binding posts. $275.

CIRCLE NO. 95 ON FREE INFORMATION CARD

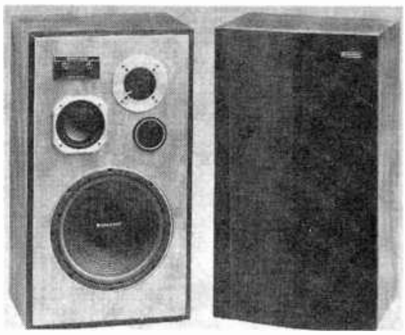
Morse-A-Word Code Reader

An eight-character Morse code reader for SWL's and ham operators has been intro-

duced by Microcraft. The unit accepts audio CW signals from the headphone jack or loudspeaker output of a communications receiver and displays corresponding characters sequentially in a moving chain. A front-panel control adjusts for code speed from 5 to 35 words per minute. Also included are a built-in code practice oscillator and monitor speaker. $250. Address: Microcraft Corporation, P.O. Box 513, Thiensville, WI 53092.

Kenwood Three-Way Speaker System

The new Kenwood LS-408-B speaker system, top of a new line of high-efficiency speakers, has a 12" woofer, 4⅜" mid-



range, and 1¾" cone tweeter. Power handling capability is said to be 20 to 160 watts, and sensitivity is 92 dB with one watt at one meter. Crossover frequencies are at 2000 and 5000 Hz; impedance is 8 ohms. The system uses a ported bass reflex design. $300.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Lightweight Isolation Transformer

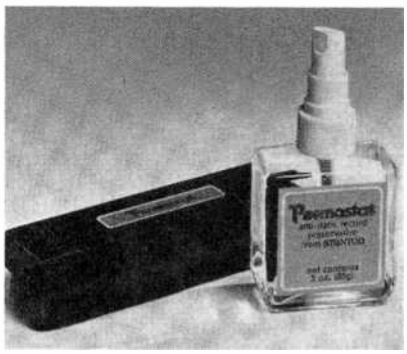
The latest member of the Isotap line of isolation transformers from VIZ Manufacturing Co. is the compact Porta-Isotap, which weighs just 8 lb. The unit is meant to be an aid in servicing solid-state TV receivers designed without power transformers. The Porta-Isotap has two fused outlets, one isolated and rated at 150 VA continuous, the other direct and rated at 500 VA. The

direct outlet is intended as a convenience in powering test instruments, a soldering iron, etc. $44.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Static Suppressor for Records

Permostat, newly introduced to the U.S. by Stanton Magnetics, is a liquid spray said to permanently eliminate static from any phonograph record to which it is applied, with no loss of sound quality, frequency response, or freedom from noise. Airborne dust attracted to the surface of a disc by



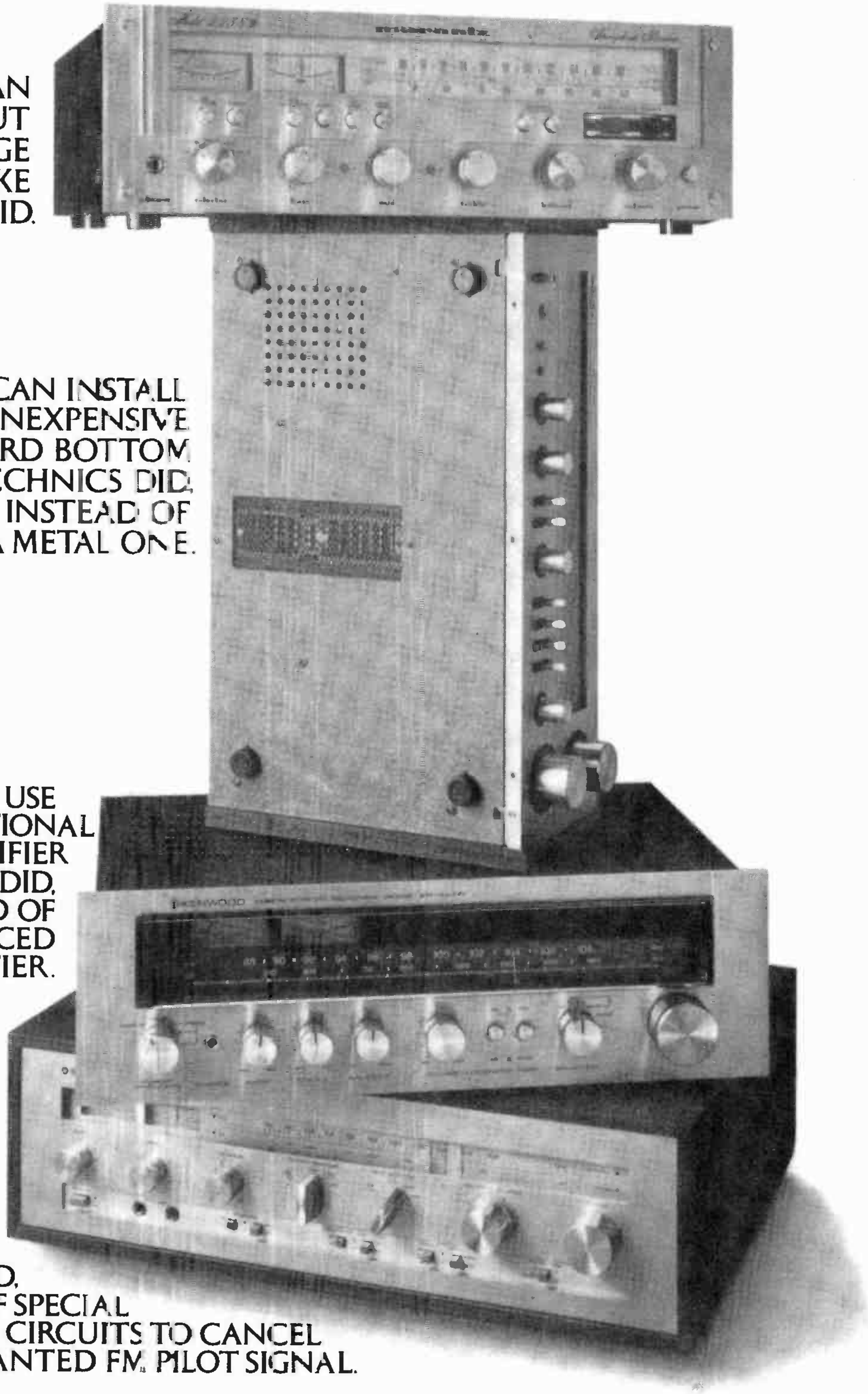
static electricity contributes to wear of both the stylus and the disc and adds surface noise. Stanton reports that Permostat causes less wear on a treated disc played 100 times at 3 grams vertical tracking force with an elliptical stylus than on a similarly played untreated record. Each kit is capable of protecting about 25 records. $19.95.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Electro-Voice Microphone Shock Mount

The Model 313A shock-mount microphone

THERE ARE A LOT OF WAYS TO BUILD A RECEIVER THAT SELLS FOR UNDER $400.



YOU CAN LEAVE OUT DUAL WATTAGE METERS LIKE MARANTZ DID.

YOU CAN INSTALL AN INEXPENSIVE PRESS BOARD BOTTOM LIKE TECHNICS DID, INSTEAD OF A METAL ONE.

YOU CAN USE A CONVENTIONAL POWER AMPLIFIER LIKE KENWOOD DID, INSTEAD OF AN ADVANCED DC AMPLIFIER.

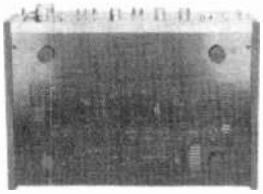
YOU CAN USE STANDARD HIGH BAND FILTERS LIKE YAMAHA DID, INSTEAD OF SPECIAL INTEGRATED CIRCUITS TO CANCEL THE UNWANTED FM PILOT SIGNAL.

PIONEER DID IT THE RIGHT WAY.

It seems that our competitors think they've mastered the art of building a moderately priced high fidelity receiver.

Unfortunately, most competitive receivers appear to be the work of cost reduction engineers, rather than high fidelity engineers.

At Pioneer, our philosophy is somewhat different. We build a receiver that sells for under $400 with the same care given to a receiver that sells for over $1000.



Metal shields our SX-780 from spurious noise.

A perfect example is the SX-780.

A STRONG CASE FOR THE METAL BOTTOM.

If you turn over our SX-780, you'll notice the bottom is made of heavy gauge metal. Not flimsy press board. It's designed that way to shield the tuning section from spurious noise and CB interference.

Then there's our special ventilating system that reduces FM drift due to overheated tuning elements and increases the life expectancy of the circuitry.

A DC AMPLIFIER WITH THE POWER TO ELIMINATE DISTORTION.

The SX-780 features the same DC power configuration found in today's most expensive receiver.

It provides cleaner sound and richer, more natural bass by eliminating feedback and transient intermodulation. (A form of distortion that keeps you from hearing the subtle overtones in your music). Which is why those receivers using a conventional power amplifier could possibly match the specs of the SX-780, but never the sound.

The DC power supply found on the most expensive receivers.

A PILOT SIGNAL CANCELING SYSTEM THAT'S ALL BUT UNHEARD OF IN THIS PRICE RANGE.

All stereo FM stations in America broadcast their music over a pilot signal of 19,000 hertz.

If not eliminated, this signal tends to create an extremely high pitched sound (hum) when combined with lower audible frequencies.

But instead of using standard high band filters like the others, Pioneer created a special integrated circuit that eliminates this pilot signal without affecting the music. So that you're assured of hearing everything the musicians had intended you to hear. Nothing more. And nothing less.

A pilot signal canceling circuit that lets you hear only music and nothing more.

Obviously, the SX-780 is the only receiver in this price range that offers you this feature. The others offer you the noise.

WATTAGE METERS THAT LET YOU SEE WHAT YOU'RE HEARING.

Wattage meters give you an accurate picture of exactly how much power is going through your speakers. So they not only help prevent unnecessary damage due to overloading, but help you make cleaner FM recordings.

You won't find them on any other moderately priced receiver.

Of course, the SX-780 has another virtue that's conspicuously absent from our competitors' models.

A built-in wood grain cabinet, which others give you the "option" of paying extra for.

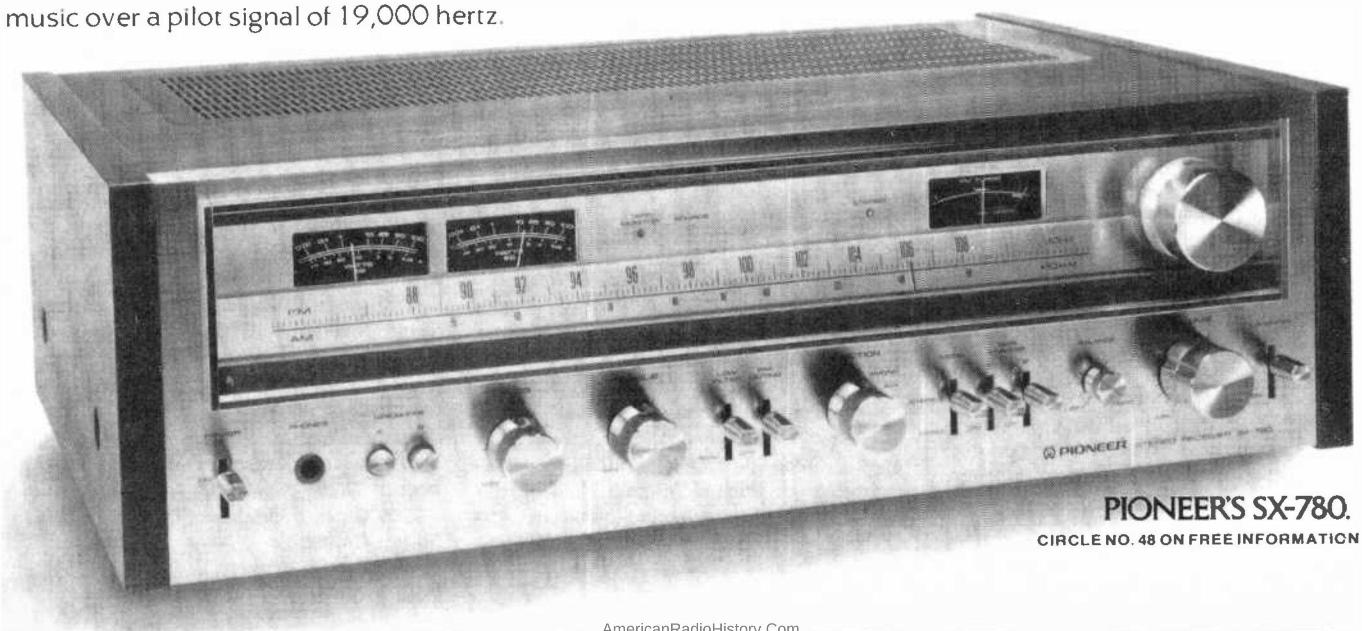
But what really separates Pioneer's SX-780 from other receivers isn't a matter of wood cabinets, wattage meters, metal bottoms, DC power, or even price.

It's our commitment to giving you a quality high fidelity receiver, no matter how much, or how little you plan to spend.

So if you're planning to spend less than $400, you couldn't ask for more than the SX-780.

PIONEER®
We bring it back alive.

POWER: 45 watts per channel min. at 8 ohms from 20-20,000 hertz with no more than .05% total harmonic distortion.
FM SENSITIVITY: Stereo; 37.0 dBf
S/N RATIO: Stereo; 72 dBf
CAPTURE RATIO: 1.0 dBf
POWER METERS: 2
SPEAKERS: A, B, AB
TONE CONTROLS: Dual
TAPE MONITORS: 2



PIONEER'S SX-780.

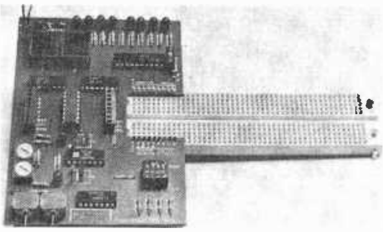
CIRCLE NO. 48 ON FREE INFORMATION CARD

clamp from Electro-Voice was designed to hold a mike with an approximate ¾" barrel diameter. A hinged metal latch is provided to hold the microphone in four replaceable urethane bands for temporary shock mounting. When used with a set screw, the 313A becomes a semipermanent shock mount for applications that don't require frequent mike changes. $23.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Universal Designer for Digital ICs

Paccom's FTK 6100 Universal Designer is offered as an aid to assembling experimental circuits with digital ICs. It is capable of plugging into breadboards from Continental Specialties, AP Products, or E & L



Instruments. Powered by a 6-volt battery, it contains two bounceless pushbuttons, two readouts with BCD inputs, four switch outputs, eight LED monitors, two variable clock generators, and two decade counters. $35, kit; $45, assembled.

CIRCLE NO. 100 ON FREE INFORMATION CARD

"Powerless" Cassette Tape Eraser

Operating independently of external power or internal batteries, and without moving parts, the Cassette Tape Eraser from Trans Globe Trade Enterprises is said to erase a recorded cassette in one second. The device contains powerful built-in magnets that are claimed to last practically indefinitely and to be capable of restoring a cassette to original tone quality while leaving minimal tape hiss. $17.95. Address: Trans Globe Trade Enterprises, P.O. Box 24797, Los Angeles, CA 90024.

New Literature

PTS ELECTRONICS TUNER CATALOG

The 1978-79 Tuner Replacement Guide & Parts Directory from PTS Electronics contains 182 pages of technical information and diagrams for TV tuners and modules as well as comprehensive descriptions of PTS products and services. Included in the catalog are sections on module repair, a list of rebuilt and exchanged modules, a module cross-reference guide, troubleshooting information, sections on PTS test instruments, tools and chemicals, and a list of tuner replacements by manufacturer. Information about uhf and vhf tuners for all major domestic and foreign brands occupies 83 pages of the publication. Sections on replacement tuner parts, antenna coils, and tuner shafts, and price lists are also included. Address: PTS Electronics, Inc., P.O. Box 272, Bloomington, IN 47401.

B & K-PRECISION DMM SELECTION GUIDE

A six-page brochure from Dynascan Corporation describes the B & K-Precision line of digital multimeters, detailing features, applications and specifications for all models. Among the DMMs listed are Models 2830 and 2810 3½ Digit DMMs, both with autozeroing, and Model 283 3½ Digit Lab DMM with high-intensity LED display for maximum readability, plus the Model TP-28 Solid-State Temperature Probe. Address: B & K-Precision, 6460 W. Cortland St., Chicago, IL 60635.

WANG IMAGE PRINTER BROCHURE

A six-page brochure from Wang describes the Intelligent Image Printer, an output device for Wang office information and computer systems said to be 50 times faster than an electronic typewriter. Using fiber optics technology to fuse light into images, the Image Printer produces collated, typewriter-quality pages at the rate of 18 per minute, and permits the mixing of type faces within documents. Address: Wang Laboratories, Inc., One Industrial Avenue, Lowell, MA 01851.

TI BUBBLE MEMORY DATA BOOK

The 48-page LCC4430 data book from Texas Instruments contains specifications on the TIB0203 magnetic bubble memory and an 8-page discussion of the fundamentals and advantages of magnetic bubble memories. Also contained in the manual are specification sheets for the interface integrated circuits designed for use with the TIB0203, including the SN74LS361 function timing generator, the SN75281 sense amplifier, the SN75380 function driver, and the SN75382 coil driver. Data sheets for standard devices which can be used in bubble memory system design, such as the TSP102 thermistor and the VSB53 Schottky-diode bridge, are included as well. Address: Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 225012, MS-308 (Attn: LCC4430), Dallas, TX 75265.

MOUNTAIN WEST SECURITY SYSTEMS

This 72-page catalog contains more than 1200 security and alarm systems. Equipment ranges from magnetic door switches, locks, alarms, and bell systems to radar, ultrasonic and infrared detectors. Product catagories include residential and commercial alarm controls, fire systems, fire and intruder detectors, remote controls, signaling devices, silent phone connections, telephone dialers, power sources, locks, tools and books. The catalog also includes information on system design, alarm application, and installation procedures with connection diagrams, as well as specifications. Address: Mountain West, 4215 N. 16th St., Box 10780, Phoenix, AZ 85064.

OHIO SCIENTIFIC FULL LINE CATALOG

The 1979 Full Line Catalog from Ohio Scientific consists of a 310-page paperback handbook supplemented by a 16-page price list, and tells "Everything you've always wanted to know about personal and small business computers." The catalog contains a series of technical reports, a review of available software, and a description of personal and small business computer applications, including capability of upgrading systems for future expansion. Send $1.00 to: Ohio Scientific, Publications Dept., 1333 South Chillicothe Rd., Aurora, OH 44202.

GTE VOICE SECURITY TERMINAL

General Telephone & Electronics offers an eight-page brochure describing the Mark IV VST-6000, a voice security terminal that protects speech transmitted over standard telephone lines while providing voice recognition. With the aid of block diagrams, the brochure explains how voice is encrypted and how secure conference calls can be established. It also provides operating modes, data rates and dimensions of the equipment. Address: Michael Thurk, GTE Sylvania Inc., 77 "A" St., Needham Heights, MA 02194.

RADIO SYSTEMS TECHNOLOGY CATALOG

The 16-page 1979 catalog from Radio Systems Technology describes the company's line of aircraft avionics and test equipment kits. Products include transceivers, intercoms, microphones, headsets, antennas, tools and other supplies of interest to general aviation aircraft owners and pilots. The catalog features several new products including a 6-channel aircraft radio band transceiver kit and two voice-actuated intercom kits. Address: Radio Systems Technology, Inc., 10985 Grass Valley Ave., Dept. P79, Grass Valley, CA 95945.


All that's new and unique in quality electronic kits you can build
SEE THEM IN THE LATEST HEATHKIT® CATALOG-
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Heathkit®
Quality Electronics You Can Build Yourself
SUMMER 1979
HEATHKIT MAIL ORDER CATALOG 845
SAVE $199.95 on the popular Modulus™ Stereo System—See page 59
The world's largest selection of easy-to-build, money-saving electronic kits for home, hobby or business
Budget-priced digital alarm clock
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DC-35 MHz dual-trace delayed-sweep oscilloscope
Digital readout AM/FM stereo receiver
Precision Heathkit weather computer
An all-in-one computer system, complete with built-in floppy disk storage
Microprocessor self-instruction program—your key to computer knowledge
NEARLY 400 OF THE FINEST ELECTRONIC KITS- ALL FULLY DESCRIBED & ILLUSTRATED IN THIS BIG, COLORFUL 104-PAGE CATALOG
FREE
SEND FOR YOURS
TODAY!
PLUS...the latest line of electronic products in easy-to-build money-saving kit form: automotive • marine • home products • avionics • clocks • security • color TV • weather • tools • test instruments • books • amateur radio • stereo HiFi • computer systems • self-learning programs.
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Heathkit products are displayed, sold and serviced at Heathkit Electronic Centers coast to coast (Units of Schlumberger Products Corporation). See the white pages of your phone book. If coupon is missing, write Heath Company, Dept. 010-550, Benton Harbor, Michigan 49022.
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Learn to service 2-way radio, microwave systems, AM/FM transmitters,

with NRI's Complete

Learn installation and maintenance of commercial, amateur or CB communications equipment.

There are more than 25 million CB sets out there, millions more two-way radios, walkie-talkies, and other communications apparatus in use by business, industry, government, police and fire departments, and individuals. That means a lot of service and maintenance jobs...and NRI can train you at home to fill one of these openings. NRI's Complete Communications Course covers all types of two-way radio equipment...AM and FM transmission and reception, television broadcasting, microwave systems, radar principles, marine electronics, mobile communications, and aircraft electronics. And NRI guarantees you will pass the exam for the commercial FCC Radiotelephone License you need to perform most servicing work, or your tuition will be refunded in full. This money-back agreement is good for six months after completion of your course.

Learn on your own 2-meter, digitally synthesized VHF transceiver.

You'll learn to service all types of communications equipment as you assemble your own VHF transceiver. NRI engineers have designed it, not only as a commercial-quality, high-performance unit, but as a unique "power-on" training tool to give you actual bench experience with the principles needed to service commercial, CB, and amateur equipment.

Then we help you get your FCC Amateur License so you can go on the air.

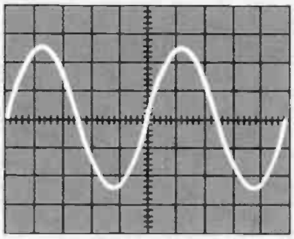
The complete course includes 48 lessons, 9 special reference texts, and 10 training kits. Included are your own electronics Discovery Lab,® antenna applications lab, CMOS digital frequency counter, and 7-scale AC/DC volt-ohm meter. You'll learn at home, at your own convenience, getting the training you need for your FCC License and the communications field of your choice.

CB specialist course also offered.

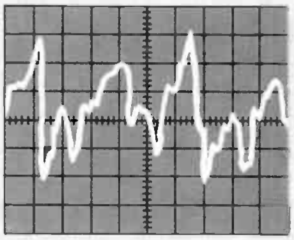
If you prefer, you can concentrate on the big field of CB radio with NRI's special course in CB servicing. You get 37 lessons, 8 reference texts and plenty of "hands-on" training with your own 40-channel CB, AC power supply, and multimeter. Also included are 14 coaching units to make it easy to get your commercial Radiotelephone FCC License...required for you to test and service communications equipment.

Many amps can deliver pure sound. The Sansui AU-919 delivers pure music.

Today's audio engineering has reached the point where you can select among a number of affordable high-power amplifiers that have virtually no "total harmonic distortion." That's good. But THD measurements only indicate an amplifier's response to a pure, continuously repeating, steady-state test signal (below, left). They don't tell you how the amp responds to the never-repeating, rapidly-changing transient waveforms of real music (below, right). And only an amplifier designed to reproduce the demanding dynamics of music signals can satisfy the critical audiophile. An amp like the Sansui AU-919.



SINE WAVE



DYNAMIC MUSIC SIGNALS

Because low THD without low TIM is like sound without music, the Sansui AU-919 is designed to respond well to both simple sine-wave test signals and also to handle the jagged, pulsive edges required for realistic reproduction of music—without imparting that harsh, metallic quality known as "transient intermodulation distortion" (TIM).

The Sansui AU-919 sounds better than conventional amps because Sansui developed a unique (patent pending) circuit that is capable of achieving both low THD and low TIM simultaneously.

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*The Diamond Differential/DC, Sansui's (patent pending) totally symetrical double ended circuitry with eight transistors, is named for its Diamond-shaped schematic representation.

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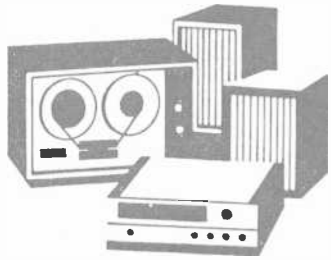

Stereo Scene

By Ralph Hodges

BEING RE-CREATED EQUAL

PROPONENTS of equalizers tend to regard them collectively as the greatest boon to come along since electrical recording, while skeptics take quite another view of them. My own experience with equalizers—which dates back to the Blonder-Tongue multi-band unit of the 1950's—has been mixed. I started out like a house afire, all but convinced that the hitherto impossible dream of flat frequency response from, say, 30 to 15,000 Hz lay literally at my fingertips, only to founder time and again on obstacles that, while little understood, were all too perceptible in terms of their musically excruciating effects. Hindsight has pinpointed misunderstanding as the chief element in my failures; a recounting of them may help others avoid the same pitfalls.

How I Tuned My Loudspeakers. Equipped with one of the first-generation octave-band equalizers of the early 70's and a pair of highly regarded but not-quite-flat omnidirectional speaker systems, I set out some nine years ago to make these speakers flat once and for all. Beginning systematically, I first acquired a sound-level meter on which a calibration curve had been taken, and a test record.

A record spanning the audio range in discrete one-third-octave bands is appropriate for this application. I used the record distributed by Altec, which is generally suitable except for its high level of vertical rumble, which should be cancelled by switching the amplifier to mono. Soundcraftsmen and ADC, among other equalizer manufacturers, offer suitable records, but the Soundcraftsmen record is meant to be used in a by-ear test, and hence has built-in loudness compensation, which will show up on a meter in the form of accentuated response at the extreme bass and treble. This is no problem for the midrange region, however. The Warble tones on the *Stereo Review* test record, also loudness compensated, can be useful too, although meter fluctuation with the warble should be expected.

Seated in my usual listening location, the meter held out in front of my face, I plotted the response from both speakers, subtracted the meter's calibration curve, and (surprise!) the resulting response curve was within a dB or two (above about 500 Hz) of the curves made by Hirsch-Houck Labs. (At lower frequencies, predictably, room modes caused wide variations in response, but I could live with these if I could get the midrange smoothed out.)

This was both encouraging and disturbing: encouraging because it suggested that measurements on loudspeakers really could be carried out with some hope of agreement between testers; disturbing because the curves plotted for the two speakers were very similar, whereas the speakers did not *sound* very similar at all. Presumably, their different positions in the room, which were far from acoustically symmetrical, gave them different sonic characteristics. At least it was true that when the right speaker was substituted for the left, it sounded very much as the original left speaker had and produced (within the bounds of instrumental and procedural accuracy) identical measurements.

Ignoring this puzzle for the moment, I decided to equalize the speakers to what the meter said was flat response. The appropriate corrections seemed to involve tilting up the extreme high end, filling in a sharp depression in the upper midrange, and suppressing a bump in the midbass that seemed to be a real part of the speakers' response, independent of their placement in the room. Although the midrange depression measured only a few dB below the reference "zero" level, the full 12 dB of boost nominally available from the equalizer was not enough to iron it out, while adjacent frequencies were highly exaggerated.

Finally, I struck the best compromise I could and sat down to listen. After excerpts from about five recordings I could no longer deny that the sound was horrendous. Fine-tuning by ear did not help much, except to demonstrate that the closer I came to removing the equalizer from the system altogether, the better the sound. Even the midbass sounded better with the bump left in. (I kept it equalized out for several days just to make sure I wasn't being seduced by the corpulent richness it lent to the sound.) Thus ended Experiment One.

How I Tuned My Room. At this point, I thought I understood the flaw in my equalization procedure so I devised another approach. I set up a high-quality omnidirectional microphone at my listening position and fed its output to a tape recorder. Through the speakers I played an organ recording with sustained chords spanning a wide frequency range. By recording a few minutes of this and comparing the tape and the original record, I was—in theory, at least—able to hear the effect of the listening-room acoustics on the reproduced sound. The idea was to adjust the equalizer so that the tape with the equalizer in sounded exactly like the record with the equalizer out. In that way I could subtract the room's contribution to the sound heard at my listening position and leave only the sound laid down by the record producer.

That didn't work either. No matter what I did I could not adjust the equalizer to make the tape sound much like the original disc recording. I did find, however, that the best adjustment my ear could find gave a better sound than a setting determined by instruments. This tape-recording technique eventually proved excellent for isolating certain acoustic problems in the room (best corrected by acoustic treatment of the walls) that had escaped direct detection but still nagged at me during normal listening—but that is another story. Meantime, I was still no happier with the equalizer in the system than with it out.

How I Tuned My Records. Soon afterward, acquaintances began telling me how useful their equalizers were in taming certain problems on records. Being a lifelong enemy of ear-piercing sibilance, bloated or absent bass, wiry violins, and overblown midrange, I found this of great interest. I had pressed my equalizer into combat against these undesirables before, and now did so again. The result was the same. Octave-band corrections were too broad to subdue sibilance and harsh violins without losing the bite of the brass and the sheen of the cymbals. Treble above about 8,000 Hz (that's really only an octave, and it is hence governed by only one control on an octave-band equalizer) could be helped out somewhat, and bass, spanning about four octaves, could be contoured quite satisfactorily for many recordings. But most adjustments attempted in the midrange wound up sounding unnatural.

At this point, a certain insight struck me, and a few visits to my acquaintances' homes confirmed its accuracy. They were all using their equalizers to introduce broad, gradual lifts or descents in system response at the frequency extremes. In short, they were duplicating the functions of a set of bass and treble controls. No doubt their equalizers afforded greater flexibility in determining the precise contour of the response slope being introduced, but I suspect that simple tone controls with variable turnover points would have served the purpose just as well.

Conclusions. Astute readers will have long ago spotted the errors in my experiments. The moderate upper midrange dip registered by my sound-level meter in Experiment One was probably a deep dip confined to a narrow range of frequencies, resulting from an acoustic interaction between loudspeaker drivers. The third-octave-band test signal, by averaging the speaker's output over a wider range of frequencies, made it seem less pronounced than it was. But trying to eliminate it with an octave-band equalizer was hopeless. In fact, the dip's effects were probably almost inaudible, and it would have been best left alone.

Had I been totally unable to restrain my native fussiness, a one-third octave or, perhaps even better, a parametric equalizer would have been the tool of choice. With the former I could have made some correction in the offending one-third-octave band without side effects elsewhere; the latter could have been tuned virtually to the exact frequency that needed to be boosted. Octave bands are too coarse for some applications—but I didn't know that then.

When I tried to adjust the equalizer so that the recording made in the listening room sounded like the original organ recording, I had hoped that my ears could ignore the reverberation time added by that same listening room. They couldn't—and what is known of the ear-brain mechanism suggests that they never could.

In correcting for the frequency response of a recording that offends, no objective standard is possible. You either like the audible result or you don't. My belief is that the use of an equalizer will give much more satisfaction to a pop/rock listener than a classical-music listener, simply because exaggeration is very much a part of the pop/rock business to begin with, because the background instrumentation is probably very basic in its harmonic structure, and because the recording studio often provides no acoustic environment to a recording other than what is injected artificially by various signal processors. In my opinion, when a recording contains a good dose of the acoustic in which the performance took place, the effects of anything more than moderate post equalization are all the more likely to sound artificial.

I hasten to point out that my difficulties in using equalizers with success is in no way intended as an indictment. In many applications—especially professional ones—they have proven almost indispensable. And, although there are sound systems that do not seem to benefit much from equalization, there are undoubtedly others that would if it were applied correctly.

In the professional sphere, equalizers are used widely for at least two purposes: adjusting the response of monitor speakers in recording-studio control rooms and suppressing feedback in sound-reinforcement systems. Studio monitor speakers are likely to be fairly directional, and the acoustics of the control room fairly dead. Under these circumstances, it is the sound that comes directly from the speakers that really counts; reflections from the room do not get very much involved. It has proven practical and effective to equalize monitor speakers for whatever response is desired right where the engineer will be sitting during a session. In other seats, the audible result may not be quite as favorable, and it is difficult to predict exactly what would happen with speakers not quite as directional. But in this application, equalization can be a great boon. Audiophiles who own fairly directional speaker systems such as full-range electrostatics also report that equalization yields great satisfaction.

In sound-reinforcement work, the equalizer is used to keep the microphone, which is inevitably picking up sound from the speakers, from responding to resonances in the auditorium and driving the system into acoustic feedback. Fortunately, the sound system usually "takes off" at pretty specific frequencies, which is why the squeal you hear from a PA installation going into feedback has a definite pitch.

The well-equipped engineer will use a real-time spectrum analyzer and an equalizer that offers control over very narrow frequency bands—one-third octave or so. With the microphone on, and with the system reproducing pink noise, he will raise the gain until the system breaks out into feedback. The analyzer will immediately indicate the approximate frequency involved, and the equalizer is used to reduce the system's output at that frequency to the point where feedback stops. Once more the gain is raised until another frequency takes off and another equalizer control is brought into play. In the end, any further increase causes feedback at almost all frequencies. When that condition is reached, system equalization is complete. The result is a system that can play much louder and usually sound much better than a comparable unequalized system.

I've not yet had the opportunity or instrumentation to try this adjustment technique in a home setting, but the experiment would be worth trying, if only for the knowledge gained. If you are willing to spend hours rather than minutes, the job could possibly be done without a real-time analyzer. This would limit your necessary acquisitions to a high-quality microphone; interstation noise from your tuner will provide an adequate test signal, provided that you subtract 3 dB per octave to allow for the fact that it is quasi-white, not quasi-pink. By reducing any feedback tendencies you discover in your system, you'll presumably be compensating for the room resonances that give rise to them.

That is the sum total of advice I can offer on the systematic use of equalizers. The rest depends on you and on the specific characteristics of your room and sound system. If you really work at it, there's a good possibility you'll come up with some effective adjustment procedures of your own. ◇

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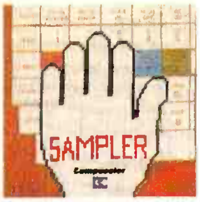

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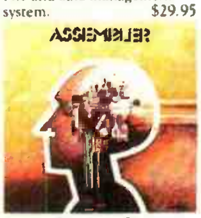

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CIRCLE NO. 10 ON FREE INFORMATION CARD

Julian Hirsch Audio Reports

Sanyo Model TP1030 fully automatic direct-drive dc servo turntable

HIRSCH-HOUCK LABS REPORT

Sanyo's Model TP1030 fully automatic, single-play record player is operated by a direct-drive brushless dc servo motor at 33⅓ or 45 rpm. Its silver-colored motorboard contrasts attractively with a walnut-veneer wooden base. A hinged, clear plastic dust cover tops the unit, which is supported on four softly sprung feet to provide isolation from conducted vibration.

Overall size, with cover lowered, is 18⅝"W x 15"D × 5⅞"H (47.3 × 38.1 × 14.9 cm), and weight is 14 lb 2 oz (6.4 kg). Suggested price is $170.

General Description. The record player's principal operating controls are four pushbuttons, two of which are for adjusting the tonearm's set-down point for 7" or 12" records. When the START/CUT button is pressed lightly, the motor and tonearm are activated and play begins. At end of play, the tonearm returns to its rest and the motor shuts off. A second touch of the START/CUT button at any time during play initiates the shut-off cycle. The remaining button, labelled REPEAT, latches in place when pressed and causes the record to be repeated indefinitely until cancelled by the START/CUT button.

The 12" aluminum-alloy platter has four rows of stroboscope dots cast into its rim, where they are illuminated by a neon lamp. Two small buttons, each with a thumbwheel vernier speed control nearby, select the operating speed. A red LED near each control indicates the speed in use at that particular time.

The tonearm, an S-shaped aluminum tube, is fitted with the standard Japanese four-pin plug-in head shell. It is balanced by a threaded counterweight that also carries the stylus force scale, calibrated from 0 to 3 grams at 0.25-gram intervals. A small lateral balance counterweight extends from the tonearm's pivot support, at right angles to the main axis of the arm. It is to be adjusted so that a front-rear tilt of the record player does not cause the tonearm to drift in either direction. An antiskating dial and cueing lever are on the motorboard near the base of the arm.

Laboratory Measurements. We installed a Shure M95ED cartridge in the tonearm for our tests. Cartridge installation instructions state that stylus overhang (beyond the center of the turntable spindle) should be set to 19/32" (15.1 mm) for minimum tracking error. We found it impossible to do this with the required accuracy by purely visual means. We eventually used an external stylus protractor to check the tracking error as the position of the cartridge in the shell was varied. The final setting was with the stylus 50 mm from the reference surface where the headshell contacts the arm. (This is a more or less standard dimension in tonearms of this type and is much easier to set up than using the method called for in Sanyo's instructions.)

When properly adjusted, the tonearm has a very low tracking error, which did not exceed 0.5°/in. over the playing surface of a 12" record and was typically not more than 0.3°/in. With the tonearm balanced according to instructions, the calibrations of the tracking-force scale on the counterweight were within 0.05 gram of the actual force at all settings.

At the lowest normal tracking forces, on the order of 1 gram, antiskating compensation was not sufficient to give identical waveform clipping in the two channels on heavily modulated passages, even when set to full scale. Increasing the tracking force by 20% or so should solve the problem, however. A second minor nuisance is that the tonearm cueing device allows the arm to drift excessively when raised and lowered again. With care, the error can be held to 3 or 4 second's worth of repeated music, however, the cueing is but marginally useful. In addition, since the rest does not restrain the tonearm from lateral motion unless the locking clip is in place, it is possible to send the stylus skidding across a disc or the empty platter.

The effective mass of the tonearm, less cartridge, was 20 grams, a typical figure for this type of arm. Capacitance to ground in each signal channel was about 120 pF and interchannel capacitance was 5 pF. These figures indicate that the tonearm is well-suited for use with almost any car-

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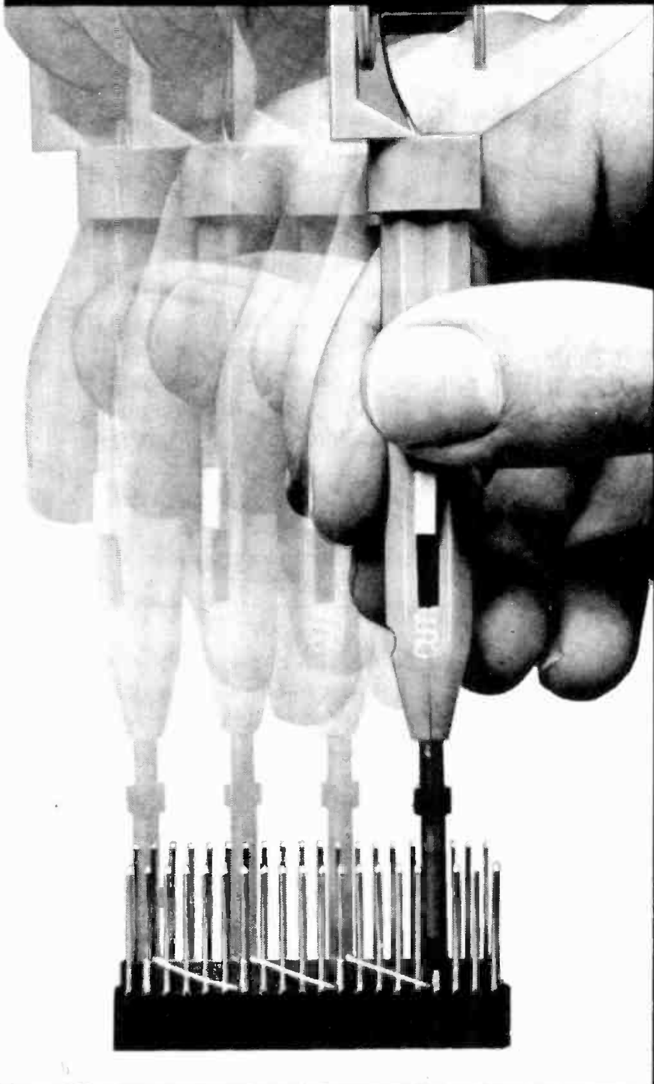

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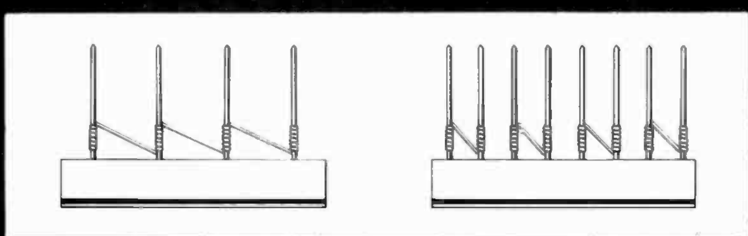

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Performance Specifications

Specification	Rating	Measured
Speed control range	±4%	+5.2% to −6.2% at 33⅓ rpm +4.2% to −4.8% at 45 rpm
Wow and flutter	0.03% wrms	0.06% wrms ±0.08% weighted peak
S/N ratio	60 dB	
Rumble	−70 dB DIN "B"	−34 dB unweighted NAB −55 dB ARLL
Tonearm tracking error	±1.5 deg	Less than 0.5° /in.
Stylus pressure force range	0 to 3 g	Confirmed (error less than 0.05 g)
Overhang	15 mm	See text

tridge, since additional capacitance can be supplied if required.

Turntable speeds could be adjusted over a range of +5.2% to −6.2% at 33⅓ rpm and from +4.2% to −4.8% at 45 rpm. The speeds did not change detectably with extreme line-voltage shifts. Turntable rumble was −34 dB (unweighted NAB) or −55 dB with ARLL weighting. Weighted rms flutter was 0.06% and weighted peak flutter was 0.08%.

Operation of the record player was smooth and quiet, and the automatic cycling times were considerably shorter than we have observed on many automatic turntables. Time from touching the START button to cartridge set-down on the record's surface, was about 8 seconds, and automatic shut-off time was 9 seconds.

Isolation afforded by the soft mounting feet was about average for a direct-drive turntable. Moderate transmission resonances were found at 27, 64, and 190 Hz, but isolation was complete above 300 Hz.

User Comment. The TP1030 offers an impressive array of features for a budget-priced turntable. These include direct drive, vernier speed control, automatic operation, repeat operation, and a laterally balanced tonearm. Its most apparent weaknesses, the inaccurate antiskating compensation and cueing device, will prove unimportant to many users and have been encountered on much more expensive record players as well. Its virtues, which include smooth, convenient automatic operation and very good overall performance, combine with its strikingly low price to make the TP1030 a fine value.

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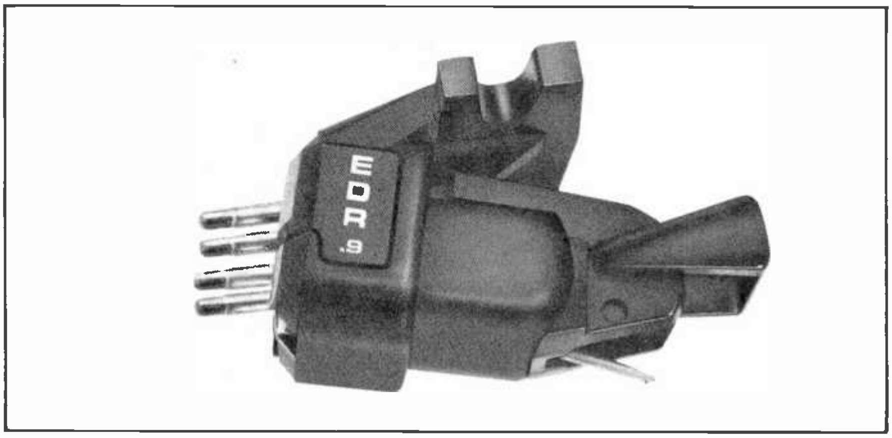

Empire Model EDR.9 extended dynamic response phono cartridge

HIRSCH-HOUCK LABS REPORT

Empire's new top-of-the-line phono cartridge is the "Extended Dynamic Response" Model EDR.9. Although it is a variable-reluctance moving-iron cartridge like others in Empire's line, the EDR.9 features a new inertial stylus damping system and has been designed to be relatively immune to capacitive loading effects. In addition to its low-inductance coils and "tuned-stylus" system, the cartridge has a "Large Area of Contact" (L.A.C.) stylus tip that is Empire's equivalent of Shibata-derived styli originally developed for playing CD-4 discs and is now used by most manufacturers in their top cartridges. This type of stylus offers an attractive combination of outstanding high-frequency tracking ability and reduced record wear for stereo use.

The EDR.9 has a swing-away stylus guard on its replaceable stylus assembly. It is elaborately packaged with a stylus brush, vial of stylus-cleaning fluid, small screwdriver, and mounting hardware in a handsome clear-plastic cylindrical holder. The whole is contained in a black leather case. Suggested retail price is $200.

General Description. Like other Empire cartridges, the EDR.9 has four magnetically shielded coils embedded in its plastic body. Three fixed magnets channel flux through the pole pieces of the coils. The rear portion of the aluminum stylus cantilever's tube is attached to a low-mass hollow ferrous tube that fits between the four pole pieces. As the stylus follows the groove modulation, the iron armature modulates the flux between the pole pieces, inducing voltages in their coils. The coils are connected in two series pairs to form the stereo-channel electrical outputs.

A distinctive feature of the EDR.9 is its low-inductance (about 250 mH) coils that make its frequency re-

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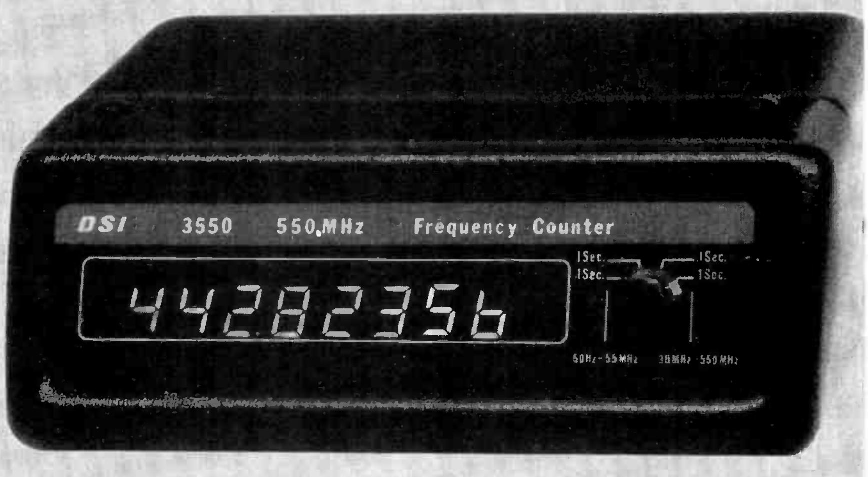

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3600A	$199.95	50Hz - 600MHz	Oven .5 PPM 17° - 37°C	10MV	10MV	50MV	8	.5 Inch	115 VAC or 8.2 - 14.5VDC	2⅛"H x 8"W x 5"D
3550W	$149.95	50Hz - 550MHz	TCXO 1 PPM 65° - 85°F	25MV	25MV	75MV	8	.5 Inch	115 VAC or 8.2 - 14.5VDC	2⅛"H x 8"W x 5"D
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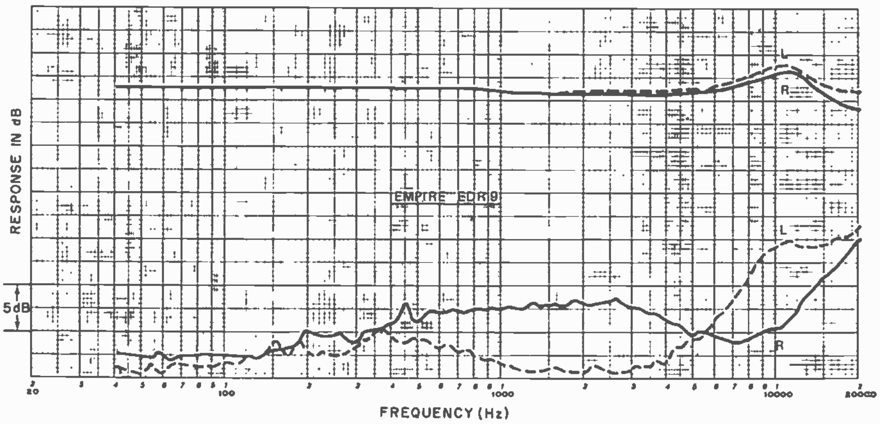

Composite response and crosstalk for left and right channels.

sponse relatively independent of load capacitance. Most magnetic cartridges have 500 to 750 mH of inductance, which inevitably resonates with the capacitance of the interconnecting cable and amplifier input to modify the frequency response in the uppermost audible octave. Cartridge designers usually use this electrical resonance to equalize the mechanical resonance of the stylus system and obtain a reasonably flat overall frequency response. This results in a more or less critical dependence on a specified load capacitance, which is not always under the control of the user, if one is to obtain the rated frequency response of the cartridge.

Another departure from conventional practice is the EDR.9's "tuned-stylus" system. Mechanical resonance of the stylus is unavoidable, occurring as it does between the compliance of the vinyl material of the record and the effective mass of the stylus, referred to the tip. If it is left unmodified, a response peak is produced at some high frequency. This resonance is normally damped by a rubber-like elastomer that supports the stylus' cantilever and often serves as its pivot. However, if enough damping is used to flatten out the response, transient performance of the cartridge may be impaired. Another problem is that the characteristics of these damping materials can change with time and variations in temperature.

Empire has designed a miniature inertial damper into the EDR.9's stylus cantilever system. It is analagous to the tonearm damping systems used by many manufacturers where the counterweight mass and support compliance forms a resonant "trap" that can greatly reduce the amplitude of the low-frequency resonance of the tonearm/cartridge system between total system mass, referred to the stylus tip, and the compliance of the stylus cantilever system.

There is a miniature iron bar at the rear of the cantilever. It is coupled to the aluminum tube by a compliance that permits it to resonate at a frequency that reduces the amplitude of the main cantilever's resonance, without employing excessive damping. The damping characteristics of the cantilever have been chosen to give the desired flatness in overall response without a critical dependence on electrical circuit resonance. (Electrical resonance should occur well above the audio range because of the cartridge's low inductance.)

Finally, the stylus tip is shaped to provide a large area of contact with the side of the groove wall, while retaining a very small radius along the direction of groove travel for good high-frequency tracking ability. A nude diamond is mounted to the hollow aluminum cantilever to minimize the effective mass of the tip.

Laboratory Measurements. We tested the cartridge in a tonearm whose mass was 20 grams and low-frequency resonance was between 7 and 8 Hz, with an amplitude of about 5 dB. We used the 100-pF load capacitance in parallel with 47,000 ohms of resistance on which the cartridge's performance specifications are based. We also measured frequency response with a total capacitance of 335 pF, which is typical of actual operating conditions in many record-playing systems. The only effect of the higher capitance was to increase the cartridge's output by about 2 dB at frequencies above 10,000 Hz.

The response with the CBS STR100 test record confirmed Empire's test data. There was a moderate, broad rise of about 2.5 dB in the response curve, centered at 10,000 Hz. Relative to the 1000-Hz level, the frequency response of the cartridge was within ±2 dB from 20 to 20,000 Hz. Channel separation was very good, measuring typically 25 to 30 dB or more in the midrange, 20 to 27 dB at 10,000 Hz, and about 15 dB at 20,000 Hz. Very similar frequency-response measurements were obtained using B&K 2009 and JVC 1007 test records. Since the EDR.9 is rated to respond out to 35,000 Hz, we tested its response with a JVC 1005 record, which sweeps from 1,000 to 50,000 Hz. The output was flat within ± 2 dB up to about 40,000 Hz, where separation was about 12 dB.

When the cartridge was operated at its 1.25-gram maximum rated force, it was able to track the 80-micron level of the German Hi Fi Institute record as well as 30-cm/s, 1000-Hz tones. Very high-level, low-frequency tones could be tracked at the 0.75-gram minimum rated force. Measured with the CBS STR160 record, the vertical stylus angle was a relatively high 30°. The output of the cartridge, using the 3.54-cm/s standard-level bands of our STR100 record, was 3.75 mV/channel with the channels balanced to within 0.8 dB.

Tracking distortion was measured with Shure's TTR102 and TTR103 test records. The TTR102 is an IM test record, with frequencies of 400 and 4000 Hz. IM distortion measured a low 2.2% at 6.7 cm/s, which is very close to the residual on the record. It increased linearly with velocity to 11% at 27 cm/s. The TTR103 tests high-frequency tracking ability with specially shaped 10,800-Hz tone bursts. The distortion was a low 0.7% at 15 cm/s, which increased linearly to 2.5% at 30 cm/s. Although it is difficult to correlate these distortion measurements with audible effects, this gradual increase in distortion is preferable to the condition where it remains low up to some critical velocity where mistracking occurs and distortion increases sharply. The EDR.9 never exhibited any severe mistracking in our tests.

Response to the 1000-Hz square waves on the CBS STR112 record was consistent with the measured fre-

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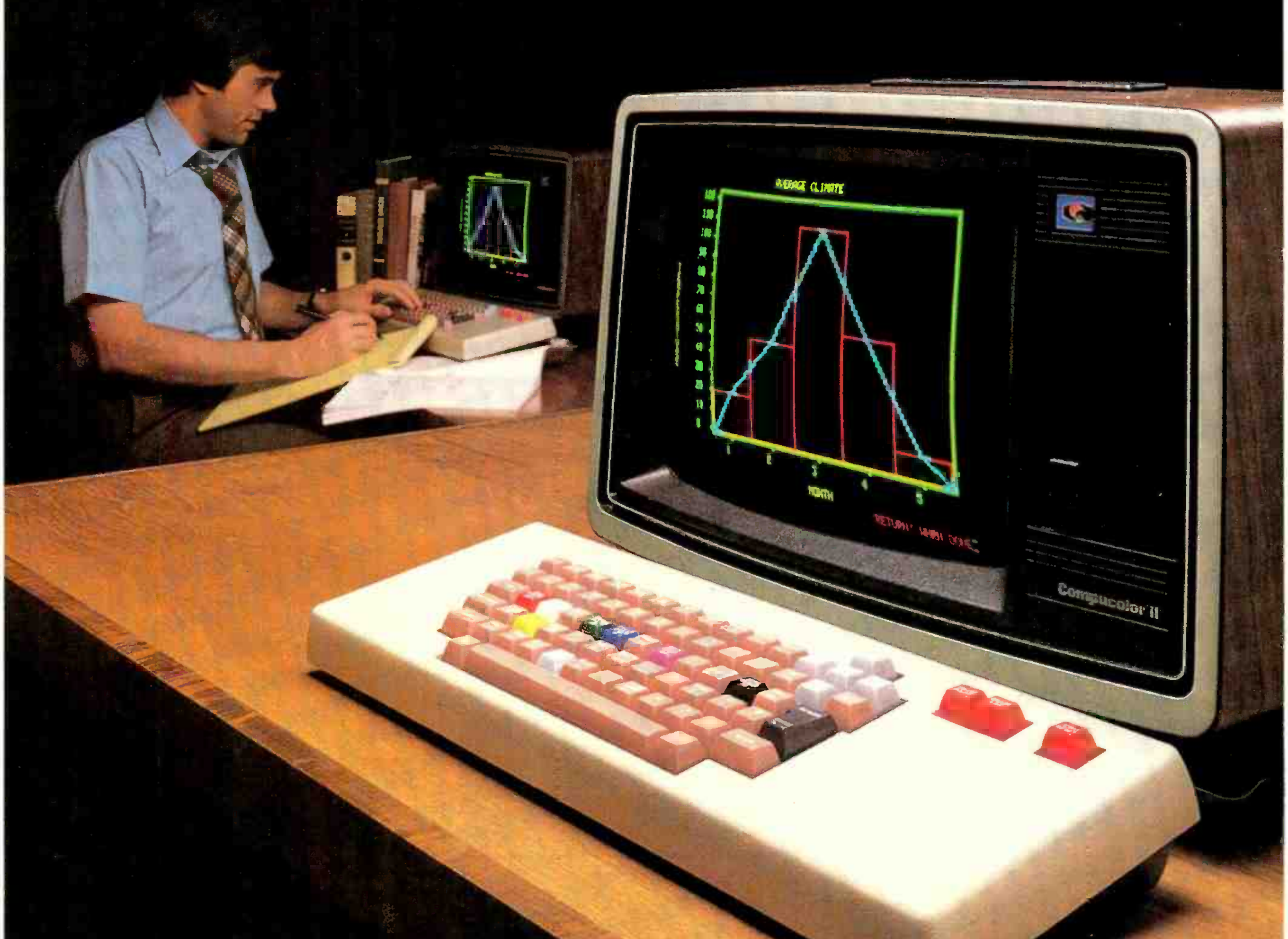

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Performance Specifications

Specification	Rating	Measured
Frequency response	20-35,000 Hz ±1.75 dB	20-35,000 Hz ±2 dB
Separation	20 dB at 20-500 Hz	—
	30 dB at 500-15,000 Hz	Confirmed
	20 dB at 15-20,000 Hz	Confirmed (see graph)
Compliance	28×10^{-6} cm/dyne	—
Tracking	38 cm/s at 1000 Hz and 0.9 gm	Not checked
Channel balance	0.75 dB at 1000 Hz	0.8 dB
Tracking angle	20°	30°(STR160)
Load impedance	47,000 ohms	—
Load capacitance	100 to 150 pF	Confirmed
Output	0.9 µV/cm/s	1.06 µV/cm/s
Inductance	250 mH	—

quency response of the cartridge. Except for a single cycle of ringing at a relatively low frequency of about 10,000 Hz, the square wave was reproduced perfectly. The high-frequency "ringing" that appears throughout the entire square wave is a characteristic of this record, and can only be seen with a cartridge whose response extends to 40,000 Hz.

User Comment. As we interpret our frequency-response measurements of the Empire EDR.9, the tuned-stylus system has the expected effect of replacing the normal single high-frequency cantilever resonance by two lower amplitude peaks, above and below the original resonance frequency. The cartridge's inductance and load capacitance roll off the upper peak, but the lower peak remains to some degree and can be seen as the rise in response at 10,000 Hz.

Because of the rather low amplitude (about 2.5 dB) of this rise, no significant coloration of the sound is produced. We played the CBS STR140 Pink Noise test record with this cartridge and with another whose response was virtually flat up to 20,000 Hz, and could not hear any differences in tonal balance or high-frequency emphasis. The EDR.9 has the smooth, effortless sound that is a hallmark of a flat-responding cartridge with high tracking ability.

When we played Shure's "Audio Obstacle Course" records, the EDR.9 had no difficulty at level 4 of each of the sections of the ERA III and ERA IV discs. At the maximum 5 level of most of the bands on both records, we began to hear traces of strain, indicating the onset of mistracking, although the bass drum of ERA III and the flute and harp solos of ERA IV were played at level 5 without difficulty. This behavior is consistent with our tracking distortion measurements.

The cartridge does not suddenly mistrack and distort at some high recorded level. Instead, its distortion increases gradually and imperceptibly, until one is finally aware of it only as a strain rather than a harshness. Since few, if any, music records have the extreme velocities found on the test records, it is probably safe to say that the EDR.9 will never be driven even close to its limits by any commercial music record.

In our opinion, the Empire EDR.9 sounded as good as, though not necessarily better than, any other cartridge we have used. We made comparisons against several competitive cartridges (in the same and higher price range) without hearing any definite points of superiority or inferiority from any of them.

If sound, per se, is not a deciding factor, the EDR.9 still offers a distinct advantage over most other moving-iron cartridges. For all practical purposes, it is not affected by changes in load capacitance. One need have no special concern with using low-capacitance cables (most record players today are so equipped), nor is there any need to add capacitance to the phono inputs of an amplifier to flatten out the cartridge's response. The EDR.9 cartridge should perform in anyone's music system just as it does on the test bench, and that is not an insignificant feature.

CIRCLE NO. 102 ON FREE INFORMATION CARD

Ace Audio Model 4000 subsonic filter

HIRSCH-HOUCK LABS REPORT

Ace Audio has developed a simple active subsonic filter that is available in both kit form and factory wired. Called the Model 4000, it is powered from its own built-in ac power supply, which can be connected for use on either 120- or 240-volt, 50- or 60-Hz power. It has unity gain and very low distortion and noise and is designed to be inserted into an amplifier tape monitoring path or between the preamplifier and power amplifier. The filter has a negligible effect on response in the audible frequency range of the system in which it is installed. It attenuates frequencies below 20 Hz at a rate of 18 dB/octave.

The Model 4000 is housed in a metal box that measures 6⅛"W × 4⅜"D × 2¼"H (15.6 × 11.1 × 7.7 cm). Prices are $59.25 for the kit and $89.50 for the factory-wired versions.

The active filter circuits are built around a dual operational-amplifier IC (Texas Instruments TL 072CP). A few discrete passive components make up the remainder of the circuitry. To ensure the correct cutoff characteristics, the capacitors in the filter circuit have 5% tolerances and the metal film resistors are 1% tolerance.

There are no controls to adjust on the filter. The only external features of the Model 4000 are the four phono jacks for the inputs and outputs of both channels and an ac receptacle on one side of the chassis.

The filter we tested was built from the kit. Assembly was simple and straightforward, involving about 25 steps. Assembly took 1½ hours.

Laboratory Measurements. The filter easily met its specifications and in most cases surpassed them by a wide margin. Our tests were performed with a standard IHF load on the outputs (a 10,000-ohm resistor, shunted by a 1000-pF capacitor). Although we had no indication that the filter's specifications were derived with this type of load, the load appeared to have no effect on the high-frequency response or other characteristics.

Our frequency-response measurement was limited to 5 Hz at the low end. However, this was sufficient to confirm the 18 dB/octave slope rating. The response was down 15 dB in the octave between 10 and 5 Hz and was down only 2 dB at 20 Hz. It was flat within ±0.2 dB from 50 to 50,000 Hz and dropped to −2 dB at 200,000 Hz.

The filter's gain was exactly 1.0, as specified. At 1000 Hz, the input impedance was 66,000 ohms (rated at 47,000 ohms), shunted by 50 pF. The unweighted hum and noise were too low to measure, being less than 100 μV (−80 dBV) at the output.

The distortion of the filter at 20 Hz was essentially that of our signal generator, or about 0.023% up to 5 volts output. Only at the maximum rated output of 8 volts could we measure any increase, at which point it was 0.034%. The 1000-Hz distortion was less than 0.008% up to 5 volts and 0.0088% at 8 volts. At 20,000 Hz, we noted the first signs of a measurable

Infrasonic Filtering

Many people concerned with "real world" system aspects of high-fidelity music reproduction recognize the problems created by record warps, which are always present to some extent—they can introduce huge infrasonic signal components into the amplifier.

Aside from the effects on sound quality of warps, the result being a function of the tonearm and cartridge, infrasonic signals can easily overdrive a power amplifier. Even if the amplifier can handle these signals, the cone of a woofer can easily be driven into its nonlinear operating region. In extreme cases, when a very powerful amplifier is used, it is possible to damage the speaker with this unwanted energy. Similar effects can occur from turntable rumble, tonearm and cartridge resonance, or simply by dropping the pickup onto a record with the amplifier's gain turned up.

A practical approach to the problem requires that the system response be limited to the audible range to avoid difficulties. But don't be misled by a lowcut filter: they're often mislabeled "subsonic." These filters usually have a slope of 6 dB/octave below cutoff. If such a filter is to provide a worthwhile attenuation in the frequency range below 10 Hz, where most warp energy is concentrated, its 3-dB-down response frequency must be well up in the midbass region. As a matter of fact it is not uncommon for an amplifier's frequency response to be affected at frequencies as high as 150 or 200 Hz. This is clearly undesirable. Using such a filter is akin to "throwing out the baby with the bath water."

Some of the more sophisticated filters use more complex circuits that give slopes of 12 or even 18 dB/octave. If properly designed, such a filter can indeed be highly effective in removing the effects of rumble or record warps with no effect on audible rumble content.

In the Ace Audio Model 4000 active filter, each channel uses one half of a Texas Instrument TL 072CP FET op amp. A direct wire connection from output to inverting input establishes the circuit gain at unity. The feedback network, using precision capacitors and resistors, provides a true 18 dB/octave cut-off slope with very low distortion and noise in the audible band.

distortion level, which increased smoothly from 0.01% at 1 volt to 0.075% at 8 volts. The measured intermodulation (IM) distortion was the 0.002% residual of our Crown IM analyzer at most output levels. It rose to 0.005% at the rated 8-volt output. These measurements confirm that the Model 4000 is a truly distortionless component with relationship to the rest of the audio system.

User Comment. We connected the Model 4000 into the tape-monitoring loop of an amplifier and used it for listening tests with a number of records. During our listening tests, we noted that the filter contributed absolutely no audible noise to the system. There was also no evidence of turn-on thumps or other transients. To see as well as hear the effects of the filter, we removed the speaker grilles and played some heavily warped records, which caused the woofer cones to move in and out rather alarmingly. At maximum listening volume, the amplifier's power meters indicated that we were driving it to its full rated output of 50 watts and sometimes beyond. The sound was muddy and occasionally broken up by the overloaded amplifier. When we switched in the filter, the visible cone movement ceased and the sound cleaned up dramatically. (There was no change in listening level.) The power meter readings also dropped from 50 watts or more to less than 10 watts, a vivid demonstration of how much amplifier power was being wasted in amplifying infrasonic noise.

In spite of its impressive effectiveness in eliminating infrasonic noises, the Model 4000 was of no value in preventing acoustic feedback when playing records. This is because such feedback normally occurs only in the audible range, where speaker systems can deliver enough acoustic power to vibrate the record player. In that range, the filter has no effect.

The Model 4000 Subsonic Filter is one of the more useful accessories one can add to a phono system if the amplifier does not presently include a sharp-cutoff low-frequency filter (very few do). It is the kind of device one can plug in and forget. Even if no switched outlet is available on the amplifier, the 3-watt consumption of the Model 4000 makes it practical to plug it into a powered outlet and leave it on.

If you have a number of warped records that are trackable by your cartridge, adding this filter to your hi-fi system should give them a new lease on life. Convince yourself of its action first by watching the speaker cones (or amplifier power meters if your amp has them) without the filter and observe the effect when it is switched in. Then forget it and enjoy the music!

Performance Specifications

Specification	Rating	Measured
Gain	Unity	1.0
Frequency response	−2.5 dB at 20 Hz −1.0 dB at 100 kHz	−2.0 dB at 20 Hz −0.6 dB at 100 kHz
Slope	18 dB/octave	Confirmed
Harmonic distortion	0.025% at 2 V out, 20-20000 Hz (typically 0.02%)	Confirmed
IM distortion	0.025% at 2 V out	0.002% at 2 V out
Slew rate	8 V/μs typical	Not measured
Input impedance	47,000 ohms	66,000 ohms, 50 pF
Output impedance	150 ohms	3 ohms
Output voltage	8 V max.	10.3 V max.
Output load	2000 ohms min.	Confirmed (very conservative)
Hum & noise	−90 dB (no ref level)	Less than −80 dB re 1 volt, unweighted
Line voltage	120 or 240 volts, 50 or 60 Hz ac	—
Power consumption	3 watts	—

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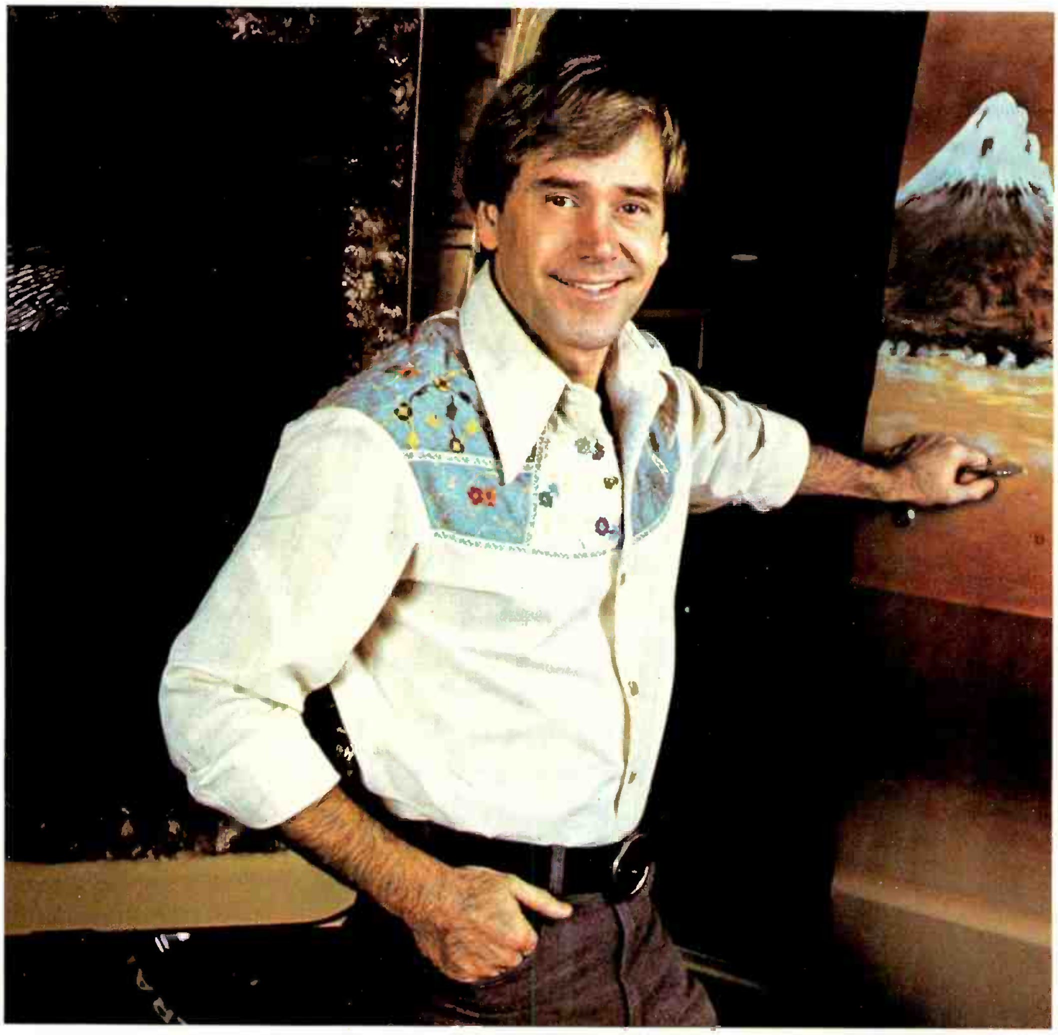

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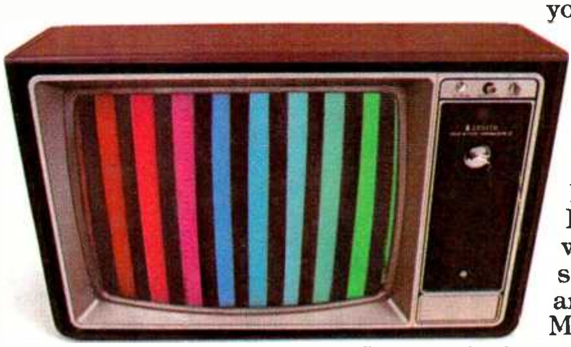

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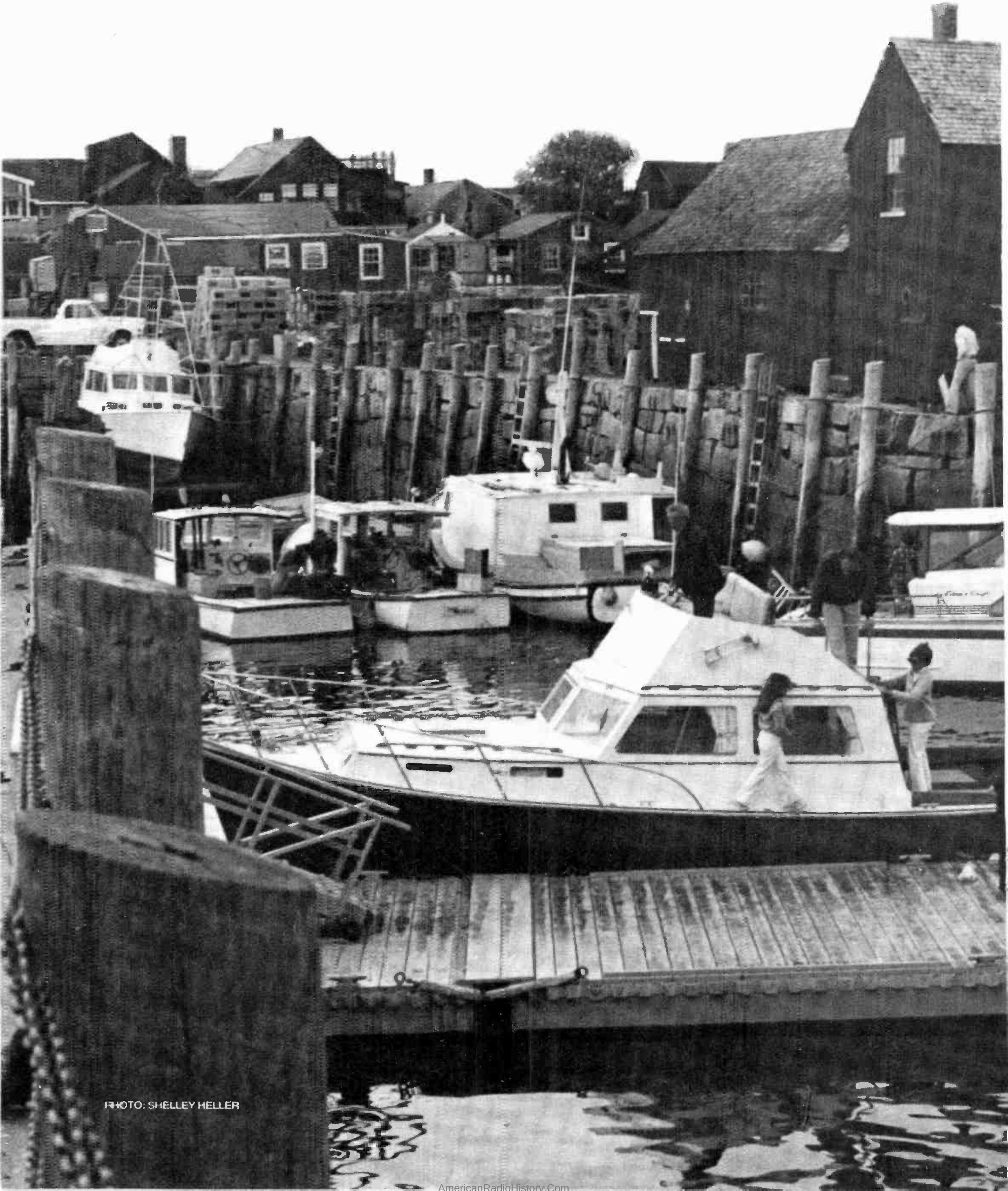

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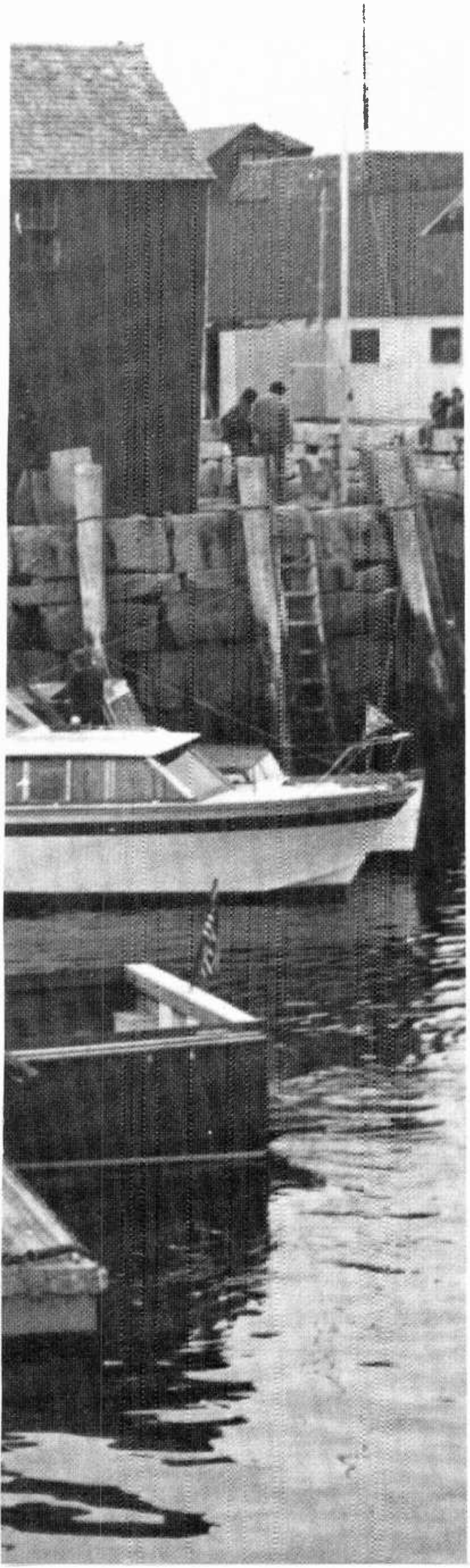
By Harold Wright



SPACE-AGE ELECTRONIC PROJECTS FOR BOATS *part one*

MODERN electronics can make operating a power boat a safer, more pleasurable experience. Various sensors, distributed around your boat, permit monitoring a number of things from a single, strategically located display panel. Among the things you can keep a check on are engine rpm and temperature, fuel level and flow, battery and alternator (or generator) status, sterndrive/rudder position, gas and fume build-up below decks, fluid levels, etc.

In this two-part article, we will be describing several projects particularly suitable for marine monitoring tasks. Each project is independent of the others, which allows you to select the arrangement that best suits your needs. All projects utilize a conventional 10-volt dc regulator to provide power from the boat's 12-to-14-volt unregulated generator/alternator output.

Voltage Monitor. The circuit shown in Fig. 1 employs 11 LEDs to display battery and alternator/generator charger voltage. The display indicates battery failure, operating status of the generator/alternator charging system, and battery overcharge. (If undetected, an overcharge condition can cause the battery to "cook," damaging the plates and producing potentially explosive hydrogen gas. Excessive voltage from the charging system can also damage other electrical/electronic equipment connected to the power line.)

The circuit is built around National Semiconductor's LM3914 dot/bar driver IC as a basic expanded-scale voltmeter. It has a range of 4.4 to 5.6 volts. Adjustment of *R3* produces a displayed range of from 11.35 to 14.5 volts on the 10 LEDs associated with *IC1*. Most manufacturers recommend a "normal" output of 14.5 volts for a properly charging generator/alternator.

The overvoltage warning indicator uses an 18-volt zener diode, *D1*, to trigger *Q1* into conduction if this potential is exceeded on the unregulated power line. When *Q1* conducts, OVERVOLTAGE *LED11* comes on. If desired, *LED11* can be replaced by a flasher circuit such as that shown in Fig. 2, or *Q1* can be used to drive a Sonalert No. SC628 or similar audible alarm.

The unregulated dc voltage from the

A variety of electronic indicators to improve safety and convenience

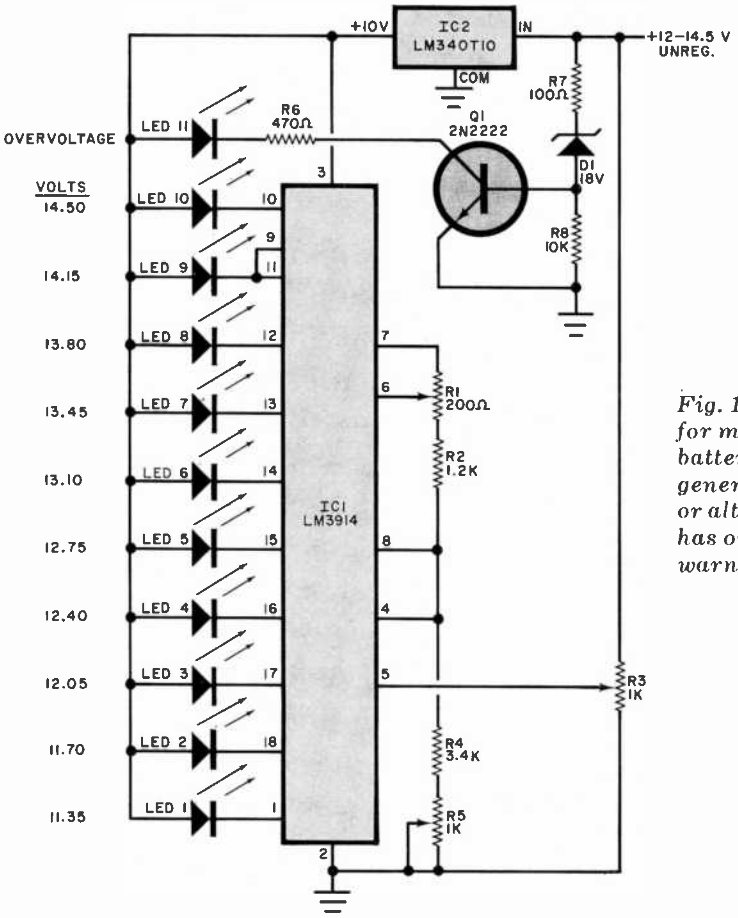


Fig. 1. Circuit for monitoring battery, generator or alternator has overvoltage warning feature.

PARTS LIST (Fig. 1)

D1—18-V, 1-W zener (1N3026B or similar)
IC1—LM3914 dot/bar driver (National)
IC2—10-V, 1-A positive voltage regulator (LM340T10 or similar)
LED1, LED2, LED3, LED11—Discrete red LED
LED4,LED5,LED6—Discrete yellow LED
LED7,LED8,LED9,LED10—Discrete green LED
Q1—2N2222 transistor
R1—200-ohm, pc multiturn trimmer pot
R2—1200-ohm, ½-W resistor
R3,R5—1000-ohm, pc multiturn trimmer pot
R4—3400-ohm, ½-W resistor
R6—470-ohm, ½-W resistor
R7—100-ohm, ½-W resistor
R8–10,000-ohm, ½-W resistor
Misc.—Perforated or printed-circuit board; suitable enclosure; IC sockets (optional); light hood; red filter; etc.

PARTS LIST (Fig. 2)

C1—4.7-µF, 15-V electrolytic
C2—0.01-µF disc capacitor
IC3—555 timer
R9—1000-ohm, ½-W resistor
R10—100,000-ohm, ½-W resistor
R6, R7, R8, D1, LED11, Q1—Same as Fig. 1

PARTS LIST (Fig. 3)

C1—0.001-µF disc capacitor
C2—0.05-µF disc capacitor
IC1—LM1830 fluid detector (National)
LED1—Bright red LED
R1—470-ohm, ½-W resistor
Misc.—Suitable stainless probe; cable; 10-V regulated dc source; etc.

boat's electrical system is maintained at 10 volts by *IC2*. This potential was selected so that regulation occurs whether the boat's engine is running or stopped. The regulator can be used as the 10-volt source for all circuits described in this article. A GE-MOV V27ZA60 or similar suppressor can be installed between the regulator's input and ground for voltage-spike protection.

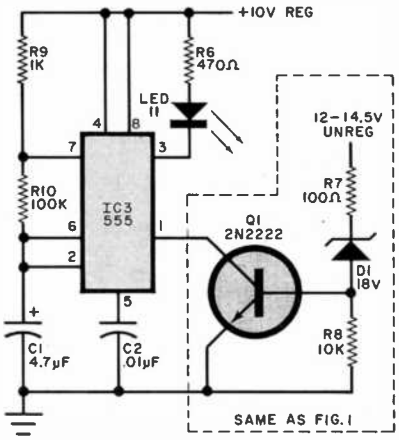


Fig. 2. Overvoltage indicator has a flash rate of 1.5 Hz.

A color-coding scheme should be used for *LED1* through *LED10* to simplify interpreting the display. Therefore, *LED1*, *LED2*, *LED3*, and *LED11* should be red to gain your immediate attention. Since *LED4*, *LED5*, and *LED6* indicate "caution" conditions, they should be yellow. Safe voltage levels are indicated by *LED7* through *LED10*; hence, these LEDs should be green.

Circuit construction is neither critical nor complicated. Except for the LEDs, all components can be mounted on perforated board or on a printed-circuit board of your own design. In either case, it is a good idea to use sockets for the ICs. The 11 LEDs should be mounted on a separate panel, with each LED identified according to the voltage it represents. (*LED11* should be identified by the legend OVER or OV for overvoltage.) The display panel itself should be hooded and faced with a neutral-density filter to permit seeing it in daylight. Incidentally, since *IC1* can deliver up to 30 mA, small incandescent lamps can replace the LEDs for better visiblilty.

Lead dress is not critical, but to avoid any possibility of oscillation, all ground leads should go to pin 2 of *IC1*.

Once the project is assembled, connect a precision dc voltmeter between pins 4 and 6 of *IC1* and adjust *R1* for a reading of 1.20 volts. Then connect the voltmeter between pin 5 and ground and adjust *R3* for a reading of 4.94 volts. Adjust *R5* until *LED5* comes on.

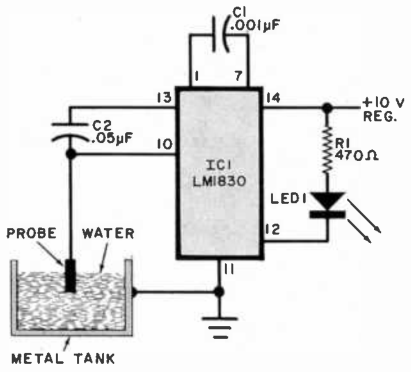


Fig. 3. Low-level detector flashes LED when probe in tank is exposed.

Now, using an adjustable dc power supply, set its output voltage to 14.5 volts and make sure that *IC2* is delivering 10 volts at its output. Adjust *R3* until *LED10* (14.5 volts) comes on. As the input to the project is varied from 11 to 14.5 volts, the LEDs should progressively light. Set the input to 18 volts and verify that *LED11* (or optional flasher) comes on or the audible alarm sounds.

Fluid-Level Indicator. Fluid level monitoring is important in a boat. You should always know, for example, the water level in the expansion tank of the engine's heat exchanger, the level in the galley's fresh-water tank and in the bilges, etc. The circuit shown in Fig. 3 is suitable for low-water-level monitoring. The IC contains a voltage regulator, oscillator, detector, and an output transistor capable of driving a LED, audible alarm, or low-current relay.

Conventional water tanks are usually metal-cased and grounded to the electrical system, which simplifies the job of sensing water levels. As shown in Fig. 3, when the probe tip is immersed in the water, the circuit is in a static state. However, when the water level drops and exposes the probe tip, the probe-to-ground circuit opens. This couples *IC1*'s internal oscillator signal to its internal detector via *C2*, presenting an output at pin 12. Frequency of oscillation is determined by the value of *C1*, which with the value shown is about 6000 Hz.

If the water tank is metal, only one probe is required, since the metal tank serves as the other element of the probe. This circuit can be used with the expansion tank of a closed system as illustrated in Fig. 4. As long as the water system is full, the output remains off. If the water level drops below the probe tip, the alarm turns on. (Note: glycol-type coolant is not electrically conductive, which precludes the use of this device where antifreeze is used.)

Four detectors can be used to keep tabs on the level in the galley's fresh-water tank as shown in Fig. 5. The probe is fabricated from a length of plastic U channel, with the probe elements themselves made from stainless-steel screws that protrude through the channel at suitable intervals. The wiring is laid flat in the U channel and secured in place with epoxy cement or silicone-rubber adhesive.

The actual detector used for the multiple probes is illustrated in Fig. 6. In this circuit, when each probe tip is covered by the water, its associated detector output goes high and sends its transistor into conduction to cause its LED to light. Hence, with a full tank of water, all the LEDs are lit. As the water level drops, the probe tips are successively exposed and extinguish each LED in turn. The EMPTY LED is optional. Its probe should be located in the plastic U channel so

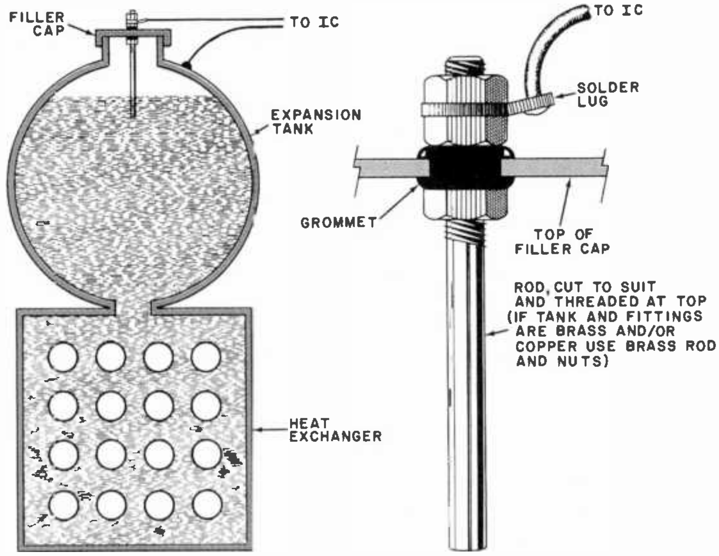


Fig. 4. Low-level warning device for closed system. Washers and lug should be covered with silicone rubber. Leakage here would produce a "full-tank" indication.

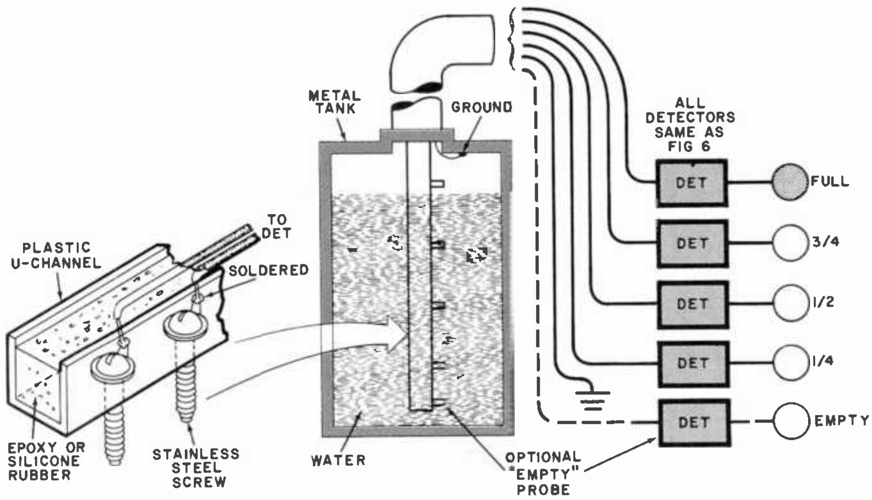


Fig. 5. Fresh water tank guage that displays liquid level on a set of LED readouts.

PARTS LIST (Fig. 6)

C1—0.002-µF disc capacitor
C2—0.05-µF disc capacitor
C3—10-µF, 15-V electrolytic
IC1—LM1830 fluid detector (National)
LED1—Bright red LED
Q1—2N2222 transistor
R1—2200-ohm, ½-W resistor
R2—470-ohm, ½-W resistor
Misc.—10-V dc regulator; interconnecting cable; etc.

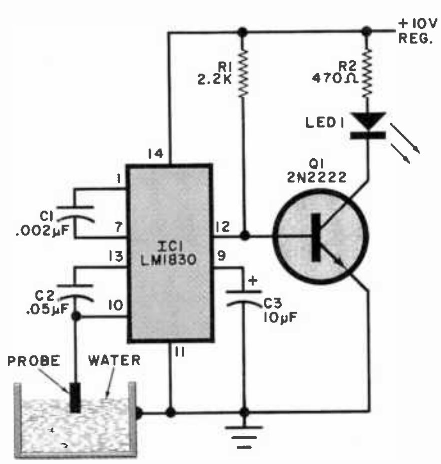


Fig. 6. High-water detector for grounded metal tank.

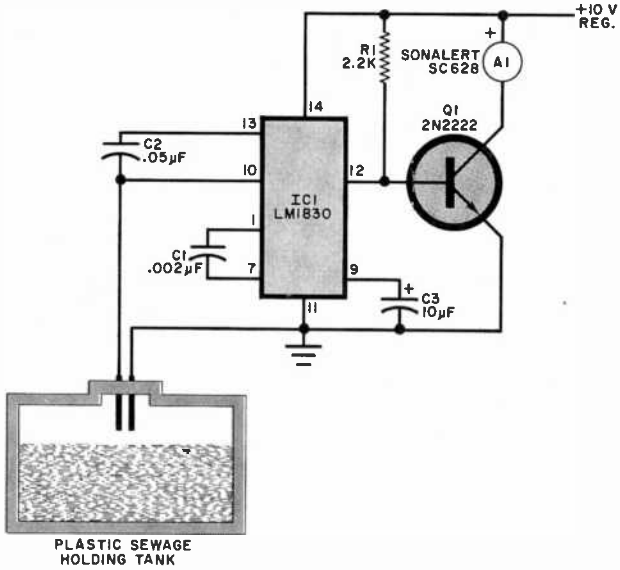


Fig. 7. Full sewage holding tank warning system. Alarm sounds when sewage touches stainless steel probes.

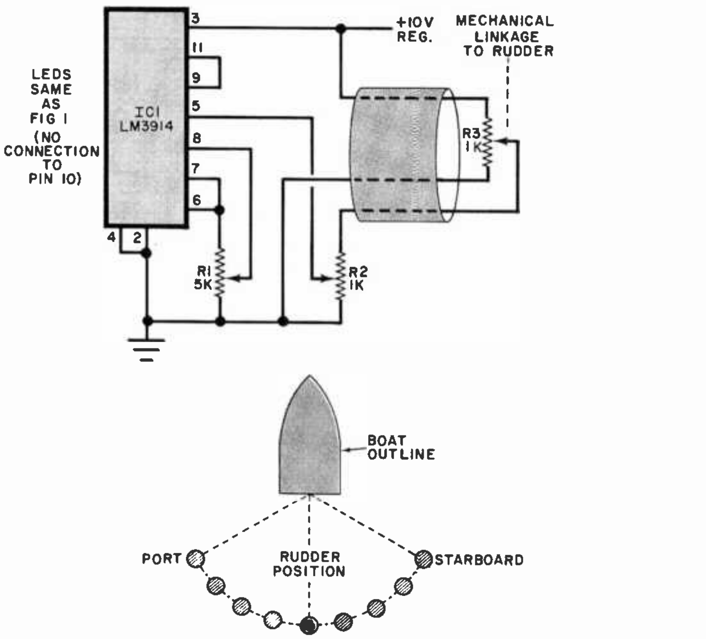


Fig. 8. Rudder/stern drive position indicator uses same LED readout as Fig. 1. LEDs are mounted in arc to indicate position.

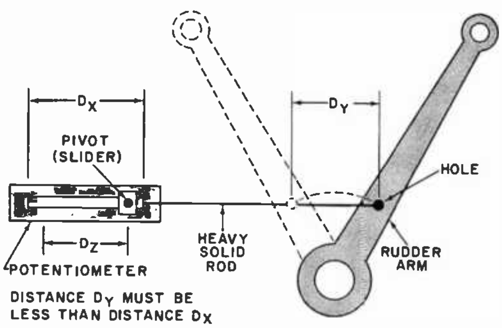


Fig. 9. Diagram showing how to make mechanical connection between rudder arm and slide potentiometer.

PARTS LIST (Fig. 7)

A1—Sonalert Model SC268 (or similar) alarm
C1—0.002-µF, disc capacitor
C2—0.05-µF disc capacitor
C3—10-µF, 15-V electrolytic
IC1—LM1830 fluid detector (National)
R1—2200-ohm, ½-W resistor
Q1—2N2222 transistor
Misc.—Stainless probe tips; interconnecting cable; 10-V regulated dc source; etc.

PARTS LIST (Fig. 8)

IC1—LM3914 dot/bar driver (National)
R1—5000-ohm, pc multiturn trimmer pot
R2—1000-ohm, pc multiturn trimmer pot
R3—1000-ohm, linear-taper, slider-type pot
Misc.—LEDs (see Fig. 1); 10-V regulated dc source; three-conductor waterproof interconnecting cable; etc.

that the LED comes on when there is a small safety reserve of water left.

The probes are designed to be removable. This permits you to periodically remove built-up mineral deposits that can produce a conductive path and lead to false indications.

Sewage-Tank Indicator. If you do your boating in an area where the law requires a sewage holding tank, the circuit shown in Fig. 7 will prove to be a handy liquid-level indicator. It employs an audible alarm instead of a LED.

Rudder-Position Indicator. The circuit in Fig. 8 can be a valuable asset to any stern-drive or inboard-engine boat. It allows the person at the wheel to always know the angular position of the rudder or stern drive. The LED display is basically the same as that shown in Fig. 1, except that there is no LED connection to pin 10 of the IC. The LEDs are best arranged in an arc, as shown in Fig. 8. The arc originates at the stern post of the rudder/stern drive that is painted on the enclosure.

The IC is wired as a basic 0-to-5-volt meter and is calibrated by *R1*. Before installation, *R1* must be set so that there is about 1300 ohms of resistance between the terminal that connects to pin 7 of the IC and the wiper, with the remaining 3700 ohms between wiper and ground. The slide-type potentiometer used for *R3* is installed near the rudder and connected to the IC via a length of waterproof three-conductor cable. Its control tab is mechanically connected to the rudder through a short length of stiff rod, as shown in Fig. 9. Because the rudder arm moves in an arc, the rod must be able to pivot slightly where it connects to the rudder and potentiometer.

After assembling the electronics package, connect everything but pin 5 of the IC. Connect a 12-to-14-volt dc source to the unregulated input (before the regulator IC in Fig. 1) and a 5-volt dc source between pin 5 of the IC and ground, with +5 volts going to pin 5. Carefully adjust *R1* until *LED9* just lights. The brightness of the LED will change slightly as this adjustment is made because *R1* controls LED current. This is why *R1* had to be adjusted before applying power. An incorrect setting could pump more than 30 mA into the LEDs, possibly damaging them. Once *R1* had been calibrated, complete the connection from pin 5 of the IC to *R2* and temporarily connect *R3* into the circuit. Set *R3* to its center position and adjust *R2* until *LED5* comes on. This point represents dead center for the rudder during final installation.

As the slider of *R3* is moved to its positive end, *LED6* through *LED9* come on progressively. Moving the slider toward the grounded end of *R3* causes the LEDs to come on in descending order.

Referring to Fig. 9, the pivot point for the drive rod must be carefully chosen. When the rudder arm is hard right or hard left, it must not place mechanical stress on the potentiometer's slider. The range of slider movement should be slightly less than that of the pickup point on the rudder arm.

Care must be taken to prevent the slider of *R3* from going all the way to its stop at either end. If the arm pushed the slider all the way to the ground end of *R3*, *LED1* would extinguish because a small voltage is required to operate the first comparator in *IC1*. This can be accomplished by making distance D_Y in Fig. 9, traversed by the rudder arm pivot point, slightly less than distance D_X. If this is done, when the rudder arm traverses the full swing from hard left to hard right, *R3*'s slider will move only distance D_Z, which is the working range of the potentiometer.

Distance D_Z can be found during calibration. Move the slider toward the ground end and note the point just before *LED1* extinguishes. Repeat the procedure to locate the point at which *LED9* just extinguishes at the other end of *R3*. Some minor trimming might be required to produce a guard band at both ends of the potentiometer.

Coming Up. This completes Part I of this article. Next month, we will cover a novel engine tachometer, a bilge-water alarm, and protection for your equipment from transient voltage spikes. ◇

BY HARRY J. MILLER

How to DETERMINE ANTENNA GAIN

Gain figures must have a common reference.

CONFUSION often arises when antenna gain is being discussed. This happens because gain is dependent on a reference—a given antenna will have varying amounts of gain, depending on what it is being compared to. Normally, the gain of an hf antenna is measured by comparing it to a horizontal, half-wave dipole. In vhf and uhf FM communications, the reference for antenna gain is a vertical half-wave dipole. However, many manufacturers advertise gain figures for their products referenced to an isotropic source (a theoretical antenna that radiates equally well in all directions). To add to the confusion, some manufacturers rate their antennas referenced to a quarter-wave ground plane.

The ground plane antenna comprises a quarter-wavelength vertical radiator positioned over a metallic ground plane—either solid sheet metal or an array of radial wires. This antenna has 0.3 dB gain over an isotropic radiator. A half-wave dipole has 2.1 dB of gain referenced to an isotropic source, or 1.8 dB over a quarter-wave ground plane antenna. The ⅝-wave vertical, which also requires a metallic ground plane, is commonly used in FM mobile installations. It has 1.2 dB of gain over a half-wave dipole, 3.0 dB over a quarter-wave ground plane, or 3.3 dB gain referenced to an isotropic antenna.

Higher omnidirectional gain can be obtained by using collinear arrays or a group of stacked half-wave dipoles. For example, four stacked vertical dipoles will provide approximately 6 dB of gain and an omnidirectional polar pattern. The gain is referenced to isotropic.

When comparing two or more antennas, be sure that all gain figures share a common reference. This can be done by adding or subtracting corrective factors. For example, two antennas are being considered for a fixed station. One has 4.0 dB gain referenced to an isotropic source (sometimes denoted 4.0 dBi) and the other has 2.0 dB over a dipole (sometimes denoted 2.0 dBd). Which has more gain? Add 2.1 dB to the gain of the antenna referenced to the dipole and note the antenna has a gain of 4.1 dBi, slightly better than that of the isotropic-referenced antenna.

The accompaning table compares antenna gains for some common antennas referenced to isotropic, ground plane, and dipole antennas. ◇

ANTENNA GAINS

Antenna Type	Gain Over Isotropic	Gain Over Ground Plane	Gain Over Dipole
Isotropic	0 dB	−0.3 dB	−2.1 dB
Ground plane	0.3 dB	0 dB	−1.8 dB
Dipole	2.1 dB	1.8 dB	0 dB
5 λ/8 Vertical	3.3 dB	3.0 dB	1.2 dB
4 Stacked λ/2 dipoles	6.0 dB	5.7 dB	3.9 dB
8 Stacked λ/2 dipoles	9.0 dB	8.7 dB	6.9 dB
2-Element Yagi	7.1 dB	6.8 dB	5.0 dB
3-Element Yagi	10.1 dB	9.8 dB	8.0 dB
4-Element Yagi	12.1 dB	11.8 dB	10.0 dB
5-Element Yagi	14.1 dB	13.8 dB	12.0 dB
2-Element quad	9.1 dB	8.8 dB	7.0 dB
3-Element quad	12.1 dB	11.8 dB	10.0 dB
4-Element quad	14.1 dB	13.8 dB	12.0 dB

a dB Primer

BY JOHN C. BATTLE, N4OE

How to work with decibels and convert them to their electrical equivalent in various areas of electronics—from communications to hi-fi

THE expression of voltage, current, and power ratios in decibels (dBs) is pervasive in literature about, and analysis of, electronic circuits. Therefore, anyone interested in electronics, from audio through amateur radio, should clearly understand the concept of decibels. Here are decibel basics, using a minimum of math.

Gain and Loss. The amount of output power from a linear electronic network is proportional to the amount of power present at its input. Thus, the power lost or gained in such a network is proportional to the amount of input power, as shown in Fig. 1. When 10 watts of power are applied to the network's input (Fig. 1A), 9 watts are dissipated as heat and 1 watt appears at the output. When 1000 watts are applied to the same network (Fig 1B), assuming that it can safely handle this increased power level, 900 watts of heat will be produced with only 100 watts of output power.

The amount of power at the output of the attenuator, P_O, is related to the input power P_I by the equation $P_O = (K)(P_I)$ with $K = 1/10$; where K is a ratio called the gain factor. Of course, it is possible to cascade two or more such networks to obtain a cumulative effect, as shown in Fig. 2. Here two attenuating networks are used. Their total effect is identical to that produced by a single attenuator with a gain factor of 1/100: $P_O = (1/10)(1/10)(P_I) = (1/100)(P_I)$.

Cascading linear electronic networks results in the multiplication of their gain factors. It might be well at this point to mention that loss is treated as a fractional gain. For example, the 10:1 attenuators of Fig. 1 have gain factors of 0.1. Contrast those with the gain factors of most amplifiers, which are often appreciably greater than unity.

Defining the dB. It would be very convenient if we could express gain factors in such a way that they are additive in nature. Then the cumulative effect of cascaded gain or loss blocks could be calculated simply by adding terms, not multiplying them. The decibel allows us to do exactly that.

A decibel expresses a ratio—specifically, 1.259:1—so the addition of decibel gains is equivalent to the multiplication of ratios or gain factors. Power gain in decibels is formally defined as: $G(\text{dB}) = 10 \log_{10}(P_O/P_I) = 10 \log_{10}(K)$. Note that the logarithm of a positive number less than one is negative. Thus, negative decibels represent fractional gain or attenuation. Positive decibels signify gains greater than one or amplification. Applying the power formula to the attenuators of Fig. 1, we see that $G = 10 \log_{10}(1/10) = 10(-1)$ or -10 dB. Table I summarizes common power ratios and their gains in decibels.

Another Definition—dBm. Power levels are also expressed in dBm, that is, the number of decibels greater or less than a reference level of one milliwatt. Mathematically, this is defined as: $P(\text{dBm}) = 10 \log_{10}(P_{mw})$ or $30 + 10 \log_{10}(P_W)$, where P_{mw} is the power in milliwatts and P_W is the power in watts.

For example, 10 watts is 10,000 milliwatts, so $P(\text{dBm}) = 10 \log_{10}(10{,}000) = 10(4)$ or $+40$ dBm. Also, $P(\text{dBm}) = 30 + 10 \log_{10}(10) = 30 + 10$ or $+40$ dBm. One microwatt is 0.001 milliwatt, so $P(\text{dBm}) = 10 \log_{10}(0.001) = 10(-3)$ or -30 dBm. Table II lists common values of power in watts and milliwatts, and their counterparts in dBm.

Converting Back. One rarely needs to convert dBm or dB back into watts or power ratios; but for the sake of completeness, we will include the relevant formulas. To convert dBw into watts, milliwatts, or gain factors (power ratios),

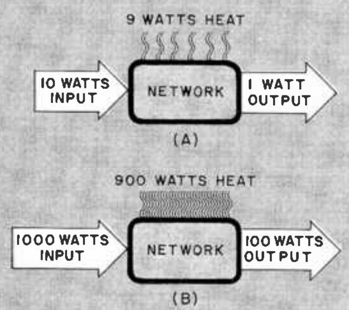


Fig. 1. In linear electronic networks, output power is proportional to input power.

Fig. 2. This drawing shows the cumulative effect of electronic attenuators placed in series.

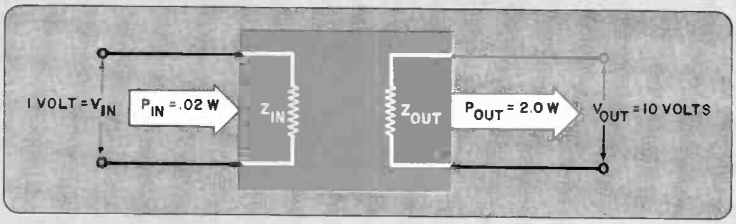


Fig. 3. Simple network illustrates voltage and power relationships.

use these relationships: $P_W = 10^{0.1\ P(dBw)}$; $P_{mw} = (10^3)\ 10^{0.1\ P(dBw)}$; $K = 10^{0.1G}$; where P(dBw) is the power in dBw, P_W is the power in watts, P_{mw} is the power in milliwatts, G the gain in decibels, and K the gain factor or power ratio. Similarly, $P_{mw} = 10^{0.1\ P(dBm)}$ and $P_W = (10^{-3})\ 10^{0.1\ P(dBm)}$ where P(dBm) is the power in dBm.

Moreover, it's also possible to use the tables in reverse. Multiplication of ratios can be accomplished by adding decibels. For example, 80 dB = 40 dB + 40 dB, so $K_{80\ dB} = (K_{40\ dB})\ (K_{40\ dB})$ or 1/100,000,000 = (1/10,000) times (1/10,000). Thus you can always break down a given number of decibels into several components that are listed in the tables. The same technique can be used for power levels in dBm: +80 dBm = +50 dB + 30 dB, and P_W = (100 watts) (1000) = 100,000 watts.

Decibels and Voltage Ratios. Expressing voltage ratios in decibels is also commonly done. The following relationship is used to compute the decibels of power gain of a voltage ratio—providing the network's input and output impedances are equal: $G(dB) = 20 \log_{10} (V_O/V_I)$, where V_O and V_I are the rms output and input voltages, respectively. Keep in mind that the input and output impedances are assumed to be equal. This is often a valid assumption in r-f work because most circuit impedances are standardized at 50 ohms. It's not always true, however, and a disparity between the impedances can lead to incorrect values of decibel gain and confusion on the part of the person doing the calculations. Unless the impedances are known to be equal, it's probably better to stick to power ratios.

Here's a simple problem worked out both ways. What are the input and output power, gain factor, and decibel gain for the network shown in Fig. 3? First, we calculate signal power using the equation $P = E^2/Z$: $P_I = 1^2/50 = 1/50 = 0.02$ watt and $P_O = 10^2/50 = 100/50 = 2.0$ watts. Then $K = P_O/P_I = 2.0/0.02 = 100$ and $G(dB) = 10 \log_{10} (K) = 10 \log_{10} (100) = 10\ (2)$ or 20 dB. In the alternative solution, we use the voltage ratio expression: $G(dB) = 20 \log_{10} (V_O/V_I) = 20 \log_{10} (10/1) = 20 \log_{10} (10) = (20)\ (1) = 20$ dB. Table III lists common voltage ratios and their resulting power gains in decibels—if input and output impedances are equal.

Applications in Communications. As mentioned earlier, an important property of decibels is their additive nature. The following real-life situation will illustrate how decibels simplify the solutions to fairly complex problems.

A radio amateur has a 2-meter trans-

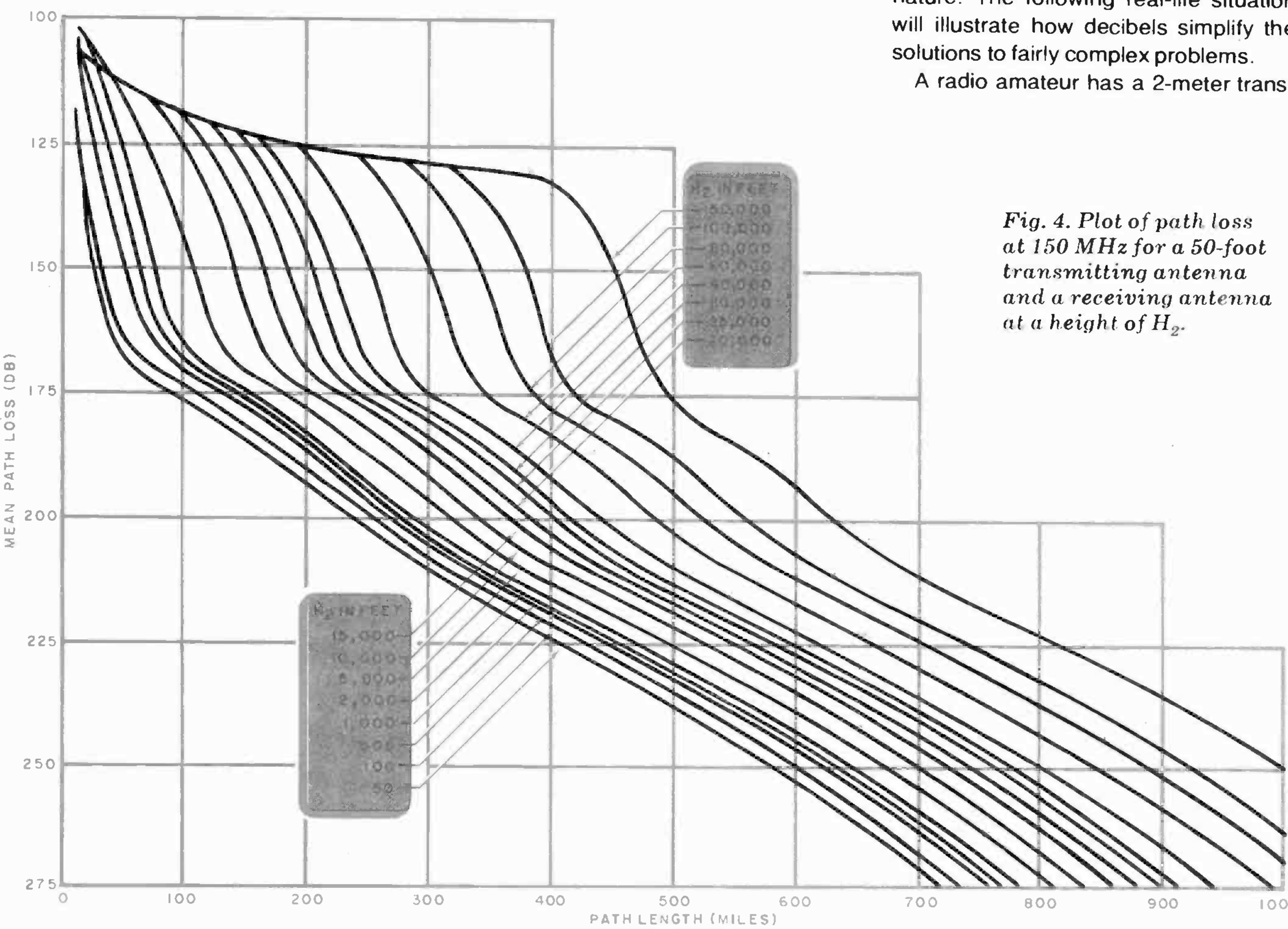


Fig. 4. Plot of path loss at 150 MHz for a 50-foot transmitting antenna and a receiving antenna at a height of H_2.

TABLE I—DECIBELS VS POWER RATIOS

Gain (dB)	Gain (power ratio)
−50	0.00001
−45	0.00003
−40	0.00010
−35	0.00032
−30	0.00100
−25	0.00316
−20	0.01000
−19	0.01259
−18	0.01585
−17	0.01995
−16	0.02512
−15	0.03162
−14	0.03981
−13	0.05012
−12	0.06310
−11	0.07943
−10	0.10000
−9	0.12589
−8	0.15849
−7	0.19953
−6	0.25119
−5	0.31623
−4	0.39811
−3	0.50119
−2	0.63096
−1	0.79433
0	1.00000
1	1.25893
2	1.58489
3	1.99526
4	2.51189
5	3.16228
6	3.98107
7	5.01187
8	6.30957
9	7.94328
10	10.00000
11	12.58925
12	15.84893
13	19.95262
14	25.11886
15	31.62278
16	39.81072
17	50.11872
18	63.09573
19	79.43282
20	100.00000
25	316.22775
30	1000.00000
35	3162.27744
40	10000.00000
45	31622.77222
50	100000.00000

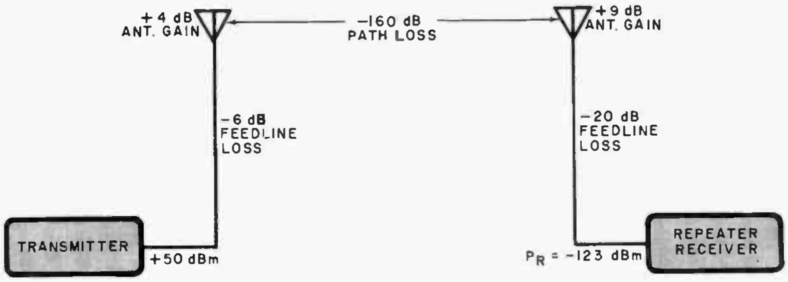


Fig. 5. Diagram showing the various gains and losses encountered in a communications system.

ceiver with 100 watts of r-f output. It is connected to a 5/8-wavelength antenna mounted on a 50-foot (15.2-m) tower via a 100-foot (30.5) length of RG-58A/U coaxial cable. He wants to work a repeater 90 air miles away whose 9-dB gain antenna is mounted on a 2000-foot (610-m) peak. The repeater requires −113 dBm of signal power at the input of its receiver for full quieting. The 2500-foot (762-m) length of low-loss coax interconnecting the repeater's antenna and receiver exhibits 20 dB of attenuation. Will his signal quiet the repeater? If not, what can be done about it?

Figure 4 is a plot of path loss at 150 MHz for a 50-foot (15.2-m) transmitting antenna and a receiving antenna at height H_2. It is taken from the "Transmission Loss Atlas for Select Aeronautical Service Bands from 0.125 to 15.5 GHz," by Gierhart and Johnson, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.25. This graph tells us that for a 2000-foot high receiving antenna, a path length of 90 miles results in an antenna-to-antenna loss of 160 dB. Of course, this is only a nominal figure. The exact path loss will depend on terrain, ground conductivity, ground moisture, the weather, etc. Also, the quoted 160-dB path loss does not take antenna gain into account.

Referring to Table II, we see that 100 watts is +50 dBm. Also, we see from the ARRL Handbook that losses for RG-58A/U are approximately 6 dB per

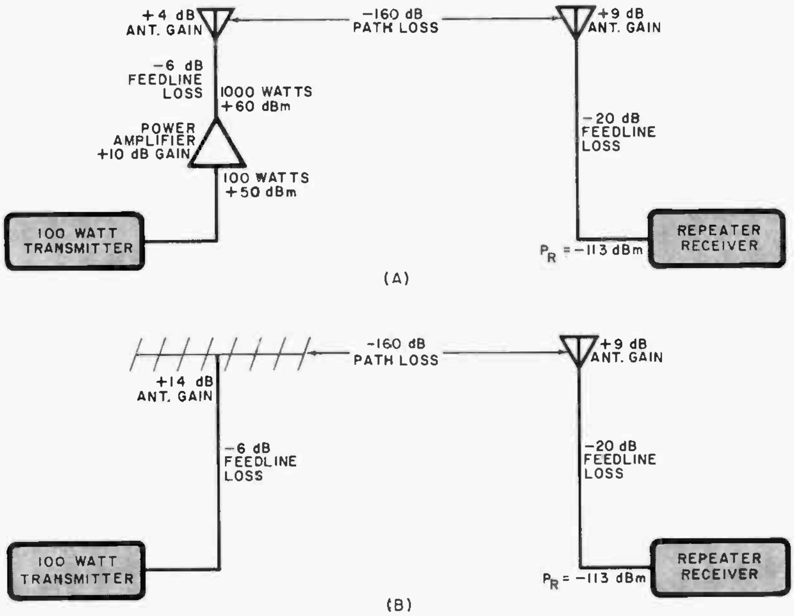


Fig. 6. To achieve full quieting, the transmitted power can be increased (A) or a different type of antenna can be used (B).

TABLE II—POWER IN dBm VS POWER IN WATTS AND MILLIWATTS

Power (dBm)	Power (milliwatts)	Power (watts)
−50	0.00001	0.00000001
−45	0.00003	0.00000003
−40	0.00010	0.00000010
−35	0.00032	0.00000032
−30	0.00100	0.00000100
−25	0.00316	0.00000316
−20	0.01000	0.00001000
−19	0.01259	0.00001259
−18	0.01585	0.00001585
−17	0.01995	0.00001995
−16	0.02512	0.00002512
−15	0.03162	0.00003162
−14	0.03981	0.00003981
−13	0.05012	0.00005012
−12	0.06310	0.00006310
−11	0.07943	0.00007943
−10	0.10000	0.00010000
−9	0.12589	0.00012589
−8	0.15849	0.00015849
−7	0.19953	0.00019953
−6	0.25119	0.00025119
−5	0.31623	0.00031623
−4	0.39811	0.00039811
−3	0.50119	0.00050119
−2	0.63096	0.00063096
−1	0.79433	0.00079433
0	1.00000	0.00100000
1	1.25893	0.00125893
2	1.58489	0.00158489
3	1.99526	0.00199526
4	2.51189	0.00251189
5	3.16228	0.00316228
6	3.98107	0.00398107
7	5.01187	0.00501187
8	6.30957	0.00630957
9	7.94328	0.00794328
10	10.00000	0.01000000
11	12.58925	0.01258925
12	15.84893	0.01584893
13	19.95262	0.01995262
14	25.11886	0.02511886
15	31.62278	0.03162278
16	39.81072	0.03981072
17	50.11872	0.05011872
18	63.09573	0.06309573
19	79.43282	0.07943282
20	100.00000	0.10000000
25	316.22775	0.31622775
30	999.99993	0.99999993
35	3162.27744	3.16227743
40	10000.00000	10.00000000
45	31622.77222	31.62277222
50	100000.00000	100.0000000

100 feet (30.5 m). Because signal losses and gains are additive (see Fig. 5), we can quickly compute P_R, the received signal power: P_R = +50 dBm − 6 dB + 4 dB − 160 dB + 9 dB −20 dB or −123 dBm. The repeater requires a signal strength of −113 dBm, so we see that we are 10 dB too low. Hence, the signal at the output of the repeater will be somewhat noisy.

Figure 6 illustrates two possible solutions to the problem. The first and most obvious is to increase the transmitted signal power. Because the signal power at the receiver is 10 dB too low, this means that the transmitter output must be increased from 100 to 1000 watts. Adding a kilowatt amplifier to the transmitting station, as shown in Fig. 6A, will raise the signal power at the repeater's receiver to −113 dBm.

The second solution to the problem involves replacing the 5/8-wavelength antenna with a directional yagi beam (Fig. 6B). A 12-element beam with a 3.5-wavelength boom will give about 14 dB of gain. The additional 10 dB over the 5/8-wavelength antenna will result in −113 dBm of signal power, and hence full quieting of the repeater's receiver.

Decibels in Audio. Anyone who wants to be conversant in the field of audio must be well versed in decibels. This is so because many of the key operating characteristics of the circuits and electromechanical transducers employed in high-fidelity applications are expressed in part or in whole using decibels. For example, the frequency response of a cartridge, speaker, or amplifier is specified as +*X*, −*Y* dB from (typically) 20 to 20,000 Hz. In the case of the cartridge, the reference employed is a certain output level in millivolts. For a speaker, the reference is the sound pressure level corresponding to the threshold of audibility (0 dB = 2 x 10^{-4} dynes/cm^2, 2 x 10^{-4} microbars, or 10^{-16} watts/cm^2.)

The power output of an amplifier is commonly specified in dBw, where 1 dBw equals 1 watt. For example, an amplifier which can provide 100 watts of continuous output power per channel can be rated as having an output of 20 dBw. Program source components such as turntables, tape decks and tuners have several decibel-related specifications. Of prime interest to any prospective purchaser is the signal-to-noise ratio (S/N) at the output of the program source. This is typically rated by driving the source to a reference output level, removing the input signal, and measuring the residual noise at the output. The decibel relationship between the reference output voltage and the residual noise is the component's S/N. For a program source to be considered one of high fidelity, it should have an S/N of 55 dB or more.

The relatively new IHF FM tuner standard specifies that signal strength in sensitivity ratings is to be expressed in dBf, where the reference is the *femtowatt* or 10^{-15} watt (0 dBf = 1 femtowatt). This was done to base sensitivity measurements on signal power, thus resolving the ambiguity caused by varying source impedances. For example, the same tuner could have an "old" IHF usable sensitivity of 2.0 µV into its 300-ohm antenna input *or* 1.0 µV into its 75-ohm input jack. Under the updated system, the tuner has a sensitivity of 11.2 dBf no matter which input and source impedance is used.

Decibels are so pervasive in the field of audio that a full appreciation of them is one mark of the true audio buff. Tape recordists especially must be comfortable with decibels. For example, when choosing a microphone, he must consider its sensitivity—its relative efficiency of converting acoustic energy into electrical energy. There are several methods of determining a microphone's sensitivity, which is usually expressed in dB below a specified reference level. The two types of ratings commonly used are the open-circuit voltage rating and the maximum power rating.

The open-circuit voltage technique measures the unloaded output of the microphone when driven by a reference SPL (for example, 1 microbar), compares it to a reference voltage (1 volt), and extracts the decibel relationship between the two. If an SPL of 1 microbar causes a microphone to develop 1 volt of output signal, its sensitivity is 0 dB. Practical microphones deliver much smaller output levels, with typical open-circuit voltage sensitivities varying from about −70 dB for dynamic moving-coil microphones to −37 dB for capacitive microphones with built-in preamplifiers.

The maximum power method involves connecting the microphone to a load equal to its internal (source) impedance, driving it with a reference SPL, and measuring the output power delivered to the load. The reference output power level is 1 milliwatt and the reference SPL is usually 10 microbars. Therefore, if a microphone driven by 10 microbars delivers 0.001 microwatt (10^{-6} milliwatt) into its optimum load, its sensitivity would be −60 dB referenced to 1 milliwatt or −60 dBm.

TABLE III DECIBELS VS VOLTAGE RATIOS

Gain (dB)	Voltage Ratio
−50	0.00316
−45	0.00562
−40	0.01000
−35	0.01778
−30	0.03162
−25	0.05623
−20	0.10000
−19	0.11220
−18	0.12589
−17	0.14125
−16	0.15849
−15	0.17783
−14	0.19953
−13	0.22387
−12	0.25119
−11	0.28184
−10	0.31623
−9	0.35481
−8	0.39811
−7	0.44668
−6	0.50119
−5	0.56234
−4	0.63096
−3	0.70795
−2	0.79433
−1	0.89125
0	1.00000
1	1.12202
2	1.25893
3	1.41254
4	1.58489
5	1.77828
6	1.99526
7	2.23872
8	2.51189
9	2.81838
10	3.16228
11	3.54813
12	3.98107
13	4.46684
14	5.01187
15	5.62341
16	6.30957
17	7.07946
18	7.94328
19	8.91251
20	10.00000
25	17.78279
30	31.62278
35	56.23413
40	100.00000
45	177.82793
50	316.22775

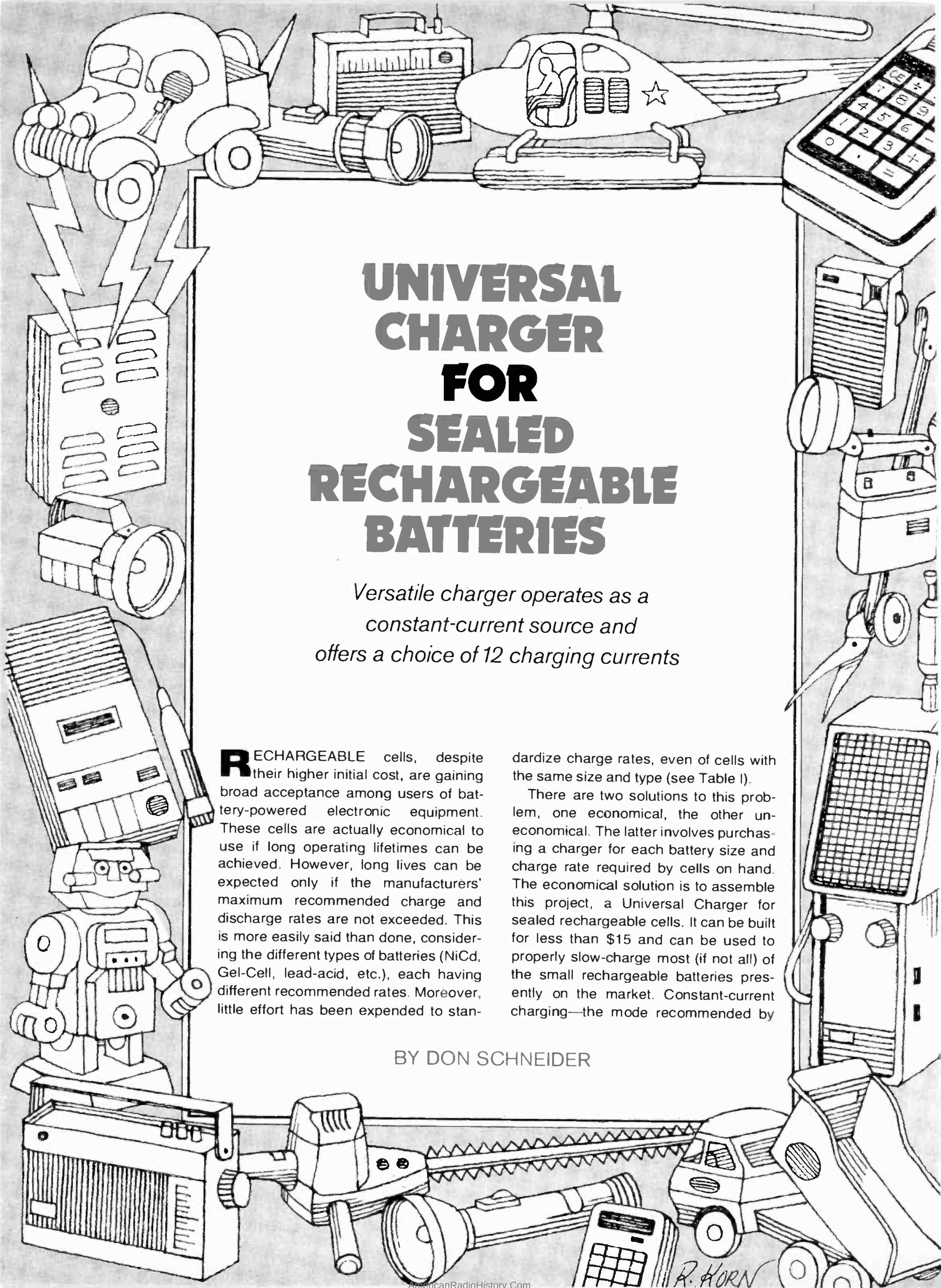
Volume Units. Many tape decks' record level meters are calibrated in "VU" as opposed to dB. Others have meters calibrated in dB. This may lead some to conclude that VUs are different from dBs. That, however, is untrue. Electrically speaking, a change in signal level of 1 VU is equivalent to a level change of 1 decibel.

A VU *meter*, however, has carefully controlled ballistic characteristics governing how the meter deflects upward from −20 to 0 VU and how much momentary overshoot will occur. It also has a specified input impedance (3900 ohms), is to be used with a 3600-ohm series resistor, has a defined scale (−20 to +3 VU), employs a particular type of rectifier, and is an average-responding meter. All of these characteristics have been chosen so that every true VU meter will respond to complex speech and musical waveforms in a consistent manner.

Few of the level meters found in consumer tape decks are true VU meters, even though most are average-responding level indicators and have a scale calibrated in "VU." As Julian Hirsch's Audio Reports usually indicate, these meters do not have the ballistic response of a true VU meter. Even so, they are useful level indicators.

A dB meter, on the other hand, need not have true VU dynamic characteristics. In fact, it is customary to mark the scale in decibels if the meter is a peak-responding indicator. The German standards organization, DIN, has established equally well-defined characteristics for peak-reading meters, but in consumer decks these, too, are often ignored by manufacturers.

Summary. Decibels are used to express power ratios. Voltage ratios can be related to power ratios if input and output impedances are known. Therefore, it's possible to express voltage ratios in decibels based on their equivalent voltage ratios. Power levels are commonly specified in decibels relative to a standard reference—usually one milliwatt, resulting in the unit dBm, or one watt, resulting in the unit dBw. Because decibels are the logarithms of ratios, they can be added to determine the cumulative effect of series connections of gain or loss blocks. In short, decibels are indispensible tools in electronic circuit and system analysis. ◇



UNIVERSAL CHARGER FOR SEALED RECHARGEABLE BATTERIES

Versatile charger operates as a constant-current source and offers a choice of 12 charging currents

RECHARGEABLE cells, despite their higher initial cost, are gaining broad acceptance among users of battery-powered electronic equipment. These cells are actually economical to use if long operating lifetimes can be achieved. However, long lives can be expected only if the manufacturers' maximum recommended charge and discharge rates are not exceeded. This is more easily said than done, considering the different types of batteries (NiCd, Gel-Cell, lead-acid, etc.), each having different recommended rates. Moreover, little effort has been expended to standardize charge rates, even of cells with the same size and type (see Table I).

There are two solutions to this problem, one economical, the other uneconomical. The latter involves purchasing a charger for each battery size and charge rate required by cells on hand. The economical solution is to assemble this project, a Universal Charger for sealed rechargeable cells. It can be built for less than $15 and can be used to properly slow-charge most (if not all) of the small rechargeable batteries presently on the market. Constant-current charging—the mode recommended by

BY DON SCHNEIDER

many battery manufacturers—is employed, and up to twelve 1.2-volt cells can be charged in series at any one time.

About the Circuit. The Universal Charger is shown schematically in Fig. 1. When power switch *S1* is closed, transformer *T1* steps down ac voltage from the power line. Modular bridge rectifier *RECT1* converts the ac into pulsating dc which is filtered by *C1*. Light-emitting diode *LED1* acts as a pilot light for the project. Zener diode *D1*, Darlington transistor *Q1*, and resistors *R2* through *R14* form a constant-current source which charges the depleted cells.

Most manufacturers recommend that their cells be slowly recharged at a rate equal to one-tenth of the maximum discharge rate. To accommodate a wide variety of cells, rotary switch *S2* offers a choice of 12 values of charging current. The switch grounds the emitter of *Q1* by way of one of 12 fixed resistors (*R3* through *R14*) whose resistance determines the magnitude of the charging current. Table II lists the current values selected by the author and the corresponding resistances of fixed resistors *R3* through *R14*. These resistances were determined experimentally, and are dependent on the zener voltage of *D1* and the dc beta of the Darlington.

Construction. The circuit of the Universal Charger is relatively simple, so point-to-point wiring techniques are recommended. Be sure to observe the polarities of all semiconductors and that of *C1*. Assemble the project in a utility box, mounting *Q1* either on a heat sink attached to the outside of the box or on the box's outer surface itself if it can dissipate the heat generated by *Q1* without the aid of a heat sink. Use an insulating mica washer, shoulder washers, and silicone thermal compound when mounting *Q1*. Be consistent when wiring *S2*, taking care to avoid inadvertent shorts.

Some variation from the values given for *R3* through *R14* will probably be required if the currents listed in Table II are to be obtained. (Of course, you can choose different charging currents to suit your own particular applications.) This variation will be due to the exact dc beta of the Darlington transistor and the zener voltage of the zener diode used.

Although the parts list specifies a particular Darlington and diode, substitutions can be freely made. The zener voltage can be as low as three volts or as high as 12 volts. (A lower zener voltage will allow a greater number of cells to be charged in series than is possible with a higher-voltage diode.) Parameters of the Darlington transistor are not critical, but it is recommended that the device used have a power dissipation equal to or greater than that of the component in the parts list (120 watts).

The best way to determine the values required for fixed resistors *R3* through *R14* is to temporarily ground the emitter of *Q1* through a 1000-ohm potentiometer before connecting any components to the emitter or to *S2*. The potentiometer should be connected to the emitter of

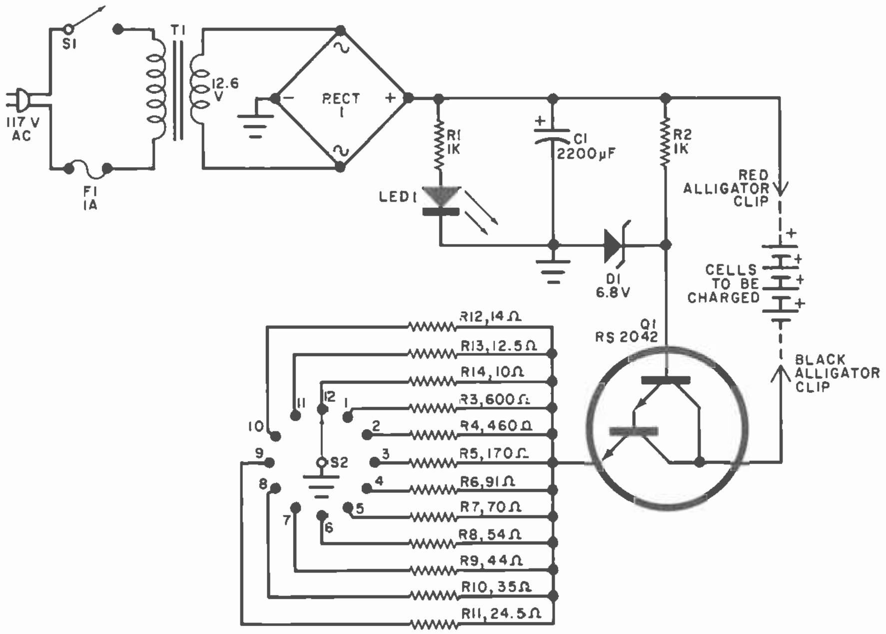


Fig. 1. Schematic shows how zener D1, Darlington Q1, and resistors R3 through R14 form constant-current source which regulates battery charging.

PARTS LIST

C1—2200-µF, 35-volt electrolytic
D1—6.8-volt, 1-watt (or greater) zener diode (see text)
F1—1-ampere fast-blow fuse
LED1—Light-emitting diode
Q1—120-watt (or greater) npn Darlington transistor (Radio Shack RS-2042 276-2042—see text)
The following are ½-watt, 5% tolerance fixed resistors unless otherwise noted. Also, see text with reference to *R3* through *R14*.
R1, R2—1000 ohms
R3—600 ohms
R4—460 ohms
R5—170 ohms
R6—91 ohms
R7—70 ohms
R8—54 ohms
R9—44 ohms
R10—35 ohms
R11—24.5 ohms, 1 watt
R12—14 ohms, 2 watts
R13—12.5 ohms, 2 watts
R14—10 ohms, 3 watts
RECT1—1.4-ampere, 50-PIV modular bridge rectifier
S1—Spst toggle switch
S2—1-pole, 12-position rotary switch
T1—12.6-volt, 1.2-ampere stepdown transformer
Misc.—Suitable enclosure, terminal strips, color-coded alligator clips, knob for *S2*, heat sink, mica washer, shoulder washers, silicone thermal compound, hook-up wire, line cord, strain relief, fuseholder, machine hardware, solder, etc.

TABLE I

Manufacturer's Type Number	Battery Size	Recommended Maximum Charge Rate (mA)
CH1.2/D	D	120
N3500D, GC3	D	350
CD10	D	400
CH1.2/C	C	120
GC2	C	150
N1650C	C	165
CD4	AA	22.5
N450AA	AA	45
CH500, GC1	AA	50
N88	8.4-V transistor	9
CD100	8.4-V transistor	15

AS A RULE, YOU CAN'T MIX BUSINESS WITH PLEASURE.

ENGINEER FRANK HOFFMAN IS ONE EXCEPTION.

For Frank Hoffman electronics is one of the "great pleasures" in life. Even when it's strictly business.

Frank is a Telecommunications Engineer from Haddonfield, New Jersey. He designs peripherals for 8080 microprocessor controlled equipment. Supervises the making of prototypes; the drafting. Everything from start to finish.

But his enthusiasm for electronics hardly ends there.

Frank operates a ham radio. Spends time listening to good music (a new stereo octave band equalizer has piqued his interest in audio). And just recently he bought a digital computer that has videographics capabilities and monitors an impressive home security system.

"I decided on the personal computer after reading an article on the Cosmac 1802 in Popular Electronics," he relates. "That and a very analytical series written by Forrest Mims for PE's Experimenter's Corner."

Popular Electronics is a tradition in the Hoffman family. Frank was introduced to it by his father, a Marine Engineer. And has been a subscriber since 1960 because "the magazine is geared to people who have a real understanding of electronics."

He's typical of today's PE readers: young, well-educated, highly skilled. In the forefront of this age of micro-computers and advanced audio and laser communications. Electronics activists who make things happen in the marketplace.

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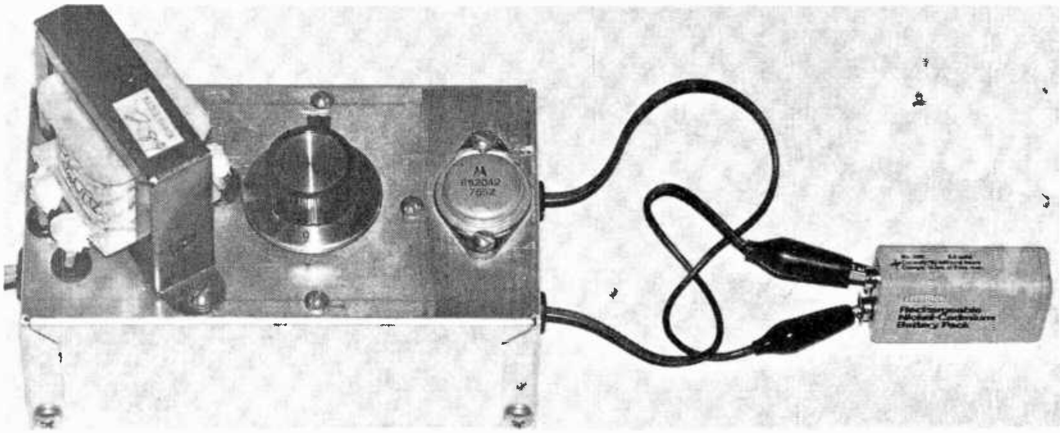


Photo of author's prototype shows components mounted on top of enclosure with clip leads used to connect battery to charger.

Q1 and to ground via leads terminated with alligator clips. Adjust the potentiometer for maximum resistance between the emitter of *Q1* and ground.

Next, connect a milliammeter between the collector of *Q1* (negative meter terminal) and the positive side of *C1* (positive meter terminal). Adjust the potentiometer so that the milliammeter indicates the lowest charging current desired. Then remove the potentiometer from the circuit and measure its resistance with an ohmmeter. Make a notation of the milliammeter and ohmmeter readings.

Insert the potentiometer back into the circuit and adjust it for the second desired (next largest) charging current. As before, disconnect the potentiometer, measure its resistance, and make a notation of the two meter readings. Repeat this procedure ten times until a total of 12 charging currents and resistance values have been determined. The required power rating for each resistor can be calculated using the familiar expression $P = I^2R$, where I^2 is the square of the charging current in amperes (pay close attention to decimal points!) and R is the measured potentiometer resistance in ohms.

Once the required resistance values have been determined, you can connect appropriate fixed resistors between the emitter of *Q1* and the lugs of *S2*. It's very possible that you will not be able to find resistors with the exact values that are needed. If you don't want to synthesize the required resistances by series or parallel (or both) combinations of standard resistor values, you can use trimmer potentiometers in place of fixed resistors. Be sure to choose trimmer potentiometers with adequate heat dissipation ratings if this approach is taken. A very definite advantage of using trimmers is that charge rates can be easily changed at some future time to accommodate newly acquired cells calling for charging currents different from those of the batteries presently on hand.

Interconnection between the charger and depleted cells is largely a matter of personal preference. The schematic suggests the use of color-coded alligator clips. This is perhaps the most convenient method when battery packs are to be charged. There are many other ways to do this, however. For example, the charger output points can be color-coded binding posts or banana jacks. If standard-package (AA, C, D, etc.) cells are to be recharged, suitable battery holders which connect the cells in series can be soldered to leads terminated with color-coded banana plugs. These plugs can then be inserted in the corresponding jacks when cells of that type are to be charged.

Use. After the batteries have been connected to the charger and *S2* placed in the appropriate position, apply line power by closing *S1*. The cells will now receive charging current. Most manufacturers recommend that NiCd cells be charged at one-tenth the maximum discharge rate for 14 hours. This is so because 40 percent more energy must be put into the cell than can be taken out. Similar recommendations are often made for Gel-Cell batteries. Once fully charged, some cells can withstand further application of charging current at the same rate and can be left connected to the charger indefinitely. Others must be disconnected from the charger circuit after they have been fully charged.

In any event, follow the manufacturer's instructions with respect to charging current and duration of charge. The flexibility inherent in the Universal Charger makes it certain that the project can be used with practically any battery that an electronics hobbyist would have occasion to use. Charging currents up to the rating of the power transformer can be obtained without overheating *Q1* because the transistor can dissipate 120 watts of heat. Also, a short circuit at the charger output will not damage the project because the transistor limits the short-circuit current to the value selected by switch *S2*. ◇

TABLE II

Position of S2	Selected Resistance	Charging Current (mA)
1	R3, 600 ohms	9
2	R4, 460 ohms	12.5
3	R5, 170 ohms	28
4	R6, 91 ohms	50
5	R7, 70 ohms	64
6	R8, 54 ohms	80
7	R9, 44 ohms	90
8	R10, 35 ohms	118
9	R11, 24.5 ohms	167
10	R12, 14 ohms	350
11	R13, 12.5 ohms	400
12	R14, 10 ohms	550

POT QUIZ

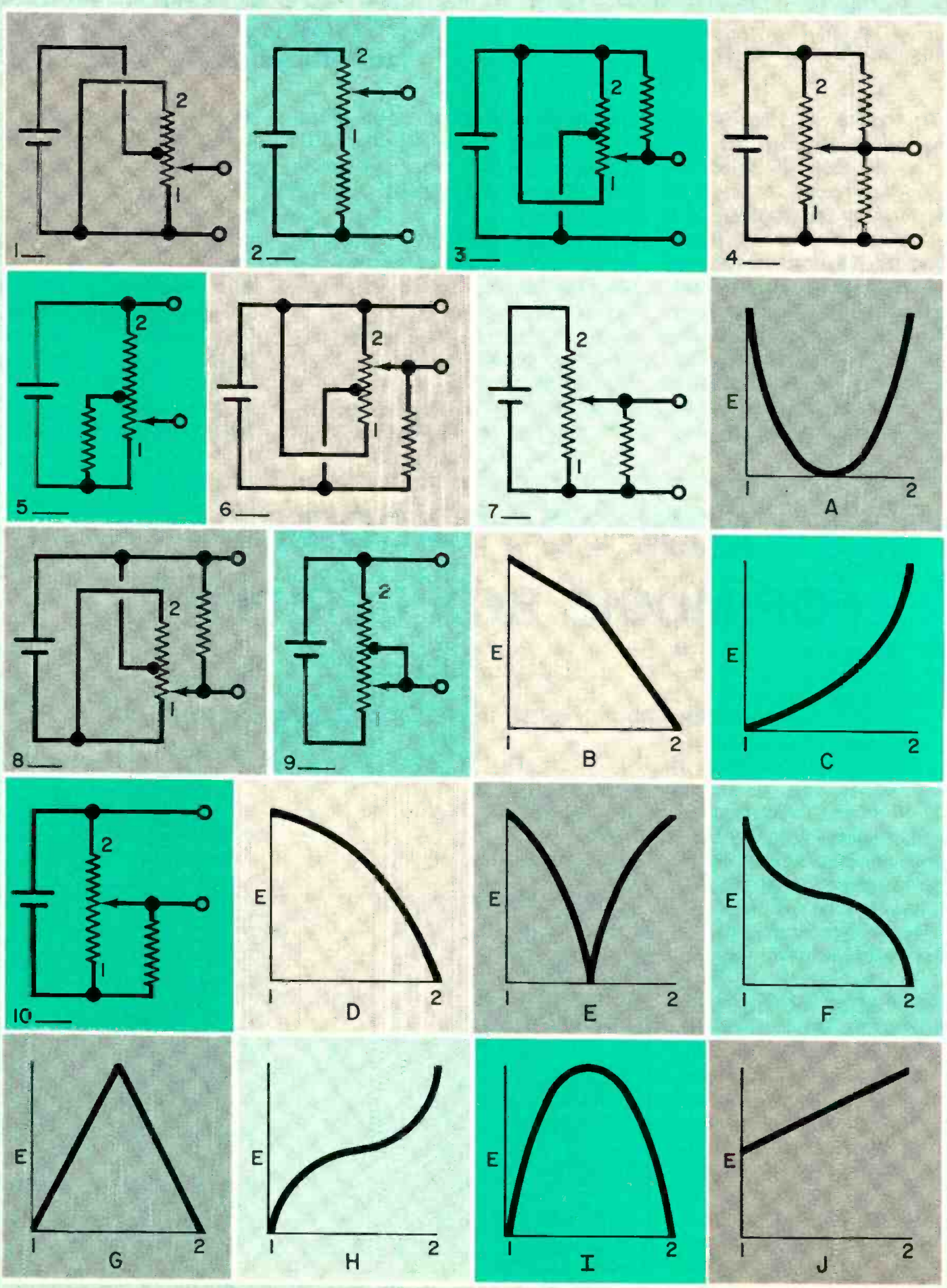
BY ROBERT P. BALIN

THE taper of a potentiometer can be easily changed to suit a particular application by the simple addition of one or more resistors. The new curve is easily predictable if you carefully observe the locations of the output terminals and which parts of a centertapped potentiometers are shunted by fixed resistors.

See if you can match the pot circuits (1-10) with their corresponding output voltage curves (A-J) produced when the wiper arm is moved from point 1 to point 2 in the circuit in each case.

Assume that all resistors and linear pots, some of which are center-tapped, have the same total resistance values.

(Answers on page 85)



BY DOUG FARRAR

CMOS logic allows more effective control of time and prevents track-change interruptions

8-Track Timer Simplifies Recording

THE 8-Track Timer (8TT) described here is the perfect companion to an 8-track tape deck. Its primary feature is a digital elapsed-time indicator that eliminates guesswork—and track changes in the middle of a song. In essence, the 8TT provides a visual indication of the amount of time used to record on one track and then tells you how much of that time you have used as you continue to record on each succeeding track. Thus, you'll always know exactly how much time remains before an end-of-track or end-of-tape occurs, and will be able to plan your recording sessions accordingly.

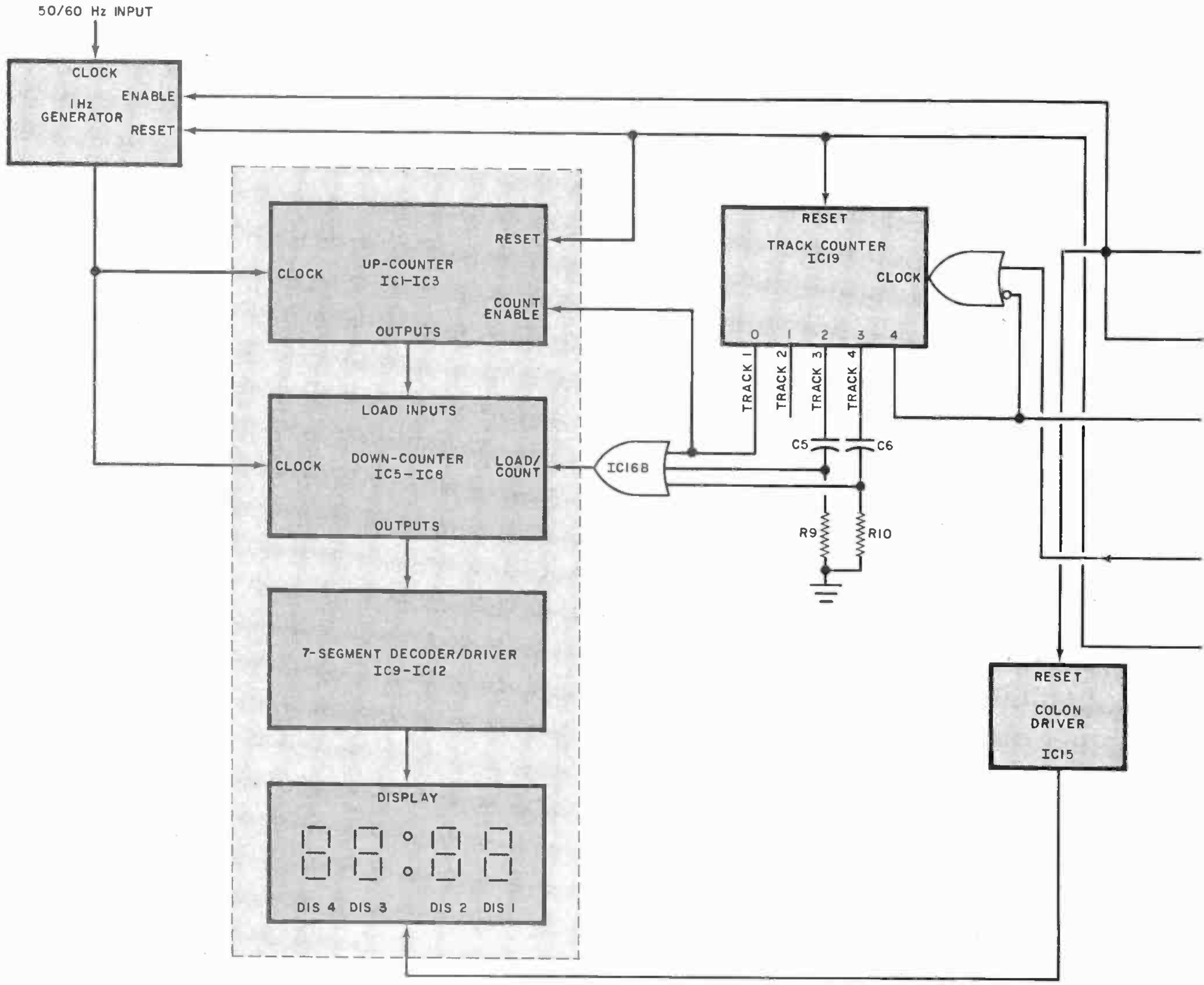
The project also offers the following:

- a PAUSE control;
- automatic shutoff after four "tracks" (that is, track pairs) have played;
- a CLEAR TAPE function that shuts the deck off after any change-of-track.

The last-mentioned function prepares the cartridge inserted in the deck for a recording session. If you don't want the 8TT to control the tape deck, simply remove line power from the project. Normal operation can then be resumed.

About the Circuit. The block diagram of the 8TT is shown in Fig. 1 and its schematic diagram in Fig. 2. A glance at the block diagram reveals five major functional sections: a 1-Hz pulse-train generator; an elapsed-time counter and display; a track counter; a motor flip-flop and controller; and a "logic" circuit.

The 1-Hz generator accepts a low-level signal derived from the ac power line and divides its frequency by either 50 or 60. The position of a jumper on the project's main printed circuit board determines which divisor is selected. This choice is of course governed by the line frequency of the commercial power source (50 or 60 Hz). The resulting train of 1-Hz pulses is employed as a time-



base for the elapsed-time counter.

CMOS up- and down-counter IC's perform the actual timing of the 8-track cartridge. The up-counter is enabled during the interval that track 1 is being used. It serves double-duty by counting the tape cartridge's start-of-track to end-of-track playing (or recording) time and by acting as a latch, storing this information for the rest of the recording session.

The outputs of the up-counter are connected to the parallel-load inputs of the down-counter. When the down-counter is placed in its asynchronous, parallel-load mode, its outputs follow the information presented to its parallel inputs. Removing the parallel-load command causes the counter to commence counting down from the last binary number to which the outputs followed the parallel inputs. The down-counter can thus be ordered to either pass the binary number generated by the up-counter directly to the display decoder/driver or

PARTS LIST

C1 through C12—0.1-µF disc ceramic
C13—500-µF, 25-volt electrolytic
D1 through D5—1N4001
F1—1-ampere fast-blow fuse
DIS1 through DIS4—FND70 or similar common-cathode LED display
IC1,IC3,IC14—4518 dual decade counter
IC2—4019 quad 2-input multiplexer
IC4,IC13,IC18—4001 quad 2-input NOR gate
IC5 through IC8—4510 decade counter
IC9 through IC12—4511 BCD-to-seven-segment decoder/driver
IC15—555 timer
IC16—4072 dual 4-input OR gate
IC17—4002 dual 4-input NOR gate
IC19—4017 decade counter/divider with 10 decoded outputs
IC20—7805 5-volt regulator
K1—12-volt relay with 250-ohm coil and 3-ampere spdt contacts
LED1,LED2—Light emitting diode
OC1—MCT-2 optoelectronic coupler
Q1—MPSA13 npn Darlington
The following are ¼-watt, 5% tolerance carbon-composition fixed resistors.
R1,R2,R3—1000 ohms
R4 through R7, R9 through R12, R48—10,000 ohms
R8,R13,R14,R15—100,000 ohms
R16—1 megohm
R17—330,000 ohms
R18—3.3 megohms
R19 through R46—220 ohms
R47—150 ohms
S1—1-pole, 5-position nonshorting rotary switch
S2—Spst toggle switch
T1—12.6-volt, 1-ampere transformer.
Misc.—Suitable enclosure, display bezel, 4-conductor chassis-mount female connectors, 4-conductor male connectors, printed circuit board, standoffs, line cord, etc.

Note—An etched, drilled and silk-screened printed circuit board is available for $15 postpaid (in U.S.) from Noveltronics, Box 4044, Mountain View, CA 94022. California residents add sales tax. Foreign orders: write for prices. Allow 2 weeks for checks to clear.

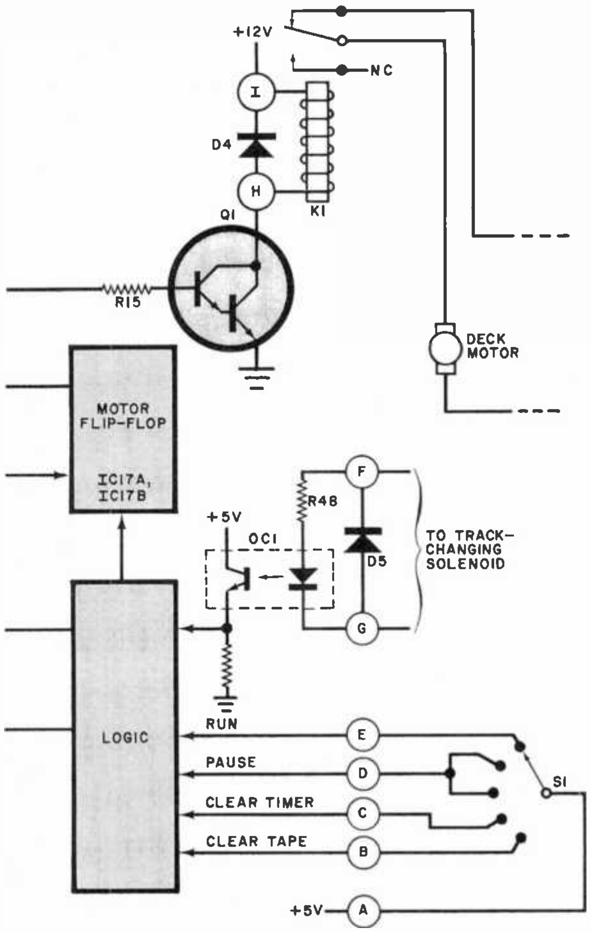


Fig. 1. Five major functional sections of the 8TT are shown in block diagram. The motor flip-flop is actually two cross-coupled NOR gates.

briefly sample the up-converter's output lines and then count down.

The first operation is performed during the time track 1 is being used and the second during the intervals associated with tracks 2, 3, and 4. The binary information present at the output of the down-counter is applied to a BCD-to-seven-segment decoder/driver network for the common-cathode LED displays.

The display's colon driver is a 555 astable multivibrator (*IC15*) that oscillates at a 2-Hz rate. The astable can be gated off by grounding its RESET input (pin 4). This happens whenever the deck is running normally and causes the display's colon to glow steadily. When the motor is shut off, the 555 indicates that fact by pulsing the display colon.

Every 8-track cartridge contains a short section of metallic tape. This tape trips a solenoid to move the deck's tape head through its four track positions. The voltage pulse generated when the solenoid is activated is sensed via optoisolator *OC1* and applied to the track counter's CLOCK input. In this way, the deck's mechanical track position is sensed by the 8TT.

Track counter *IC19* controls the operation of the up- and down-counters. During the track 1 interval, *IC19* enables the up-counter and places the down-counter in its parallel-load mode by way of OR gate *IC16B*. At the end of track 1, the track counter prevents the up-counter from incrementing further and enables the down-counter. At the start of tracks 3 and 4, a pulse generated by either *R9C5* or *R10C6*, respectively, is applied to the down-counter by way of *IC16B*. This loads the up-counter's latched value into the down-counter which then decrements toward zero.

Because each track should take an equal amount of playing time, the display will read 0:00 (or close to it) at the ends of tracks 2, 3, and 4. At the end of track 4, the track counter inhibits further timing and sets the motor flip-flop, stopping the deck motor.

The motor flip-flop is controlled by the logic section. Setting the flip-flop disables the 1-Hz generator, allows the display colon driver to oscillate, and energizes relay *K1*, which is mounted inside the tape deck. The relay's normally closed contacts are wired in series with one of the deck motor's power leads, so that setting the flip-flop removes power from the deck's motor.

The position of rotary switch *S1* determines the 8TT's operating mode. Setting it to its CLEAR TIMER position resets the up-counter and the track counter, and sets the motor flip-flop. This readies the 8TT for the start of a recording session. Placing *S1* in the PAUSE position sets the motor flip-flop, but switching it to the RUN position resets the motor flip-flop. With the switch in the RUN position, recording proceeds as previously described. Placing *S1* in its CLEAR TAPE position initially resets the motor flip-flop and allows the tape to run. At the first change of tracks, the 8TT sets the flip-flop. This stops the deck, leaving the cartridge "cleared" for recording.

Readily available CMOS IC's comprise almost all of the 8TT circuit. A regulated 5-volt and unregulated 12-volt supply is used as the power source. The 12-volt ac waveform developed across the transformer secondary is conditioned to a level compatible with the CMOS logic circuit before being applied to the input of the 1-Hz generator.

Construction. Almost all of the 8TT circuit fits on a single pc board whose etching and drilling and parts placement guides are shown in Figs. 3 and 4. An unusual feature of the board is the "wireless" connection between the logic and display sections. After the board has been fabricated as a single unit, it is cut along the indicated line. The two sections are then soldered together along the cut line to form a right angle. The resulting structure is rigid. The logic board is mounted parallel to the bottom of the project enclosure using spacers as shown in Fig. 5. This automatically positions the display board vertically.

Before soldering the two boards together at a right angle, mount and solder all components and jumpers on each board. Note that *C13*, the elec-

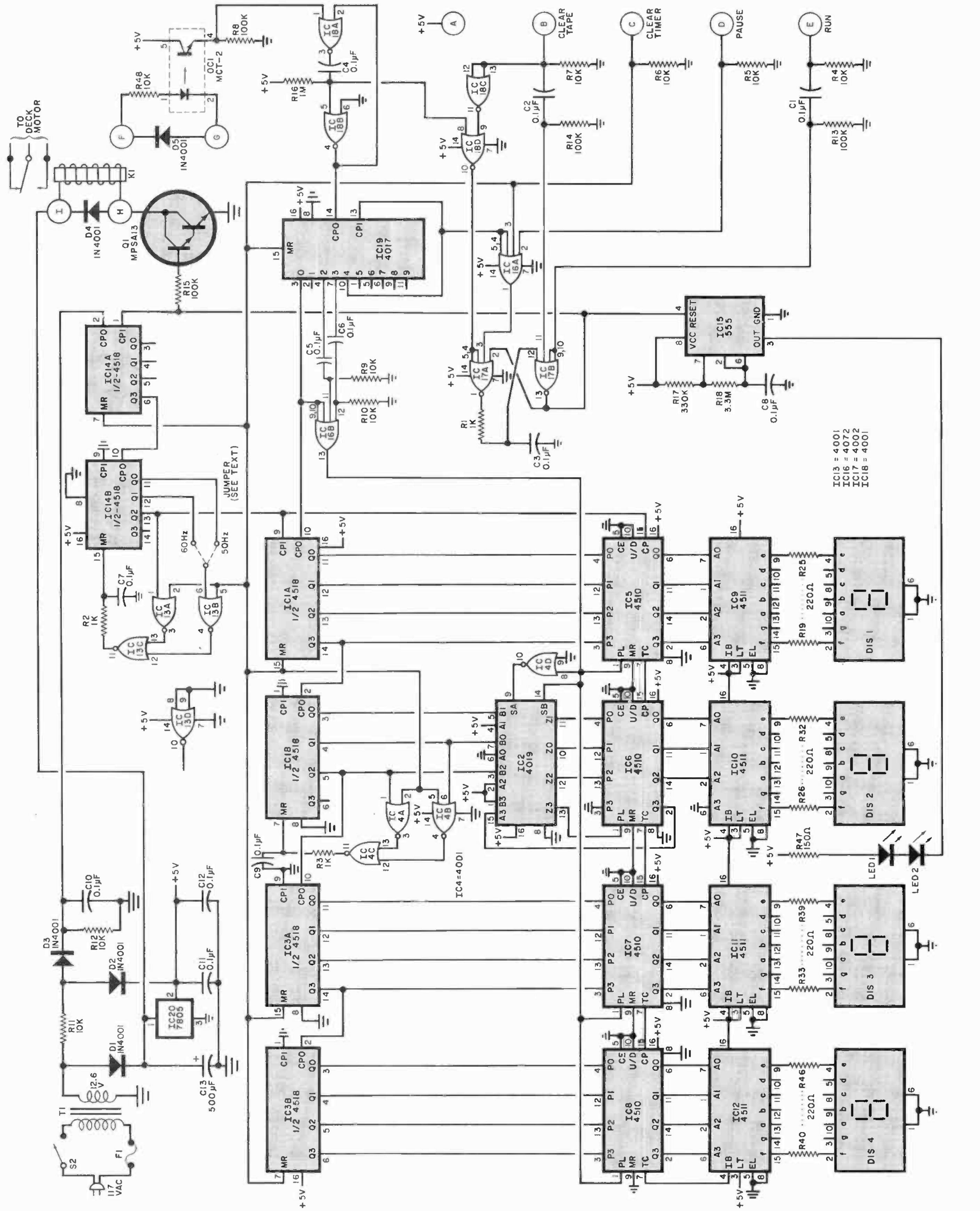


Fig. 2. Schematic diagram of 8TT. CMOS logic is used throughout.

trolytic filter capacitor in the power supply, is located on the display board, but is mounted on the foil side. This allows the vertical display board to fit flush with the front panel of the project enclosure. If the line frequency of the available power source is 60 Hz, use a jumper to connect pin 12 of *IC14B* to pin 6 of *IC13B*. If a 50-Hz ac source is used, the jumper should interconnect pin 11 of *IC14B* and pin 6 of *IC13B*.

Mount the logic board on spacers at least 2" high so that power transformer *T1* can be mounted directly beneath it. The regulator IC (*IC20*) should be mounted directly to the project enclosure to provide heat sinking. Be sure to add a thin layer of silicone heat-sink compound to improve thermal transfer between the IC package and project enclosure. A 1" × 2½" (2.5- × 6.4-cm) rectangular hole should be cut into the project enclosure's front panel for the digital display. To increase the legibility of the display, affix a red filter to the back side of the front panel using epoxy or similar adhesive.

The tape deck to be controlled must be slightly altered (see Fig. 6). Mount relay *K1* inside the deck enclosure at a convenient location. Cut one of the power leads running to the motor. Connect one end of the severed lead to the normally closed contacts of the relay and connect the other end to the relay's pole. The coil leads will be connected to a jack to be described shortly.

Now locate the track-changing solenoid. When a track change occurs, dc voltage will be momentarily applied across the solenoid. The polarity of this applied voltage must be determined. This is most easily accomplished by means of an oscilloscope or voltmeter. With the meter or scope probes connected across the solenoid, depress the deck's program or track change pushbutton and note the meter's (or scope trace's) deflection. Compare this with the polarity of the probes and determine which side of the solenoid becomes positive with respect to the other. Mark this lead with a small flag of vinyl tape.

Make a hole on the tape deck's rear apron large enough to accommodate a chassis-mount, 4-conductor female connector. Install this connector and solder the leads from the track-changing solenoid and relay coil to the connector lugs. An identical connector should be in-

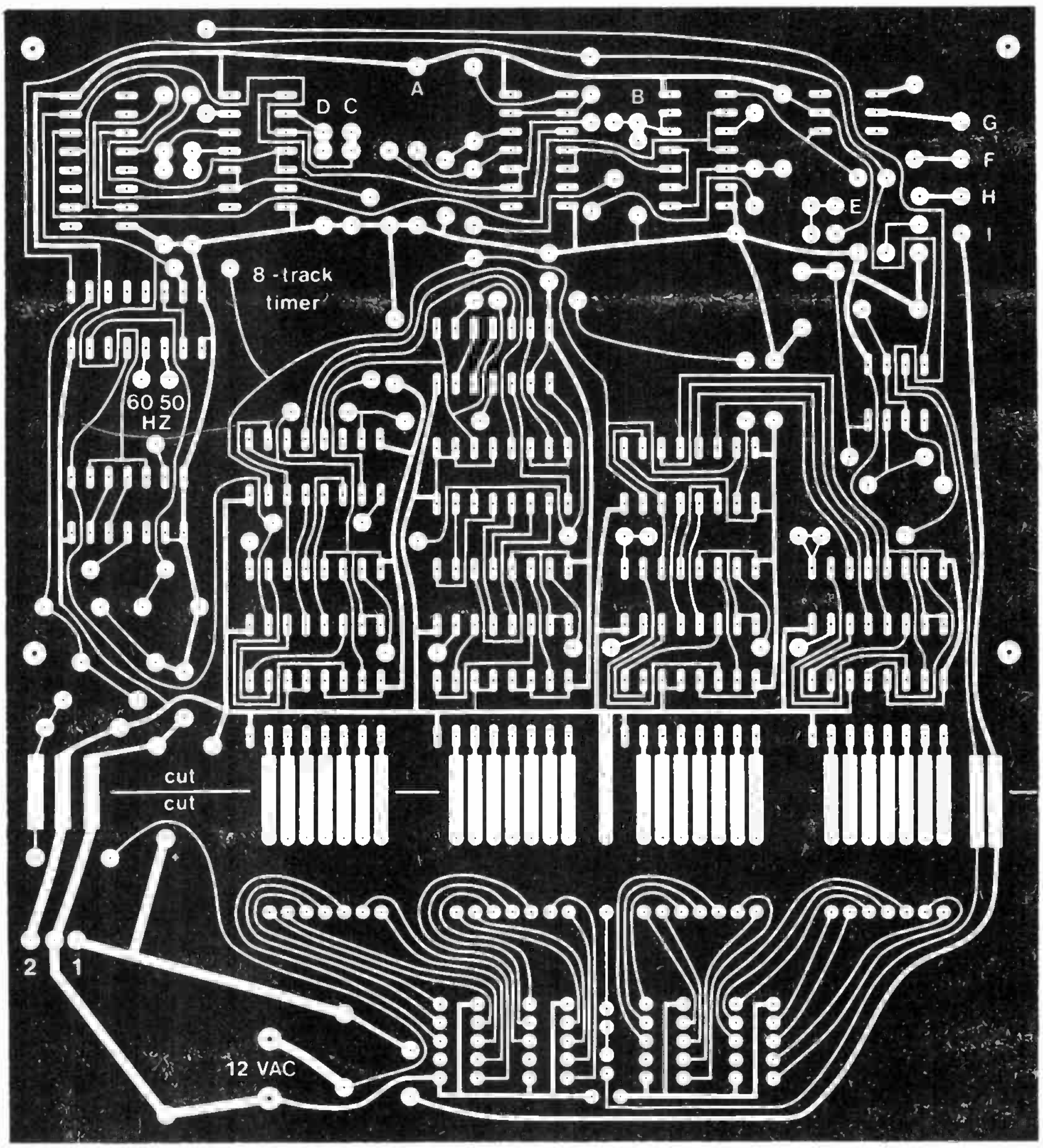


Fig. 3. Actual-size foil pattern for the 8TT's single pc board.

stalled on the rear apron of the 8TT enclosure and appropriate leads from the pc board soldered to it. Be sure that the connections to this second jack match those made to the first. The circled-letter markers on the schematic correspond to the designated foil pads on the project's printed circuit board.

For convenience, protective diodes *D4* and *D5* can be soldered to the lugs of one of the female connectors—either the one mounted on the rear apron of the project enclosure or that installed on the rear apron of the 8-track tape deck. Prepare a 4-conductor cable of a length sufficient to interconnect the project and tape deck. Solder the cable conductors to the lugs of male connectors compatible with the rear-apron female connectors. Take care to solder each conductor to the identically corresponding lug on each connector.

Flexible hook-up wire should be used to interconnect the main circuit board and rotary switch *S1*, the rear-apron connector, and the off-board power supply components. Rotary switch *S1* should be wired so that there are two adjacent PAUSE positions between the RUN and CLEAR TIMER positions. This minimizes the possibility of inadvertently entering the CLEAR TIMER mode (which would erase the information stored in the 8TT latch) when a switch to the RUN position was actually intended.

Testing and Use. Interconnect the 8TT and tape deck with the 4-conductor cable that you have prepared. Insert a tape cartridge into the deck and apply power to both the 8TT and the deck. Then place rotary switch *S1* in its CLEAR TIMER position. If all is well, the deck motor will stop turning, the display will read 0:00 and the display colon will blink on and off at a 2-Hz rate. Switching to the PAUSE position will cause no change. Placing the 8TT in its RUN mode, however, will cause the deck motor to start running and the display to function as an elapsed-time indicator. The display colon will glow steadily.

After approximately one minute of running time, make a mental note of the interval indicated by the display and depress the tape deck's track change pushbutton switch. The elapsed time indicated by the display will begin to decrement toward 0:00. Depressing the track-change pushbutton twice more will initiate the same count-down sequence, starting each time at the first track's running interval.

If you find that track counter *IC19* has trouble following the track state, decrease the value of *R48*. This will allow more current to flow through the LED in optoelectronic coupler *OC1* and provide stronger pulsing of the internal phototransistor. If the problem persists, doublecheck the wiring associated with the optocoupler and the solenoid to ensure that the voltage applied across the LED is of the correct polarity.

Depress the track-change pushbutton switch one more time. The 8TT will interpret this to mean that the tape has ended and will turn off the deck motor, cease timing, and cause the display colon to blink on and off. Any further depression of the track-change pushbutton will be ignored by the 8TT.

Once these operations have been verified, place rotary switch *S1* in its CLEAR TAPE position. The deck motor will then begin to run but will be shut off at the first change of tracks. Place *S1* in its CLEAR TIMER position and then in its PAUSE position. Prepare the cartridge for recording as required by your deck and you're ready to go.

Employ the 8TT's PAUSE mode when you want to stop recording momentarily. By keeping an eye on the 8TT's display, you will be able to interleave the program material neatly between the track-change interruptions.

If you want to use your tape deck without the assistance of the 8TT, simply remove power from the project by opening toggle switch *S2*. Although the deck has been modified in that the 4-conductor female connector and relay *K1* have been installed inside it, the deck is unaltered electrically. This means that the deck will function normally with the 4-conductor umbilical cable disconnected. Practically speaking, you can even leave the

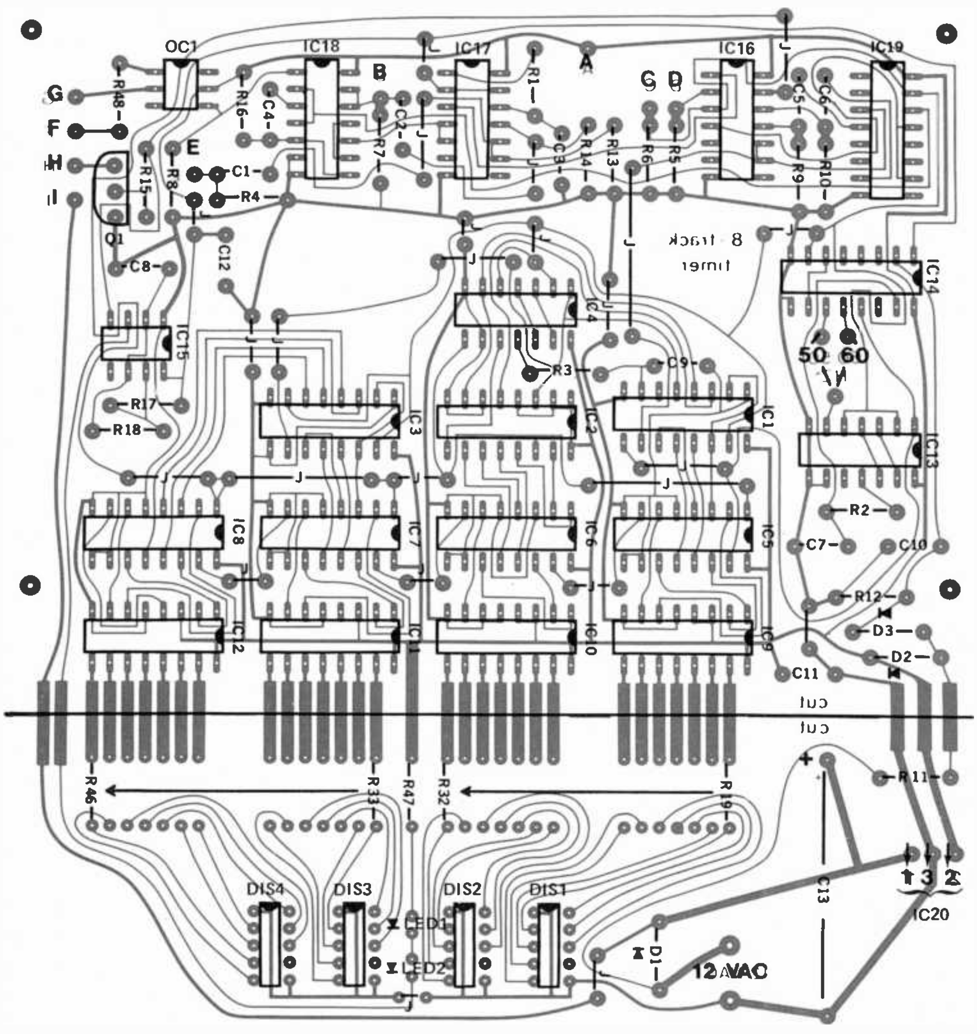


Fig. 4. Component placement guide for the 8-Track Timer.

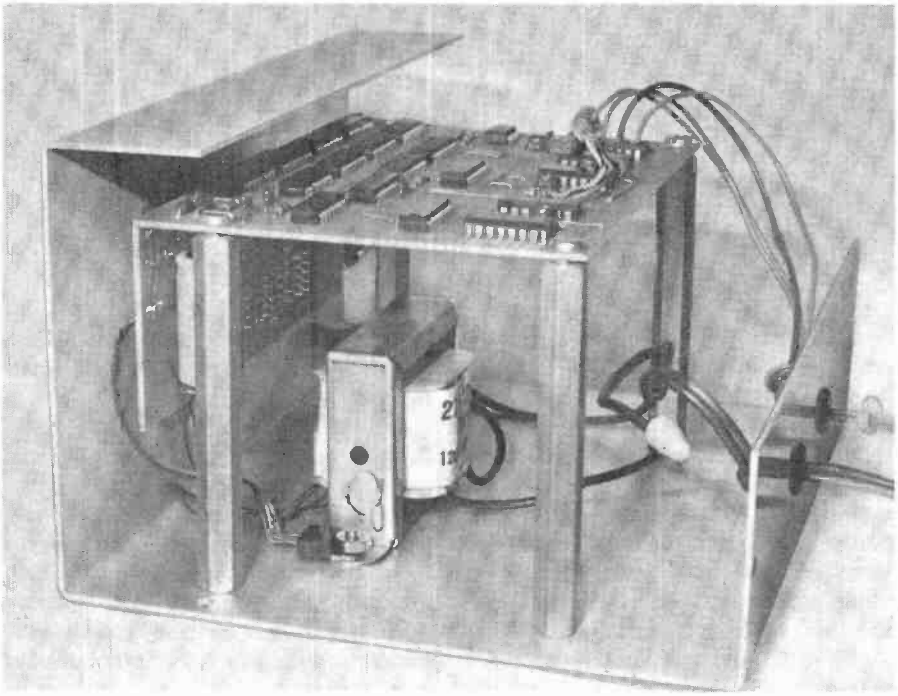
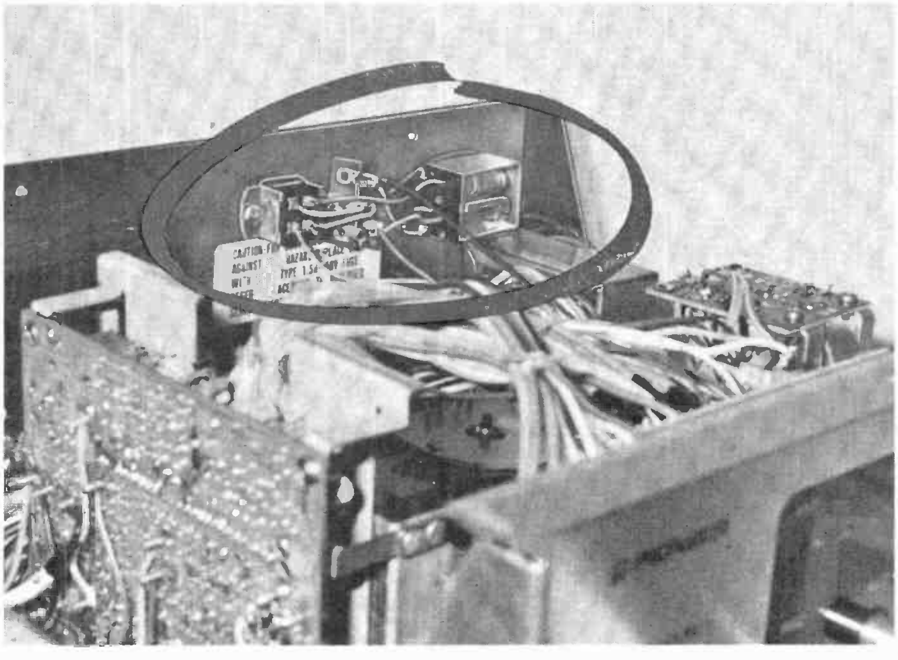


Fig. 5. Interior view of author's prototype reveals printed circuit board mounting details.

Fig. 6. View of tape deck shows how relay and connector were mounted on deck's rear apron.



cable connected to both units. As long as the 8TT's power switch is in its OFF position, the deck will behave as if the 8TT were not connected to it. Also, because the interface between the deck and timer consists of a relay and optoelectronic coupler, there is no possibility that hum will be introduced into the deck by the 8TT.

One word of warning: fluctuations in tape speed, caused either by worn components in the deck's transport or by a binding tape cartridge will make the indications given by the 8TT misleading (if not useless). For best results, make sure your tape deck is in good working order and that the cartridges you use are in good condition. ◇

Build the Poor Man's Servant

BY HAL LEFKOWITZ, WB2DEX

An inexpensive project which activates or deactivates appliances at the clap of your hands.

DID YOU know that with the expenditure of just a few dollars and about an hour's work, you can have a servant for your home that will turn electrical appliances on and off at just the clap of your hands? The "Poor Man's Servant" does just that—allowing you, among other things, to turn your television or radio on and off without moving from your chair or bed.

As shown in the schematic, the heart of the circuit is a small, preassembled, sound-activated switch module that can be purchased for as little as 88 cents from dealers who advertise in the Electronics Market Place section of this magazine. The module contains a small ceramic microphone element which provides gate drive for an SCR. It also has a sensitivity adjustment so that the user can set the sound level at which the SCR will begin to conduct.

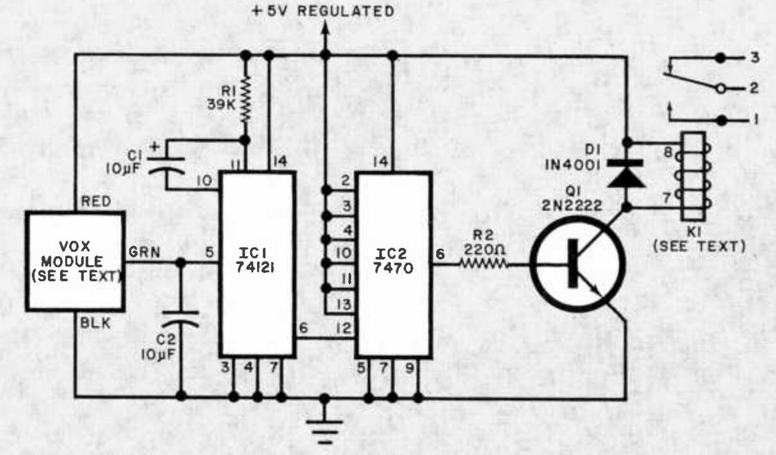
To call the module a true VOX (voice-operated switch) is somewhat misleading. It will respond to a voice, but only if the speaker is close by and talking directly at the module in a loud voice. However, it is much more sensitive to certain sounds. For example, the SCR can be triggered by a clap of the hands from as far away as 20 feet (6.1 m), even though a television or radio is playing in the same room.

There are three leads on the module. The red lead is connected to the positive side of the power supply. The black lead is grounded, and the remaining (green) lead is used to trigger *IC1*, a 74121 monostable multivibrator. Clapping your hands causes the module to trigger the one-shot, which in turn toggles flip-flop *IC2*. The $\bar{Q}$ output of the flip-flop then goes high, providing gate current for relay driver *Q1*. This transistor turns on and energizes the coil of relay *K1*, whose contacts can be used to apply line power to an appliance. Another clap of the hands causes the flip-flop to toggle again, forcing its $\bar{Q}$ output low and depriving *Q1* of base drive. The relay then deenergizes and removes power from the appliance.

The relay specified in the parts list has a 6-volt coil and dpdt contacts rated at 5 amperes. However, a different relay with more sets of contacts can be substituted for it if more complex switching functions are required. No matter what relay is used, be sure to connect diode *D1* across its coil as shown in the schematic. This diode protects relay driver *Q1* from inductive spikes generated when the relay is keyed.

Construction. The Poor Man's Servant is a relatively simple circuit and can be duplicated using printed circuit, wrapped wire, or point-to-point wiring techniques. It requires +5 volts at approximately 100 mA. Any suitable power supply can be used, and both the project and the supply can be housed in a small enclosure.

Be sure to observe the polarities of electrolytic capacitors and diodes as well as the pin basing of IC's and transistors. Use the minimum amount of heat and solder consistent with the formation of good connections and, if desired, employ IC sockets or Molex Soldercons to simplify assembly.



Schematic diagram of the Poor Man's Servant. Module responds to sound and toggles flip-flop which keys relay K1 *via driver transistor* Q1.

PARTS LIST

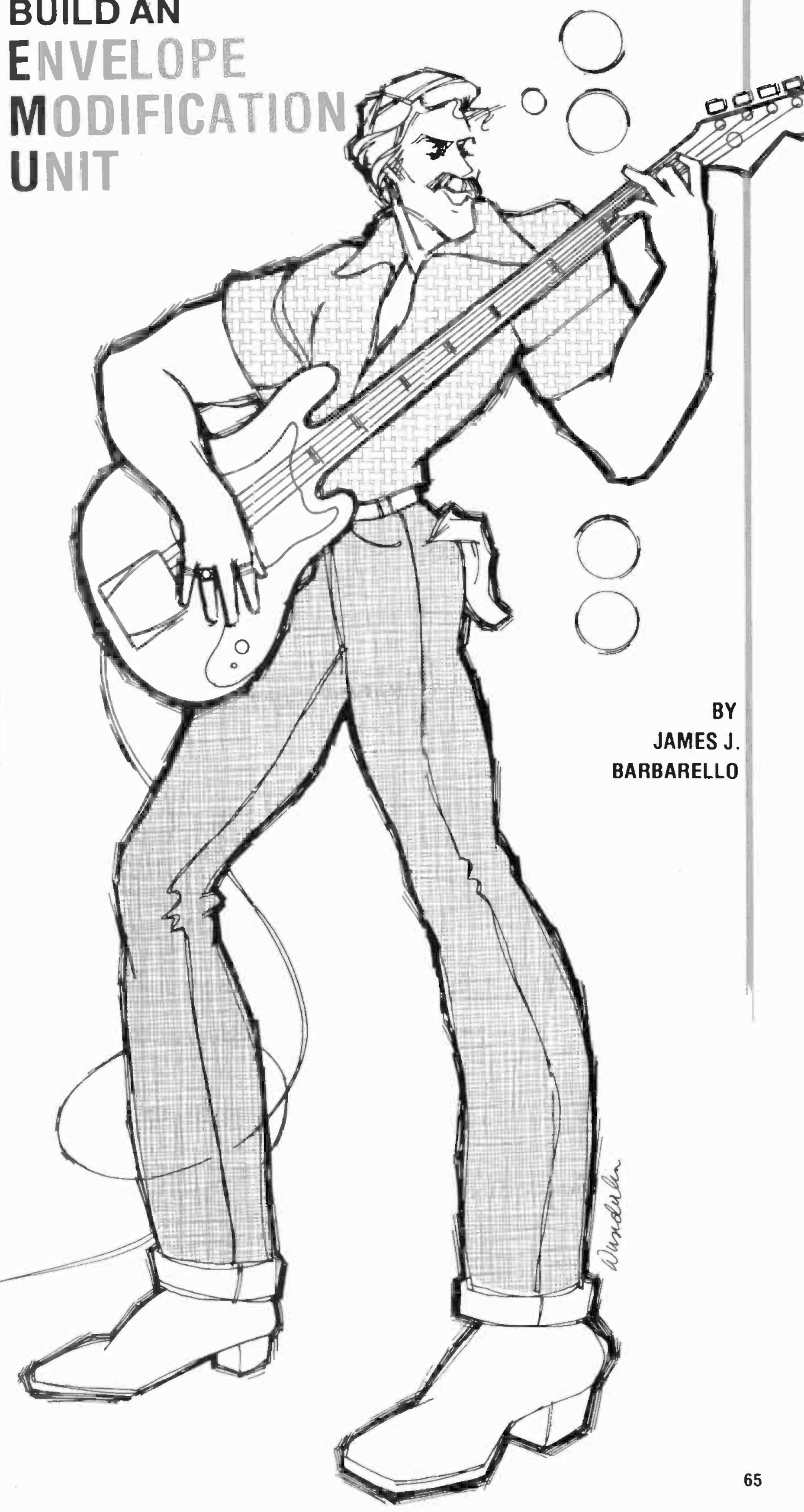
C1—10-µF, 16-volt electrolytic
D1—1N4001 rectifier
IC1—74121 monostable multivibrator
IC2—7470 J-K flip-flop
K1—6-volt relay with dpdt, 5-A contacts
Q1—2N2222 npn switching transistor
R1—39,000-ohm, ¼-W 10% resistor
R2—220-ohm, ¼-W 10% resistor
Misc.— Vox module, 5-volt regulated power supply, printed circuit or perforated board, IC sockets or Molex Soldercons, hookup wire, suitable enclosure, hardware, etc.
Note: The following are available from EDI, 4900 Elston Avenue, Chicago, IL 60630: Vox module, Part No. S-45, for $0.88; 6-volt relay with 5-ampere dpdt contacts, Part No. G-296, for $0.99. Illinois residents, add sales tax.

Use. The Poor Man's Servant can be placed in a convenient spot and powered continuously. It will then be your faithful attendant, ready at all times to obey your command. Just clap your hands and it will perform the task assigned to it. Clap your hands again and it will instantaneously retire. ◇

BUILD AN ENVELOPE MODIFICATION UNIT

Can be used to vary attack, sustain, and decay of any electronic instrument

BY
JAMES J.
BARBARELLO



PERHAPS the most important sound characteristic a musical instrument produces is its amplitude envelope. A percussion or a stringed instrument, for example, has a sound with a steep attack and a slow decay time. A wind instrument, on the other hand, has longer attack and shorter decay times. While electronic music synthesizers generally permit the player to exercise full control over the attack, decay, and (usually) sustain of every note played, electric instruments (guitars, pianos, etc.) do not offer this flexibility. The Envelope Modification Unit, or EMU, described here can give the electric musical instrument much the same flexibility.

The EMU interfaces with most electrified instruments and can be used to modify the attack, sustain, and decay times to produce many interesting sound effects. It does not lengthen the intrinsic amplitude envelope, but it can shorten the envelope to produce the sound of a guitar being played while a hand damps the strings—without eliminating the harmonics, as would occur if a hand were actually used. It can also be used to alter the envelope to produce the "whooping" effect one hears when a magnetic tape is played backwards.

The electrical demands of the EMU are so low that a pair of 9-volt batteries can be used to power it. Of course, if you prefer, you can use an appropriate line-operated power supply. Also, if you wish, you can add a foot switch to permit you to bypass the EMU to obtain an unmodified sound envelope.

About the Circuit. As shown in Fig. 1, the audio signal from the musical instrument is applied to the EMU via *J1*. It is then coupled to the inverting inputs of *IC1A* and *IC1B*. The *IC1A* circuit is operated as a unity-gain inverting amplifier that buffers the input signal to drive transconductance amplifier *IC2*.

The output from *IC2* is generated across *R4* and buffered by *IC3A*. From here, it is delivered to output jack *J2*. Buffering of both the input and the output of *IC2* eliminates any possible loading and overloading problems usually encountered when using a transconductance amplifier.

The input signal is amplified by *IC1B* and then rectified and filtered by *D1*, *R7*, and *C1*. The amplitude of the negative-going signal generated across *R7* is proportional to the amplitude of the input signal. This signal voltage is then used to toggle Schmitt trigger *IC3B*, whose reference at pin 2 is set to −0.8 volt by divider network *R8/R9*. With no input, the output of the trigger is high and applies about +0.8 volt to noninverting input pin 3 of *IC3B*.

When the detected potential goes below the −0.8-volt reference, the output of *IC3B* goes low. Resistors *R7* and *R10* set the quiescent input level of *IC3B* and provide some hysteresis. The negative-going step voltage produced when the output potential goes low is differentiated and level shifted by *C2*, *R11*, and *R12* to trigger conventional timer *IC4*, which is operated as a one-shot monostable multivibrator.

When the detected potential drops to zero, the output of *IC3B* returns to high. The resulting positive pulse has no effect on *IC4*. (This IC is not wired in the conventional manner. Instead, it is arranged to operate between −9 volts and ground, to provide signal compatibility for transconductance amplifier *IC2*.) When *IC4* is triggered, its output at pin 3 rises from its negative voltage toward ground. This allows *C3* to charge through *D2* and *R14*. The rise time is determined by the values of *C3* and *R14*. Capacitor *C5* eliminates the turn-on spike that could be transmitted through the circuit and be heard as a "pop."

When the timing cycle of *IC4* is completed, pin 3 returns to −9 volts and the potential across *C3* decays through *R15*, *D3*, and pin 3 of *IC4*. The time constant here is determined by the values of *C3* and *R15*. The voltage across *C3* provides the programming current for *IC2* via *R13*, whose value determines the maximum gain.

When the ground connection to *R16* and *R17* is broken via *J3*, *C4* cannot charge. This keeps *IC4* on indefinitely and results in a constant gain through the system. When the ground is restored, normal operation resumes.

Construction. Although any method of construction can be used to assemble the EMU, a printed-circuit board is recommended. The actual-size etching and drilling and the components-placement guides for such a board are shown in Fig. 2. When completed, the pc assem-

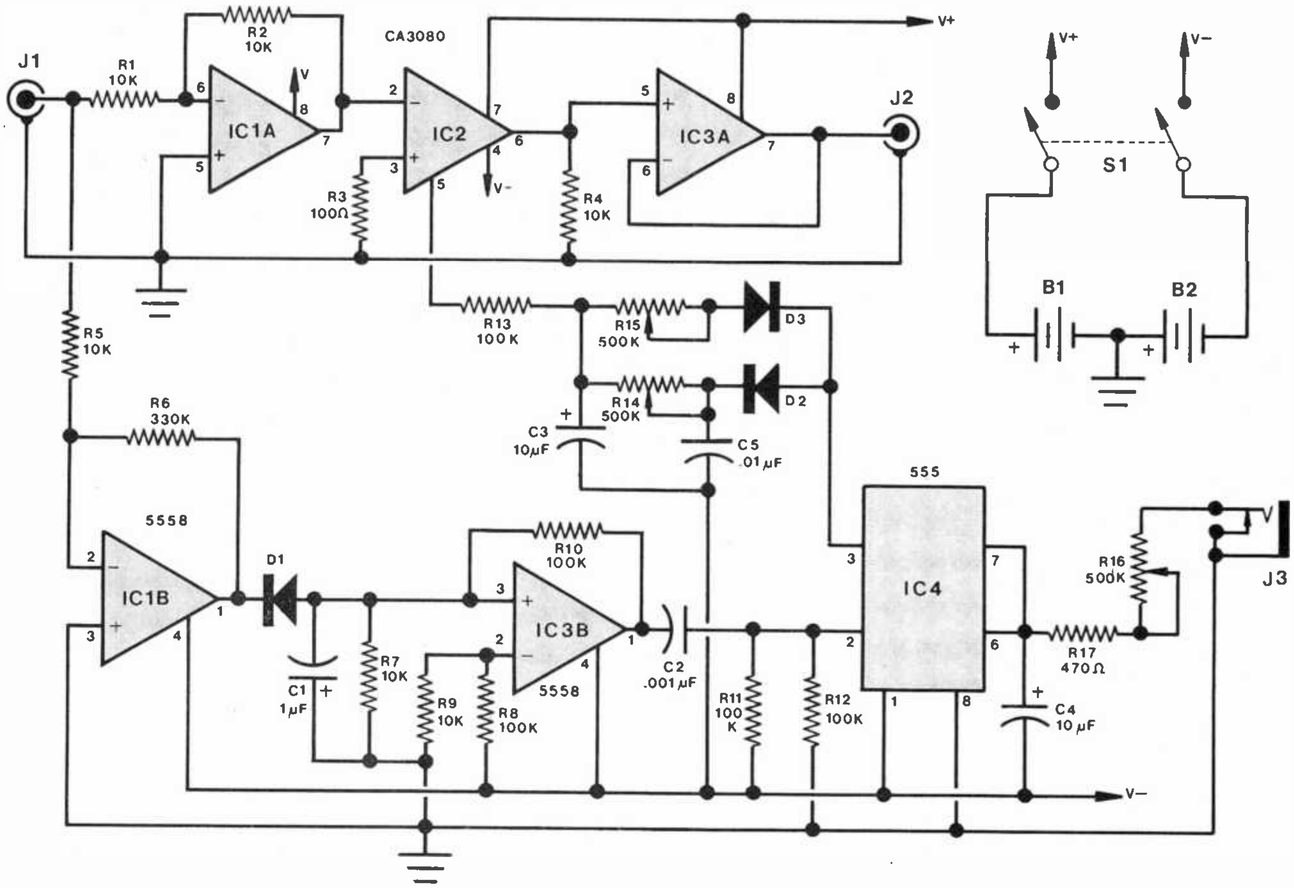


Fig. 1. Transconductance amplifier IC2 has its input and output buffered by IC1A and IC3A respectively. Gain of IC2 is varied by circuit containing IC4, which is triggered by IC3B and IC1B.

PARTS LIST

B1, B2—9-volt battery
C1—1-μF, 25-volt electrolytic
C2—0.001-μF disc capacitor
C3, C4—10-μF, 25-volt electrolytic
C5—0.01-μF disc capacitor
D1,D2,D3—1N914 or similar switching diode
IC1,IC3—5558 or MC1458 dual op amp
IC2—CA3080 transconductance amplifier
IC4—555 timer
The following are ¼-watt, 10% tolerance:
R1,R2,R4,R5,R7,R9—10,000 ohms
R3—100 ohms
R6—330,000 ohms
R8,R10,R11,R12,R13—100,000 ohms
R10—100 ohms
R17—470 ohms
R14,R15,R16—500,000-ohm linear-taper potentiometer
J1,J2—Phono jack
J3—Closed-circuit jack
Misc.—Suitable enclosure; battery holders (2); control knobs (3); machine hardware; hookup wire; solder; etc.
Note: The following items are available from BNB Kits, RD#1, Box 241H, Tennent Rd., Englishtown, NJ 07726: Complete kit of parts, not including case, No. EMU-E for $21.50; printed-circuit board No. EMU-PC for $6.50. Postage and handling included for U.S. and Canada only. New Jersey residents, please add 5% sales tax.

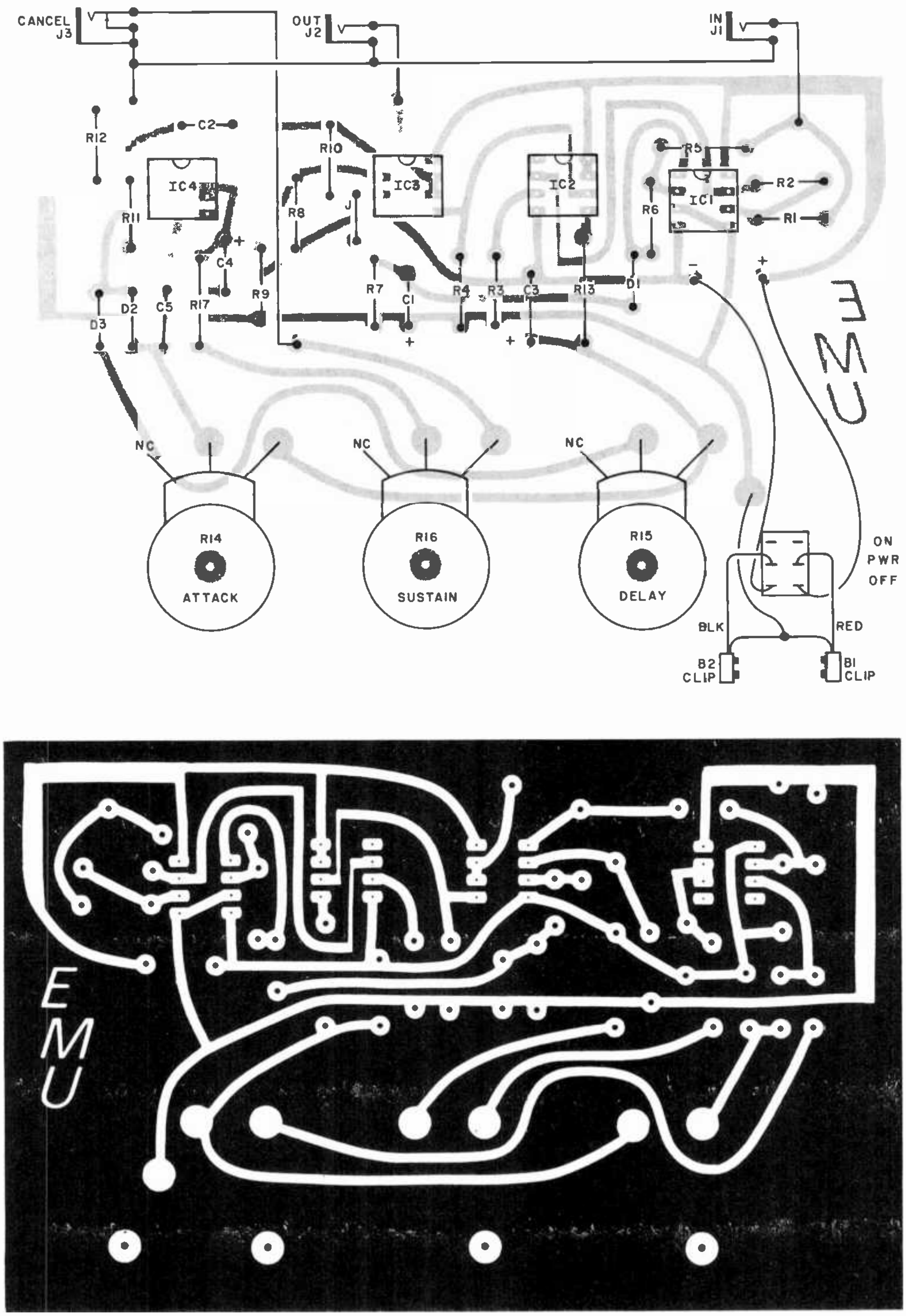


Fig. 2. The actual-size etching and drilling guide for a suitable pc board is shown at left below. Component placement guide is at top.

bly can be mounted inside any convenient case that can accommodate it, the batteries and their holders, and the jacks and controls.

Using the EMU. The proper attack, sustain, and decay settings for each different sound effect must be arrived at by experimenting with the EMU.

The SUSTAIN control sets the time from the onset of the attack to the onset of the decay. Accordingly, if the sustain time is set too short, it will override the ATTACK setting. For example, when setting a short stacatto envelope, the sustain may be shorter than the attack. This would result in no output from the EMU because *IC4* will not be on long enough to allow *C3* to charge. If this occurs, increase the SUSTAIN setting enough to obtain an output.

In another situation, if the controls are set for a short-duration envelope, a high-level input may cause multiple triggering. If this occurs, decrease the input signal level until the multiple triggering just ceases.

If at any time distortion appears in the output, decrease the level of the input signal until it disappears.

Jack *J3* (see Fig. 1) is provided for plugging in an optional footswitch. When the footswitch is open, the EMU is effectively cancelled and the input signal passes through *IC1A*, *IC2*, and *IC3A* pass through without modification. (These three stages operate as a simple unity-gain amplifier in this case.) Closing the footswitch completes the circuit from *R16* and ground to allow timer *IC4* to operate, placing the sound-modifier circuits into the system. ◇

Experimenter's Corner

By Forrest M. Mims

LED BARGRAPH DISPLAY CHIPS

THE HEART of many LED bargraph circuits is the quad comparator, a chip that contains four independent comparators. Connecting two or three such chips to a voltage divider comprising a string of series-connected resistors (Fig. 1) results in a straightforward but complex bargraph readout.

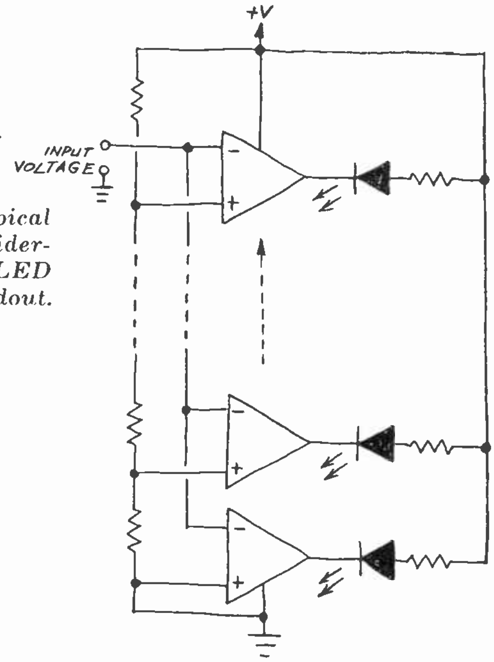


Fig. 1 Typical voltage divider-comparator LED bargraph readout.

Recently, however, semiconductor manufacturers in the United States, England, and Japan have announced new ICs that combine on a single chip the voltage divider and comparators required for a multiple-level bargraph LED display. The new chips have many fascinating applications and are very easy to use. This month, we'll take a close look at three of these chips: Texas Instruments' TL490C/TL491C and National Semiconductor's LM3914.

TL490C/TL491C Bargraph ICs. With the exception of their outputs, these two 10-step analog level detectors are functionally identical. Each contains a resistor voltage divider and ten comparators. They will light a 10-element row of LEDs in adjustable increments of 50 to 200 millivolts per LED.

Both chips incorporate output transistors that allow direct drive of the LEDs. The TL490C has open-collector outputs capable of sinking as much as 40 mA at 32 volts max. The TL491C, on the other hand, has open-emitter outputs capable of sourcing a maximum of 25 mA at up to 55 volts. Figure 2 shows how LEDs are connected to both a current source and a current sink.

These new devices are very easy to use. Figure 3, for example, is a simple 10-element readout. I assembled it on a solderless breadboard using a Texas Instruments data sheet as a guide. Potentiometer *R1* provides a variable voltage to the circuit for demonstration purposes. Varying the setting of *R1* lengthens or shortens the bar of glowing LEDs as the input voltage increases or decreases.

Note that the circuit requires a supply of 10 to 18 volts for proper operation. The chip *can* be powered by a 9-volt bat-

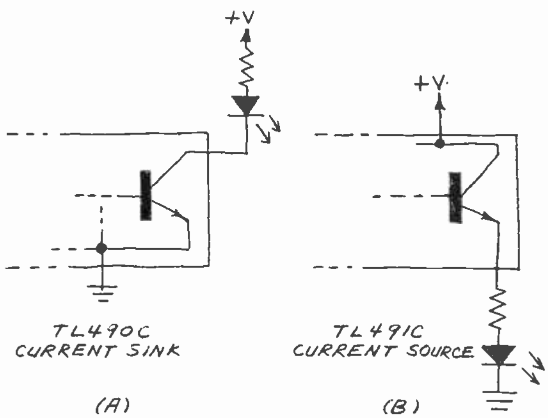


Fig. 2. LEDs connected to current sink (A) and current source (B).

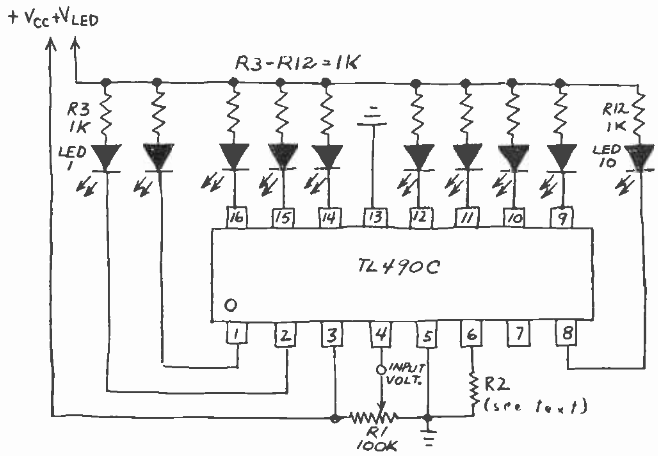


Fig. 3. Basic 10-element bargraph readout using TL490C.

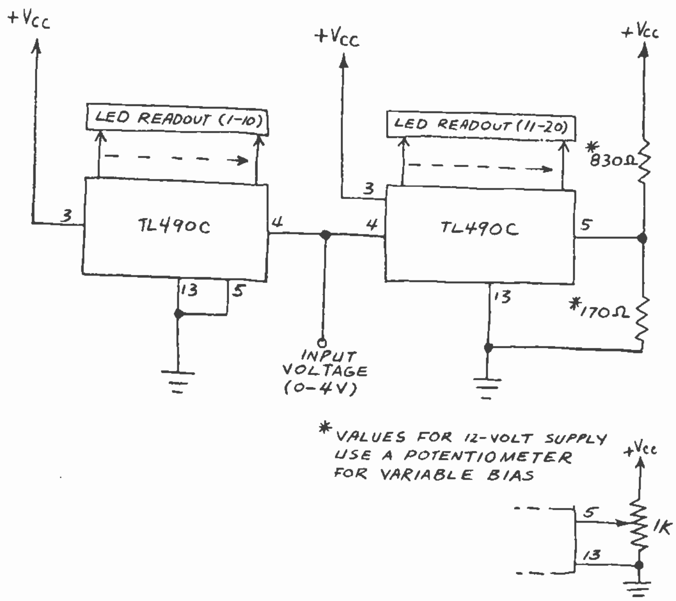


Fig. 4. How to cascade two TL490C chips. A voltage divider provides bias for cascade input of second chip.

tery; but, if that is done, the highest-order LED will fail to glow. A pair of 9-volt batteries connected in series makes an excellent power supply for portable operation. Be sure to use alkaline batteries for best results.

Both the TL490C and TL491C incorporate a THRESHOLD input that allows the sensitivity of the bargraph readout to be varied from 200 millivolts per LED to 50 mV/LED. This is accomplished by connecting pin 6 to ground via a series resistor. TI provides an elaborate formula for calculating the input voltage required to activate the first LED: $0.84/V_{IN} = 1 + (R2 + 700)(2240)/(700R2)$ where V_{IN} is the threshold voltage and *R2* is the resistance between pin 6 and ground.

If this formula seems a little cumbersome, connect a 1000-ohm potentiometer between pin 6 and ground and adjust *R1* so that the first LED just begins to glow. The input threshold voltage can then be measured by placing the probes of a multimeter between the wiper of *R1* and ground. Of course, if you prefer to work with figures, you can algebraically manipulate and simplify the given equation, solving it for V_{IN}.

Considering the number of comparators within each IC package, the total current drain of one of these chips is moderate when no LEDs are on. However, with even a fairly high-value current-limiting resistor connected in series with each LED, current consumption is substantial when all the LEDs are glowing. (Each output pin can sink up to 60 mA of current.) Here are representative values I measured when a TL490C was connected as shown in Fig. 3.

Total Current Demand

V_{CC}	+10 V	+12 V
No LEDs on	11 mA	11 mA
5 LEDs on	54 mA	64 mA
10 LEDs on	93 mA	114 mA

The basic circuit in Fig. 3 has many interesting applications. With *R1* removed and a CdS photocell connected from the positive supply to the input of the IC (pin 4), the circuit functions as a light meter. As the light level at the sensitive surface of the photocell is increased, more LEDs will glow. The photocell may respond to light from the LEDs so be sure to point its sensitive surface away from the rest of the circuit.

You can even measure resistance with the circuit by connecting a resistor between V_{CC} and pin 4. Moisten your index fingers and touch these two points if you want to see the LEDs respond to your body resistance.

For practical, "ballpark" resistance measurements, you'll need to calibrate the circuit with some resistors of known values. If my preliminary results are valid, the circuit will not necessarily respond in a linear fashion to resistance changes.

Connecting a capacitor between pin 4 and ground provides an interesting demonstration of the effects of capacitance. Assuming the capacitor is discharged initially, all the LEDs will glow when the capacitor is first connected to the circuit. They will then wink off in sequence as the capacitor charges. For best results, use a component with a large amount of capacitance (at least 1000 microfarads). Smaller capacitors charge too quickly to allow you to follow the flashing LEDs.

Both the TL490C and TL491C include a CASCADE input that permits the user to cascade up to ten chips to form a 100-element bargraph. Figure 4 shows two TL490C chips connected in cascade. Note how a two-resistor voltage divider provides a 2-volt bias for the CASCADE input of the second of two TL490Cs. The second chip subtracts this reference voltage from the input voltage at pin 4 to automatically arrive at the correct threshold.

LM3914 Dot/Bar Display Driver. This new National IC does everything the TI chips do and more! Like them, it has a self-contained voltage divider and ten comparators, the nucleus of a 10-element bargraph readout. Of more importance, however, is its self-contained decoding network that converts the chip from a straightforward bargraph driver into a more sophisticated moving-dot driver. A single MODE CONTROL input (pin 9) allows easy selection of either mode.

The National Semiconductor data sheet doesn't explain how the LM3914 achieves moving-dot operation. The moving-dot circuits I've described in previous columns required a fair amount of logic to convert a bargraph output into a moving-dot readout. It would be interesting to discover which approach National has selected.

Why is the moving-dot mode so important? One application that comes immediately to mind is a simplified solid-state oscilloscope with a LED screen. More about this later. Another advantage of the moving-dot readout is that one of ten outputs can be selected by a variable voltage. Think of the possibilities! You can connect one or more outputs to relays, drive transistors, optoisolators, or SCRs. In this way, you can make motors, alarms, and many other devices responsive to such variables as changing temperature, humidity, wind speed, weight, pressure, light, or any other analog function that can be converted into a continuously variable voltage by a suitable low-cost transducer.

Figure 5 shows how to use the LM3914 as a basic bargraph driver. Compare this circuit with the TL490C version in Fig. 3. You'll note the circuits are very similar. One major difference, however, is the use of a fixed resistor (*R1*) to control the brightness of the LEDs. This single resistor effectively programs the current available to each LED, thereby eliminating the need for individual current-limiting resistors.

The operation of *R1* as the LED-brightness control is dependent upon an internal reference voltage available at pin 7.

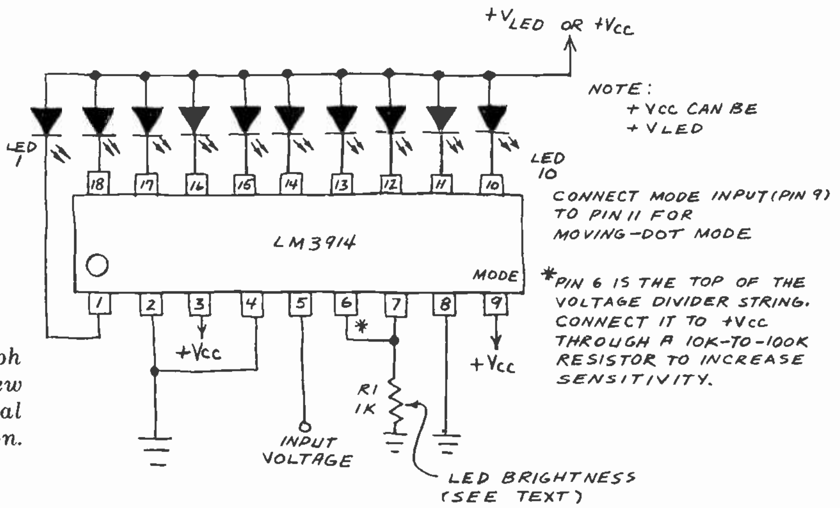


Fig. 5. A 10-LED bargraph readout employing the new LM3914 IC from the National Semiconductor Corporation.

The current passing from pin 7 through *R1* to ground is approximately one-tenth of the current passing through each illuminated LED. Since the voltage reference output is typically 1.3 volts, the LEDs will receive 13 mA of current when the resistance of *R1* is 1000 ohms. (Why? Ohm's law says that the current flowing through a resistor equals the voltage across it divided by its resistance. In this case, the current is 1.3/1000 or 0.0013 A. The LED current is ten times greater or 13 mA.)

To use the LM3914 in the moving-dot mode, mode control pin 9 should be disconnected from the positive supply voltage and connected to pin 11. This modification is easily made to the circuit in Fig. 5.

The LM3914 can be cascaded to form a moving-dot readout having 200 or more elements by connecting pin 9 of the first chip in the series to pin 1 of the next higher chip. This connection pattern is continued for each chip except the last. Pins 9 and 11 of the last IC are tied together. The only other requirement is a 20,000-ohm resistor in parallel with *LED9* of each chip (between $+V_{CC}$ or $+V_{LED}$ and pin 11) except for the first one. For details, see the National data sheet.

Figure 6 shows an interesting circuit from the National data sheet that causes the bargraph readout to flash. This circuit can be programmed to flash when the input voltage reaches a specified level by connecting the junction of *R1* and *C1* to any of the ten LED outputs. (The LEDs flash when the input voltage is sufficient to activate the selected LED output.) This flashing mode is very noticeable and makes for an eye-catching warning indicator.

A Unique Moving-Dot Application. Several readers have found interesting applications for the moving-dot readout described in the Experimenter's Corner of October 1978. Perhaps the most intriguing was developed by Leonard J. Lynch of Dekalb, IL. He had previously constructed a wind-powered generator capable of charging up to 48 2-volt storage cells. Unfortunately, the output of the wind charger is rarely constant. This means the number of cells being charged must be automatically altered to maintain a constant charge rate.

Leonard solved this problem by replacing the LEDs in the moving-dot indicator circuit with optoisolators connected to pass transistors that automatically switch additional banks of storage cells on line as the voltage from the wind charger increases. When the highest voltage level is exceeded, an overrange circuit composed of an optoisolator and a relay changes the pitch of the generator's propeller.

The LM3914 can be used in Leonard's circuit with few modifications and a lot less soldering. It can also be used in an ultra-simple solid-state oscilloscope that, less the 9-volt battery required for power, fits in an empty match box! I'll describe this pocket scope and another, larger LED scope in a forthcoming Project of the Month. ◇

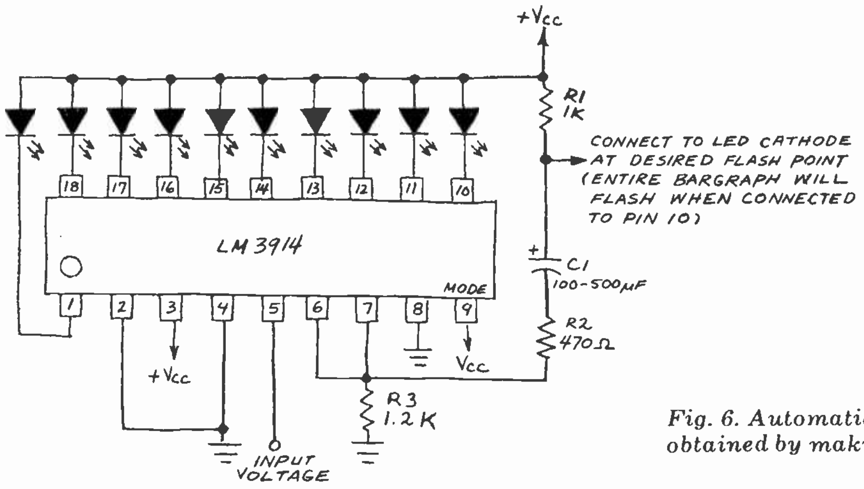


Fig. 6. Automatic bargraph flashing can be obtained by making connection suggested.

Hobby Scene Q&A

By John McVeigh
Technical Editor

IMPROVING FM RECEPTION

Q. I'm trying to receive a distant (80 air miles) FM station transmitting on approximately 100 MHz, but am troubled by "splash over" from a local station transmitting on approximately 102 MHz. How can I reduce the local station's signal into my tuner so that I can listen to the distant station undisturbed? —Larrie Christianson, Wausau, WI.

A. If signals from the two transmitters are arriving at your home from two different directions, you can try installing a highly directional antenna aimed to favor the distant station at the expense of the local one. Of course, a rotator can be installed to aim the antenna for best reception of the station to which you are listening at the moment. If for one reason or another an outdoor antenna is not feasible (or the transmitters lie in the same direction), you could install a tuneable trap at the tuner's antenna input.

Jerrold Electronics manufactures two such traps. The Model RFT-300 is a relatively simple and inexpensive trap designed for use with 300-ohm lines. It will provide, according to the manufacturer, 18 dB of attenuation over a tuneable notch 0.25 MHz wide. The Model TFM-2, with input and output impedances of 75 ohms, is a more sophisticated trap comprising two tuneable LC circuits in a modified bridged-T configuration. When both circuits are tuned to the same frequency, the manufacturer claims that signal rejection will be 40 dB minimum, with an insertion loss 1.5 MHz above or below the notch frequency of only 3 dB. The Model TFM-2 trap can be used with 300-ohm systems if balun/matching transformers are used at its input and output.

Have a problem or question in circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.

CRYSTAL SET COMPONENTS

Q. I am having a very hard time trying to locate a germanium crystal detector as used in early broadcast receivers. Please tell me where I can obtain one and, if possible, the "catwhisker" assembly associated with it. —Bill Jackson, Wrightsville, GA.

A. The early broadcast receivers did not employ germanium detectors. Rather, various mineral and man-made crystals were used, including galena, silicon, perikon (copper pyrites and zincite), molybdenite and Carborundum. Galena, which is actually lead sulphide (PbS), is the principal ore of lead. It was the most popular detector because it was the most sensitive. *Steel galena* resembles a piece of broken steel rod, contains a small amount of silver, and is not as sensitive. It became popular, however, because it is somewhat easier to adjust. The crystals used as detectors were mounted in clips, in tin-foil cups, floated in mercury or more commonly mounted in a small "pill" of an alloy with a low melting temperature. (Some experimenters who tried to mold their own holders used a mixture of lead with too high a melting point, only to discover that the heat had destroyed the galena's sensitivity.)

The "catwhisker" is a length of fine, stiff wire which is used to probe the crystal until an "active" spot is found. (This metal-to-semiconductor interface is similar to today's point-contact diodes.) Different crystals require different catwhiskers. Galena calls for a clean, stiff wire (plated copper, brass or platinum, preferred in that order) with very little pressure. For steel galena, a German-silver catwhisker is best. Tungsten catwhiskers are preferred for use with silicon crystals, but molybdenum is sometimes used. Chromium or steel are recommended for Carborundum detectors (which also require a bias battery), and many different metals have been used successfully with molybdenite.

Those who want more information on diode detectors (including more recent designs) should refer to Hank Olson's very interesting article in the January 1976 issue of *ham radio* magazine. Readers who want to procure crystal set components should send 25¢ for a catalog to Modern Radio Laboratories, Box 1477, Garden Grove, CA 92642. The catalog includes a variety of crystal set kits, mounted galena crystals, crystal stands and catwhisker assemblies, as well as hard-to-find Carborundum detectors and coil sliders.

If you want to use contemporary components to build a crystal set, a readily available 1N34A or similar germanium diode makes an effective detector. *Don't* use a silicon diode!

MOBILE CB NOISE

Q. I recently purchased a Royce 40-channel CB transceiver for my truck and was very happy with it. About one month after installation, however, I started to get high-frequency noise through it. The noise gets louder as the truck goes faster. The volume control has no effect on the noise, but the squelch does. How can I eliminate the interference? —Oliver Vallee, Belmont, CA.

A. If the noise you are hearing is a high-pitched whistle or whine, the source of the interference is the alternator. The fact that the volume control has no effect on the noise implies that it is reaching the audio stages after the control. This is consistent with the alternator being the source of the noise if it is travelling along the positive supply lead into the transceiver and hence to the base of an audio transistor.

Clean the slip rings of the alternator and make sure the brushes are making good contact. If not, replace them. (Brush or slip-ring deterioration occurring *after* you installed the rig would explain why the noise appeared a month later.) Install a 0.5-μF coaxial capacitor or an LC noise suppressor at the OUTPUT terminal of the alternator. (Both are available from most electronics and automotive supply stores.) Be sure the capacitor or noise suppressor can handle the maximum output current of the alternator. Do *not* install a capacitor at the alternator FIELD terminal. Finally, make sure that the engine block, chassis, and negative battery terminal are connected together with grounding straps or *clean* metal-to-metal bonds. (Make sure the battery's positive terminal is making good contact to its cable, too.)

Product Test Reports

Nakamichi Model T-100 Audio Analyzer

Compact and portable, the T-100 combines measurement functions of many hi-fi test instruments

THE NAKAMICHI Model T-100 Audio Analyzer is a compact portable audio test instrument whose functions include those of a number of separate pieces of test equipment. Among these are an ac voltmeter, an A-weighted microvoltmeter, audio oscillator, harmonic distortion analyzer, frequency meter, wow/flutter meter, and peak voltmeter. Although it does not provide all the potential capabilities of these instruments, it can replace them in the specific limited areas of testing normally required for the adjustment and performance verification of tape recorders, record players, and audio amplifiers.

The Model T-100 is being offered to advanced audiophiles and tape-recording enthusiasts who wish to be able to measure the performance of their systems and components. However, its greatest appeal is likely to be to servicing organizations, because of its versatility and portability, and to dealers who wish to be able to demonstrate the performance of their hi-fi equipment.

The analyzer measures 13½"W × 9½" D × 3" H (34.3 × 24 × 7.5 cm); weighs 9.5 lb (4.3 kg). It is ac-line powered and comes in a portable carrying case to which is attached a shoulder strap. Suggested retail price is $800.

General Description. Half of the instrument's front panel is devoted to its display, a solid-state equivalent of the analog meters generally found on test instruments. It consists of a two-channel horizontal bar graph, with each bar made up of a large number of tiny individual plasma cells (neon lamps). As individual cells become ionized, a horizontal orange bar is formed, the length of which is proportional to the magnitude of the parameter being measured.

For audio level measurements, the two bars indicate the left and right channel signals against a common scale located between them, calibrated over a 30-dB range. The analyzer contains a logarithmic converter that is used in most of its modes and allows accurate measurements to be made over a very wide range of amplitudes without changing ranges. Many other measurements require only a single scale, with the channel selection made with a front-panel-control, so that the upper bar graph is also labelled for SPEED (±3% range) and the lower scale is labelled for THD and WOW/FLUTTER (0.1% to 3%). A separate snap-in scale, also furnished, has each channel calibrated directly in volts from 0 to 30, with a WATTAGE scale between them that indicates from 0.1 to 100 watts at 8 ohms.

At the far right of the front panel is a switch for selecting any of 21 discrete audio OSCILLATOR frequencies in the 20- to 20,000-Hz range, as well as a pink-noise output. A knurled control shaft below the OSCILLATOR selector switch is provided for adjusting the output level of the oscillator signal over a range from 0 to a maximum of 1.2 volts.

To the left of the OSCILLATOR switch are two lever switches for adjusting the sensitivity of the metering and measuring circuits. The INPUT LEVEL switch has positions for 0.1, 1, and 10 volts, which correspond to a point about 70% of the way up-scale on the bar displays, not to full-scale indications. The INPUT LEVEL switch has +20-, 0-, and −20-dB ranges, and the METER RANGE switch has 1% and 0.1% positions. Two small controls labelled INPUT LEVEL L and R, with CAL at their clockwise limits function only in the PEAK meter mode, where they are used to adjust the input sensitivity of the instrument.

The FUNCTION switch in the center of the panel places the instrument into each of its specialized functions. Logic circuitry and dc-controlled FET switches allow a single switch of reasonable complexity to perform a great many functions that are often unrelated without risk of stray coupling and unreliable switch contacts.

At the counterclockwise end of the FUNCTION switch are three positions for speed and flutter measurements. The SPEED CAL position is used with a small similarly labelled knob below it to tune the flutter meter circuits to 3000 Hz, as shown on the SPEED (upper) scale as a center-0 indication. Then, if one plays a standard flutter test tape into the Model T-100, the upper bar display indicates the frequency error between its output and the 3000-Hz calibration frequency. This is the tape speed error (over a ±3% range in 0.1% steps). Simultaneously, the lower WOW/FLUTTER bar display indicates the DIN peak flutter, either weighted or unweighted, according to the switch position. The flutter display's range is from 0.1% to 3% when the METER RANGE switch is set to 1% and from 0.01% to 0.3% when it is set to 0.1%. In the flutter modes, the output terminals from the analyzer carry a precise 3000-Hz frequency signal that can be recorded on tape for a combined record/playback flutter measurement if a standard flutter tape is not available.

The next two FUNCTION switch positions are for measuring total harmonic distortion at a 400-Hz frequency. In this mode, the oscillator supplies a low-distortion 400-Hz signal, regardless of the setting of the OSCILLATOR switch. The distortion measurement is made by nulling out the 400-Hz fundamental in the signal entering the instrument from the tape recorder or other equipment and reading the residual signal (from 800 to 10,000 Hz). Nulling is automatic, as is the setting of the full level signal reference for the measurement. As long as the upper bar display indicates between −10 and +10 dB, the lower bar indicates directly and continuously in THD,

Product Focus

The Nakamichi Model T-100 Audio Analyzer is replete with circuit features that make it difficult to single out any specific area in which it differs from similar products. (The fact that there are no similar products is a further complication!) However, we feel that the logarithmic voltage converter which gives this tiny instrument so much of its versatility is worthy of special mention.

In any of the analyzer's operating modes, except SPEED, the final readout on the bar displays is logarithmic, covering a 30-dB range with uniform scale intervals. The signal to be displayed is available as a voltage with dc and infrasonic ac components and an amplitude that is linearly proportional to the function being measured. To compress these widely different signal amplitudes into a 30-dB logarithmic scale, they are fed to one input of a voltage comparator. The other input receives a signal whose amplitude varies exponentially with time.

The exponential signal is derived from a square-wave reference oscillator, whose output charges a capacitor through a resistance. The voltage appearing across the capacitor increases exponentially with time. When it is less in amplitude than the signal voltage going into the comparator, the output of the comparator is a logic 1. When the reference voltage exceeds the signal voltage, the comparator switches to a logic 0. Thus, the comparator's output is a train of pulses at a frequency determined by the clock oscillator, whose duty cycle (the width of the logic 1 state) is proportional to the logarithm of the input signal voltage. The pulse train is integrated, and the resulting voltage, after additional processing, controls the length of the bar graph indication.

over the same scale ranges used in the flutter measurement, from 0.01% to 3% in two ranges. The two switch positions are for measuring the left and right channels separately.

The next two FUNCTION switch positions are for LEVEL measurements. They are used with the OSCILLATOR switch. The OSC OUTPUT and recorder's level controls are adjusted to give a 0-dB or other reference level indication on the recorder's meter. The oscillator's signal amplitude is constant over its full frequency range. When the FUNCTION switch is set to LEVEL −20 dB, the oscillator's output drops by exactly 20 dB, which is the usual test condition for record/playback frequency response.

In the LEVEL mode, the displays have a standard VU-meter ballistic response. In the PEAK LEVEL mode, the display can respond to transients as short as 10 ms with full accuracy and have a 2-second decay time to make transients more visible. The NOISE-A (−40-dB) switch setting is used for measuring the output noise from a tape deck or amplifier. The meter sensitivity is automatically increased by 40 dB in this mode and a standard A-weighting network is inserted in the metering circuit. At full sensitivity settings of the INPUT LEVEL switches, noise levels as low as 10 μV (−100 dB, referred to 1 volt) can be measured.

The ac receptacle for the plug-in line cord and a POWER switch are recessed into the right side of the instrument. In a similar recess on the left side are the two INPUT and two OUTPUT jacks (the latter in parallel, since all signal outputs from the analyzer go in common to both channels on the item being tested). Another pair of jacks, labelled SCOPE, carries the

Performance Specifications

General
Input impedance: 50,000 ohms
Scope out: low impedance

Oscillator
Spot frequencies: 20, 40, 63, 100, 160, 250, 400, 630, 1k, 1.5k, 2k, 3k, 4k, 5k, 6.3k, 8k, 10k, 12k, 15k, 18k, 20k Hz.
Output voltage: 1.2 volts maximum (variable)
Level deviation: ±0.2 dB (20 to 20,000 Hz)
Output distortion: Less than 0.3% (20 to 20,000 Hz)
Less than 0.01% @ 400 Hz (THD measurement)
Frequency accuracy: ±2%
Output impedance: 600 ohms

Level Measurement
Range: −80 to +30 dB (0 dB = 1 volt)
Frequency response: 20 to 20,000 Hz ±0.3 dB
Ballistics: Average (rms): 0.3 s (VU)
Peak: 10 ms rise time, 2 s fall time (DIN PEAK)

Wow & Flutter
Center frequency: 3000 Hz
Input level range: 3 mV to 30 V
Indication: DIN peak (weighted and unweighted)
Frequency range: 0.2 to 200 Hz.
Tape speed range: ±3%

Distortion Meter
Measurement frequency: 400 Hz
Input voltage range: 100 mV to 30 V
Distortion range: 0.01% to 0.3%; 0.1% to 3%.
Automatic input control range: 20dB (−10 to +10 dB)
Frequency characteristics: 800 to 10,000 Hz (−0.3 dB)
Residual noise: −90dB (input range 0 dB)
−85 dB (input range −20 dB)
Fundamental frequency rejection: 400 Hz ±3%: −100 dB (0.001%)
400 Hz ±5%: −70 dB (0.03%)

Noise Level
Frequency characteristics: IHF-A curve
Range: 100 to −10 dB (0 dB = 1 volt)
Indication: Average value
Power requirements: 100, 120, 220, 240 volts, 50 to 60 Hz
Power consumption: 15 VA
Note: All specifications were met or exceeded except for meter ballistics (average), where there was a 40% low reading on 0.3-second bursts.

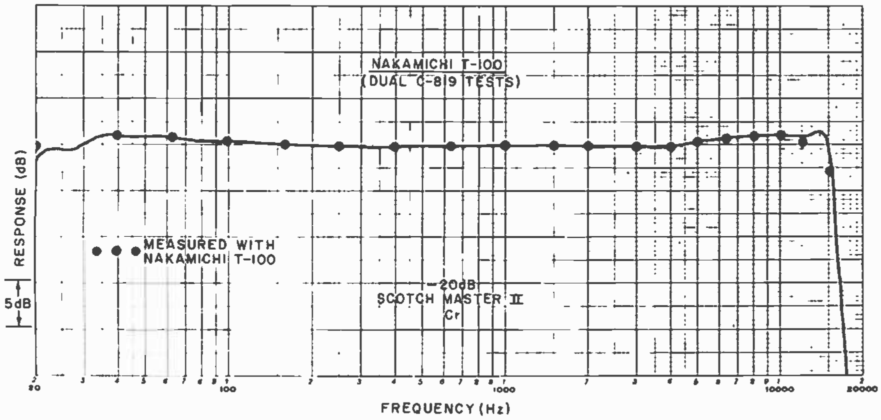


Chart shows use of the T-100 in making record/playback response tests of a Dual tape deck. Continuous line was made with General Radio plotter.

processed signal before it is passed through the display's logarithmic converter for viewing on an oscilloscope.

The analyzer's circuitry is contained on seven small plug-in circuit modules. Two folding feet under the instrument tilt it upward for easier viewing. (The display is best viewed head-on.)

The Model T-100 is supplied with a comprehensive operating manual and a technical supplement that describes some of its novel features. There is also a page of charts that show the relationships between the control settings and the analyzer's display, as well as a block diagram permanently affixed to the top of the instrument itself.

Laboratory Measurements. For almost all tape-deck measurements, the Model T-100 is simply patched to the deck's input and output jacks with the supplied cables. Our first measurement was the record/playback response at a −20-dB level. Our test data (circled points on the graph) is shown superimposed on the swept response curve measured with our General Radio response plotter. At only two points was there a measurable difference between the two sets of data. At 20 Hz, the initial transient of the chart recorder's pen response to the beginning of the swept signal caused it to read slightly low. The fixed reading from the analyzer was correct. At 12,000 Hz, we noted that the analyzer gave about a 0.5-dB lower reading than the swept measurement—a negligible error. It is apparent, though, that the discrete frequency measurement cannot show the precise shape of the curve as it "breaks" beyond 14,000 Hz.

We measured the record/playback THD at 400 Hz with the Model T-100 and our Hewlett-Packard Model 3580A spectrum analyzer (on which we measured only the third-harmonic component). In general, the two distortion readings agreed within about 10%.

The S/N, referred to the level that gave 3% playback distortion, was 62 dB with the Model T-100 and improved to 68 dB with the recorder's Dolby circuit switched in. We measured 61.5 and 65 dB through our external A-weighted filter and meter, respectively. In this case, we suspect that the Model T-100's reading was more accurate, because of the reduced likelihood of stray hum and noise pickup in the interconnecting wiring.

Speed and flutter were measured with a TDK test tape on playback only, using our Meguro flutter meter as a check on the Model T-100. Both instruments gave identical speed readings of +0.25%, as well as identical weighted peak flutter readings of 0.05%. The Model T-100's unweighted peak test condition, which gave a 0.15% reading, is not duplicated on the Meguro meter, and the latter's JIS (wrms) mode, which gave a very low 0.03% reading, is not provided on the Model T-100.

The ballistics of the bar displays are supposed to correspond to VU-meter standards, which require a reading of 99% to 100% of the steady-state reading when driven by 1000-Hz tone bursts of 0.3-second duration at a 1-Hz repetition rate. The Model T-100's response was considerably slow, giving 40% low readings (−4.5 dB). In the PEAK LEVEL mode, however, the display was identical on steady-state and burst signals.

As a voltmeter, the Model T-100 was as accurate as it could be interpreted. The number of lighted segments in each bar gives a resolution of about 0.3 dB. It was accurate within these limits from 5 to 60,000 Hz. The response dropped to −3 dB at 115 kHz and to −10 dB at 200 kHz. The distortion of the built-in oscillator was 0.13% at 20 Hz, 0.018% at 1000 Hz, and 0.16% at 20,000 Hz. When the oscillator is automatically set to 400 Hz for THD measurements, its distortion was less than 0.01%. We examined the PINK NOISE output on our spectrum analyzer and determined that it had the required −3-dB/octave slope with increasing frequency.

User Comment. The Model T-100 does its primary task, the testing of tape recorders, with an ease and accuracy that seem almost deceptive. It is also useful, though somewhat less convenient, for many other high-fidelity system and component tests, such as phono-cartridge frequency-response measurements, turntable flutter and rumble measurements, amplifier S/N measurements, and frequency response measurements on amplifiers, filters, microphones, etc. Although its inherent performance limitations are well beyond those of most ordinary components, it is ironic that it cannot make definitive measurements on Nakamichi's own amplifiers or others with "state-of-the-art" noise and distortion levels.

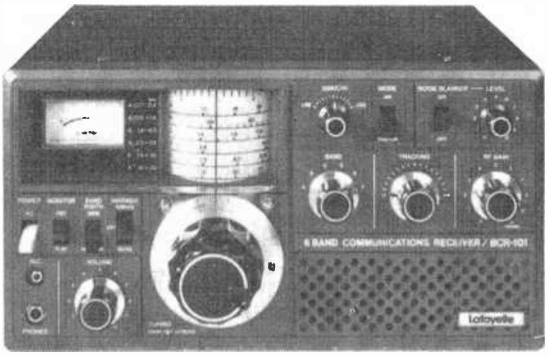
One thing we learned about the Model T-100 is that it takes a considerable period of time to become a familiar tool to the user. We doubt that it could be used successfully without careful study of the manual. Much of the manual's "cookbook" approach to measurements presupposes little or no knowledge of the instrument or even of basic measuring processes. However, it entirely omits certain fundamental steps, such as establishing a reference level before making a noise measurement.

There will undoubtedly be some audiophiles who will invest in the Model T-100 as an adjunct to their high-fidelity systems, since connecting it across the speaker outputs of their systems makes the analyzer an excellent peak-power indicator. It's limited, however, to 100 watts. Again, the major markets for this instrument will almost certainly be the hi-fi equipment service shop, where it can save a lot of time and pay for itself quickly, and the showroom, where it can be used to demonstrate to the prospective buyer the capabilities of the equipment that interests him.

CIRCLE NO. 104 ON FREE INFORMATION CARD

(More Test Reports Overleaf)

Lafayette BCR-101 AM/CW/SSB Receiver



A very satisfactory receiver for the SWL... and adequate for the novice ham.

THE Lafayette Model BCR-101 is a moderately priced, general-coverage AM/CW/SSB communication receiver. It has a tuning range from 170 to 400 kHz and from 530 kHz to 30 MHz in six bands. On the three lower bands, up to 4.0 MHz, it employs single conversion in a superheterodyne circuit, with a 455-kHz i-f. On the three higher bands, from 3.5 to 30 MHz, dual conversion is used, with a tunable first i-f from 1650 to 2150 kHz. The tunable second-conversion oscillator, operated by the bandspread dial, covers 1195 to 1695 kHz and converts the incoming signals to 455 kHz.

A switch-defeatable variable-threshold noise blanker is built-in. There is also a front-end tracking control for peaking the tuning of the r-f stage. Another worthwhile feature is an input socket for operating the receiver from a 13.8-volt dc source (such as a vehicle or boat electrical system).

The receiver measures 12"W × 9½"D × 7"H (30.1 × 24.1 × 17.8 cm) and weighs 13.5 lb (6.1 kg). Price is $249.95.

General Description. The drum-type main tuning dial of the receiver has separate scales for each band and for logging. Concentric with the tuning knob is a bandspread tuning knob and dial, the latter calibrated from 0 to 500 kHz in 5-kHz intervals. Front-panel jacks permit the receiver's audio to be routed to an external tape recorder and to headphones. (When phones are plugged in, the receiver's built-in 5" × 1" speaker is defeated.)

On the rear apron are phono jacks for connecting an external audio signal and for taking an output from the receiver's first oscillator to drive an external frequency counter. Although the oscillator output is meant as an aid to alignment, it can also be used to obtain a highly accurate frequency display from the receiver. Also on the rear apron are antenna and ground terminals for a 50-to-75-ohm antenna and a hinged ferrite-rod antenna for reception on AM.

The receiver's tuned r-f amplifier and first mixer employ dual-gate MOSFETs. The first oscillator is isolated by an amplifier and emitter-follower from the output jacks; hence, a cable connecting to a frequency counter will not affect tuning.

From the first mixer, the signal is directed by diode switches to one of two i-f selectivity sections. On the three lower bands, the signal goes directly to a 455-kHz i-f transformer. On the higher bands, it first passes through a tunable 2.15-MHz i-f section, whose two tuned circuits track with the second local oscillator. The signals from the first i-f and second oscillator are combined in a second mixer, whose 455-kHz output (or the output of the single 455-kHz transformer on the low bands) is routed through diode switches to the noise blanker and from there to the two 455-kHz i-f selectivity sections.

There are separate WIDE and NARROW bandwidth selectivity modes. The WIDE mode employs three tuned circuits and the NARROW mode has two and a ceramic filter. The 455-kHz output of the selected circuit is routed through two amplification stages to either of two detectors, the latter determined by the MODE switch. A simple half-wave diode detector is used for AM reception. For CW and SSB, it is replaced by a two-diode product detector in which the signal is heterodyned with the 455-kHz signal from the bfo. The bfo is tunable over a range of a few kilohertz.

A single rectifier, operated from the final i-f stage, is used to drive the S meter through a two-stage amplifier. Its output is also combined with an adjustable dc voltage from the r-f gain control to supply agc to one gate of the r-f stage and to the first stage of second i-f amplification.

The audio signal from the detectors goes to an i-f amplifier that supplies a nominal 2 watts to the built-in 8-ohm speaker. The marker oscillator contains a 500-kHz crystal and an IC divider that generates harmonics at 500- and 50-kHz intervals. When the markers are used to set the main tuning dial to a multiple of 500 kHz, the bandspread dial must be set to zero.

Laboratory Measurements. Calibration of the main tuning dial was reasonably accurate. Errors were as great as 50 or 100 kHz at the highest frequencies, but were proportionately less on the lower bands.

When using 50-kHz markers, a large number of spurious signals was discovered that made it difficult to identify and count markers as we tuned. Fortunately, the 500-kHz marker could be used to set the main tuning dial close enough to the nearest 500-kHz calibration point so that the bandspread dial could be used for closer readout of the frequency. We found the calibration good enough, however, to set the receiver within 10 kHz of any desired frequency and, if care was exercised, to within 5 kHz.

Sensitivity for a 10-dB (S + N)/N ratio with an AM signal modulated 30% at 1000 Hz was typically about 2 μV at frequencies above 1.4 MHz but somewhat poorer at lower frequencies. CW sensitivity for a 10-dB (S + N)/N was 0.7 to 1.3 μV on the various bands. Image rejection was 63 to 85 dB, depending on the frequency. (We measured sensitivity at the center of each band.)

Wide- and narrow-bandwidth modes were not too different from each other, judging from the audio-frequency response measured at the receiver's output. We varied the modulation frequency applied to the signal generator in the AM mode and plotted the receiver's audio output in both selectivity modes. Response was down 6 dB at 30 Hz in both cases at the low end and down 6 dB at 2000 and 1700 Hz at the high end in the wide and narrow modes, respectively. Audio output at the clipping point measured about 1.5 watts into 8 ohms.

With no antenna connected to the re-

Performance Specifications

Specification	Rating	Measured
Frequency coverage	Band A: 170-400 kHz B: 530-1500 kHz C: 1.4-4.0 MHz D: 3.5-7.5 MHz E: 7.5-15 MHz F: 15-30 MHz	
Antenna input	50 to 75 ohms unbalanced (Ferrite loopstick on band B)	
Sensitivity	Band B: 110 μV/meter Other bands: 1 μV or better (Measurement method not specified)	Not measured on B Band AM CW A 7 μV 1.1 μV C 2.5 μV 1.3 μV D 2.0 μV 1.3 μV E 1.8 μV 0.7 μV F 2.0 μV 1.1 μV (10 db S+N/N)
Selectivity (−6 dB)	8 kHz (wide) 3 kHz (narrow)	2 kHz (wide) 1.7 kHz (narrow)
Image rejection	Band A: 70 dB B: 65 dB C: 60 dB D: 65 dB E: 60 dB F: 50 dB	72 dB NA 63.5 dB 66.5 dB 83 dB 85.5 dB
Intermediate frequencies	First: 2.15 MHz Second: 455 kHz	
Audio output (8 ohms)	2 watts	1.5 watts at clipping
Power requirements	110 V, 50/60 Hz ac at 10 watts max. or 13.8 V dc, less than 500 mA	

ceiver, we searched for "birdies" and spurious responses. One strong S9 birdie appeared at 5.1 MHz. Much weaker responses were observed at 6.8, 8.5, 10.2, 11.9, and 13.6 MHz. None of the birdies was strong enough to interfere with normal reception.

User Comment. Past experience with modestly priced communication receivers has taught us that they rarely perform and "feel" like high-priced equipment. Nevertheless, if they perform properly in the essential areas of stability and tuning ease, they can be perfectly satisfactory for the SWL and novice Amateur. (The latter has a more critical requirement, since a receiver that prevents a new ham from carrying on effective QSOs can discourage him from pursuing his hobby.)

Judged solely on its own merits, the BCR-101 is a very satisfactory receiver for the SWL and is at least adequate for the novice ham. Tuning is a bit "rubbery," with enough backlash to be annoying on SSB, but it is tolerable for CW, and AM listeners will hardly notice it. Accuracy of the tuning dial's calibration was a pleasant surprise. Once it had been zeroed to the nearest multiple of 500 kHz, we found that WWV and CHU appeared "on the nose." Spot checks of intermediate points in the ham bands revealed that the bandspread's dial calibrations were truly meaningful.

On the 1.4-to-4.0-MHz band, our test receiver oscillated at maximum gain, but was stable at reduced settings of the control. There was no sign of instability on the other bands. The noise blanker had no discernible effect on impulse noise. When receiving strong AM broadcast stations, we had to reduce the setting of the r-f gain control to eliminate unpleasant audio distortion. The agc system's time constant was fairly fast. There is no way to disable the agc, but if "pumping" becomes annoying, one need only turn down the r-f gain control.

In spite of some shortcomings, the BCR-101 left us with a distinctly favorable impression of its performance. As stated earlier, a low-cost receiver simply cannot be judged by the rigid standards applicable to an expensive receiver. In its own right, the BCR-101 is quite impressive. With care, it can serve as a most satisfactory receiver for the novice ham or SWL and can even be useful as a standby general-coverage receiver for the experienced ham.

CIRCLE NO. 105 ON FREE INFORMATION CARD

Soft ware Sources

By Leslie Solomon
Technical Director

Graphic Games. A number of low-cost software games are now available for the TRS-80, POLY, and PET computers. Among them are WWII Bomber, Lunar Lander 5 and Biorhythm. Requiring only 4K of memory, these come on a cassette for $9.94. Specify computer. Software Industries, 902 Pinecrest, Richardson, TX 75080.

PET Utilities. The Micro-SET I provides five functions to help PET users. These are: CREATE TAPE that makes an ASCII file of a program, subroutine or collection of lines for addition to another program; ADD FROM TAPE that uses an ASCII file tape to add previously stored lines to the program; DELETE that removes lines numbered between your specified limits; PROGRAM INFO that reports the number of lines in a program, identifies the first and last lines and the number of free bytes; and RENUMBER that changes line numbers in a specified range. Micro-SET is used with PET's having at least 8K of RAM. Price is $15 per copy. Micro Software Systems, PO Box 1442, Woodbridge, VA 22193.

Video Software. EVIOS—extended video input/output system, written for the Vector Graphic Flashwriter II video board, can maximize the capabilities of any video terminal and is designed to allow complete control over every facet of software programming. The program includes cursor motion commands, selective screen erasing and five different fields: reverse video, horizontal line, vertical line, graphics and reduced intensity. It also features paging or scrolling, superseding or overlaying screen fields, printing special video characters and a mode that prints control sequences from BASIC as a normal character string. In addition, the input has control sequences to other programs without causing errors, allowing the screen to be cleared while in BASIC. Package includes manual, interfacing and programming examples, a source listing and a 2708 PROM. Price is $75. Vector Graphic Inc., 31364 Via Colinas, Westlake Village, CA 91361 (Tel: 213-991-2302).

6800 Language. STRUBAL+ (STRuctured BAsic Language plus), comprised of elements of BASIC, PL/M, COBOL and assembly language is compatible with existing BASIC software, provides structured programming, business-type record structures and file accessing methods, and includes assembly language for low-level system operations. Also available are EDIT68, a line oriented text editor; RA6800ML a two-pass macro assembler that generates relocatable and linkable object code; LNKEDT68 a linkage editor utility designed to work with STRUBAL+ and RA6800ML; XREF68 a utility designed to produce a cross-reference listing of an input cross-reference file; and a Cross Assembler for the specific microcomputer written for use on an M6800. Catalog available from Hemenway Associates, Inc., 151 Tremont St., Suite 8P, Boston, MA 02111.

Games. For the Exidy Sorcerer, there are six games; LEM (Lunar lander), Nuclear Reaction, Pie Lob, Bounce, Checkers (novice level) and Dodgem. Catalog CS-5001 at $7.95 plus 75¢ postage. For the Ohio Scientific Superboard II/Challenger 1P, there are four games; Dodgem, Tank Attack, Free-for-All, and Hidden Maze. Catalog CS-6001 at $7.95 plus 75¢ postage. Creative Computing, Software, Box 789-M, Morristown, NJ 07960 (Tel: 201-540-0445).

Computer Bits

By Hal Chamberlin

AUDIO CASSETTE RECORDING FORMATS

NOWADAYS many hobbyists take the audio-cassette recording format used by their computer systems for granted. However, four years ago this was not at all true since no really good technique was available and users at the time were screaming for something that simply worked. (The first hobbyist cassette data storage system called "Hobbyists Interchange Tape System" or HITS, was introduced in POPULAR ELECTRONICS in the "Computer Bits" column of September, 1975.) Audio and digital engineers were quick to respond and now there are over a dozen widely used formats. Although a standards conference was held in late 1975 to stem the tide, deficiencies in that standard and competitive pressures in the marketplace continue to produce an even wider variety of formats. In this column, we will be looking at some of the more distinctive recording techniques in use mostly as a matter of historical interest rather than critical evaluation of their strengths and weaknesses.

Characteristics of Recorders. Any viable method of recording digital data on an audio cassette recorder must take into account the various signal distortions inherent in the medium. A typical design goal is to be able to use virtually any kind of recorder, including a $30 "cheapie", since two recorders would be needed for any real file-handling application. Recorders in this price range are plagued by limited frequency response (300-3000 Hz), and very poor speed regulation (±10%). Also, most severely distort recorded waveforms because of the limited frequency response and phase shifts through low-quality audio amplifiers. To a lesser extent, all magnetic recording media are subject to sensitivity variations and even complete dropouts, although the use of higher quality and more expensive tape reduces this kind of problem.

Thus it is obvious that a straight digital bit system such as that shown in Fig. 1 cannot be recorded with any degree of success. To overcome waveform distortion and speed variation it is necessary instead to modulate the digital information onto some sort of carrier wave which is then recorded. During playback, the modulation is separated from the carrier to recover the original bit stream intact.

A complete data recording system actually operates at three levels of encoding. The lowest level, which was just discussed, addresses the problem of recording and recovering bits. The second level is concerned with combining these bits into bytes since blindly grouping them by eights is usually not satisfactory. The third level, which is software dependent, handles combined data and identification bytes in complete tape *records*. Even though only a handful of techniques are popular on each level, the number of combinations is almost infinite and each may have a specific advantage. In this discussion we will be concerned with the lowest level of individual bit-encoding techniques.

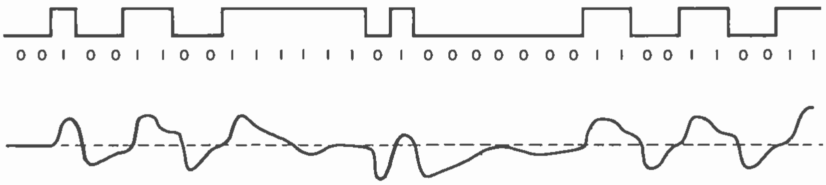


Fig. 1. Lower waveform illustrates typical distortion of a pure digital signal.

Modulation. When a steady carrier wave is modulated, something about it must be changed and that change must be recognizable at the receiver. Because of the limited frequency response of the recorder, only sine-wave carriers can be seriously considered. A sine wave has only three properties that can be modulated; amplitude, frequency and phase. Looking again at the recorder, we see that any one of these characteristics can be distorted by the recording process. Thus, no modulation process can be totally immune to recorder deficiencies. The key to acceptable performance is to make the modulation gross enough so that the "noise" due to the recorder is small in comparison.

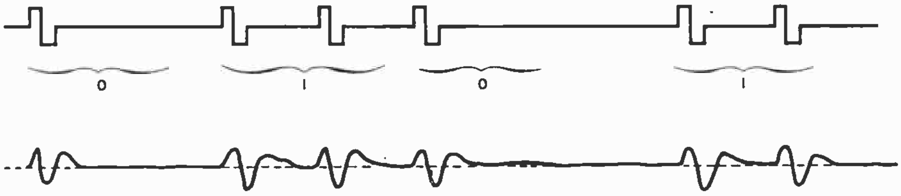


Fig. 2. "Pulse" modulation is actually another form of amplitude modulation.

Frequency Modulation. Frequency modulation is probably the most popular type of modulation. When used to encode binary data, it becomes *frequency shift keying*. Early audio cassette interfaces actually copied the frequency-modulation technique in wide use for communicating data over voice grade telephone lines. Unfortunately, the degree of modulation (binary 0 at 2225 Hz and binary 1 at 2025 Hz) was not sufficient to overcome tape speed variations in low-cost recorders. Another early interface used the international standard radio teletype frequencies (0=2975 Hz and 1=2125 Hz) which, being more widely separated, worked considerably better. A serious shortcoming of both methods was that *timing* information about the bits was not recovered. Thus, if a string of zeroes was encoded there was no way to tell, except by marking time, where one bit stopped and the next began. Marking time was subject to substantial error because tape speed variations distorted the timing.

All later methods provide for measuring time using the data itself. This is called *self clocking* because there is sufficient *redundant* information in the signal to tell where bit boundaries are regardless of speed variations. Because of the redundant information, however, the speed of these techniques is less than that theoretically possible with nonredundant recording. As a practical matter, the greater reliability of self-clocking methods outweighs their slower speed.

One popular self-clocking frequency-modulated encoding technique is called the Kansas City standard because it was designed by a committee that met in Kansas City in November of 1975. With this technique, a binary one was defined as 8 cycles of a 2400-Hz tone and a zero was 4 cycles of 1200 Hz. Bits were therefore timed by *counting cycles* of the carrier frequency. Because of the wide separation of frequencies, a simple single-shot circuit was sufficient to discriminate between them. A nice property of the standard was that it could be easily upgraded. The normal data rate of 300 bps (bits per second) could be increased to 600, 1200, or even 2400 bps by reducing the number of cycles for each bit. The 2400-bps rate is interesting in that a zero is only one-half a cycle of 1200 Hz. The resulting modulation is very similar to the popular "Tarbell" format which is known for its high-speed capability. A problem with these formats is that waveform distortion has to be low enough to allow accurate cycle counting, which is usually by zero-crossing detection.

There does exist a self-clocking frequency modulation technique that does not depend on cycle counting for timing. The trick is to convert each bit into *three* bits which are then recorded with a non-clocking frequency-modulation technique. If a zero is to be recorded, it is converted into 1-0-0 and if a one is to be recorded, it is converted into 1-1-0. Thus, the bit boundaries can be identified by noting the transitions from 0 to 1. The decision between 0 and 1 for the entire bit cell is arrived at by *comparing* the amount of time within the cell that is spent at a 1 level to that spent at a 0 level. Since the decision is based on a comparison rather than absolute timing, the technique is almost totally immune to speed variations! This method is also known as the "⅓–⅔" method or "ratio recording". The limit of speed-variation is reached where the FM detector can no longer accurately distinguish between 0 and 1 levels. However, this could be overcome with an afc (automatic frequency control) circuit similar to that used in FM radio receivers.

This technique was first used on the KIM-1 microcomputer and generally works quite well although it is fairly slow. Unfortunately, the carrier frequencies chosen (3700 Hz for 1 and 2400 Hz for 0) are a little high for reliable use with most low-cost cassette recorders. Like the Kansas City standard, methods are available to upgrade the normal 134 bps by factors of 3 and 6 to a respectable 800 bps without producing any serious loss in reliability.

Amplitude Modulation. Although amplitude modulation is less used than frequency modulation, it has some important technical advantages—and some disadvantages. The main advantage is that speed variations from one recorder to the next have no effect on the data recovery process. The primary disadvantage is that variations in recording level and tape output may require the recorder's volume control to be adjusted for accurate data recovery. Some may see this as an advantage over FM methods since volume controls are standard but speed controls are not.

Amplitude modulation with binary data is often called tone-no-tone recording since that is the result of 100% modulation. One potential problem with amplitude modulation is that the automatic level control (alc) feature found in many cassette recorders tries to counteract changes in signal amplitude. To prevent alc problems, the selected format must avoid long periods of silence. With such a format, the alc feature (which only functions during recording) can become an advantage since it ensures that all tapes are recorded at the same volume level.

The basic idea of the HITS format, mentioned above, is the same as the ⅓–⅔ method except that a logic 1 is signified by the presence of a high-frequency tone while a logic-0 level is the absence of any tone. Since silence never lasted longer than ⅔ of a bit time, there was no problem with recorders having alc. Although the 300-bps speed was modest, it was quite adequate for *interchange* purposes. The system was quite insensitive to recorder variations, a requirement for interchange. In particular, since only one tone frequency was used, it tolerated head alignment errors (which severely alter the recorder's frequency response curve) quite well.

Another widely used recording method, although termed *pulse modulation*, is in reality another form of amplitude modulation (Fig. 2). The method was first proposed by the writer in 1975 in The Computer Hobbyist newsletter as a local and interchange standard. Although its initial usage was small, it was quietly adopted by Radio Shack for its TRS-80 computer and now is probably the most widely used format to be found.

In the system, a "pulse" is defined as exactly one cycle of a 4-kHz tone surrounded on both sides by silence. Every bit on the tape begins with a "mark" pulse. A zero bit is detected if the mark pulse is the only pulse seen within a 2-millisecond period which is the bit cell time. A one bit is signified by a second pulse occurring shortly (1 millisecond) after the first. The method has a speed variation tolerance of about ±20% which is limited by the ratio of the bit cell time to the spacing between the mark pulse and the "one" pulse. One interesting property of the method is that the bit rate need not be constant, although too big a gap between bits can cause problems with the alc. The standard speed of 500 bps can be reduced for better reliability (250 bps is used in the Level I TRS-80) and increased (2000 bps has been reported on a good-quality recorder) for faster operation.

Digital Recording. Even the fastest audio cassette interface is painfully slow when searching through files of tens or hundreds of thousands of bytes and even with all kinds of built-in error detection schemes still does not have the reliability needed for extensive business use. Direct *digital recording*, which avoids the distortions in audio circuitry, is the answer for high-speed, highly reliable recording on magnetic media. The recording techniques used in digital cassette systems and floppy disks will be discussed in a future column. ◇

"Sorry Bill. I ran you through the computer last night and you just didn't make it."

Amateur Radio

By Karl T. Thurber, Jr., W8FX

SETTING UP YOUR STATION

THE TRANSMITTER and receiver (or transceiver) and the station accessories are all just so much electronic equipment until they are arranged in a fashion that results in efficient, convenient operation. A well-planned station is a joy to operate; a poorly arranged one causes unnecessary operator fatigue and frustration.

Many considerations shape a good station arrangement besides the required interconnections between the equipment. Personal operating preferences play a large role. The point to keep in mind is that it's worth taking the time to set up your station properly. No other decisions apart from the selection of your equipment will determine how much enjoyment you derive from your new hobby.

The Operating Position. A comfortable chair and a sturdy desk are imperative. The author has for years used two double-decker file cabinets supporting a heavy-duty wooden door. Together they form an oversized operating console larger than an "executive" desk.

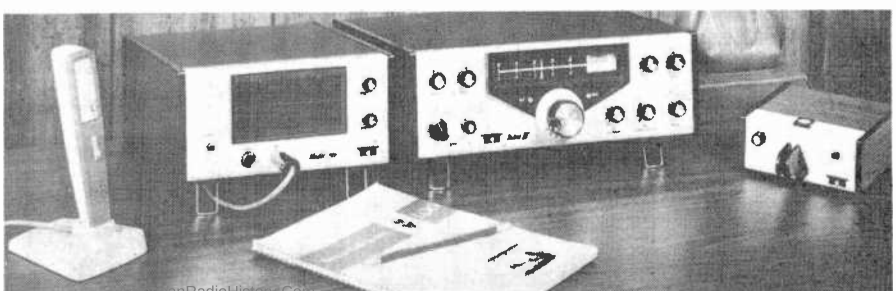
The location of the receiver or transceiver should be determined first, because all the other equipment will be grouped around it. Place the receiver so that it is within easy reach and is conveniently tuned. A right-handed operator should place the receiver to the left. This allows tuning the receiver with the left hand while writing down call letters, etc., with the right. Similarly, a left-handed operator should place the receiver to the right side of the table.

The transmitter is usually not adjusted as often as the receiver, so it should be to the right of the receiver in a right-handed operator's station. The front of the transceiver (or transmitter and receiver) should be tilted up slightly. This makes the dials easier to read and the control knobs easier to grasp. Realizing this, many manufacturers place taller rubber feet under the front of their products' enclosures. If your equipment does not have this feature, you can shim up the front simply by placing a small board under the front feet.

Other items, such as an auxiliary station receiver, antenna coupler, directional wattmeter or SWR bridge, keyer, etc., should be located near the piece of gear they support. Stacking equipment is permissible as long as adequate ventilation is provided for heat-generating transmitters, amplifiers, etc. Receivers usually generate a small amount of heat (about 40 watts for contemporary models) but still require some ventilation for convection cooling. Small "Muffin" or similar fans will keep transmitters, transceivers, and other components cool and extend the lives of vacuum tubes (if your equipment uses them).

Other accessories, such as the key or keyer "paddle" should be located so they can be moved around the desk-top for comfort while you are shifting position in the operating chair. A 24-hour clock, preferably set to UTC, should be placed in a spot where it can be viewed easily. One of the many digital clock kits with 24-hour display capability makes an excellent beginner's construction project and a valuable addition to your station. Some people like to use a foot switch for going from transmit to receive. This can generally be wired across the transmit-

Complete station with Ten-Tec's mike, power supply, transceiver, and keyer.



ter's or transceiver's transmit-receive switch.

Consideration should also be given to locating an extension phone at the operating location, particularly if third-party message "traffic" is handled. Other gear, especially large accessories such as power supplies and auxiliary units can be located out of sight under the operating console or on separate tables or cabinets. This will keep clutter on the main operating console to a minimum. Consider, also, QSL card storage and display. Do you want to "paper" the wall with your rare DX catches or store them in file drawers? Be sure to allow space for the storage of log books, technical manuals, and pamphlets.

The actual location of the station might be dictated by factors not totally under your control. The attic, basement, and den are popular locations. Remember that damp basement locations will tend to damage equipment through mildew formation and will encourage rusting. Excessively hot attic locations will shorten component life and may make operating a chore rather than a pleasure. The location chosen should not result in excessively long feedlines to the antenna and consequent signal losses.

Wiring. Care should be taken to keep r-f cables (coax, twinlead, or open-wire) as short as possible, and to prevent the rear of the operating console from becoming a "rat's nest" of wires. Small, plastic cable ties and adhesive-backed clamps will keep the wiring neat and simplify any future equipment servicing. Fused, multiple-outlet ac power boxes or strips should be used for power distribution to your setup.

For safety's sake, it should be possible to remove ac power from the *entire* station by throwing one well-marked, wall-mounted switch. All members of your household should know the location and function of this switch. A station running high power might require an independent ac line from the main fuse box to prevent circuit overload and the resulting fire hazard. An independent line will also prevent light-dimming in step with your CW sending—most annoying to other members of the family!

Lightning Protection. Don't neglect proper grounding for the station proper as well as the antenna system. The antenna, regardless of what type of transmission line is used, should be disconnected from the equipment when not in use and placed at dc ground to prevent static build-up and possible equipment damage. Such damage often occurs during electrical storms even without "direct hits" by lightning. Installing a heavy-duty lightning arrester on the transmission line will offer a degree of on-the-air protection. Both Hy-Gain and Cush-Craft manufacture inexpensive units which can save the front end of your transceiver or receiver and prevent other, more catastrophic damage. Removing all equipment from the ac power line via the main station power switch during severe weather is a good idea because high voltage transients induced on power lines by nearby lightning hits have ruined more than one piece of valuable ham gear.

Getting on the Air. Every amateur worth his salt takes great pride in observing both good operating practices and FCC regulations. Hams self-regulate their hobby activities by adhering to a code of ethics which stresses gentlemanliness, loyalty, cooperation and public services. This includes Novices.

The Radio Amateur's Operating Manual, published by the American Radio Relay League, goes into considerable detail as to correct operating procedures for such activities as message handling, public service activities, emergency operation, and contest participation. We will not elaborate on them, but here are several of the most important operation considerations:

- Make your transmissions brief, even during "rag-chew" contacts. This will stimulate conversation and promote *two-way* communications. Don't make speeches. It is generally wise to avoid discussing subjects such as politics and religion over the air.
- Listen first before transmitting. Never intentionally disrupt a QSO in progress, particularly emergency traffic.
- Keep CQs short with short breaks for listening. Limit transmission length. (Thirty-seven consecutive CQs before signing one's call sign will rarely result in a reply. Almost no one will have the patience to wait for your call letters!)
- Give honest signal reports, not "599", to everyone. (See Table.) Honest reports can save operators from possible FCC citation for trouble caused by faulty equipment.
- Take any technical or operating criticism in stride. Never argue on the air.

Rather, display sportsmanship and courtesy.

- When a DX station is heard, maintain proper perspective and operating discipline. Don't become a "DX Hog." Call him *only* when he clears with another station.
- Keep a complete, accurate log. Although FCC requirements have been eased, it pays to keep a good record of station operations for future reference. A complete log is also a source of pride!

R-S-T SIGNAL REPORTING SYSTEM

Readability

1. Unreadable.
2. Barely readable, some words or characters distinguishable.
3. Readable with much difficulty.
4. Readable with practically no difficulty.
5. Perfectly readable.

Signal Strength

1. Faint signals, barely audible.
2. Very weak signals.
3. Weak signals.
4. Fair signals.
5. Fairly good signals.
6. Good signals.
7. Moderately strong signals.
8. Strong signals.
9. Extremely strong signals.

Tone

1. Sixty-cycle ac or less, very rough.
2. Very rough ac, very harsh.
3. Rough ac tone, rectified but not filtered.
4. Rough tone, trace of filtering.
5. Filtered rectified ac, but ripple-modulated.
6. Filtered tone, trace of ripple modulation.
7. Near pure tone, some trace of ripple.
8. Near perfect tone, slight trace of ripple modulation.
9. Perfect tone, no trace of either ripple or modulation of any kind.

Note: If the signal has the inherent stability of crystal control, add the letter X to the RST report. If there is a chirp, the letter C may be added to so indicate. And for a click, add K. (For example a weak, very rough, barely readable and chirpy signal might rate a "low-ball" signal report of "236C", an extremely poor report and one not usually given out even when deserved. A super-outstanding signal in all respects might be given a "599X".)

- Decide how you are going to handle QSL cards. If you agree on the air to exchange cards, do so!
- Listen to well-run traffic nets and good operators and try to learn from their operations.
- Consider installing an emergency power source so that the station can be put to public service in case of a natural disaster.
- Participate in local emergency and public service activities, such as the Civil Defense-affiliated Radio Amateur Civil Emergency Service, the ARRL's Amateur Radio Public Service Corps, the Military Affiliate Radio System, and local radio patrols.
- Frequently check your transmitter for any evidence of vfo instability, key clicks, chirp, hum, and drift. Do this into a dummy load, not an antenna!
- Attempt promptly to resolve an RFI complaint from neighbors. This may not always be an easy task, but having "clean" r-f equipment to start with and exhibiting a willingness to resolve interference complaints will go a long way toward enhancing the public's image of amateur radio. Before you receive any RFI complaints, make sure that your own home entertainment equipment is RFI-free. Besides preserving domestic tranquility, this will enable you to show a complaining neighbor that *your* television and audio systems do not display symptoms of interference and that the susceptibility of his equipment to r-f is the cause of the problem.

Onward and Upward. Very few, if any, individuals have, as a long-range goal, to remain a Novice. Although its privileges have recently been expanded by the FCC, the license's capabilities are nevertheless circumscribed by CW-only operation, the 250-watt power limit and restricted frequency allocations. Thus, when you receive a Novice license, you should keep in mind that it is only an entry to the hobby and set your sights on the General or higher class license as soon as you get started on the air.

As you might already know, there are five amateur radio licenses: Amateur Extra, Advanced, General, Novice and Technician Classes. The Extra Class license (the highest) and the Advanced have tough code, theory, and regulations exams and are probably not of immediate interest to the newcomer. The General Class license has the same code requirement as the Advanced (13 wpm as opposed to 20 wpm for the Extra), authorizes privileges on parts of every ham band and is the next logical step up from the Novice.

The Technician Class license, on the

other hand, requires the applicant to take the same theory and regulations examination as the General, but specifies a code test of only 5 wpm, the same as the Novice code exam. However, it conveys operating privileges only on parts of the 6- and 2-meter ham bands, all frequencies above 220 MHz and on the hf Novice bands.

The Novice license, of course, is the basic entry-level ticket, though one need not start with it if he or she can qualify directly for a higher license. It conveys very limited operating privileges: CW only on 3.700-3.750 MHz, 7.100-7.150 MHz, 21.1-21.2 MHz, and 28.1-28.2 MHz. Privileges have recently been expanded, as previously mentioned, to allow vfo control and 250 watts of input power. Despite these restrictions, the Novice license, which is available only through the mail, is a very excellent means of entry into amateur radio. It has a minimum of requirements, yet it provides sufficient privileges to "sample" a broad range of activities available to amateur radio operators.

Once you've been on the air for a few months, you should think about upgrading your license. Continued on-the-air practice and listening to the ARRL's W1AW code practice sessions are probably the best ways to develop the proficiency needed to pass the General Class code exam. Technical skills are developed by undertaking construction projects, as well as by studying ham literature. It's also wise (and rewarding) to enroll in one of the several hundred license classes sponsored by local radio clubs around the country. If one of these courses is conducted in your area, the task of preparing for the General Class license examination will be greatly simplified. If not, an experienced local ham will usually be more than willing to help. Radio Shack, Ameco, 73 Magazine and the American Radio Relay League (ARRL) all publish excellent study guides, code courses, and other training aids that will be a real help in upgrading your license.

The newcomer is advised to consider joining the ARRL, a nonprofit association of U.S. and Canadian amateurs. The League is the generally recognized spokesman for amateur radio in both countries, representing the ham in legislative matters and publishing the monthly magazine *QST* and numerious technical manuals, including many beginner-oriented publications. Its mailing address is c/o ARRL, 225 Main St., Newington, CT 06111. ◇

POTENTIOMETER QUIZ ANSWERS

(Quiz is on page 56)

1-G. E is between wiper and negative.
At 1 and 2, E=0
At center tap, E=input
At ½ and ¼, E=½ x input

2-J. E is between wiper and positive.
At 1, E=½ x input
At 2, E=input

3-E. E is between wiper and C.T.
At 1 and 2, E=input
At C. T., E=0
At ½ and ¾. E is more than ½ x input
E is not shunted, hence is more than linear value.

4-H. E is between wiper and positive.
At 1, E=0
At 2, E=input
At center tap, E= ½ x input
At ¼, E is more than ¼ x input
At ¾, E is less than ¾ x input

5-B. E is between wiper and positive.
At 1, E= input
At 2, E=0
At center tap, E is more than ½ x input

6-I. E is between wiper and positive.
At 1 and 2, E=0
At center tap, E=input
At ¼ and ¾. E is more than ½ x input
E is not shunted, hence is larger than linear value.

7-C. E is between wiper and negative.
At 1, E=0
At 2, E=input
E is shunted, hence is always smaller than linear value.

8-A. E is between wiper and C.T.
At 1 and 2, E=input
At center tap, E=0
At ¼ and ¾, E is less than ½ x input
E is shunted, hence is smaller than linear value.

9-F. E is between wiper and positive.
At 1, E=input
At 2, E=0
At ¼, E= 2/3 x input
At C. T., E= ½ x input
At ¾, E= 1/3 x input

10-D. E is between wiper and positive.
At 1, E=input
At 2, E=0
Between 1 and 2, E is not shunted, hence always larger than linear.

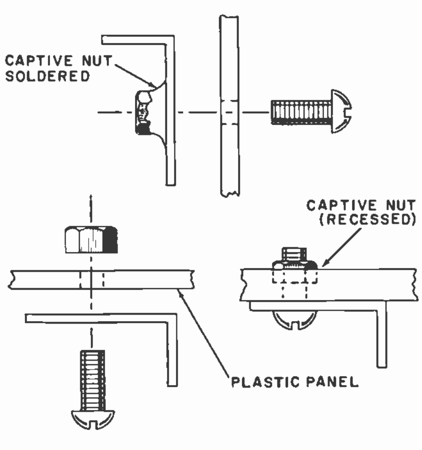
Tips & Techniques

MOUNTING FERRITE BEADS

Shielded plugs, adapters, and in-line jacks will easily accommodate ferrite beads, resulting in a shielded and r-f decoupled connector. Simply slip a bead with the proper ferrite mix and inner diameter over the inner conductor of the cable before soldering it to the connector. Most ferrite beads are insulators, so they won't create a short circuit between the inner and outer conductors. Some, however, such as Amidon Associates' FB-75B-101, are composed of a semiconductor material and may require an external insulating layer for isolation. Typical applications for bead/connector combinations include keeping r-f out of audio equipment, containing r-f inside transmitters, etc.—*Richard Mollentine, WA0KKC, Overland Park, KS.*

CAPTIVE MACHINE NUTS EASE SCREW INSTALLATION AND REMOVAL

Captive machine nuts permit installation and removal of screws from one side of a panel without requiring access to the other side. As shown in the drawings,



machine nuts can be soldered to steel chassis and the foil pattern on printed circuit boards or they can be imbedded into acrylic plastic panels to be held captive. You start by drilling a hole just large enough to pass the threads of a machine screw, insert the screw, and screw on the nut until it is comfortably tight. Then, using a soldering gun, flow sufficient solder between nut and panel or pc board to assure a good bond, or heat the nut while slowly tightening the hardware until the nut embeds about half its thickness into the plastic. In either case, allow the joints to completely cool before removing the screw.—*J.C. Smolski, Teheran, Iran.*

CLEARING METER FACES

Plastic meter faces, bezels, and dial windows can be restored by removing scratches and "fogginess" as follows. Using a dry cottom cloth, rub the scratched surface with cigarette ash. The ash acts as a very fine abrasive. With a little bit of elbow grease, you can restore the meter face to "like new" condition. This method was used to clear up the S/r-f meter on a Johnson CB transceiver that was "cleaned" with a solvent—the type that attacks plastic!

During the rubbing process, a static charge may build up on some meter faces, causing the needle to drift or remain at one spot. This problem can be avoided by removing the face from the meter before restoration. After you have polished the meter face, set it aside, to allow the static charge to dissipate, or apply a thin coating of liquid dishwashing detergent to the face. Allow the detergent to dry before re-assembling the meter. Dishwashing detergent can also be applied to VOM or VTVM meter faces when static is a problem.—*Alan W. Otto, Charleston Heights, SC.*

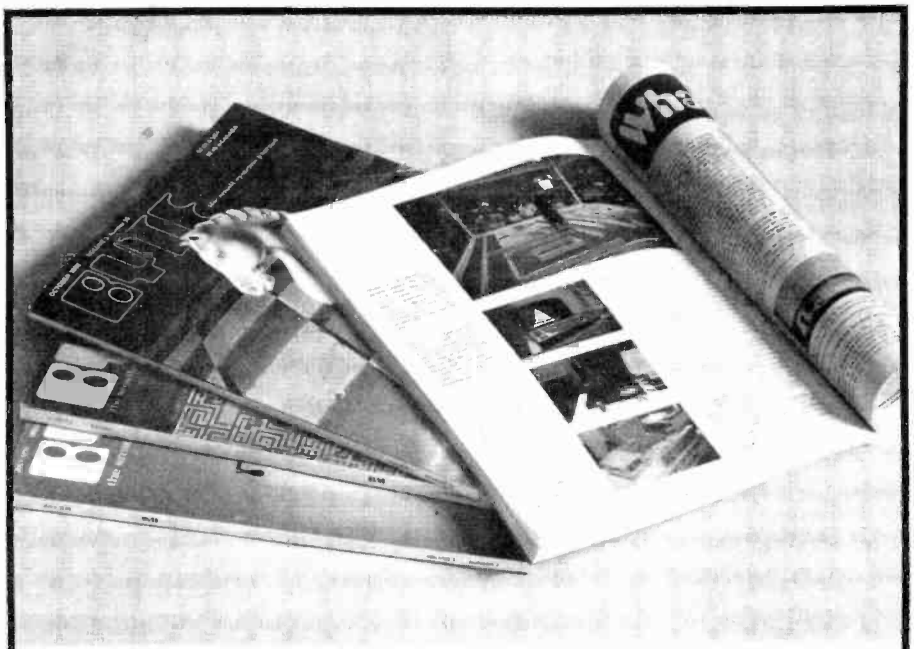
NONMETALLIC ALIGNMENT TOOL

Critical adjustments performed as part of a receiver alignment often call for the use of a nonmetallic screwdriver. If you don't have such a screwdriver, cut off the ends of a ⅛-inch (3.2-mm) diameter plastick knitting needle. Then file each end of the needle to form spade tips. The resulting tool can be used whenever a low-torque, nonmetallic screwdriver is needed.—*Harry J. Miller, Sarasota, FL.*

JUNKED LOUDSPEAKER DOUBLES AS ANTENNA-MAST ROOF MOUNT

Many of the items that are ordinarily junked can be put to good use, some not for applications for which they were intended. A good example is the loudspeaker, which can be modified to serve as a made-to-order antenna mast. Remove the cone and magnet, saving the

latter for use in your shop to mount tools on a wall, keep machine hardware in one place, etc. Now, substitute a ½" (12.7-mm) diameter pipe fitting for the magnet, using a threaded flange, as shown in the photo. Fasten the speaker basket to the roof with pan-head sheet-metal screws. Assemble the antenna, fasten it to the mast, and slip the mast over the pipe fitting. Aim the antenna in the desired direction and clamp and guy the mast.—*Glen Stillwell, Manhattan Beach, CA.*



Electronics Library

THE BASIC BOOK OF HAM RADIO

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Here's a comprehensive guide for those who want to learn more about the world of Amateur Radio. Descriptions of the many activities in which hams can participate, such as contests, talking to foreign hams ("DX chasing"), experimentation, public and emergency communications services, television operations, and bouncing signals off orbiting satellites and the Moon, are included. A guide to ham gear enables the new ham to select equipment. Tips for the beginner enlighten the operator as to carrying on communications and setting up his station. A discussion of salient FCC rules and regulations is included, as well as a glossary of "ham talk." *Published by Simon and Schuster, New York, NY 10020. 128 pages (8⅛" × 10 ¾"). $4.95 soft cover.*

THE HOME COMPUTER HANDBOOK

by Edwin Schlossberg, John Brockman, and Lyn Horton

This introductory book discusses possible upcoming uses of home computers. The what's and how's of home computers are then related, along with a brief examination of microprocessors. Next, typical home computer products are presented to the reader. Chapter 8 describes how to select, use, and maintain your own home computer system, and the book closes with a look at some available software. *Published by Bantam Books, 666 Fifth Ave., New York, NY 10019. 246 pages. $2.95 soft cover.*

HOME RECORDING FOR MUSICIANS

by Craig Anderton

The arrival in the marketplace of high-quality, multitrack open-reel tape decks offers the musician the chance to produce his own demo tapes. This book shows the musician how to record his material at home, how to get the most out of the equipment he presently has and how to choose needed additional items. It includes information on tape decks (from cassette to semi-pro multitrack open-reel models), microphones, setting up a home recording studio, tapes, mixing, noise reduction, special effects, etc. A demonstration record accompanying the book lets you hear typical sounds you can create. *Published by Guitar Player Books, Box 615, Saratoga, CA 95070. 182 pages (8½" × 11"). $9.95 soft cover.*

PROJECT OF THE MONTH

BY FORREST M. MIMS

HIGH-CURRENT LED PULSER

INFRARED LEDs make ideal optical sources for remote controls, intrusion alarms, reflective and break-beam object sensors, signaling devices and TV commercial killers. However, unless an efficient heat sink is employed, most infrared LEDs are restricted to a maximum continuous forward current of no more than 100 milliamperes. At this current, a high-quality GaAs:Si LED will deliver from 6 to 10 milliwatts of optical power. This is roughly equivalent to the *visible* radiation emitted by a small one- or two-cell penlight with a prefocused lamp.

Rapidly pulsing a LED at very high current levels makes it possible to obtain much higher power outputs. For example, a G.E. 1N6264 LED that emits 6 mW at 100 mA of forward current will emit 60 mW when driven by 1-ampere pulses a few microseconds wide.

Figure 1 shows a simple circuit that can deliver high current pulses to an LED. This pulser is considerably more powerful than the LED transmitter module that was the Project of the Month for February 1979. With the parts values shown, it will apply hefty 2.7-ampere pulses at a rate of about 100 Hz to a LED. The pulses are about 17 microseconds wide. They can be readily detected by a simple phototransistor receiver such as the Project of the Month for January 1979. Current drain from a small TR175, 7-volt mercury battery is 5 mA.

Many different LEDs can be used with the pulser. For most LEDs, the peak current exceeds by a factor of three the component's maximum continuous rating. Applying even larger pulses will not necessarily destroy a LED, but might shorten its useful life. For best results, use infrared emitters made from GaAs:Si rather than GaAs diodes. Good choices include the TIL-32 (Texas Instruments), 1N6264 (General Electric), OP-190 and OP-195 (Optron) and 276-142 (Radio Shack).

You might have difficulty finding the transistors specified in Fig. 1. If so, you can substitute a common npn silicon device such as the 2N3904 or 2N2222 for *Q1*. The choice of *Q2* is more critical, however. If maximum current is to be delivered to the LED, *Q2* must be a *germanium* transistor. A germanium pn junction has a smaller forward voltage drop than a silicon pn junction, and this causes a germanium transistor to have a lower effective "on" resistance. The LED therefore receives more current if a germanium device is used.

The 2N1132 works better than any other germanium transistor I've tried. The 2N1305 is easier to find and will deliver about 2 amperes to the LED. If you can't find a suitable germanium transistor you can substitute a common pnp silicon switching transistor such as the 2N3906 or 2N2907. Less current will be delivered to the LED, but the optical output will still be adequate for many applications.

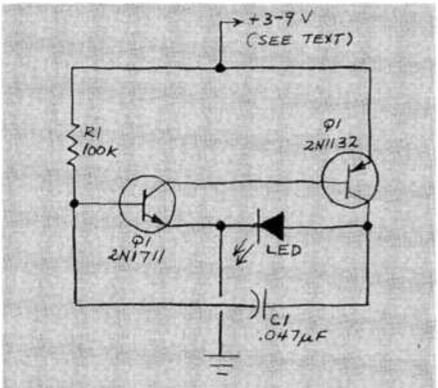

Fig. 1. High-current LED pulser.

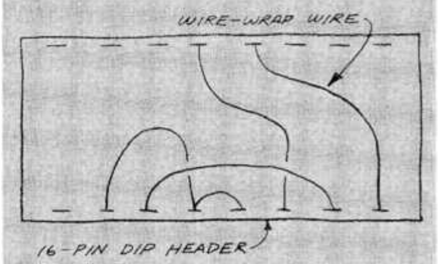

Fig. 2. Connections for LED pulser.

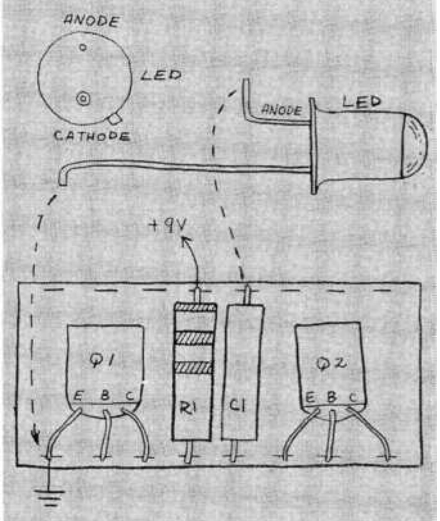

Fig. 3. Pulser component placement.

For example, if *Q1* is a 2N3904, *Q2* is a 2N3906 and the circuit is powered by a standard 9-volt battery, 1.1-ampere pulses will be delivered to a LED. Because of the different characteristics of the silicon transistors, the repetition rate will jump to 1400 and the current demand will increase to about 100 mA. That's enough to quickly deplete even an alkaline battery, so for best results the resistance of *R1* should be increased to reduce the pulse-repetition rate and the operating current. For example, if the value of *R1* is changed to 1 megohm, the repetition rate will decrease to 120 Hz and the current drain to a much more reasonable 8 mA.

Once you've made a final selection of component types and values, you can assemble a permanent version of the LED pulser on a DIP header or postage-stamp-sized perforated board. I took the latter approach for my germanium-transistor unit because the transistors are packaged in TO-5 cans. It was still possible to install the pulser, TR-175 battery, switch and adjustable lens in a brass tube measuring 0.5" × 3.25" (1.3 cm × 8.3 cm).

Figure 2 shows how to assemble the pulser on a DIP header if silicon transistors in plastic packages are used. Interconnect the pins on the header with Wire-Wrap leads, but don't solder them in place yet. Use lengths of wire that are longer than necessary, securing them in place by wrapping their free ends under the header.

Figure 3 shows where the components go. To make things as compact as possible, use a miniature tubular capacitor for *C1* instead of a ceramic disc. Any capacitance from 0.01 μF to 0.05 μF is satisfactory, but the smaller values will increase the pulse-repetition rate and reduce the current to the LED somewhat. If you must use a disc for *C1*, try bending it over the top of the header so that it will present a lower profile and leave room for the LED.

If you use a miniature tubular capacitor for *C1*, the completed circuit will use only half the space in the DIP header's cover. Instead of installing the cover, I clipped all the pins from the header and mounted it on a snap terminal salvaged from a discarded 9-volt battery. The conductive strips at each terminal were trimmed to size and folded over each end of the header to secure it in place. Taking care to observe the polarity, I soldered short connection wires from the header to the two metal strips. The result is a tiny but powerful LED transmitter that snaps directly onto the terminals of a 9-volt battery.

Whether you use germanium or silicon transistors, with a little care you can install the complete pulser in a pen-light, lipstick tube, pill bottle or other small container. Although the germanium unit is more powerful, even the silicon pulser projects a beam that can be received at 1000 feet or more at night using a simple phototransistor receiver—provided you use a 2- or 3-inch lens at each end of the link. ◇

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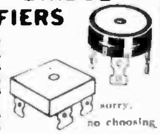

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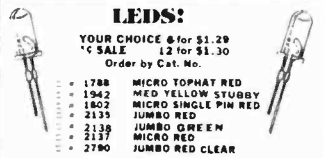

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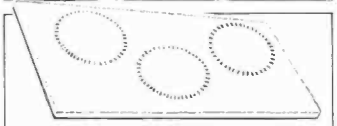

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25	25	.17	Axial	.18
25	50	.24	P.C.	.25
50	15	.17	Axial	.18
50	25	.19	Axial	.20
50	100	.21	Axial	.22
100	15	.23	Axial	.24
100	25	.25	P.C.	.26
100	50	.35	Axial	.36
100	100	.39	Axial	.40
150	15	.23	Axial	.24
200	15	.24	P.C.	.25
220	25	.32	P.C.	.33
250	16	.29	Axial	.30
250	25	.32	Axial	.33
250	50	.45	Axial	.46
300	15	.31	Axial	.32
300	25	.33	P.C.	.34
500	15	.33	P.C.	.34
500	25	.36	P.C.	.37
500	50	.39	Axial	.40
1000	15	.55	P.C.	.56

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☐ 50	.35	.36
☐ 100	.43	.44
☐ 200	.54	.55
☐ 400	.61	.62
☐ 600	.79	.80
☐ 800	.90	.91
☐ 1000	1.19	1.20

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Rated @ 5-9 Watts. Wavelength: 904 nm.

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- mechanically triggered

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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.

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- 24 hr. alarm
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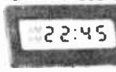
- Power interrupt indication
- Green color 0.6" display
- 110V AC 60Hz input
- Factory assembled.

NOT A KIT $17.50 EACH

LCD CLOCK MODULE!



- 0.5" LCD 4 digits display
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- D.C. powered (1.5V battery)
- 12 hr. or 24 hr. display
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- On board dual back up lights
- Dual time zone display
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NIC1200 (12 hr) $24.50 EA.
NIC2400 (24 hr) $26.50 EA.

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- 12 hours real time format
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- Power failure indicator
- Count down timer 59 mins
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$8.50 EACH

#FLM 701

Transformer $1.75

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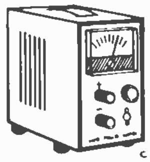

for our 0-30V Power Supply. It is a nice looking metal cast case with giant 4" volt/amp meter; output binding post and fuse holder, on/of switch and line cord! ONLY $21.50 EA.

CASE 030

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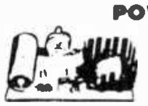

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Power Supply 6~18V DC

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9 Steps 4 Colors

LED VU

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IN KIT FORM $18.50

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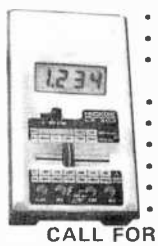

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- 200 hours 9V battery life
- Auto zero; polarity; overrange indication
- 100MV DC F.S. sensitivity
- 19 ranges and functions
- D.C. volt. 0.1 MV to 1000 V
- A.C. volt: 0.1 V to 600 V
- Resistance: 0.1Ω to 20 MΩ
- D.C. current: 0.01Ω A to 100 MA

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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 for counter. Unit operated by 9—12 DC. $15.50

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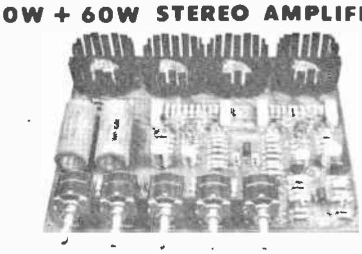

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#FMM2

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	1N914	100v	10mA	.05
	1N4005	600v	1A	.08
	1N4007	1000v	1A	.15
	1N4148	75v	10mA	.05
	1N4733	5.1v	1 W Zenner	.25
	1N4749	24v	1W	.25
	1N753A	6.2v	500 mW Zener	.25
	1N758A	10v	"	.25
	1N759A	12v	"	.25
	1N5243	13v	"	.25
	1N5244B	14v	"	.25
	1N5245B	15v	"	.25
	1N5349	12v	3W	.25

QTY.	SOCKETS/BRIDGES				
	8-pin	pcb	.16	ww	.35
	14-pin	pcb	.20	ww	.40
	16-pin	pcb	.25	ww	.45
	18-pin	pcb	.30	ww	.95
	20-pin	pcb	.35	ww	1.05
	22-pin	pcb	.40	ww	1.15
	24-pin	pcb	.45	ww	1.25
	28-pin	pcb	.50	ww	1.35
	40-pin	pcb	.55	ww	1.45
	Molex pins	.01	To-3 Sockets		.35
	2 Amp Bridge		100-prv		.95
	25 Amp Bridge		200-prv		1.50

QTY.	TRANSISTORS, LEDS, etc.		
	2N2222M	(2N2222 Plastic .10)	.15
	2N2222A		.19
	2N2907A	PNP	.19
	2N3906	PNP (Plastic)	.19
	2N3904	NPN (Plastic)	.19
	2N3054	NPN	.55
	2N3055	NPN 15A 60v	.60
	T1P125	PNP Darlington	1.95
	LED Green,	Red, Clear, Yellow	.19
	D.L.747	7 seg 5/8" High com-anode	1.95
	MAN72	7 seg com-anode (Red)	1.25
	MAN3610	7 seg com-anode (Orange)	1.25
	MAN82A	7 seg com-anode (Yellow)	1.25
	MAN74	7 seg com-cathode (Red)	1.50
	FND359	7 seg com-cathode (Red)	1.25

QTY.	9000 SERIES		QTY.		
	9301	.85		9322	.65
	9309	.50		9601	.30
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	8T97	1.75
	74S188	3.00
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	4001	.20		4018	.75		4035	.75		4071	.25
	4002	.25		4019	.35		4037	1.80		4081	.30
	4004	3.95		4020	.85		4040	.75		4082	.30
	4006	.95		4021	.75		4041	.69		4507	.95
	4007	.25		4022	.75		4042	.65		4511	.95
	4008	.75		4023	.25		4043	.50		4512	1.50
	4009	.35		4024	.75		4044	.65		4515	2.95
	4010	.35		4025	.25		4046	1.25		4519	.85
	4011	.30		4026	1.95		4047	2.50		4522	1.10
	4012	.25		4027	.35		4048	1.25		4526	.95
	4013	.40		4028	.75		4049	.65		4528	1.10
	4014	.75		4029	1.15		4050	.45		4529	.95
	4015	.75		4030	.30		4052	.75		MC14409	14.50
	4016	.35		4033	1.50		4053	.95		MC14419	4.85
							4066	.75		74C151	2.50

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QTY.			QTY.			QTY.			QTY.		
	7400	.20		7492	.45		74H20	.25		74LS76	.70
	7401	.20		7493	.35		74H21	.25		74LS86	.95
	7402	.20		7494	.75		74H22	.40		74LS90	.85
	7403	.20		7495	.60		74H30	.30		74LS93	.85
	7404	.20		7496	.80		74H40	.35		74LS96	2.00
	7405	.35		74100	1.15		74H50	.30		74LS107	.90
	7406	.25		74107	.35		74H51	.30		74LS109	1.50
	7407	.55		74121	.35		74H52	.20		74LS123	1.95
	7408	.20		74122	.55		74H53	.25		74LS138	2.00
	7409	.25		74123	.55		74H55	.25		74LS151	.95
	7410	.20		74125	.45		74H72	.35		74LS153	1.15
	7411	.25		74126	.45		74H74	.35		74LS157	1.15
	7412	.25		74132	.75		74H101	.95		74LS160	1.15
	7413	.45		74141	.90		74H103	.55		74LS164	2.90
	7414	.75		74150	.85		74H106	1.15		74LS193	2.00
	7416	.25		74151	.95		74L00	.30		74LS195	1.15
	7417	.40		74153	.95		74L02	.30		74LS244	2.90
	7420	.25		74154	1.15		74L03	.35		74LS259	1.50
	7426	.25		74156	.70		74L04	.40		74LS298	1.50
	7427	.25		74157	.65		74L10	.30		74LS367	1.95
	7430	.20		74161/9316	.75		74L20	.45		74LS368	1.25
	7432	.30		74163	.85		74L30	.55		74LS373	2.50
	7437	.20		74164	.75		74L47	1.95		74S00	45
	7438	.30		74165	1.10		74L51	.65		74S02	.45
	7440	.20		74166	1.75		74L55	.85		74S03	35
	7441	1.15		74175	.90		74L72	.65		74S04	.35
	7442	.55		74176	.95		74L73	.70		74S05	.45
	7443	.45		74177	1.10		74L74	.75		74S08	.45
	7444	.45		74180	.95		74L75	1.05		74S10	.45
	7445	.75		74181	2.25		74L85	2.00		74S11	.45
	7446	.70		74182	.75		74L93	.75		74S20	.35
	7447	.70		74190	1.25		74L123	1.95		74S22	.55
	7448	.50		74191	1.25		74LS00	.40		74S40	.30
	7450	.25		74192	.75		74LS01	.40		74S50	.30
	7451	.25		74193	.85		74LS02	.45		74S51	.35
	7453	.20		74194	.95		74LS03	.45		74S64	.15
	7454	.25		74195	.95		74LS04	.45		74S74	.70
	7460	.40		74196	.95		74LS05	.45		74S112	.60
	7470	.45		74197	.95		74LS08	.45		74S114	.85
	7472	.40		74198	1.45		74LS09	.45		74S133	85
	7473	.25		74221	1.50		74LS10	.45		74S140	.75
	7474	.30		74298	1.50		74LS11	.45		74S151	.95
	7475	.35		74367	1.35		74LS20	.45		74S153	.95
	7476	.40		75491	.65		74LS21	.45		74S157	.98
	7480	.75		75492	.65		74LS22	.45		74S158	.80
	7481	.85		74H00	.20		74LS32	.50		74S194	1.50
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	7483	.95		74H04	.30		74LS38	.65		74S257 (8123)	2.50
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	7486	.55		74H08	.35		74LS42	.95			
	7489	1.05		74H10	.35		74LS51	.75			
	7490	.55		74H11	.25		74LS74	.95			
	7491	.70		74H15	.45		74LS75	1.20			

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	LM301	.45		LM320T15	1.65		78L12	.75
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	LM318	1.50		LM340T15	.95		LM723	.40
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	LM320H15	.79		LM340T24	.95		LM739	1.50
	LM320H24	.79		LM340K12	1.25		LM741 (8-14)	.45
	7905 (LM320K5)	1.65		LM340K15	1.25		LM747	1.10
	LM320K12	1.65		LM340K18	1.25		LM1307	1.75
	LM320K15	1.65		LM340K24	1.25		LM1458	.65
							LM3900	.95
							LM75451	.65
							NE555	.45
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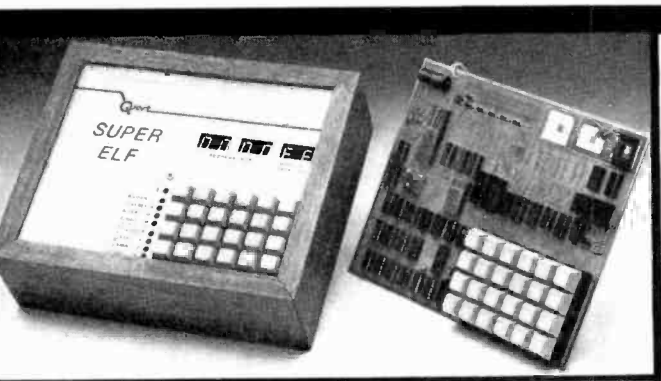

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7442N	50
7445N	69
7447N	60
7448N	69
7450N	17
7474N	29
7475N	49
7485N	88
7489N	2.00
7490N	43
7492N	43
7493N	43
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74125N	39
74145N	69
74150N	69
74151N	69
74154N	1.00
74157N	.69
74161N	.87
74162N	87
74163N	.87
74174N	96
74175N	90
74190N	1 15
74192N	87
74193N	85
74221N	1 55
74298N	1 65
74365N	.95
74366N	.95
74367N	.95

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	1 15
74LS75N	47
74LS90N	51
74LS93N	51
74LS95N	1 89
74LS107N	35
74LS112N	35
74LS113N	72
74LS132N	35
74LS136N	35
74LS151N	67
74LS155N	67
74LS157N	67
74LS162N	91
74LS163N	91
74LS174N	.95
74LS190N	1 06
74LS221N	1 95
74LS258N	67
74LS367N	1 35

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	1 50
LM311H/N	90
LM317T K	2 92
LM318	1 35
LM320K-5	1 60
LM323K-5	6 95
LM320K-12	1 60
LM320K-15	1 60
LM320T-5	1 60
LM320T-8	1 60
LM320T-12	1 50
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

LM379M	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
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	15 95
8750CJ	13 95
LD130	9.95
9400CJ/V/F	7 40
ICL7103	9.50
ICL7107	14.25
8702	17.95

CMOS	
CD4001 Fair	50
CD4000	16
CD4001	21
CD4002	21
CD4006	1.10
CD4007	21
CD4008	.21
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	.95
8096	.95
8097	.95
8098	.95
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
21L02-1	1 18
21F02	1.25
2104A-4	4 95
2107B	4 95
2111-1	3 75
2112-2	3 95
2114L-3	6.75
4116	10 95
2513B	6 30
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	3.30
MM5311	3.60
MM5312	4 30
MM5313	3.60
MM5314	3.90
MM5315	4 00
MM5316	5 00
MM5318	3 50
MM5369	2.10
MM5841	14.45
MM5865	7 95
CT7001	5 30
CT7002	10.95
CT7010	8 95
CT7015	8.95
MM5375AA N	3.90
MM5375AB N	4.90
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	2.30
8214	8 30
8216	2 30
8224	2 30
8228	5 35
8251	8.50
8253	10 00
8255	9 25
8257	19 50
8259	19 50
1802CP plas	13 95
1802DP plas	17 95
1861P	11 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	1UP
8	.15	22	.30
14	.14	24	.35
16	.16	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	4.75

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 14.50
comp w/spec sock

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
TIP33A	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 T018	15
Green, Yellow T018	.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	$235.00
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
10000		20V	2 50
12000		30V	3 50
35000		25V	5 00
55000		25V	5 00
82000		15V	6 00
60000		40V	6 00
76000		40V	6.00
120000		10V	6 00

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 eight 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 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game.

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.

Attention Elf Owners
New products in hardware and software coming soon.

Tiny Basic cassette $10.00, on ROM $38.00, 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.

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 version $450.00. 4K Assembler $85.00. 8K Basic Interpreter $100.00. Power supply assembled in case $60.00.

Multi-volt 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 Godbout	$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 NO. 42 ON FREE INFORMATION CARD

Active Electronic Sales Corp.

EPROM'S

Special of the Month

1702A-6 ~~$6.95~~ $4.45
256 x 8 1.5 uS

2708 $9.95
IK x 8 450 NS

ELECTRONICS Market Place

MICROCOMPUTER BOARDS

SYM-1 MICROCOMPUTER BOARD

- Hardware compatibility with KIM-1
- Standard interfaces include audio cassette with remote control both 8 bytes second (KIM) and 185 bytes second (SYM-1) cassette formats TTY and RS232 system expansion bus TV KB expansion board interface four I O buffers and an oscilloscope single-line display
- Single +5V power requirements

SYM-1 $329.00

NEC MICROCOMPUTER TK-80A

- The TK 80A is a complete microcomputer on a board based on the industry standard 8080A The board has both 1K RAM and 1K Electrically Erasable PROM expandable to 4K x 8 and 8K x 8 respectively on board It also features 300 or 1200 baud cassette interface the Kansas City type and three 8-Bit Programmable I O Ports (24 lines) Keypad with 25 real keys (not a glorified calculator keypad) and 8 big bright ½ digits for display are also included

TK-80A $299.00

Rockwell International AIM65

AIM 65 features on-board thermal printer and alphanumeric display and a terminal-style keyboard It has an addressing capability up to 65K bytes, and comes with a user-dedicated 1K RAM Two installed 4K ROMs hold a powerful Advanced Interface Monitor program, and three spare sockets are included to expand on-board ROM or PROM up to 20K bytes An application Connector provides for attaching a TTY and one or two audio cassette recorders and gives external access to the user-dedicated general purpose I/0 lines Also included as standard are a comprehensive AIM 65 User's Manual, a handy pocket reference card, an R6500 Hardware Manual, an R6500 Programming Manual and and an AIM 65 schematic AIM 65 is packaged on two compact modules The circuit module is 12 inches wide and 10 inches long, the keyboard module is 12 inches wide and 4 inches long They are conected by a detachable cable

AIM65 $375.00

MULTIBUS MEMORY

LARGE SCALE MULTIBUS MEMORY
MEMORY ONLY

SIZE (BYTES)	MUPRO PRODUCT NUMBER	INTEL · EQUIV PART NUMBER	PRICE
16K	MBC-016/8	SBC-016	$ 715
32K	MBC-032/8	SBC-032	1125
48K	MBC-048/8	SBC-048	1475
64K	MBC-064/8	SBC-064	1795
32K	MBC-032/16	SBC-032	1125
64K	MBC-064/16	SBC 064	1795

MICROPROCESSOR CHIPS

CPU's

Part No.	Price
8080A	5.50
8085	12.95
6800	7.95

INTERFACE SUPPORT CIRCUITS

Part No.	Price	Part No.	Price
8212	1.98	8255	4.95
8214	3.95	8257	10.95
8216	1.98	8259	14.95
8224	2.75		
8226	1.98	6810	3.95
8228	3.98 ~~4.75~~	6820	3.95
8238	3.98 ~~4.75~~	6821	3.95
8251	5.50	6850	4.95
8253	14.95	6852	4.95

Zilog

Z80-CPU	$13.60
Z80A-CPU	$16.20
Z80-PIO	$10.90
Z80A-PIO	$13.10
Z80-CTC	$10.90
Z80A-CTC	$13.10
Z80-DMA	$32.20
Z80-SIO/0	$45.00
Z80A-SIO/0	$50.00
Z80-SIO/1	$45.00
Z80A-SIO/1	$50.00
Z80-SIO/2	$45.00
Z80A-SIO/2	$50.00

MOS Static RAM's

Part No.	Price
2101 (1K 22 PIN)	~~$2.45~~ $2.39
2102LFPC (1K 350NS (Low Power))	~~$1.19~~ $1.14
2102-1PC (1K 450NS)	~~$.99~~ 0.94
2114 (4K (1K x 4) 300NS)	~~$6.99~~ $6.75
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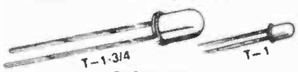
LED220	T-1-3/4	5mm Red	.11
LED222	T-1-3/4	5mm Green	.15
LED224	T-1-3/4	5mm Yellow	.14



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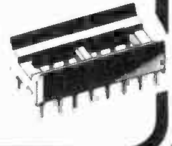

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74C922	Keyboard Encoder (16 keys)	5.95

ICM CHIPS

ICM7045	CMOS Precision Timer	24.95
ICM7205	CMOS LED Stopwatch/Timer	19.95
ICM7207	Oscillator Controller	7.50
ICM7208	Seven Decade Counter	19.95
ICM7209	Clock Generator	6.95

NMOS READ ONLY MEMORIES

MCM6571	128 X 9 X 7 ASCII Shifted with Greek	13.50
MCM6574	128 X 9 X 7 Math Symbol & Pictures	13.50
MCM6575	128 X 9 X 7 Alphanumeric Control Character Generator	13.50

MISCELLANEOUS

TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	19.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
4N33	Photo-Darlington Opto-Isolator	3.95
MK50240	Top Octave Freq. Generator	17.50
DS0026CH	5Mhz 2-phase MOS clock driver	3.75
TIL308	.27" red num. display w/integ. logic chip	10.50
MM5320	TV Camera Sync. Generator	14.95
MM5330	4½ Digit DPM Logic Block (Special)	3.95
LD110/111	3½ Digit A/D Converter Set	25.00/set

LITRONIX ISO-LIT 1
Photo Transistor Opto-Isolator (Same as MCT 2 or 4N25)
2/99¢

SN 76477 SOUND GENERATOR
Generates Complex Sounds
Low Power - Programmable
3.95 each

TV GAME CHIP AND CRYSTAL
AY-3-8500-1 and 2.01 MHZ Crystal (Chip & Crystal includes score display, 6 games and select angles, etc. **7.95/set**

EXAR

XR205	$8.40			XR2242CP	1.50
XR210	4.40			XR2264	4.25
XR215	4.40			XR2556	3.20
XR320	1.55	JE2206KA	14.95	XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	2.85
XR567CP	.99	XR2207	3.85	XR4194	4.95
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.30	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.39	XR2212	4.35	XR4739	1.15
XR1489	1.39	XR2240	3.45	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

C10681	50	2N3055	89	2N3904	4/1.00
MPSA05	30	MJE3055	1.00	2N3905	4/1.00
MPSA06	5/1.00	2N3392	5/1.00	2N3906	4/1.00
TIS97	6/1.00	2N3398	5/1.00	2N4013	3/1.00
TIS98	6/1.00	PN3567	3/1.00	2N4123	6/1.00
40409	1.75	PN3568	4/1.00	PN4249	4/1.00
40410	1.75	PN3569	4/1.00	PN4250	4/1.00
40673	1.75	MPS3638A	5/1.00	2N4400	4/1.00
2N918	4/1.00	MPS3702	5/1.00	2N4401	4/1.00
2N2219A	2/1.00	2N3704	5/1.00	2N4402	4/1.00
2N2221A	4/1.00	MPS3704	5/1.00	2N4403	4/1.00
2N2222A	5/1.00	2N3705	5/1.00	2N4409	5/1.00
PN2222 Plastic	7/1.00	MPS3705	5/1.00	2N5086	4/1.00
2N2369	5/1.00	2N3706	5/1.00	2N5087	4/1.00
2N2369A	4/1.00	MPS3706	5/1.00	2N5088	4/1.00
MPS2369	5/1.00	2N3707	5/1.00	2N5089	4/1.00
2N2484	4/1.00	2N3711	5/1.00	2N5129	5/1.00
2N2906	4/1.00	2N3724A	65	PN5134	5/1.00
2N2907	5/1.00	2N3725A	1.00	PN5138	5/1.00
PN2907 Plastic	7/1.00	2N3772	2.25	PN5139	5/1.00
2N2925	5/1.00	2N3823	1.00	2N5210	5/1.00
MJE2955	1.25	2N3903	5/1.00	2N5449	3/1.00
2N3053	2/1.00			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	.045
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	.15	.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

Transistor Checker

— Completely Assembled —
— Battery Operated —

The ASI Transistor Checker is capable of checking a wide range of transistor types, either "in circuit" or out of circuit. To operate, simply plug the transistor to be checked into the front panel socket, or connect it with the alligator clip test leads provided. The unit safely and automatically identifies low, medium and high-power PNP and NPN transistors. Size: 3¾" x 6¼" x 2"
"C" cell battery not included.

NEW

Trans-Check $29.95 ea.

Custom Cables & Jumpers

NEW  NEW

DB 25 Series Cables

Part No.	Cable Length	Connectors	Price
DB25P-4-P	4 Ft.	2-DP25P	$15.95 ea.
DB25P-4-S	4 Ft.	1-DP25P/1-25S	$16.95 ea.
DB25S-4-S	4 ft.	2-DP25S	$17.95 ea.

Dip Jumpers

DJ14-1	1 ft.	1-14 Pin	$1.59 ea.
DJ16-1	1 ft.	1-16 Pin	1.79 ea.
DJ24-1	1 ft.	1-24 Pin	2.79 ea.
DJ14-1-14	1 ft.	2-14 Pin	2.79 ea.
DJ16-1-16	1 ft.	2-16 Pin	3.19 ea.
DJ24-1-24	1 ft.	2-24 Pin	4.95 ea.

For Custom Cables & Jumpers, See JAMECO 1979 Catalog for Pricing

CONNECTORS

25 Pin-D Subminiature

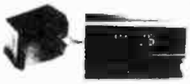
DB25P (as pictured)	PLUG (Meets RS232)	$2.95
DB25S	SOCKET (Meets RS232)	$3.50
DB51226-1	Cable Cover for DB25P or DB25S	$1.75

PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out — Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100 (.100 Spacing)	PINS (Wire Wrap)	$6.95
50/100 (.125 Spacing)	PINS (Wire Wrap) R681-1	$6.95

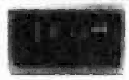
4-Digit Clock Kit



- Bright .357" ht. red display
- Sequential flashing colon
- 12 or 24 hour operation
- Extruded aluminum case (black)
- Pressure switches for hours, minutes & hold functions
- Includes all components, case and wall transformer
- Size: 3¼ x 1¾ x 1¼

JE730 $14.95

Jumbo 6-Digit Clock Kit



- Four .630"ht. and two .300"ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾ x 3⅛ x 1¾

JE747 $29.95

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701

6-Digit Clock Kit $19.95

REMOTE CONTROL TRANSMITTER & RECEIVER

- CAN BE USED AS REMOTE CONTROL FOR TV
- USE IT FOR YOUR OWN GARAGE DOOR OPENER
- TRANSMITS BETWEEN 25 AND 50 FEET
- THOUSANDS OF USES FOR REMOTE CONTROL APPLICATIONS
- TRANSMITTER USES A 9 V BATTERY
- SCHEMATIC INCLUDED

$19.95

Digital Stopwatch Kit

- Use Intersil 7205 Chip
- Plated thru double-sided P.C. Board
- LED display (red)
- Times to 59 min. 59.59 sec. with auto reset
- Quartz crystal controlled
- Three stopwatches in one: single event, split (cummulative) & taylor (sequential timing)
- Uses 3 penlite batteries
- Size: 4.5" x 2.15" x .90"

JE900 $39.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

8080A	CPU	$ 9.95
8212	8-Bit Input/Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator/Driver	3.95
8226	Bus Driver	3.49
8228	System Controller/Bus Driver	5.95
8238	System Controller	5.95
8251	Prog. Comm. I/O (USART)	7.95
8253	Prog. Interval Timer	14.95
8255	Prog. Periph. I/O (PPI)	9.95
8257	Prog. DMA Control	19.95
8259	Prog. Interrupt Control	19.95

6800/6800 SUPPORT DEVICES

MC6800	MPU	$14.95
MC6802CP	MPU with Clock and Ram	24.95
MC6810API	128X8 Static Ram	5.95
MC6821	Periph. Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	12.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	7.95
MC6852	Synchronous Serial Data Adapt	9.95
MC6860	0-600 bps Digital MODEM	12.95
MC6862	2400 bps Modulator	14.95
MC6880A	Quad 3-State Bus Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS—MISCELLANEOUS

Z80(780C)	CPU	$19.95
Z80A(780-1)	CPU	24.95
CDP1802	CPU	19.95
2650	MPU	19.95
8035	8-Bit MPU w/clock, RAM, I/O lines	19.95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU w/hardware, multiply & divide	49.95

SHIFT REGISTERS

MM500H	Dual 25 Bit Dynamic	$.50
MM503H	Dual 50 Bit Dynamic	.50
MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	.89
2504T	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4.95
2522	Dual 132 Bit Static	2.95
2524	512 Static	.99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4.00
2529	Dual 240 Bit Static	4.00
2532	Quad 80 Bit Static	2.95
2533	1024 Static	2.95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	2.49

UART'S

A-Y-5-1013	30K BAUD	5.95

MICROPROCESSOR MANUALS

M-Z80	User Manual	$7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

ROM'S

2513(2140)	Character Generator(upper case)	$9.95
2513(3021)	Character Generator(lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

RAM'S

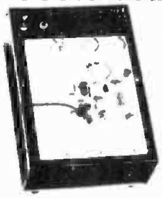
1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	9.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin	9.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00

PROM'S

1702A	2048	FAMOS	$5.95
2716INTEL	16K*	EPROM	59.95
TMS2516 (2716)	16K*	EPROM	49.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I.	16K**	EPROM	29.95
	**Requires 3 voltages, —5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

CSC CONTINENTAL SPECIALTIES

Proto Board 203



A total ready to use power breadboard prototest device with a built in regulated, short proof power supply. Just plug in and start building! 2 extra floating 5-way binding posts for external signals. Self contained with power switch indicator lamp and power fuse. 24 14 pin DIP capacity. Attractive two tone quality case. All metal construction. 9¾"L x 6½"W x 2¾"H 5 lbs.

PB 203 **$75.00**

Model Number	L x W x H (Inches)	Price
PB-6	6.0 x 4.5 x 1.4	$15.95
PB-100	6.0 x 4.5 x 1.4	$19.95
PB-101	6.0 x 4.5 x 1.4	$22.95

Proto Board 203A

All the features of the PB 203 plus additional power supply flexibility, provides 1% Regulated 5VDC supply (same specifications as PB 203). Regulated separate +15VDC and −15 VDC 0.5A supplies, each with internally and independently adjustable output voltage. Ripple and noise of + and − 15V supplies 10mV at 0.25A.

PB 203A **$124.95**

Model Number	L x W x H (Inches)	Price
PB-102	7.0 x 4.5 x 1.4	$26.95
PB-103	9.0 x 6.0 x 1.4	$44.95
PB-104	9.8 x 8.0 x 1.4	$54.95

THE SINCLAIR PDM35

DC Volts (4 ranges)
Range 1mV to 1000V
Accuracy of reading 1.0% ± 1 count.
Note: 10MΩ input impedance
AC Volts (40 Hz-5 kHz)
Range 1V to 500 V
Accuracy of reading 1.0% ± 2 counts.
DC Current (6 ranges)
Range 1 nA to 200 mA
Accuracy of reading 1.0% ± 1 count.
Note: Max. resolution 0.1 nA
Resistance (5 ranges)
Range 1Ω to 20 MΩ.
Accuracy of reading 1.5% ± 1 count.
Also provides 5 junction-test ranges
Dimensions: 6 in x 3 in x 1½ in.
Weight: 6½ oz
Power Supply: 9 V battery or Sinclair AC adapter (Battery not incl.)
Sockets: Standard 4mm for resilient plugs

Options: AC adapter for 117 V 60 Hz power. De-luxe padded carrying wallet

PDM35: Digital Multimeter (completely assembled) . . . $59.95
PDM-AC: 117V AC Adapter . . . 6.95
PDM-DP: Deluxe padded carrying case. . . 6.95

CSC 100 MHz 8-Digit Counter

CONTINENTAL SPECIALTIES CORPORATION

- 20 Hz-100 MHz Range
- 6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power sources, i.e. batteries, 110 or 220V with charger, 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95

ACCESSORIES FOR MAX 100:
Mobile Charger Eliminator use power from car battery — Model 100 — CLA $3.95
Charger/Eliminator use 110 V AC — Model 100 — CAI $9.95

REGULATED POWER SUPPLY

NEW

JE200 5V-1 AMP POWER SUPPLY

- Uses LM309K
- Heat sink provided
- PC Board construction
- Provides a solid 1 amp @ 5 volts
- Can supply up to ±5V, ±9V and ±12V with JE205 Adapter
- Includes components, hardware & instructions
- Size: 3½"x5"x2"H

JE200 $14.95

JE205 ADAPTER BOARD

— Adapts to JE200 —
±5V, ±9V and ±12V

- DC/DC converter w/ +5V input
- Toriodal hi-speed switching XMFR
- Short circ. protection
- PC Brd. construction
- Piggy-back to JE200 board
- Size: 3½"x2"x9/16"h

JE205 $12.95

$10.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets — 25¢
1979 Catalog Available—Send 41¢ stamp

FREE A 1979 CATALOG

Jameco ELECTRONICS

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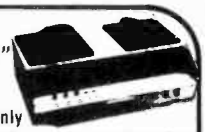
MAIL ORDER ELECTRONICS – WORLDWIDE
1021 HOWARD AVENUE, SAN CARLOS, CA 94070
ADVERTISED PRICES GOOD THRU JULY

The Incredible "Pennywhistle 103"



$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate	300 Baud.
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark, High = 025 space, 2225 mark
Receive Sensitivity	−46 dbm accoustically coupled.
Transmit Level	−15 dbm nominal. Adjustable from −6 dbm to −20 dbm
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz.
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar)
Power Requirements	120 VAC, single phase, 10 Watts
Physical	All components mount on a single 5" by 9" printed circuit board. All components included.

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align

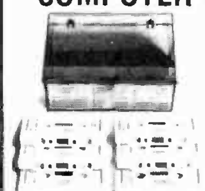
TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K. Kit comes complete with:

- 8 each UPD416-1 (16K Dynamic Rams) 250NS
- Documentation for conversion

TRS-16K $75.00

COMPUTER CASSETTES

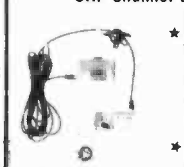


- 6 EACH 15 MINUTE HIGH QUALITY C-15 CASSETTES
- PLASTIC CASE INCLUDED 12 CASSETTE CAPACITY
- ADDITIONAL CASSETTES AVAILABLE #C-15-$2.95 ea

CAS-6 $14.95
(Case and 6 Cassettes)

SUP 'R' MOD II

UHF Channel 33 TV Interface Unit Kit



Wide Band B/W or Color System
★ Converts TV to Video Display for home computers, CCTV camera, Apple II, works with Cromeco Dazzler, SOL-20, IRS-80, Challenger, etc.
MOD II is pretuned to Channel 33 (UHF).
★ Includes coaxial cable and antenna transformer

MOD II $29.95 Kit

Function Generator Kit

- Provides 3 basic waveforms: sine, triangle & square wave
- Frequency range from 1 Hz to 100K Hz
- Output amplitude from 0-volts to over 6 volts (peak to peak)
- Uses a 12V supply or a ±6V split supply
- Incl. chip, P.C. board, components and instructions

JE2206B $19.95

IDEAL FOR TRS 80 — CASSETTE CONTROLLER

"Plug/Jack interface to any computer system requiring remote control of cassette functions"

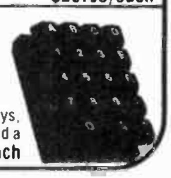
The CC100 controls cassette motor functions, monitors tape location with its internal speaker and requires no power. Eliminates the plugging and unplugging of cables during computer loading operation from cassette.

#CC-100 $29.50

63-Key Unencoded Keyboard

This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK $29.95/each

Hexadecimal Unencoded Keypad



19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key. $10.95/each

CIRCLE NO. 31 ON FREE INFORMATION CARD

REGULATED POWER SUPPLIES

POWER SYSTEMS # PS1111
115-230V 50/60 cy. in 5v DC at 35A out.
6"x 16¾"x 15¾" 26 lbs. shipping weight $55.00

POWER SYSTEMS # PS1106
115-230V 50/60 cy. in 12v DC at 15A out.
5"x 16¾"x 5" 19 lbs. shipping weight. $49.00
(OV PROTECT)

C/MOS (DIODE CLAMPED)

4001	20	4019	.37	4049	40	74C73	65
4002	20	4020	90	4050	40	74C74	45
4007	18	4021	90	4051	1.00	74C86	40
4009	37	4022	90	4053	1.10	74C93	75
4010	37	4023	18	4055	1.25	74C151	1.40
4011	20	4024	75	4066	70	74C160	1.05
4012	20	4025	18	4069	.45	74C161	1.05
4014	75	4027	.37	4071	20	74C174	1.05
4015	75	4028	80	4072	21	74C175	1.05
4016	37	4029	95	4076	97	74C901	48
4017	1.05	4030	33	4520	70	74C902	48
4018	90	4035	97	74C00	22	74C914	1.70
		4042	65	74C02	22		
		4044	65	74C10	22		

1488 RS232 INTERFACE	$1.40	2117 16K DYN RAM	7.95
1489 RS232 INTERFACE	[illegible]	[illegible] 4K STAT RAM	9.95
2509 TRI STATE STAT SR	1.35	4116-2	9.95
2513 CHARAC GEN UP	6.75	5280 2107B 4K DYN RAM	1.40
2518 HEX 32 BIT SR	2.20	4395 40601	[illegible]
2522 STATIC SHIFT REG	1.95	5204 4K PROM	4.95
2708 8K EPROM 450 ns	12.95	82S23	[illegible]
TMS 4050NL	2.95	82S126	2.95
TMS 3409 NC 80 BITS DYN SR	1.35	82S129	1.75
2716 [illegible]	35.95	AY5 1013 UART	5.75
2102 1 (450 ns)	.90	1M1 6402B	4.95
21L02 1 (450 ns)	1.25	8701C TELEDYNE 8 BIT A/D CONVERT	[illegible]
MM5270 4K DYN	1.45	[illegible] 1482 R PSAT	6.95
MK4008P	1.95	8080A	[illegible]
2101 1 256 x 4 STATIC	2.45	8224	2.95
2111 1 256 x 4 STATIC	3.45		
2112 1 256 x 4 STATIC	2.75		
2114 4K STAT RAM 450 ns	8.50		
8T10 [illegible]	[illegible]	8T14 2.25	8T18 2.25

CRYSTALS $3.45 ea.
2.000 MHz
4.000 MHz
5.000 MHz
6.000 MHz
8.000 MHz
10.000 MHz
20.000 MHz

RIBBON CABLE
FLAT (COLOR CODED)
#30 WIRE
26 cond. - .50/per foot
40 cond. - .75/per foot
50 cond. - .90/per foot

CTS 206-8 eight position dip switch $1.60
CTS 206-4 four position dip switch. $1.45
LIGHT ACTIVATED SCR's to 18 200 V 1A .. $.70

SILICON SOLAR CELLS
2¼" diameter .4V at 500 ma $4.00
4" diameter .4V at 1 AMP $10.00

LED READOUTS

FND 359 C.C. .4" $ .60
FCS 8024 4 digit C.C. .8" display $5.95
FND 503 C.C. .5" $ .85
FND 510 C.A. .5" $ .85
DL 704 .3" C.C. $ .85
DL-704 C.A. .3" $ .75
DL 747 C.A. .6" $1.50
HP3400 .8" CC $1.95
HP3405 .8" CA $1.95

PRINTED CIRCUIT BOARD

4" x 6" DOUBLE SIDED EPOXY BOARD 1/16" thick
$.60 ea .... 5/$2.60

7 WATT LD-65 LASER DIODE IR $8.95

2N 3820 P FET $ .45
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2N2646 UJT $ .45
ER 900 TRIGGER DIODES 4 $1.00
2N 6028 PROG UJT $ .65

MINIATURE MULTI-TURN TRIM POTS
100, 1K, 2K, 5K, 10K, 20K, 50K,
200K, 1Meg, 2Meg, $.75 each 3/$2.00

CHARGED COUPLE DEVICES
CCD 201C 100×100 Image Sensor $95.00
CCD 202C 100×100 Image Sensor $145.00

VERIPAX PC BOARD $16.95
Our new Prototyping is a hi density 4½" x 6½" single sided 1/16" epoxy board. It will hold 40, 24, 16 (134 units), 14 + 8 pin IC's. There are three busses, +5V, ground and a floating buss. There is a pad for a TO-220 regulator. There is a 22 pin edge connector with .156" spacing.

FP 100 PHOTO TRANS .... $ .50
RED, YELLOW, GREEN LARGE LED's 2" .... 6/$1.00
TIL-118 OPTO-ISOLATOR .... $ .75
MCT 6 OPTO ISOLATOR .... $ .80
1 WATT ZENERS 3.3, 4.7, 5.1, 5.6, 9.1, 10, 12, 15, 18, or 22V .... 6/$1.00
MCM 6571A 7 x 9 character gen ... $ 10.75

UNIVERSAL 4K×8 MEMORY BOARD KIT
$69.95
32-2102-1 fully buffered, 16 address lines, on board decoding for any 4 of 64 pages, standard 44 pin buss, may be used with F 8 & KIM

Silicon Power Rectifiers

PRV	1A	3A	12A	50A	125A	240A
100	.06	.14	.35	.90	3.70	5.00
200	.07	.20	.40	1.30	4.25	6.50
400	.09	.25	.65	1.50	6.50	9.50
600	.11	.30	.80	2.00	8.50	12.50
800	.15	.35	1.00	2.50	10.50	16.50
1000	.20	.45	1.25	3.00	12.50	20.00

SAD 1024 a REDICON 1024 stage analog "Bucket Brigade" shift register $14.95

IN 4148 (IN914) 15/$1.00
.1 uf 25V ceramic caps 16/$1.00, $5.00/100

RS232 CONNECTORS
DB 25P male $2.95
DB 25S female $3.50
HOODS $1.50

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323K 5V 3A ... $ 5.75
309K ... $ 1.10
723 .... $ .50
320T 5, 12, or 15 V ... $ 1.10
340K 12, 15 or 24 V ... $ 1.10
340T 5, 6, 8, 12, 15, 18 or 24V $ 1.10
78 MG ...... $ 1.35
79 MG ...... $ 1.35

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2N1546 PNP GE TO-3 .... $ .75
2N4908 PNP Si TO 3 $ 1.00
2N5086 PNP Si TO 92 4 $ 1.00
2N3137 NPN Si RF .... $ .55
2N3919 NPN Si TO 3 RF $ 1.50
2N1420 NPN Si TO 5 .... 3/$ 1.00
2N3767 NPN Si TO 66 $ .70
2N2222 NPN Si TO 18 5 $ 1.00
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MPSA 13 NPN Si .... 4/$ 1.00

TTL IC SERIES

		7447	.58	75491	70
		7448	68	75492	70
7400	15	7450	18	74154	94
7401	15	7472	25	74155	58
7402	15	7473	28	74157	55
7403	15	7474	28	74161	55
7404	18	7475	45	74162	80
7405	18	7476	30	74163	55
7406	22	7480	31	74164	85
7408	18	7483	65	74165	95
7409	18	7485	87	74173	1.20
7410	15	7486	28	74174	95
7411	18	7489	1.25	74175	85
7412	18	7490	42	74176	75
7413	36	7491	58	74177	75
7414	60	7492	43	74180	65
7416	22	7493	43	74181	1.90
7417	25	7494	67	74190	1.00
7420	18	7495	65	74191	85
7425	30	7496	65	74192	79
7426	22	74107	28	74193	79
7427	28	74121	30	74194	80
7430	18	74122	40	74195	50
7432	22	74123	45	74196	86
7437	22	74125	40	74197	80
7438	22	74126	40	74279	.55
7440	18	74145	65	74298	90
7441	70	74148	1.10	74368	62
7442	45	74150	1.00	74393	1.25
7445	65	74151	61	75322	1.50
		74153	61	74325	1.50

DATA CASSETTES 1/2 HR $ .95

14 pin headers 3/$1.00

MM5387AA $5.95
M7001 .... $7.50
MM5369 .... $3.75

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MTA 106 SPDT $ .95
MTA 206 DPDT $ 1.70
MTA 206 P-DPDT CENTER OFF $ 1.85
MSD 206 P-DPDT CENTER OFF LEVER SWITCH $ 1.85

Full Wave Bridges

PRV	2A	6A	25A
100			1.30
200	.75	1.25	2.00
400	.95	1.50	3.00
600	1.20	1.75	4.00

DIP SOCKETS

8 PIN .17 24 PIN .35
14 PIN .20 28 PIN .40
16 PIN .22 40 PIN .60
18 PIN .25

SANKEN AUDIO POWER AMPS

Si 1010 G 10 WATTS $ 7.80
Si 1020 G 20 WATTS $15.70
Si 1050 G 50 WATTS $28.50

TANTULUM CAPACITORS

.22UF	35V	5/$1.00	6.8UF	35V	4/$1.00
.47UF	35V	5/$1.00	10UF	10V	$ .25
.68UF	35V	5/$1.00	22UF	25V	$ .40
1UF	35V	5/$1.00	15UF	35V	3/$1.00
2.2UF	20V	5/$1.00	30UF	6V	5/$1.00
3.3UF	20V	4/$1.00	33UF	20V	$ .40
4.7UF	15V	5/$1.00	47UF	20V	$.35
			68UF	15V	$ .50

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74LS138, 74LS139, 74LS151, 74LS153, 74LS155, 74LS156, 74LS157, 74LS160, 74LS161, 74LS162, 74LS163, 74LS164, 74LS168, 74LS169, 74LS170, 74LS173, 74LS174, 74LS175, 74LS181, 74LS190, 74LS191, 74LS192, 74LS193, 74LS195, 74LS196, 74LS197, 74LS241, 74LS257, 74LS258, 74LS259, 74LS285, 74LS266, 74LS279, 74LS290, 74LS293, 74LS365, 74LS366, 74LS368, 74LS375, 74LS386, 74LS390, 74LS670

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LM 201	.75
LM 301/748	.25
LM307	.30
LM 308	.75
LM 311	.75
LM 318	1.20
LM 324	.95
LM 339	1.10
LM 358	.70
LM 370	1.15
LM 377	1.60
LM 380	.95
LM 382	1.25
LM386	.80
LM 387	1.25
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CA 3080	.95
LM 537	2.50
LM 553	2.50
LM 555	.49
LM 556	.85
560	2.00
565	.95
566	1.10
567	1.10
703	.90
7301	.75
709	.25
711CH	.40
741C or V	.30
747	.50
LM 1310	2.50
1456	.95
1458	.50
3900	.40
8038CC	3.90
791	1.95
LF356H	1.20

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PRV	TRIACS 1A	TRIACS 10A	TRIACS 25A	SCR'S 1.5A	SCR'S 6A	SCR'S 35A
100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	1.20	2.20
600	1.70	2.30	3.60		1.50	3.00

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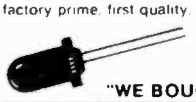
#FLV5057 Medium Size Clear Case RED EMITTING. These are not retested off-spec units as sold by some of our competition. These are factory prime, first quality, new units.



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"THE COLOSSUS"
FAIRCHILD SUPER JUMBO LED READOUT

A full .80 inch character. The biggest readout we have ever sold! Super efficient. Compare at up to $2.95 each from others!

YOUR CHOICE $1.49 EA

FND 847 Common Anode
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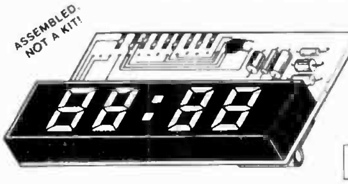
(6 for $6.95)

NATIONAL SEMICONDUCTOR
MILITARY TIME FORMAT!
MA1008D BRAND NEW!

JUMBO CLOCK MODULE



$4.95
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REG. $9.95

ADD $1.95 FOR AC XFMR

FEATURES:
- FOUR JUMBO ½ INCH LED DISPLAYS
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- 24 HR ALARM SIGNAL OUTPUT
- 50 OR 60 Hz OPERATION
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- SLEEP & SNOOZE TIMERS
- DIRECT LED DRIVE (LOW RFI)
- COMES WITH FULL DATA

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50% OFF SALE!

PERFECT FOR USE WITH A TIMEBASE.

COMPARE AT UP TO TWICE OUR PRICE!

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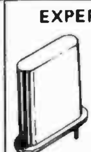
16K DYNAMIC RAM CHIP
WORKS IN TRS-80 OR APPLE II

16K X 1 Bits. 16 Pin Package. Same as Mostek 4116-4. 250 NS access. 410 NS cycle time. Our best price yet for this state of the art RAM. 32K and 64K RAM boards using this chip are readily available. These are new, fully guaranteed devices by a major mfg.

VERY LIMITED STOCK!

"MAGAZINE SPECIAL" — 8 For $79.50

EXPERIMENTER'S CRYSTAL



262.144KHZ. This frequency is 2 to the 18th power. Easily divided down to any power of 2, and even to 1HZ. New by CTS-Knight. A $5 value.

$1.25 each
4.00 MHZ — $1.75

MINI PROJECT CASE

Black Molded Plastic 2⅞x1⅝x2 in. Has open front, with mounting ears so unit can be easily attached to auto dash, etc. Case has molded card guides for mounting PC Board inside. Perfect for digital clocks, car burglar alarms, or almost any electronic project. Can also be used for encapsulating circuits or modules.

75¢ each
Super Special Purchase!

FAIRCHILD PNP "SUPER TRANSISTOR"

2N4402 TO-92 Plastic. Silicon PNP Driver. High Current. VCEO-40 HFE-50 to 150 at 150 MA. FT-150 MHZ. A super "BEEFED—UP" Version of the 2N3906.

8 FOR $1

G.I. FULL WAVE BRIDGE

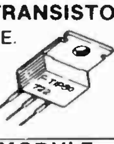
4 AMP 600 PIV
3/4 In. Square
With Lugs, #LM-1
75¢ ea. 3 For $2

MOTOROLA POWER TRIAC

TO-220 CASE
15 AMP 400 PRV
SPECIAL 89¢ each
5 FOR $3.95

COMPLEMENTARY POWER TRANSISTORS

SILICON NPN AND PNP. TO-220 CASE.
VCEO - 40V PD - 30 WATTS
FOR AUDIO POWER AMPS, ETC.



TIP29 - NPN
TIP30 - PNP
YOUR CHOICE
3 FOR $1

FET SALE!

2N4304. Brand New
N Channel, Junction Fet
BVGDO-30V IDSS-15 MA Typ.
1500 uMHOS. TO-18 Plastic Case. Mfg. by Teledyne.
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Large Manufacturers Surplus. 5¼x10½ In. Made of 3/8 in. tempered glass with heating element laminated on back. Works off 120 VAC. Protected by thermostat and two thermal fuses. Rated 120 Watts. Use for any heating applications. Perfect for heating ferric chloride to increase PC board etching efficiency. Units are brand new, non-submersible.

WHILE THEY LAST — $2.99 each

SONY 30 WATT AUDIO AMP MODULE

#STK-056. 30 WATTS SUPER CLEAN AUDIO. 20 HZ to 100 KHZ ± 2 DB. HYBRID, SILICON, SELF-CONTAINED MODULE. ONLY 1¾x2½ IN. WITH DATA. COMPARE AT UP TO TWICE OUR PRICE!

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LEADER Test Instruments

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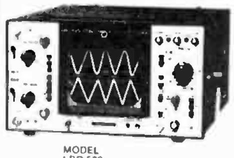
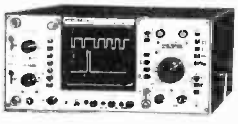

MODEL LBO-520

The 30 MHz Dual Trace Oscilloscope with Delay

- 5mV sensitivity.
- Built-in delay line.
- Single shot trigger (CH-1, CH-2).
- 5" P-D-A CRT assures brighter, sharper trace.
- 20 nS/cm sweep capability plus 11.7 nSec rise time.

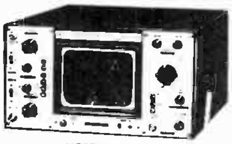
LIST PRICE: $1050 OUR PRICE: $888


MODEL LBO-515

25 MHz Dual Trace, Oscilloscope Delayed Sweep

- Sweep delay, continuously variable from 1 uSec to 5 Sec.
- 5 mV/Div. Vertical Sensitivity with ±3% acc.
- Rectangular CRT with internal graticule.
- 14 nSec rise time.
- CH-1 or 2 trigger; HF filter; and TV sync.

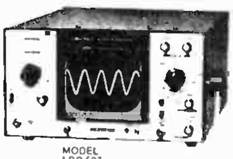
LIST PRICE: $1395 OUR PRICE: $1180


MODEL LBO-508

The 20 MHz Dual Trace Oscilloscope

- Add & subtract modes (with CH-2 invert).
- Front panel X-Y operation.
- 17.5 nanosec rise time.
- Automatic trigger from either channel, including TV sync.
- 10 mV sensitivity.

LIST PRICE $769 •OUR PRICE: $635

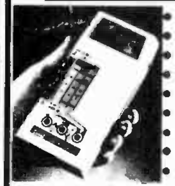

MODEL LBO-507

The 20 MHz Single Trace Triggered Oscilloscope

- Outstanding trigger sensitivity over entire operational range.
- 10 mV sensitivity and 17.4 nSec rise time.
- X5 magnification (±5%) delivers 100 nS/cm maximum speed for easy, precise readings.

LIST PRICE: $549 OUR PRICE: $455

FLUKE® DIGITAL MULTIMETERS NEW



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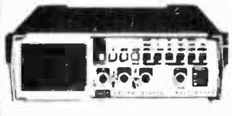

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XR346CP	2.70	XR2204CP	1.33	XR2212CP	4.37	XR2567CP	2.76
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XR1488P	1.31	XR2207N	5.25	XR2242CP	1.50	XR4558CP	.75
XR1489AN	1.42	XR2207P	4.28	XR2264CP	4.24	XR4739CN	1.53
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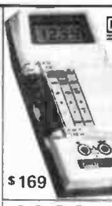

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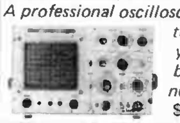

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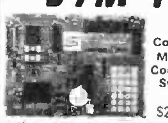
SYM-1



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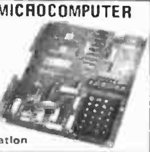

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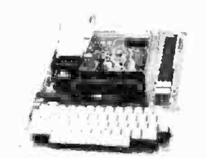

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74xx	7480 . . $0.49↑	74181 . $1.95↑	74LS42. $0.66↑	74LS192 $0.97↑	74S78 . $0.58	74C42 . $0.94	4006 . . $1.19↑	4085 . . $0.69↑
	7482 . . .0.55↑	74182 . .0.78↑	74LS47. .0.78↑	74LS193 .0.97↑	74S86 . .0.58↓	74C48 . .1.27↑	4007 . . .0.22↑	4086 . . .0.69↑
	7483 . . .0.59↑	74184 . .1.95↑	74LS48. .0.76↑	74LS194 .0.87↑	74S112 . .0.58	74C73 . .0.71↑	4008 . . .0.78↑	4089 . . .2.75
7400 . . $0.15↑	7485 . . .0.79↓	74185 . .1.95↑	74LS51. .0.27↑	74LS195 .0.87↑	74S113 . .0.58	74C74 . .0.48	4009 . . .0.43↑	4093 . . .0.99↓
7401 . . .0.17↑	7486 . . .0.27	74188 . .3.25↑	74LS54. .0.27↑	74LS196 .0.85↑	74S114 . .0.58	74C76 . .0.71↑	4010 . . .0.43↑	4099 . . .2.10
7402 . . .0.17↑	7489 . . .1.75	74190 . .0.95	74LS55. .0.27↑	74LS197 .0.85↑	74S132 . .0.75	74C83 . .1.37↑	4011 . . .0.22↑	4104 . . .2.20↓
7403 . . .0.17↑	7490 . . .0.43↑	74191 . .0.95	74LS73. .0.38↑	74LS221 1.90↑	74S133 . .0.38	74C85 . .1.37↑	4012 . . .0.22↑	4503 . . .0.98
7404 . . .0.18↑	7491 . . .0.58↑	74192 . .0.80	74LS74. .0.38↑	74LS251 .0.99↑	74S134 . .0.38	74C86 . .0.49↑	4013 . . .0.39↑	4507 . . .0.99↑
7405 . . .0.18↑	7492 . . .0.43↑	74193 . .0.80	74LS76. .0.38↑	74LS253 .0.99↑	74S135 . .0.49	74C89 . .3.95	4014 . . .0.95↑	4510 . . .1.13↑
7406 . . .0.24	7493 . . .0.43↑	74194 . .0.87↑	74LS78. .0.38↑	74LS257 .0.74↑	74S138 . .0.77	74C90 . .0.97↑	4015 . . .0.95↑	4511 . . .1.04↑
7407 . . .0.24	7494 . . .0.65↑	74195 . .0.87↑	74LS83. .0.78↑	74LS258 .0.74↑	74S139 . .1.50	74C93 . .0.97↑	4016 . . .0.39↑	4512 . . .0.98↑
7408 . . .0.20↑	7495 . . .0.65↑	74196 . .0.87↑	74LS85. .0.97↓	74LS259 1.81↑	74S140 . .0.47	74C95 . .1.09↑	4017 . . .1.04↑	4516 . . .1.22↑
7409 . . .0.20↑	7496 . . .0.65↑	74197 . .0.87↑	74LS86. .0.38↑	74LS260 .0.54↑	74S151 . .0.89↓	74C107 . .0.69↑	4018 . . .1.04↑	4518 . . .1.13↑
7410 . . .0.17↑	7497 . . .2.45	74198 . .1.45↑	74LS90. .0.56↑	74LS266 .0.38↑	74S153 . .0.75↓	74C151 . .1.89↑	4019 . . .0.39↑	4519 . . .0.62
7411 . . .0.20↑	74107 . .0.29	74199 . .1.45↑	74LS92. .0.56↑	74LS279 .0.58↑	74S157 . .0.76	74C154 . .2.90	4020 . . .1.13↑	4520 . . .1.13↑
7412 . . .0.24↑	74109 . .0.32	74251 . .1.09↑	74LS93. .0.56↑	74LS283 .0.99↑	74S158 . .0.75↓	74C157 . .1.89↑	4021 . . .1.13↑	4527 . . .1.67↑
7413 . . .0.25	74121 . .0.34↑	74279 . .0.75↑	74LS95. .0.87↑	74LS290 .0.64↑	74S174 . .1.50	74C160 . .1.17↑	4022 . . .0.95↑	4528 . . .0.86
7414 . . .0.70↑	74122 . .0.39↑	74283 . .2.20↑	74LS107 .0.38↑	74LS295 .0.99↑	74S175 . .1.45	74C161 . .1.17↑	4023 . . .0.22↑	4532 . . .0.86
7416 . . .0.24↑	74123 . .0.49↑	74290 . .0.89↑	74LS109 .0.38↑	74LS298 .0.99↑	74S189 . .2.75	74C162 . .1.17↑	4024 . . .0.79↑	4539 . . .1.10
7417 . . .0.24↑	74125 . .0.39↑	74293 . .0.89↑	74LS112 .0.38↑	74LS365 .0.66↑	74S194 . .1.75	74C163 . .1.17↑	4025 . . .0.22↑	4555 . . .0.67
7420 . . .0.19↑	74126 . .0.39↑	74298 . .0.92	74LS113 .0.38↑	74LS366 .0.66↑	74S200 . .3.25	74C164 . .1.09↑	4027 . . .0.39↑	4556 . . .0.88
7421 . . .0.27↑	74132 . .0.65	74365 . .0.62	74LS114 .0.38↑	74LS367 .0.66↑	74S206 . .3.75	74C165 . .1.09↑	4028 . . .0.88↑	4582 . . .0.88
7423 . . .0.25	74141 . .0.79↑	74366 . .0.62	74LS123 .0.98↑	74LS368 .0.66↑	74S253 . .0.95	74C173 . .1.29↑	4029 . . .1.13↑	4584 . . .0.74
7425 . . .0.25	74145 . .0.69↑	74367 . .0.62	74LS125 .0.48↑	74LS386 .0.38↑	74S257 . .1.15	74C174 . .1.15↑	4030 . . .0.29↑	4702 . . .7.10
7426 . . .0.24↑	74147 . .1.60↑	74368 . .0.62	74LS126 .0.48↑	74LS390 1.69↑	74S258 . .1.15	74C175 . .1.15↑	4031 . . .2.97	4703 . . .8.25
7427 . . .0.25↑	74148 . .1.29↑	**74LSxx**	74LS132 .0.80↑	74LS393 1.69↑	74S280 . .2.25	74C192 . .1.37↑	4034 . . .2.75	4704 . . .7.30
7430 . . .0.19↑	74150 . .0.89↑		74LS133 .0.38↑	74LS490 1.49↑	74S287 . .3.20	74C193 . .1.37↑	4035 . . .0.99↑	4705 . . .9.25
7432 . . .0.24↑	74151 . .0.59	74LS00. $0.27↑	74LS136 .0.38↑	74LS670 2.33↑	74S289 . .3.55	74C195 . .1.08↑	4040 . . .0.99↑	4706 . . .9.75
7437 . . .0.24↑	74152 . .0.59	74LS01. .0.27	74LS138 .0.93↑		74S300 . .1.60	74C200 . .7.50	4041 . . .0.78↑	4707 . . .9.25
7438 . . .0.24↑	74153 . .0.59↓	74LS02. .0.27↑	74LS139 .0.93↑	**74Sxx**	74S305 . .1.90	74C221 . .1.89↑	4042 . . .0.78↑	4708 . . .14.35
7439 . . .0.29↑	74154 . .0.99↑	74LS03. .0.27↑	74LS151 .0.74↑		74S310 . .2.85	74C901 . .0.48	4043 . . .0.69↑	4710 . . .6.40
7440 . . .0.19↑	74155 . .0.69↑	74LS04. .0.28↑	74LS152 .0.74↑	74S00 . . $0.35	74S312 . .1.05	74C902 . .0.48	4044 . . .0.69↑	4720 . . .6.95
7441 . . .0.88↑	74156 . .0.69↑	74LS05. .0.28↑	74LS153 .0.84↑	74S02 . . .0.35	74S313 . .1.55	74C903 . .0.59↑	4046 . . .1.79↑	4723 . . .0.93
7442 . . .0.48↑	74157 . .0.64↑	74LS08. .0.28↑	74LS154 1.09↑	74S03 . . .0.35	74S341 . .4.10	74C904 . .0.59↑	4047 . . .1.99↑	4724 . . .1.29
7443 . . .0.69↑	74158 . .0.64↑	74LS09. .0.28↑	74LS155 .0.74↑	74S04 . . .0.36	74S342 . .1.20	74C905 . .6.00	4048 . . .0.95	4725 . . .3.95↑
7444 . . .0.69↑	74160 . .0.87↑	74LS10. .0.27↑	74LS156 .0.74↑	74S05 . . .0.36	74S343 . .4.95	74C906 . .0.59↑	4049 . . .0.39↑	40014 . .0.90
7445 . . .0.69↑	74161 . .0.87↑	74LS11. .0.27↑	74LS157 .0.74↑	74S08 . . .0.38	74S346 . .1.25	74C907 . .0.59↑	4050 . . .0.39↑	40085 . .1.37↓
7446 . . .0.69↑	74162 . .0.87↑	74LS12. .0.27	74LS158 .0.74↑	74S09 . . .0.38	74S362 . .2.15	74C908 . .1.19↑	4051 . . .1.19↑	40097 . .0.54
7447 . . .0.62↑	74163 . .0.87↑	74LS13. .0.46↑	74LS160 1.01↑	74S10 . . .0.35	74S387 . .4.70	74C909 . .1.78	4052 . . .1.19↑	40098 . .0.54
7448 . . .0.69↑	74164 . .0.87↑	74LS14. .0.99↑	74LS161 1.01↑	74S11 . . .0.38		74C910 . .6.00	4053 . . .1.19↑	40106 . .0.90
7450 . . .0.19↑	74165 . .0.87↓	74LS15. .0.27↑	74LS162 1.01↑	74S15 . . .0.38		74C914 . .1.19↑	4060 . . .1.49↑	40160 . .1.17↑
7451 . . .0.19↑	74166 . .1.20↑	74LS20. .0.27↑	74LS163 1.01↑	74S20 . . .0.35	**74Cxx**	74C918 . .1.49↑	4066 . . .0.78↑	40161 . .1.17↑
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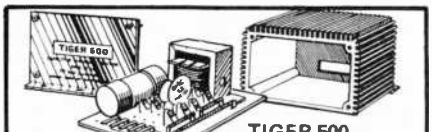

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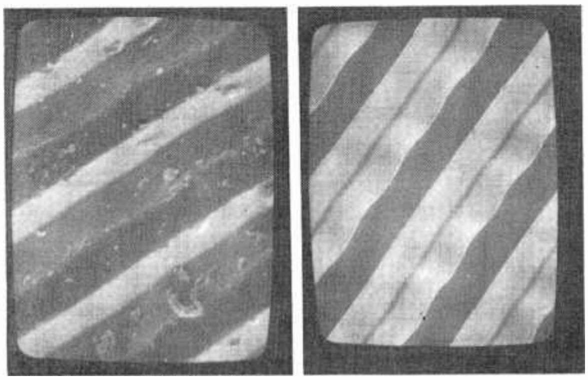
Personal Electronics News

Electron-microscope photos of a new, unplayed phono disk before (left) and after treatment with Audio Groome's "Disco Film" are shown here, as provided by the manu-



facturer, Empire Scientific Corp. The "garbage" in the photo at left is said to be a by-product of the manufacturing process which can permanently damage delicate record grooves during the first playing. The new treatment is claimed to remove this material before initial playing as well as acting to clean older records.

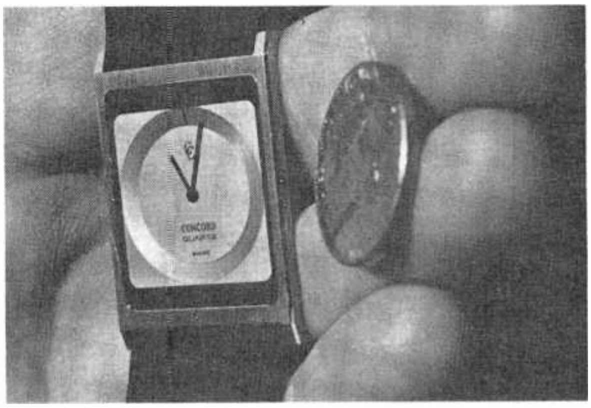
With AM stereo broadcasting a possible reality soon, the Institute of High Fidelity (IHF) has filed comment with the FCC that requests an effective date be seleced for broadcast of AM stereo to allow for orderly marketplace transition. Without such a fixed date, the IHF believes the consumer might be disappointed in purchasing AM stereo components for which the ability to receive AM stereo signals would not be realized for a lengthy period of time or which would not comply with the reception standards for broadcasters. The FCC's proposed rule-making of October 19, 1978 provided only that an AM broadcast station may begin transmitting stereophonic programs upon type acceptance of its equipment. The type of stereo system accepted by the FCC has not yet been determined.

The first multi-disc opera set on prerecorded cassettes by Columbia Masterworks will be Madama Butterfly, starring Renata Scotto and conducted by Lorin Maazel. The package will consist of a standard album-size box, containing a full-size libretto and three cassettes with Dolby noise reduction.

Disneyland isn't the only place where electronic puppets perform. Computer-animated shows in the Pizza Time Theatre, Mountain View, Calif., uses a DEC PDP-11 and a Sykes floppy disk with 32K memory. The equipment controls actions of eight "cartoon" models, one of which plays piano at a bar.

Video-disc marketing advanced in two ways recently. On one front, Magnavox introduced its Maganavision (R) Optical Player in the Seattle-Tacoma area and added six more locations to its outlets already located in the Atlanta region. These players use the MCA DiscoVision discs which are played by use of laser beams. At the same time, RCA has decided to launch its "SelectaVision" Video Disc in the U.S. They expect a multi-billion dollar business by the 1980s for their capacitive-type cartridge/disc system.

"Thin is beautiful," even with wristwatches. Thus the thin-as-a-nickel (1/16"-thick) Swiss-made "Concord Delirium I" has achieved an esthetic goal as well as some



technical aims. Moreover, it's an analog timepiece, running counter to the digital trend. However, the working mechanism is all electronic except for a 0.36-mm thick stepping motor. A quartz element operates at 32,769 Hz, with a tuning fork reportedly accurate to within 10 seconds/month. A CMOS IC produces one 8-millisecond impulse every 20 seconds. Time setting is accomplished by pushing a recessed button; time zone settings are controlled by a microprocessor. The integrated backplate is made of 18-karat gold as are some other parts. Only $4,400.

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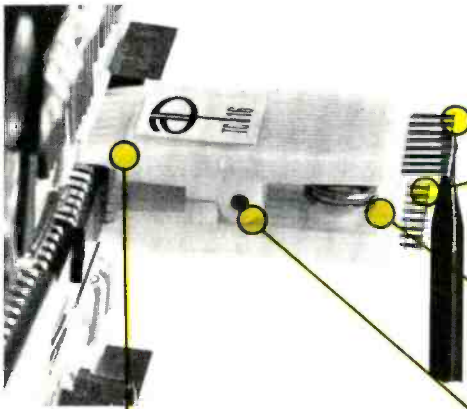

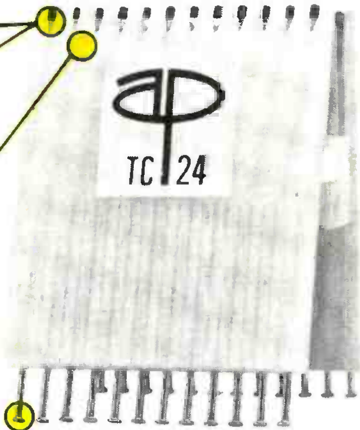

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