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

Tested In This Issue

Sanyc Empir Lafay

Receiver
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.
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 an old 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 entirely 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 free trial and even refund your $3.50 postage and handling. If you decide to keep your unit, you 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.

JULY 1979
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 land public service frequencies! The Bearcat 220 is one scanner which can monitor all public service bands plus the exciting aircraft band. The Bearcat 220 covers seven bands, Low VHF, High VHF, UHF, UHF-1, 2-meter and mobile. It is a direct rebatable feature! It is the new, no-crystal Bearcat 220 scanner tunes in all the real excitement of the AM aircraft band — plus every FM public service frequency — with pushbutton ease. Only the Bearcat 220 can monitor 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 10 frequencies of his choice. You can mix and monitor any combination of aircraft, marine or public service channels at the same time.

New Bearcat 220! The Bearcat 220 feature normal search operation, where frequency limits are set and the scanner automatically searches channels as programmed. It also searches all marine or aircraft frequencies by preprogrammed, time-deallocated frequencies which are stored in a read only memory (ROM) no reprogramming is needed! The new Bearcat 220 is a crystalless synthesized scanner and features pushbutton selection of desired frequencies. A decimal display indicates all channel frequencies and operations and you don’t have to memorize the computized channel list. The lockout feature lets you listen for hours with no current drain on the battery. When the handy front panel search rate button is pressed, it automatically searches any set automatic squelch position for easier operation, or manually. The 2400 Hz Selectivity feature allows for user defined selectivity. In addition, the Bearcat 220 has connectors for external antennas, powered VFO and audio out.

**Many Important Features**

- **The new Bearcat 220 feature normal search operation, where frequency limits are set and the scanner automatically searches channels as programmed.**
- **It also searches all marine or aircraft frequencies by preprogrammed, time-deallocated frequencies which are stored in a read only memory (ROM) no reprogramming is needed!** The new Bearcat 220 is a crystalless synthesized scanner and features pushbutton selection of desired frequencies. A decimal display indicates all channel frequencies and operations.

**Bearcat Scanner Specifications**

- **Bearcat 220 Specifications**

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Power Input</th>
<th>Audio Output</th>
<th>Selectivity</th>
<th>S/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low VHF Band</td>
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<td>20 mW</td>
<td>550 Hz</td>
<td>36 dB SNR</td>
</tr>
<tr>
<td>2 meter amateur band</td>
<td>244-146 MHz</td>
<td>30 mW</td>
<td>1500 Hz</td>
<td>36 dB SNR</td>
</tr>
<tr>
<td>144-44 MHz</td>
<td>30 mW</td>
<td>1500 Hz</td>
<td>36 dB SNR</td>
<td></td>
</tr>
<tr>
<td>440-450 MHz</td>
<td>30 mW</td>
<td>1500 Hz</td>
<td>36 dB SNR</td>
<td></td>
</tr>
<tr>
<td>UHF Band</td>
<td>500 mW</td>
<td>30 mW</td>
<td>1500 Hz</td>
<td>36 dB SNR</td>
</tr>
<tr>
<td>300-500 MHz</td>
<td>30 mW</td>
<td>1500 Hz</td>
<td>36 dB SNR</td>
<td></td>
</tr>
</tbody>
</table>

**Bearcat 220 Features:**

- **20 Channels: 2 banks—Scan up to 20 frequencies at the same time.**
- **7 Band Coverage:** Includes Low and High VHF bands; VHF, UHF-1, the entire 2 meter and 2 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 scanning rating #1 for second highest quality grade for FCC certified technologically sophisticated scanning equipment.
- **Self-Decontour—If the Bearcat 220 uses two AA size batteries to maintain channel memory, you can remove the battery pack, your scanner will electronically erase all programmed channels, in case your scanner falls into enemy hands.**
- **Scrambler/Tape Audio Out—** Top secret cryp
tographic messages may be received and decoded by connecting the Bearcat 220’s external speaker jack to correctly keywowed decydec device, or 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 attack case for untainted, unobstructed 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 superior construction.
- **Aircraft Search—** Push one button to automatically scan the entire aircraft band.
- **Marine Search—** Push one button to automatically scan marine frequencies.
- **Priority—** Samples programmed priority channel on frequency 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 scan range.
- **Speed—** Choice of either 1 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 channel to prevent missing transmissions when “calls” and “answers” are on the same frequency.
- **Simple Programming—** Simply punch in the frequency you wish to monitor.
- **Decal Display—** The large decimal display shows channels and frequency as well as features selected.
- **Patented Track Tuning—** Receives frequencies across the full band without adjustment. Circuitry is automatically aligned to each frequency monitored.
- **Cryp
tographic—** Without even buying a crystal, you can select from all frequencies not of current interest 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—** Mixes frequency and feature selection easy for simple programming.
- **Space Age Circuitry—** Custom integrated circuits! Bearcat tradition in scanning.
- **Rolling Zeros—** This Bearcat exclusive tells you which channels your scanner is monitoring.
- **AC/DC—** Operates at home, office or in your vehicle.

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

- Military
- Aeronautical Mobiles
- Air Force
- Air Traffic
- Amateur Satellite
- Ham Radio
- Army
- Police
- Fire
- Rescue
- Coast Guard
- Rescue
- Sheriff
- Border Patrol
- Security
- Sheriff’s Office
- Air Traffic Control
- Radio Control
- Police
- Air Traffic Control
- Coast Guard
- Marine Corps
- Hamilton
- Meteorological Aids
- Ham Radio
- Sheriff
- Sheriff's Office
- Annapolis
- Mobile Telephone
- Motion Picture
- National Park Service
- National Weather Service
- NASA
- NOAA
- National Weather Service
- NOAA
- Weather
- Energy Exploration
- Police
- Weather Radio
- Drop Parachute
- Roll Carrier
- Sea Rescue
- Weather Rescue
- Sea Rescue
- Special Industries
- Sheriff's Office
- Starline
- Sheriff's Department
- U.S. Marshall
- Utility Companies
- Veteran Administration

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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 Salzberg
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
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 Gunplexer. 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 a/f.

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. 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.

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. Pavlick, 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 as 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.

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°C, 68°F, 90°F, 105°C, and 155°C are equal to 36°F, 122°F, 162°F, 189°F, 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.
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CIRCLE NO. 12 ON FREE INFORMATION CARD

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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-cylinder 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. 85 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 dB in stereo, with stereo THD 0.09% at 65 dB, 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.

CIRCLE NO. 92 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 superstructure. 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

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. 93 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/ant-override, dimmer, and instant channel-access switches; and S/r-f modulation/SWR meter. Specifications include: 4 watts r-f output; 0.5-mV or less sensitivity for 10 dB (S + N)/N; 60-dB spurious and adjacent-

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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.

Now.
Tune in all the real excitement of the wild blue yonder, at the touch of a button.

The new, no-crystal Bearcat 220 Scanner searches and tunes in the entire aircraft band. Jets at 30,000 feet. All the tense tower talk. Everything is pre-programmed in space-age memory banks.

Only the 7-band Bearcat 220 Scanner also brings home every public service frequency, too. Pre-programmed Marine frequencies. Police action. Fire calls. Weather warnings. You name it.


After all, Bearcat invented Scanning. And we'll stop at nothing to bring you all the excitement—of land, sea, and air.
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.

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.

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, 4¾” 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.

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.

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.

Electro-Voice Microphone Shock Mount

The Model 313A shock-mount microphone...
(We need your opinion)

A system with remote for less than the other people charge for just a telephone answering machine

This ad's a test. A kind of consumer survey. With a special Free Offer. To see if the low price of the new Call Jotter remote telephone answering system can turn one of the biggest selling business items into one that's successful with consumers, too.

Ordinariness, like this comes from a consumer panel. Focus groups. But the manufacturer wasn't about to commit for the enormous sum required based on talk. He wanted facts. And came to us, as one of the largest mail merchandisers, for help. Because orders are facts he could act on.

Quality Features
For our part, we tested the Call Jotter thoroughly. And can tell you it's exceptionally well made. (It has to be to get our guarantee.) With solid state, microprocessor technology, and plug-in simplicity, it's F.C.C. approved. And delivers the freedom and convenience you get with systems selling for $299.95—which is the going price, as you know, for remote telephone answering machines.

One thing we did tell the manufacturer: something extra should be given to those who participate in this test. He agreed. So, you'll receive with your order a FREE professionally recorded tape that answers and records 30 messages...a FREE blank tape for recording your own messages or for when you're using the machine as a cassette recorder and player...and a FREE adapter for connecting the Call Jotter to your telephone jack.

An Extraordinary Convenience
Now, we ask you, how much would it be worth to you, to your wife, even your teen-age children to never miss or worry about a phone call again? And to get your messages without having to wait until you get home—from any phone, anywhere in the world. Resetting the machine to take 30 more messages by touching a button on the Tele-Key remote control.

Of course, you'll use your Call Jotter to answer the phone when you're working outside and when you're in a part of the house where there's no telephone.

How much would you spend for an answering machine when the phone rings and you're up on a ladder painting the house? It's true—isn't it—the phone always seems to ring at exactly the wrong time. Like the critical moment in your favorite show and whenever you're taking a nap.

Get your message from any phone anywhere in the world.

Think of the time you've spent just waiting for someone who's promised to call. And what value would you place on your privacy...on working without interruption?

Because your Call Jotter has a monitoring system that lets you listen without answering, you can go back to what you were doing the instant you know it's a nuisance call or for someone who's out of the house. Naturally, you can take any call that's important.

Two For The Price of One
For additional value, Call Jotter works with a single cassette, like a pocket recorder or dictating machine, so you'll use it to listen to your favorite tapes and for recording your own tapes, for dictating letters and memos to be transcribed at the office.

Save $130.00!
You'll use your Call Jotter, then, when you're away—whether it's running to the corner store or spending a month in Europe.

Still—we agree, you probably wouldn't want to spend $259.95 for something that isn't business-related. With Call Jotter, though, you save $130.00! And that's a different story.

At $169.95 (plus $4.35 shipping and handling) Call Jotter's the lowest priced remote telephone answering machine you can get. (Without the remote, it's even less, only $99.95 plus $4.35 shipping and handling.)

Now, we invite you to discover the convenience and freedom it brings—especially if you're an active family—without risking one cent.

You can order either model with any national credit card simply by calling the toll free number below at any time. If you prefer, send your check to Douglas Dunhill at the address below. (Illinois residents are required to add the sales tax.)

Call 800-621-5554
Illinois Residents Call 800-972-7858
In operation 24 hours, 7 days a week.

Remember, the low, down-to-earth price includes the Tele-Key remote control and the two FREE tapes plus the FREE adapter that fits your telephone jack. (If you don't have a phone on a jack, the telephone company will install one for a modest, one time charge when your system arrives.)

You Must Be Satisfied
Use your Call Jotter for 30 days. If you're not completely satisfied return it to us for a complete refund, no questions asked. Simply use the carton it comes in and follow the simple procedure in the directions we send you. If this test is successful, the manufacturer will go into full production and you'll be seeing the unit in stores everywhere in six to nine months.

You'll have played a part in this success—for which we thank you. Meanwhile, we'll be filling orders while we can from the supply on hand.

- Approved for connection in accordance with telephone company filed F.C.C. regulations
- Uses standard 60-minute cassettes
- Plugs into any phone on a jack with adapter supplied free
- Dynamic microphone, full fidelity speaker, push-button tape controls, call light, recorder-player operates on standard A.C. current
- Tele-Key complete with 9V battery for remote control from any phone anywhere in the world (2" x 3" x 1 1/4" - 4 oz.)
- Hi-fi styling. Black and walnut color. Just 9 1/2" x 10 1/2" x 2 1/2"

The convenience and freedom you want... At the price you've been waiting for.

Douglas Dunhill
INC. AFFORDABLE QUALITY

JULY 1979
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.
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.

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.

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.

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.

POWER: 45 watts per channel min. at 8 ohms from 20-20,000 hertz with no more than 0.5% total harmonic distortion.

FM SENSITIVITY: Stereo, 37.0 dBs

S/N RATIO: Stereo, 72 dBs

CAPTURE RATIO: 1.0 dBs

POWER METERS: 2

SPEAKERS: A, B, AB

TONE CONTROL S: Dual

TAPE MONITORS: 2

PIONEER'S SX-780.

CIRCLE NO. 48 ON FREE INFORMATION CARD
New Literature

PTS ELECTRONICS TUNER CATALOG
The 1978-79 Tuner Replacement Guide & Parts Directory from PTS Electronics contains 152 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 2630 and 2810 3 1/2 Digit DMMs, both with autotection and Model 283 3 1/2 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 LCCC4430 data book from Texas Instruments contains specifications on the TI80203 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 TI80203, 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: LCCC4430), 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 categories 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-activated intercom kits. Address: Radio Systems Technology, Inc., 10985 Grass Valley Ave., Dept. P79, Grass Valley, CA 95945.

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.

"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.
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Learn to service 2-way radio, microwave systems, AM/FM transmitters, with NRI's Complete Communications Course.

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.
Communications Course.

NRI instructor/engineers
Each NRI student is assigned his own course instructors, there to help you over any rough spots, explain problems, and give you the advice you need as you progress toward your future. And each one knows what he's talking about, because he was more than likely involved in the design of your course or some of the NRI equipment you use. NRI instructors are practical, experienced people who really know their field and do their best to pass their knowledge on to you.

You get more for your money from NRI.
NRI employs no salesman, pays no commissions. We pass the savings on to you in reduced tuition, top-quality professional equipment, and reliable testing instruments necessary for a successful career. You can pay hundreds of dollars more at other schools, but you can't get better training.

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Get your free catalog and discover why NRI is the leader in home technical training. In 65 years of service, we've helped over a million students start to build new careers. Mail the card today and get started on your new future. If card has been removed, write to:

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NRI can train you at home to service TV equipment and audio systems. Choose from courses to meet your needs and budget, with our complete Master Course in TV/Audio/Video Systems Servicing covering the entire field of electronic home entertainment. You learn to install and repair stereo systems, PA systems, car radios and tape players, musical instrument amplifiers, video tape and disc units, AM/FM radios, black and white and color TV. You get practical bench training as you build your own 25" (diagonal) solid-state color TV complete with computer tuning that lets you program an entire evening's entertainment. You also assemble your own solid-state stereo and professional test instruments.

Learn computer electronics.

Now! Build your own microcomputer as you train.
Train to become one of the new breed of computer technicians...at home with both the equipment hardware and the programming software. Over two years and one-half million dollars in development, the new NRI course in Microcomputers and Microprocessors covers this exciting new opportunity field thoroughly and completely. As you learn, you get "hands-on" experience, building test instruments you use and keep, proving theory in the unique NRI Discovery Lab®, and assembling the exclusive NRI designed-for-learning microcomputer. This unique "teaching" machine demonstrates and clarifies concepts from the very first stages of construction. Finished, it's a completely functional dual-language unit, ready to go to work as your personal microcomputer or basis for a commercial system. It's all part of the most up-to-date, complete home study course ever offered. Mail the card for full facts.
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.

Our DD/DC (Diamond Differential/DC)* circuitry provides the extremely high drive current necessary to use proper amounts of negative feedback to reduce conventionally-measured THD (no more than 0.008%, 5Hz-20,000Hz into 8 ohms at 110 watts, min. RMS) without compromising our extraordinary 200V/μSec slew rate, ensuring vanishingly-low TIM, as well. The power amplifier frequency response extends from zero Hz to 500,000Hz.

Since ultimate tonal quality depends on more than the power amplifier alone, Sansui also uses its DD/DC* circuitry in the phono equalizer section—where current demands are also particularly high—to prevent TIM. ICL (input capacitorless) FET circuits are used throughout the AU-919, and a "jump switch" is provided that will let you run pure DC from the Aux input to the output.

Visit your authorized Sansui dealer today, and he'll show you a lot more that the AU-919 has to offer. Like twin-detector protection circuitry and our Penta-Power Supply system. Two-deck monitoring/recording/dubbing facilities. And a high-performance ICL/FET pre-preamp for moving-coil cartridges.

Then listen to the AU-919 with the most demanding music you can find: You'll hear the way the music should sound. Like music. Not just like sound.

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

SANSUI ELECTRONICS CORP.
Linwood, New Jersey 07031 - Gardena, Ca. 90247
Sansui Electric Co., Ltd., Tokyo, Japan
Sansui Audio Europe S.A., Antwerp, Belgium
In Canada: Electronic Distributors

Sansui
PROONENTS 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 those 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. Meanwhile, 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 vi-
hence the corrections. The result was the same. Octave-band equalizers before, and this is how it should be. 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—even 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 electrostats 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 squelch 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 un-quantized 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 quas-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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Sanyo Model TP1030 fully automatic direct-drive dc servo turntable

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 18¾"W x 15"D x 5¾"H (47.3 x 38.1 x 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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Circle No. 38 on free information card
Performance Specifications

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<tr>
<th>Specification</th>
<th>Rating</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed control range</td>
<td>±4%</td>
<td>+5.2% to −6.2% at 33 1/3 rpm</td>
</tr>
<tr>
<td>Wow and flutter</td>
<td>0.03%wrms</td>
<td>+4.2% to −4.8% at 45 rpm</td>
</tr>
<tr>
<td>S/N ratio</td>
<td>60 dB</td>
<td>−34 dB unweighted NAB</td>
</tr>
<tr>
<td>Rumble</td>
<td>−70 dB DIN “B”</td>
<td>−55 dB ARLL</td>
</tr>
<tr>
<td>Tonearm tracking error</td>
<td>±1.5 deg</td>
<td>Less than 0.5° /in.</td>
</tr>
<tr>
<td>Stylus pressure force range</td>
<td>0 to 3 g</td>
<td>Confirmed (error less than 0.05 g)</td>
</tr>
<tr>
<td>Overhang</td>
<td>15 mm</td>
<td>See text</td>
</tr>
</tbody>
</table>

To carriages, since additional capacitance can be supplied if required. Turntable speeds could be adjusted over a range of +5.2% to −6.2% at 33 1/3 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.

CIRCLE NO. 101 ON FREE INFORMATION CARD

Empire Model EDR.9 extended dynamic response phono cartridge

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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<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
<th>Frequency Range</th>
<th>Accuracy Over Temperature</th>
<th>@ 144MHz</th>
<th>@ 220MHz</th>
<th>@ 450MHz</th>
<th>Number of Readouts</th>
<th>Size of Readouts</th>
<th>Power Requirements</th>
<th>Size</th>
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<tbody>
<tr>
<td>3700</td>
<td>$269.95</td>
<td>50Hz - 700MHz</td>
<td>Proportional Oven 0° - 40°C</td>
<td>10MV</td>
<td>10MV</td>
<td>50MV</td>
<td>8</td>
<td>5 Inch</td>
<td>115 VAC or 8.2 - 14.5VDC</td>
<td>3&quot;H x 8&quot;W x 6&quot;D</td>
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<tr>
<td>3600A</td>
<td>$199.95</td>
<td>50Hz - 600MHz</td>
<td>Oven 5 PPM 17° - 37°C</td>
<td>10MV</td>
<td>10MV</td>
<td>50MV</td>
<td>8</td>
<td>5 Inch</td>
<td>115 VAC or 8.2 - 14.5VDC</td>
<td>2.5&quot;H x 8&quot;W x 5&quot;D</td>
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<tr>
<td>3550W</td>
<td>$149.95</td>
<td>50Hz - 550MHz</td>
<td>TCXO 1 PPM 55° - 85°F</td>
<td>25MV</td>
<td>25MV</td>
<td>75MV</td>
<td>8</td>
<td>5 Inch</td>
<td>115 VAC or 8.2 - 14.5VDC</td>
<td>2.5&quot;H x 8&quot;W x 5&quot;D</td>
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<tr>
<td>3550K</td>
<td>$99.95</td>
<td>50Hz - 550MHz</td>
<td>TCXO 1 PPM 55° - 85°F</td>
<td>25MV</td>
<td>25MV</td>
<td>75MV</td>
<td>8</td>
<td>5 Inch</td>
<td>115 VAC or 8.2 - 14.5VDC</td>
<td>2.5&quot;H x 8&quot;W x 5&quot;D</td>
</tr>
</tbody>
</table>

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CIRCLE NO. 18 ON FREE INFORMATION CARD
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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## Performance Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Rating</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency response</td>
<td>20-35,000 Hz ± 1.75 dB</td>
<td>20-35,000 Hz ± 2 dB</td>
</tr>
<tr>
<td>Separation</td>
<td>20 dB at 20-500 Hz</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>30 dB at 500-15,000 Hz</td>
<td>Confirmed</td>
</tr>
<tr>
<td></td>
<td>20 dB at 15-20,000 Hz</td>
<td>Confirmed (see graph)</td>
</tr>
<tr>
<td>Compliance</td>
<td>28 x 10^6 cm/dyne</td>
<td>—</td>
</tr>
<tr>
<td>Tracking</td>
<td>38 cm/s at 1000 Hz and 0.9 gm</td>
<td>—</td>
</tr>
<tr>
<td>Channel balance</td>
<td>0.75 dB at 1000 Hz</td>
<td>0.8 dB</td>
</tr>
<tr>
<td>Tracking angle</td>
<td>20°</td>
<td>30°(STR160)</td>
</tr>
<tr>
<td>Load impedance</td>
<td>47,000 ohms</td>
<td>—</td>
</tr>
<tr>
<td>Load capacitance</td>
<td>100 to 150 pF</td>
<td>Confirmed</td>
</tr>
<tr>
<td>Output</td>
<td>0.9 μV/cm/s</td>
<td>1.06 μV/cm/s</td>
</tr>
<tr>
<td>Inductance</td>
<td>250 mH</td>
<td>—</td>
</tr>
</tbody>
</table>

Frequency 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-cartridge 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.

---

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 6 1/4"W x 4 3/4"D x 2 1/4"H (15.6 x 11.1 x 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 072C). 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 1 1/2 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 0.00868% 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 low-cut 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.

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

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

To sell an advanced DMM for under $70 we had to cut corners.

And we sure did! First, we cut off the dealer’s mark-up. Then we shaved off the overhead costs of national sales offices and warehouses. Finally, as if that wasn’t enough, we even cut out the high labor costs of factory assembly lines.

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Sabtronics International Inc.
13426 Floyd Circle M/S 24 • Dallas, Texas 75243
Telephone 214/783-0994

Brief Specifications

DC Volts: 100µV to 1000V in 5 ranges
AC Volts: 100µV to 1000V in 5 ranges
DC Current: 0.1µA to 10 A in 6 ranges
AC Current: 0.1µA to 10 A in 6 ranges
Resistance: 0.1Ω to 20 MΩ in 6 ranges
Diode Test Current: 0.1µA, 10µA, 1mA
ACV Frequency Response: 40Hz to 40kHz
Input Impedance: 10 MΩ on ACV and DCV
Overload Protection: 1200 VDC or RMS on all voltage ranges except 250 VDC or RMS on 200mV and 2V AC ranges. Fuse protected on ohms and mΩ ranges.
Power Requirements: 4.5 to 6.5 VDC (4 “C” cells) optional NiCd batteries or AC adapter/charger
Display: 0.35” (9.2mm) Digits reading to ± 1999
Size: 8”W x 6.5”D x 3”H (203 x 165 x 76 mm)
Weight: 1.5 lbs. (0.68Kg) excl. battery

To: Sabtronics International, Inc. 13426 Floyd Circle M/S 24, Dallas, TX 75243

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Price</th>
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<tr>
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<td>$69.95 plus $4.01 shipping and handling each</td>
<td>$69.95</td>
</tr>
<tr>
<td>Model 2010A Digital Multimeter Assembled</td>
<td>$99.50 plus $4.01 shipping and handling each</td>
<td>$99.50</td>
</tr>
<tr>
<td># AC-115 AC adapter/charger(s)</td>
<td>$7.50 each</td>
<td>$7.50</td>
</tr>
<tr>
<td># NV-12 NiCd Battery set(s)</td>
<td>$17.00</td>
<td>$17.00</td>
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<tr>
<td># TP-20 Touch and Hold Probe(s)</td>
<td>$18.00</td>
<td>$18.00</td>
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<tr>
<td>For delivery in Texas, add 5% Sales Tax</td>
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I enclose ( ) check ( ) money order for TOTAL $ __________

or, please charge to my ( ) Visa ( ) MasterCharge Code # __________

Account No. __________ Expiration Date: __________

Name __________________________
Street __________________________
City __________ State __________ Zip __________________________

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July 1979
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Mail today!
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, stern-drive/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
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 V27Z60 or similar suppressor can be installed between the regulator’s input and ground for voltage-spike protection.

![Fig. 1. Circuit for monitoring battery, generator or alternator has overvoltage warning feature.](image)

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 visibility.

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. 2. Overvoltage indicator has a flash rate of 1.5 Hz.](image)

![Fig. 3. Low-level detector flashes LED when probe in tank is exposed.](image)

**PARTS LIST (Fig. 1)**

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>18-V, 1-W zener (1N3026B or similar)</td>
</tr>
<tr>
<td>IC1</td>
<td>LM3914 dio/bar driver (National)</td>
</tr>
<tr>
<td>IC2</td>
<td>10-V, 1-A positive voltage regulator (LM340T10 or similar)</td>
</tr>
<tr>
<td>LED1, LED2, LED3, LED11</td>
<td>Discrete red LED</td>
</tr>
<tr>
<td>LED4, LED5, LED6</td>
<td>Discrete yellow LED</td>
</tr>
<tr>
<td>LED7, LED8, LED9, LED10</td>
<td>Discrete green LED</td>
</tr>
<tr>
<td>Q1</td>
<td>2N2222 transistor</td>
</tr>
<tr>
<td>R1</td>
<td>200-ohm, pc multiturn trimmer pot</td>
</tr>
<tr>
<td>R2</td>
<td>1200-ohm, 1/2-W resistor</td>
</tr>
<tr>
<td>R3</td>
<td>100-ohm, 1/2-W resistor</td>
</tr>
<tr>
<td>R4</td>
<td>470-ohm, 1/2-W resistor</td>
</tr>
<tr>
<td>R5</td>
<td>1000-ohm, 1/2-W resistor</td>
</tr>
<tr>
<td>R6</td>
<td>10,000-ohm, 1/2-W resistor</td>
</tr>
</tbody>
</table>

Misc. — Perforated or printed-circuit board; suitable enclosure; IC sockets (optional); light hood; red filter; etc.

**PARTS LIST (Fig. 2)**

<table>
<thead>
<tr>
<th>Part</th>
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</tr>
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<tbody>
<tr>
<td>C1</td>
<td>4.7-µF, 15-V electrolytic</td>
</tr>
<tr>
<td>C2</td>
<td>0.01-µF disc capacitor</td>
</tr>
<tr>
<td>IC3</td>
<td>555 timer</td>
</tr>
<tr>
<td>R9</td>
<td>100-ohm, 1/2-W resistor</td>
</tr>
<tr>
<td>R10</td>
<td>100,000-ohm, 1/2-W resistor</td>
</tr>
<tr>
<td>R6, R7, R8, D1, LED11, Q1</td>
<td>Same as Fig. 1</td>
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</table>

**PARTS LIST (Fig. 3)**

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0.001-µF disc capacitor</td>
</tr>
<tr>
<td>C2</td>
<td>0.05-µF disc capacitor</td>
</tr>
<tr>
<td>IC1</td>
<td>LM1830 fluid detector (National)</td>
</tr>
<tr>
<td>LED1</td>
<td>Bright red LED</td>
</tr>
<tr>
<td>R1</td>
<td>470-ohm, 1/2-W resistor</td>
</tr>
</tbody>
</table>

Misc. — Suitable stainless probe; cable; 10-V regulated dc source; etc.
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 that it is capable of detecting the appropriate liquid level on a set of LED readouts.

**PARTS LIST (Fig. 6)**

- C1—0.002-µF disc capacitor
- C2—0.006-µF disc capacitor
- C3—10-µF, 15-V electrolytic
- IC1—LM1830 fluid detector (National)
- LED1—Bright red LED
- Q1—2N2222 transistor
- R1—2200-ohm, 1/2-W resistor
- R2—470-ohm, 1/2-W resistor
- Misc.—10-V dc regulator; interconnecting cable; etc.
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.

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.
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 gain 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 source. 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 ½-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 dBi). 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 accompanying table compares antenna gains for some common antennas referenced to isotropic, ground plane, and dipole antennas.
HE 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: $G(dB) = 10 \log_{10} (P_O/P_I) = 10 \log_{10} (K)$. 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: $P(dBm) = 10 \log_{10} (P_{mw})$ or $30 + 10 \log_{10} (P_I)$. When $P_{mw}$ is the power in milliwatts and $P_I$ is the power in watts.

For example, 10 watts is 10,000 milliwatts, so $P(dBm) = 10 \log_{10} (10,000) = 10 (4)$ or +40 dBm. Also, $P(dBm) = 30 + 10 \log_{10} (10) = 30 + 10$ or +40 dBm. One microwatt is 0.001 milliwatt, so $P(dBm) = 10 \log_{10} (0.001) = 10 (-3)$ 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 $P_{dB}$ into watts, milliwatts, or gain factors (power ratios),
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use these relationships: $P_w = 10^{\log_{10} \frac{P_{\text{dBm}}}{100}}$, $P_{\text{mw}} = (10^\frac{K}{10})^{\log_{10} \frac{P_{\text{dBm}}}{100}}$, where $P(\text{dBm})$ is the power in dBm, $P_w$ is the power in watts, $P_{\text{mw}}$ is the power in milliwatts, $G$ the gain in decibels, and $K$ the gain factor or power ratio. Similarly, $P_{\text{mw}} = 10^{G}P_{\text{dBm}}$ and $P_w = 10^{\log_{10} \frac{P_{\text{dBm}}}{100}}$ where $P(\text{dBm})$ 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, $80 \text{ dB} = 40 \text{ dB} + 40 \text{ dB}$, so $K80 \text{ dB} = (K40 \text{ dB}) (K40 \text{ dB})$ 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: $+80 \text{ dBm} = +50 \text{ dB} + 30 \text{ dB}$, and $P_w = (100 \text{ watts}) (1000) = 100,000 \text{ watts}$.

**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: $G(\text{dB}) = 20 \log_{10} \frac{V_0}{V_1}$, where $V_0$ and $V_1$ 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 $P = E^2/Z$. $P_1 = 1^2/50 = 1/50 = 0.02 \text{ watt}$ and $P_0 = 10^2/50 = 100/50 = 2.0 \text{ watts}$. Then $K = P_0/P_1 = 2.0/0.02 = 100$ and $G(\text{dB}) = 10 \log_{10} (100) = 20 \text{ dB}$. In the alternative solution, we use the voltage ratio expression: $G(\text{dB}) = 20 \log_{10} \frac{V_0}{V_1} = 20 \log_{10} \frac{10}{1} = 20 \log_{10} (10) = (20)(1) = 20 \text{ dB}$. 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-
TABLE I—DECIBELS VS POWER RATIOS

<table>
<thead>
<tr>
<th>Gain (dB)</th>
<th>Gain (power ratio)</th>
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<td>0.00001</td>
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<tr>
<td>-45</td>
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<tr>
<td>50</td>
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</table>

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

The receiver 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 H2. 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
### TABLE II—POWER IN dBm VS POWER IN WATTS AND MILLIWATTS

<table>
<thead>
<tr>
<th>Power (dBm)</th>
<th>Power (milliwatts)</th>
<th>Power (watts)</th>
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<tbody>
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<td>-50</td>
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<td>0.0000001</td>
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<td>0.9999993</td>
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<tr>
<td>45</td>
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<td>31.6227722</td>
</tr>
<tr>
<td>50</td>
<td>100000.00000</td>
<td>100.000000</td>
</tr>
</tbody>
</table>

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: $P_R = +50 \text{ dBm} - 6 \text{ dB} + 4 \text{ dB} - 160 \text{ dB} + 9 \text{ dB} - 20 \text{ dB}$ or $-123 \text{ dBm}$. The repeater requires a signal strength of $-113 \text{ dBm}$, so we see that we are $10 \text{ dB}$ too low. Hence, the signal at the output of the repeater will be somewhat noisier.

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 $10 \text{ dB}$ 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 $-113 \text{ dBm}$.

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 $-113 \text{ dBm}$ 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 $+X, -Y \text{ dB}$ 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 ($0 \text{ dB} = 2 \times 10^{-4} \text{ dynes/cm}^2, 2 \times 10^{-4} \text{ microbars}, \text{ or } 10^{-16} \text{ watts/cm}^2$).

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 measur-
ing 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 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 tempertowatt 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 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 dBf 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 milliwatt ($10^{-6}$ milliwatt) into its optimum load, its sensitivity would be

<table>
<thead>
<tr>
<th>Gain (dB)</th>
<th>Voltage Ratio</th>
</tr>
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<tbody>
<tr>
<td>-50</td>
<td>0.00316</td>
</tr>
<tr>
<td>-45</td>
<td>0.00562</td>
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<tr>
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</table>

-60 dB referenced to 1 milliwatt or -60 dBm.

**Volume Units.** Many tape decks’ recorded 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 indispensable tools in electronic circuit and system analysis.
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 $RECT_1$ converts the ac into pulsating dc which is filtered by $C1$. Light-emitting diode $LED_1$ 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 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

---

**TABLE I**

<table>
<thead>
<tr>
<th>Manufacturer’s Type Number</th>
<th>Battery</th>
<th>Recommended Charge Rate (mA)</th>
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<tr>
<td>CH1.2/D</td>
<td>D</td>
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<td>N3500D, GC3</td>
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<td>350</td>
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<td>CD10</td>
<td>D</td>
<td>400</td>
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<td>150</td>
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<td>45</td>
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<tr>
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</tr>
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<td>NB8</td>
<td>8.4-V transistor</td>
<td>9</td>
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<tr>
<td>CD100</td>
<td>8.4-V transistor</td>
<td>15</td>
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**PARTS LIST**

<p>| | |</p>
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<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>$C1$—2200-µF, 35-volt electrolytic</td>
<td></td>
</tr>
<tr>
<td>$D1$—6.8-volt, 1-watt (or greater) zener diode</td>
<td>(see text)</td>
</tr>
<tr>
<td>$LED_1$—Light-emitting diode</td>
<td></td>
</tr>
<tr>
<td>$Q1$—120-watt (or greater) npn Darlington transistor</td>
<td>(Radio Shack RS-2142 276-2042—see text)</td>
</tr>
</tbody>
</table>

The following are 0.5-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 |          |
| $RECT_1$—1.4-ampere, 50-PIV modular bridge rectifier |          |
| $S1$—Spti 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. |          |
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.

THE PE READER.
THE ELECTRONICS ACTIVIST.

Popular Electronics

World's largest-selling electronics magazine for 25 years.
Ziff-Davis Publishing Co., One Park Ave., N.Y., N.Y. 10016
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 $P = I^2 R$, 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.

![Photo of author's prototype shows components mounted on top of enclosure with clip leads used to connect battery to charger.](image-url)
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 center-tapped 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)
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.

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 63. The position of a jumper on the project’s main printed circuit board determines which frequency 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

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
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<tbody>
<tr>
<td>C1 through C12</td>
<td>401 1-µF disc ceramic</td>
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<td>C13</td>
<td>500-µF, 25-volt electrolytic</td>
</tr>
<tr>
<td>D1 through D5</td>
<td>1N4001</td>
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<tr>
<td>F1</td>
<td>1-ampere fast-blow fuse</td>
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<tr>
<td>DIS1 through DIS4</td>
<td>1/2-inch FND70 or similar common-cathode LED display</td>
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<tr>
<td>IC1, IC3, IC4</td>
<td>4518 dual decade counter</td>
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<tr>
<td>IC2</td>
<td>4019 quad 2-input multiplexer</td>
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<tr>
<td>IC4, IC13, IC18</td>
<td>4001 quad 2-input NOR gate</td>
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<tr>
<td>IC5 through IC8</td>
<td>4510 decade counter</td>
</tr>
<tr>
<td>IC9 through IC12</td>
<td>4511 BCD-to-seven-segment decoder/driver</td>
</tr>
<tr>
<td>IC15</td>
<td>555 timer</td>
</tr>
<tr>
<td>IC16</td>
<td>4072 dual 4-input OR gate</td>
</tr>
<tr>
<td>IC17</td>
<td>4002 dual 4-input NOR gate</td>
</tr>
<tr>
<td>IC19</td>
<td>4017 decade counter/divider with 10 decoded outputs</td>
</tr>
<tr>
<td>IC20</td>
<td>7505 5-volt regulator</td>
</tr>
<tr>
<td>K1</td>
<td>12-volt relay with 250-ohm coil and 3-ampere spdt contacts</td>
</tr>
<tr>
<td>LED1, LED2</td>
<td>Light-emitting diode</td>
</tr>
<tr>
<td>OC1</td>
<td>MCT-2 opto-electronic coupler</td>
</tr>
<tr>
<td>Q1</td>
<td>MPSA13 npn Darlington</td>
</tr>
</tbody>
</table>

The following are 1/4-watt, 5% tolerance carbon-composition fixed resistors:

- R1, R2, R3 | 1000 ohms |
- R4 through R7 | 1000 ohms |
- R8 through R12, R48 | 10,000 ohms |
- R8, R13, R14, R15 | 100,000 ohms |
- R16 | 1 megohm |
- R17, R18 | 330,000 ohms |
- R19 through R46 | 3.3 megohms |
- R47 through R48 | 220 ohms |
- R49 through R50 | 150 ohms |
- S1 | 1-pole, 5-position nonshorting rotary switch |
- S2 | Spst toggle switch |
- T1 | 12-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 94042. California residents add sales tax. Foreign orders write for prices. Allow 2 weeks for checks to clear.

AmericanRadioHistory.Com
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" x 2 1/2" (2.5- x 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 STT'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 opto-electronic 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 (it 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

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 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 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.

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

PARTS LIST

- C1—10-μF, 16-volt electrolytic
- D1—IN4001 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, 1/4-W 10% resistor
- R2—220 ohm, 1/4-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.

BY HAL LEFKOWITZ, WB2DEX

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.

POPULAR ELECTRONICS
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

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

BUILD AN ENVELOPE MODIFICATION UNIT

BY JAMES J. BARBARELLO

JULY 1979
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 R2 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.](image)

### PARTS LIST

- **B1, B2**—9-volt battery
- **C1**—1-μF, 25-volt electrolytic
- **C2**—0.01-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**—555 or MC1458 dual op amp
- **IC2**—CA3080 transconductance amplifier
- **IC4**—555 timer
- **R1, R2, R4, R5, R7, R9**—10,000 ohms
- **R3**—100 ohms
- **R6, R10, R11, R12, R13, R14, R15**—330,000 ohms
- **R16—470 ohms
- **R17—470 ohms
- **R18, R19, R20—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.
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 staccato 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.
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.

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

attery; 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. TL 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 measured when a TL490C was connected as shown in Fig. 3.

<table>
<thead>
<tr>
<th>VCC</th>
<th>+10 V</th>
<th>+12 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>No LEDs on</td>
<td>11 mA</td>
<td>11 mA</td>
</tr>
<tr>
<td>5 LEDs on</td>
<td>54 mA</td>
<td>64 mA</td>
</tr>
<tr>
<td>10 LEDs on</td>
<td>93 mA</td>
<td>114 mA</td>
</tr>
</tbody>
</table>

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, it 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 TL49C0 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.
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 \( \text{LED9} \) of each chip (between \( +Vcc \) or \( +VLED \) 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 Experimenters’ 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 over-range 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.
IMPROVING FM RECEPTION

Q. I'm trying to receive a distant (80 air miles) FM station transmitting on approximately 100 MHz, but I'm 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? —Lannie 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 tunable 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 tunable notch 0.25 MHz wide. The Model TFM-2, with input and output impedances of 75 ohms, is a more sophisticated trap comprising two tunable 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.

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 detector elements (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 traveling 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.)
Nakamichi Model T-100 Audio Analyzer

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

T HE 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 them 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 × 9¾" D × 3" H (34.3 × 23.2 × 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 SLED (±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 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

**POPULAR ELECTRONICS**
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 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.

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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 recording cord/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 1 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 vol) 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: −50 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 (0.01%)
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.
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 phonocartridge 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)
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 × 9⅞"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

<table>
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<tr>
<th>Specification</th>
<th>Rating</th>
<th>Measured</th>
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<tr>
<td>Frequency coverage</td>
<td></td>
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<tr>
<td>Band A: 170-400 kHz</td>
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<td>Band B: 530-1500 kHz</td>
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<td>Band C: 1.4-4.0 MHz</td>
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<td>Band D: 3.5-7.5 MHz</td>
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<td>Band E: 7.5-15 MHz</td>
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<td>Band F: 15-30 MHz</td>
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<td>Antenna input</td>
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<td>(Ferrite loopstick on band B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band B: 110 µV/meter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other bands: 1 µV or better</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Measurement method not specified)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band A: 7 µV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band C: 2.5 µV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band D: 2.0 µV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band E: 1.8 µV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band F: 2.0 µV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selectivity (-6 dB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 kHz (wide)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 kHz (narrow)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image rejection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band A: 70 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band B: 65 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band C: 60 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band D: 65 dB</td>
<td></td>
<td></td>
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<tr>
<td>Band E: 60 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band F: 50 dB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate frequencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First: 2.15 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second: 455 kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audio output (8 ohms)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 watts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 watts at clipping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>110 V, 50/60 Hz ac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 10 watts max.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.8 V dc, less</td>
<td></td>
<td></td>
</tr>
<tr>
<td>than 500 mA</td>
<td></td>
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</tr>
</tbody>
</table>

receiver, 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.

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Credit Card No. ............
MasterCharge Bank No. .......
Exp. Date ............

Name:...........................................
Address:...........................................
City:.................................. State:........... Zip:...........

Signature:...........................................

CIRCLE NO. 32 ON FREE INFORMATION CARD
AmericanRadioHistory.Com
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 Pine Crest, Richmond, 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. EVOS—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+ (STRuc-tured 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; LNKED68 a link- age editor utility designed to work with STRU- BAL+ 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 M680. 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 75c 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 75c postage. Creative Computing, Software, Box 769-M, Morristown, NJ 07960 (Tel: 201-540-0445).
AUDI0 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 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.

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 non-redundant 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 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 "1/2-1/2" method or "ratio recording". The limit of speed-variation is reached where the FM detector cannot 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 1/2-1/2 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 1/2 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 Hobbyst newsletter as a local and interchannel 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! 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 do 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.

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JULY 1979

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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-
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 unnecessarily 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 gentleness, 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 operations, 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.

---

**GUAYABERA SHIRT:**

For decades the GUAYABERA shirt has been synonymous with graceful and casual living in Latin America. The elegant design and casual free tailoring will insure confidence in your dress and appearance turning a simple evening into an event.

**Intricate design** — The front and back of the shirt have 3 pleats. Each pleat is formed with 6 double stitched folds with a ½ inch plain stripe in the middle for balance. Each sleeve has a pleat running the length of the sleeve. The bottoms of the shirt and sleeves have an inch and a half border with buttons.

**4 pockets** — are wide and deep allowing you to carry otherwise bulky materials with ease and grace. The unflapped pockets are double stitched.

**Comfortable fit** — the GUAYABERA is designed to wear loosely allowing maximum freedom of movement. The free hanging shirt has two side vents with 3 slits which may be unbuttoned to adjust to your particular build. As the evening wears on the 65% dacron — 35% cotton GUAYABERA will keep its shape and fresh look.

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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!
- 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 numerous technical manuals, including many beginner-oriented publications. Its mailing address is c/o ARRL, 225 Main St., Newington, CT 06111.

JULY 1979

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 ¾, 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
E is not shunted, hence is larger than linear value.

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 ¼ 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
A: ½, E=2/3 x input
At C.T., E=½ x input
At ½, 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.

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Tips & Techniques

MOUNTING FERRITE BEADS
Shielded plugs, adapters, and in-line jacks will easily accommodate ferrite beads, resulting in a shielded 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, Tehran, Iran.

CLEARING METER FRAMES
Plastic meter faces, bezels, and dial windows can be restored by removing scratches and “fogginess” as follows. Using a dry cotton 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

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apply a thin coating of liquid dishwashing detergent to the face. Allow the detergent to dry before re-attaching 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 1/4-inch (3.2-mm) diameter plastic 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 1/4" (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.

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THE BASIC BOOK OF HAM RADIO
by the Editors of Consumer Guide and the American Radio Relay League

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 (8½" x 11"). $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 (8¼" x 11"). $9.95 soft cover.

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PLAY A SUPPORTING ROLE IN THE METROPOLITAN OPERA THIS SEASON.
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 TR-175, 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 (Option) 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.

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-stamped-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” x 3.25” (1.3 cm x 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.

Project of the Month

BY FORREST M. MIMS

Fig. 1. High-current LED pulser.

Fig. 2. Connections for LED pulser.

Fig. 3. Pulser component placement.
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**3 ELEMENT 120 VAC HOTPLATE $6.88 for $5.89**

This Top Quality Multi-Purpose Heat Station. Built-in Thermostat. Novor® Ac Inductor Lamp and I.R. Heat Glass Surface for even heat distribution. Generators up to 180° C. 120 watts. Use for photographic applications, soldering, and for crafting. Price in boxes $10.58 x 5.58 x 1.58 W. 1 Cat. No. 92C02413

**1 AMP 20 for $2.49 MINI RECTIFIERS**

4 FOR $2.50

**25 AMP BRIDGE RECTIFIERS**

2 FOR $1.29

4 FOR $1.30

**1Na000 Epoxy Rectifiers**

2 FOR $1.29

4 FOR $1.30

**LEDs:**

YOUR CHOOSE 4 FOR $1.29

1798 Micro-Temp Red
2381 333U1500 50
2381 333U1500 100
2381 333U1500 250
2381 333U1500 500
2381 333U1500 1000
2381 333U1500 2000
2381 333U1500 5000

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**1 AMP 20 for $2.49 MINI RECTIFIERS**

4 FOR $2.50
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2114     | $6.50
4K (1K x 4) 40NS | $6.50

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---------|--------
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---------|--------
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AY9-1015 | $5.80
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| LED211  | T-1 3mm Green| .14 |
| LED212  | T-1 3mm Yellow| .13 |
| LED220  | T-1/4 3mm Red | .11 |
| LED222  | T-1/4 3mm Green | .15 |
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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 manufacturer, 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 selected 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., use 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 1" 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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