A THEFT ALARM FOR HANDHELD CALCULATORS

14278

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MARCH 1976/75c

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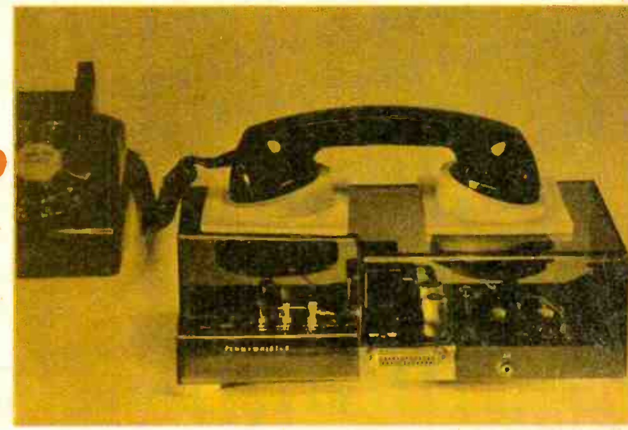
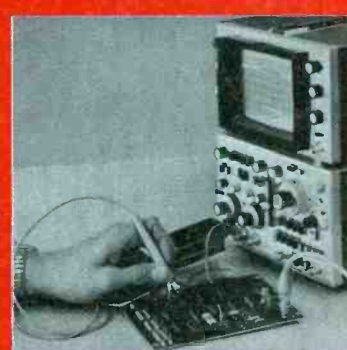


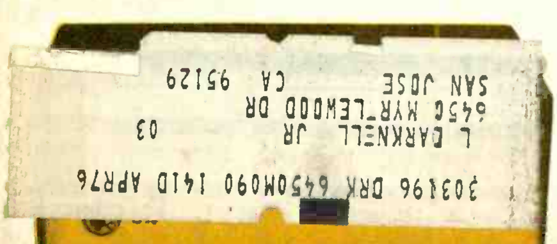
How to Minimize Scope-Probe Combination Errors



The Care & Feeding of NiCd Batteries

A LED-Readout Audio Power Meter

REVEALS POWER LEVELS FROM AMPLIFIERS



TEST REPORTS:

AUDIO: Marantz 5220 Front-Load Cassette Deck
Onkyo TX-220 AM/Stereo FM Receiver

CB: Midland 13-882B Mobile AM Transceiver

PLUS: Heathkit GB-1201 7-Function Stop Watch

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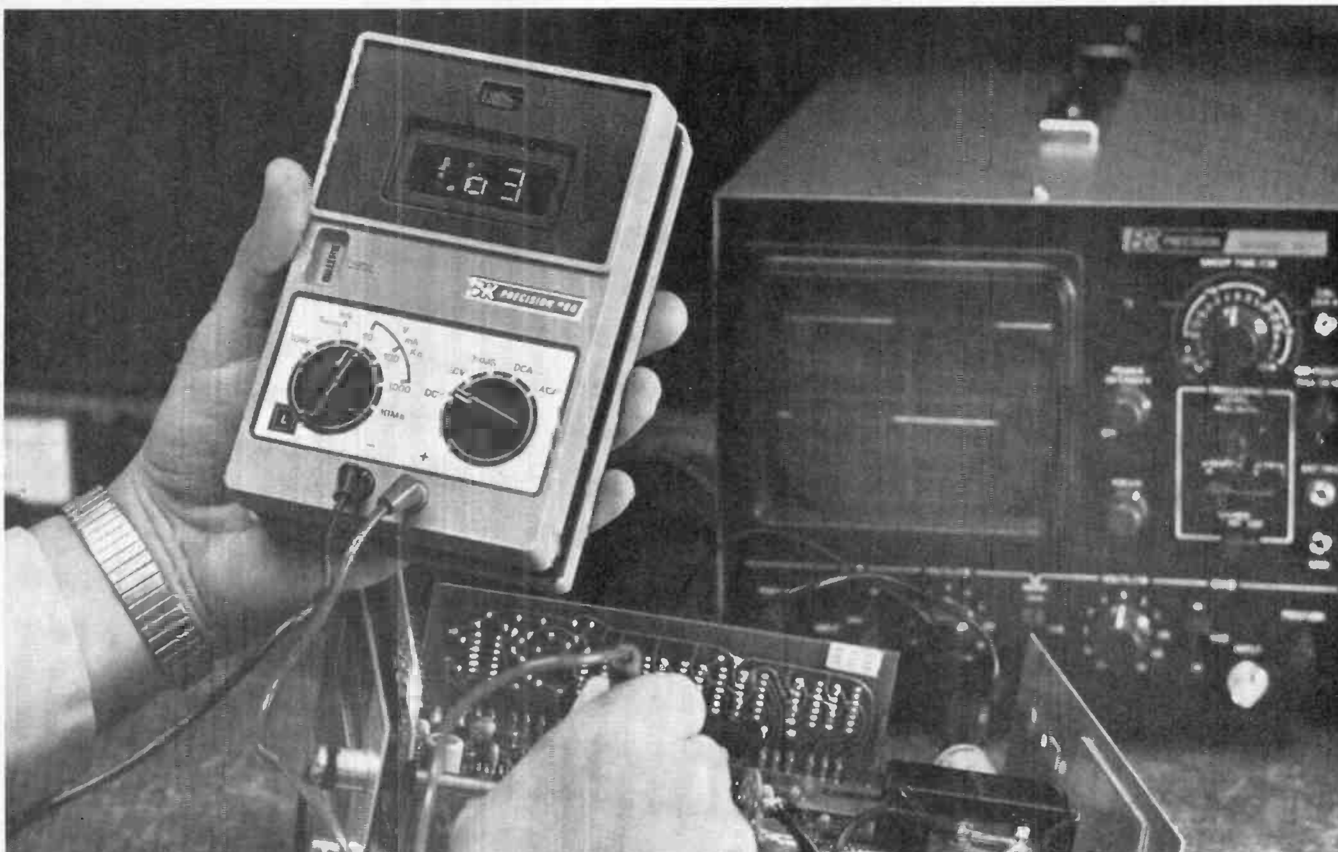

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MARCH 1976 VOLUME 9, NUMBER 3

Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

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Editorial

NEW-PROJECT STUMBLING BLOCKS

There are a handful of exciting construction projects that we've wanted to present to you for the past two years or so. Unfortunately, we couldn't—due to one stumbling block or another.

For example, we've had many electronic games in our hands for use with conventional TV receivers. However, we "blinked" on this one because Magnavox, which claims some fifty patents in this area, initiated a string of infringement law suits (against some manufacturers). Finally overcoming this problem, we faced a second one—Class I device requirements by the FCC.

According to the reg's, one cannot simply remove TV antenna leads and substitute a device to supply a modulated r-f carrier signal directly to the receiver's antenna terminals. The premise here is that many people would not bother to remove the antenna leads, possibly causing reception interference on neighbors' receivers. Furthermore, any old transfer switch may not have sufficient isolation to prevent the minuscule radiation demanded by the FCC.

It was interesting to observe the efforts of one author trying to get type approval of a Class I device for a TV game. Isolation of 60 dB must be provided by the switch, he learned. (A typical toggle switch is lucky to have −10 dB at 60 MHz, and a slide switch might reach −20 dB.) It turned out that there's only one switch that will provide the required −60 dB isolation. The kicker here is that the switch company won't do business for less than a 10,000-quantity purchase. He wound up designing his own! Next, he learned that the device must be clean from 10 kHz to 1000 MHz. How can one be sure that there isn't a tiny 16-microvolt glitch at 999 MHz? Easy. Buy a $23,000 spectrum analyzer (or rent one).

The Class I device mentioned above has been submitted to the FCC for type approval—along with the required $1500 filing fee. If it's accepted, there's a $500 grant fee. If not, there goes $1500.

We don't question the need to protect the consumer from someone transmitting a TV game signal up and down the block. However, the cost for type approval of a device that might sell for about $20 is inordinately high, greatly exceeding charges made by private test laboratories. Moreover, there's a long waiting list in Washington, D.C. for official approval.

Considering all this, we've decided not to wait any longer! So next month we'll publish two electronic TV games—with or without r-f, depending on what happens in the interim period. If type approval isn't received, readers will have to go directly into the TV receiver's video stage to be on the legal side of things.

Another project area that we've been holding back on concerns interconnecting devices to telephones. The FCC has noted that the Carterfone Decision placed the burden of proof of harm to telephone installations by interconnect equipment upon the carriers, not the users. This applies equally to devices which have direct electrical connection. Happily, for hobbyists, the latest FCC pronouncement (Docket No. 19528) covers a registration program for interconnect devices, spelling out technical requirements. The certification program is simple (and free).

An FCC registration number is issued to the applicant, who must notify the telephone company of plans, including the FCC registration number issued. This would be for telephone company informational purposes, not approval. So good-bye acoustic couplers! And to authors out there, let's see those hard-wire telephone innovations that we formerly rejected.

Art Salsberg

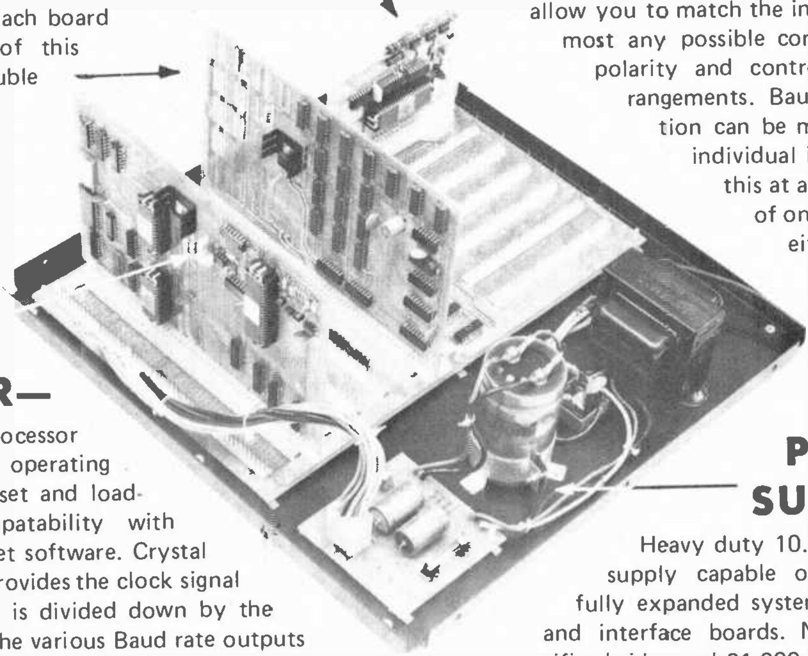
WHY SETTLE FOR LESS— THAN A COMPLETE 6800 SYSTEM

MEMORY—

All static memory with selected 2102 IC's allows processor to run at its maximum speed at all times. No refresh system is needed and no time is lost in memory refresh cycles. Each board holds 4,096 words of this proven reliable and trouble free memory. Cost—only $125.00 for each full 4K memory.

INTERFACE—

Serial control interface connects to any RS-232, or 20 Ma. TTY control terminal. Connectors provided for expansion of up to eight interfaces. Unique programmable interface circuits allow you to match the interface to almost any possible combination of polarity and control signal arrangements. Baud rate selection can be made on each individual interface. All this at a sensible cost of only $35.00 for either serial, or parallel type



PROCESSOR—

"Motorola" M6800 processor with Mikbug® ROM operating system. Automatic reset and loading, plus full compatability with Motorola evaluation set software. Crystal controlled oscillator provides the clock signal for the processor and is divided down by the MC14411 to provide the various Baud rate outputs for the interface circuits. Full buffering on all data and address busses insures "glitch" free operation with full expansion of memory and interfaces.

POWER SUPPLY—

Heavy duty 10.0 Amp power supply capable of powering a fully expanded system of memory and interface boards. Note 25 Amp rectifier bridge and 91,000 mfd computer grade filter capacitor.

Mikbug® is a registered trademark of Motorola Inc.

DOCUMENTATION—

Probably the most extensive and complete set of data available for any microprocessor system is supplied with our 6800 computer. This includes the Motorola programming manual, our own very complete assembly instructions, plus a notebook full of information that we have compiled on the system hardware and programming. This includes diagnostic programs, sample programs and even a Tic Tac Toe listing.

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Letters

MORE CB JARGON

In "How to Use CB Radio 'Buzz' Words" (CB Scene, January 1976), I found some important words missing and some words misused. Below I have listed some of these missing words and definitions, as culled from my own "ratchetjawing" and from friends on the air:

Beaver—any female.

Seatcover—a female in a car.

Ratchetjaw—one who often talks on radio.

Portable parking lot—a truck transporting cars.

Beams—any directional antennas.

Stick—any nondirectional antenna.

Turn the house around—rotating a beam antenna to copy better.

Copy—hear a transmission.

Copy the mail—just listening to the radio with very little talking.

88's—kisses and hugs (for a woman, a sign of affection).

44's—hugs to the little ones.

My goodness!—a pause with no meaning.

Four wheeler—a car.

Eighteen wheeler—a truck.

Junk—a nonderogatory term for radio equipment (i.e. "We may run junk, but we run superior junk!).

Pull the plug—shut off the radio.

Re Linear—one doesn't say he uses a linear, but he may imply it by indicating he's wearing sneakers.

Candyman, Federal Candy Co., Candy Paper—the first two refer to the Federal Communications Commission (FCC), the last to the tickets it issues.

Green stamps—dollars.

Grasser—low in signal strength.

—Allan S. Adelman, Philadelphia, Pa.

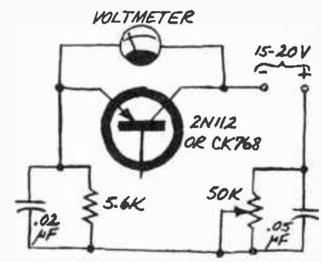
BROBDINGNAGIAN IC'S?

I was very interested in building "A Wireless Audio System For Remote Speakers" (January 1976). After looking at the etching and drilling guides for the transmitter and receiver, it appears that you goofed and printed enlargements.—*E. Taffe, W2IGR, Palisades Park, N.J.*

Yes, the guides were mistakenly published two times actual size. If you're making your own boards and are not equipped to photographically reduce the guides, send a self-addressed, stamped envelope to POPULAR ELECTRONICS and we'll send you the proper-size guides.

AN ALTERNATE APPROACH

In the "Negistor" article (December 1975), it was stated that oscillation was obtained from an npn transistor with open base under reverse-bias conditions. I have obtained similar results from the same type of circuit and also from forward-biased *pnp germanium* transistors. One of my pnp circuits is shown below. To test for negative



resistance, I adjust the setting of the potentiometer so that the voltmeter's pointer rises to a peak indication and then begins to fall back toward the zero index. The oscillations I have observed with such a circuit have a sinusoidal waveform and a 0.5-volt peak at about 7000 Hz.—*I. Queen, Brooklyn, N.Y.*

OCTAL VERSUS HEXADECIMAL

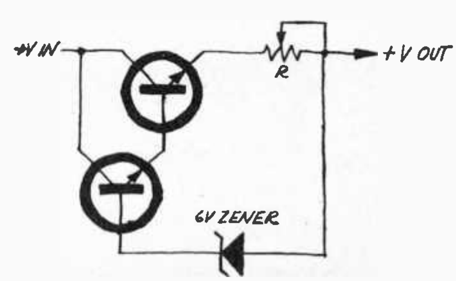
I take exception to the statement in the November 1975 Computer Bits column that only "pockets" of programmers still use octal notation. On the contrary, octal notation is currently in widespread use. In fact, I wouldn't hesitate to say that it is more widely used than hexadecimal notation. The reason is that there are more computers of all types (particularly micro's and mini's) designed for eight-bit octal documentation than there are 16-bit hexadecimal machines.—*Don R. Walters, Ann Arbor, Mich.*

CREDIT WHERE CREDIT IS DUE

"Programming the Altair 680" (December 1975) was erroneously bylined by Paul Van Baalen and me. The credit for writing this article rightly belongs to William H. Gates.—*H. Edward Roberts, Albuquerque, N.M.*

MISSING CIRCUIT

The diagram below should have appeared in the February Letters column with John Hanson's suggestion for a simple current-limiting circuit for pass-transistor regulators.



For the $400-class CB customer Realistic has what's really new and 4000 places to find it.

Reading time 48 seconds:

Not everyone has four C-notes to lay out for hobby or business equipment. But on the other hand, the new Realistic Navaho TRC-57 actually costs no more than a basic 35mm SLR camera. And for 399.95* you get an AM/SSB base/mobile transceiver with everything you'd expect — plus a lot you wouldn't. ✚ Digital phase-locked synthesizer and crystal lattice filter for unusual selectivity. ✚ Automatic modulation gain control for full power always, whether you talk loud or soft. ✚ ANL and blanker for chopping out noise. ✚ LED-indicator AM/USB/LSB mode lights. ✚ Separate SWR and S/RF power meters that turn red on transmit. ✚ Precise LED-readout clock switchable for 12 or 24-hour time. And of course it's FCC Type Accepted and UL listed. The new Navaho. You get something more by accepting nothing less!

*Retail price may vary at individual stores and dealers.

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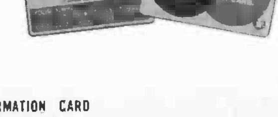

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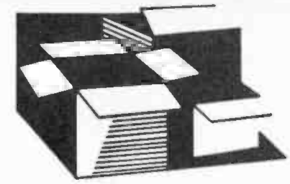
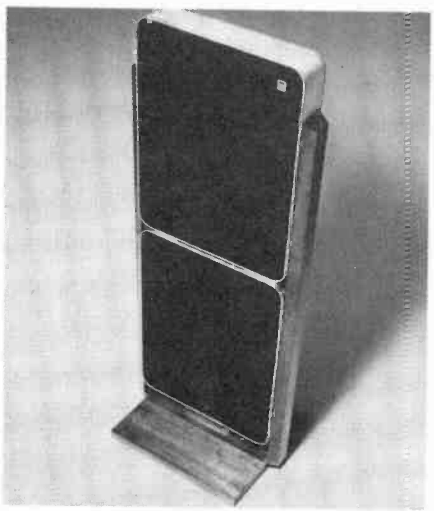


New Products

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

FOUR-DRIVER SPEAKER SYSTEM

Bertagni Electroacoustic Systems, Inc. now has a four-driver speaker system which incorporates no-cone, no-piston technology and nonenclosure styling, the Model d120. With a sound-radiating area of 1700 sq in., it is the largest of the Geostatic™ line but measures only 3¾" front-to-back. Thinness is achieved by exciting a



tension-flexed diaphragm; separate areas of the diaphragm are activated by multiple drivers to produce high, middle, and low frequencies. Claimed frequency response is 25 to 20,000 Hz ±2 dB, HD is 1.2% measured with 90 dB, 80-Hz tone at 1 meter. The d120 will handle up to 250-W rms, but operates on power as low as 25-W rms. $499.00.

CIRCLE NO. 84 ON FREE INFORMATION CARD

PACE CB TRANSCEIVER WITH WEATHER CHANNELS

Pace's new Model CB 145 mobile transceiver provides synthesized 23-channel coverage, as well as receive capabilities on the two NOAA vhf weather channels. Features 4-W r-f output, delta tune, noise blanker, anl, r-f gain control, S/r-f meter, and switch-selected PA operation. Also has indicator lights for transmit and receive, as well as CB, WX-1, and WX-2 operating modes. Comes with a dynamic PTT mike. $209.95

CIRCLE NO. 85 ON FREE INFORMATION CARD

ECONOTRACE CURVE TRACER

Lab Science's Model EC-101 Econotrace displays semiconductor characteristic curves on any scope having an external horizontal input. The device has switches for polarity selection, base current per step in microamps, and also has two transistor sockets on the front panel. The display is sized using the scope's vertical gain control. Leakage, noise, saturation voltage, linearity, breakdown, and beta can be measured. The Econotrace operates from a 9-volt battery which has a normal operational lifetime of one year. Current limiting and low test voltages protect the device under test. Measures 4" × 2⅞" × 1⅞" (10.2 × 7.3 × 4.8 cm), weighs 2 lb (0.91 kg). $39.50

CIRCLE NO. 86 ON FREE INFORMATION CARD

MOBILE TRANSCEIVER LOCK

Shur-Lok Manufacturing's Model CB 700 is designed to discourage the theft of your mobile transceiver. The locking bracket is made of heavy gauge metal stampings and is electroplated flat black. The lock, according to Shur-Lok, has tempered shackles, a pick-proof barrel, and two keys. It can be adjusted to fit up to the largest AM/SSB mobile transceiver currently on the market. $14.95

CIRCLE NO. 87 ON FREE INFORMATION CARD

REALISTIC MOBILE PA AMPLIFIER

Radio Shack announces its new Realistic Model MPA-10 mobile PA amplifier. Designed to operate from 12-volt dc sources, the solid-state amplifier is rated at 10W rms output into 8 ohms. Claimed frequency response at full power is 200 to 10,000 Hz. Has tone and volume controls and push-button selection of MIC or AUX inputs. Measures 6½" × 4⅛" × 1½" (16.5 × 10.5 × 3.8 cm) and comes with a dynamic mike, hanger, and mounting hardware. $39.95

CIRCLE NO. 88 ON FREE INFORMATION CARD

REMOTE-READING RAIN GAUGE

An Electronic Digital Rain Gauge (No. 72,165) for gardening hobbyists, farmers, homeowners, and weather buffs empties


ALTAIR 680
ALTAIR DISK
ALTAIR 8800 COMPUTER

itself; is said to accurately record rainfall up to 100 feet away, by tenths of an inch, to 999.9". Accumulated total inches of rainfall for any period (hour, day, week, etc.) can be recorded; the counter can be reset to start a new count period. The hermetically sealed outdoor collector includes 30 ft. of waterproof wire. A 9-V transistor battery powers the device. Edmund Scientific Co. markets the unit at $44.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

DC REGULATED POWER SUPPLY KIT

GC Electronics' Calectro Division has a ready-to-assemble dc regulated power-supply kit, Cat. No. G2-100. It can be used in place of batteries in radios, tape recorders, and other electronic devices using 2 to 25 V, up to a current drain of 500 mA. Voltage output remains constant, even when output load varies from zero to full load. The kit comes with an illustrated, step-by-step instruction booklet.

CIRCLE NO. 91 ON FREE INFORMATION CARD

3M/WOLLENSAK CASSETTE DECK

The new Model 4766 by 3M/Wollensak is a stereo cassette deck with a direct-drive transport. It also has a bias switch to match the deck for use with ferric-oxide, chromium-dioxide, or ferri-chrome tape. Peak indicator lights monitor transients while recording and VU meters monitor average signal levels. Dolby noise reduction circuitry is built-in. $429.95.

CIRCLE NO. 92 ON FREE INFORMATION CARD

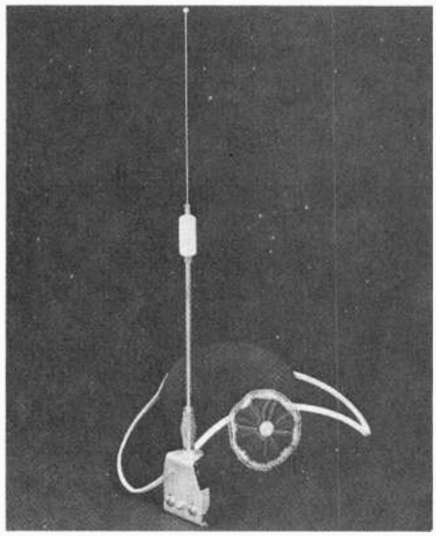
TENNELEC MEMORYSCAN MONITOR

Tennelec's Memoryscan Model MS-2 allows the listener to monitor 16 channels in the vhf LO and HI bands, as well as the uhf band. Frequencies assigned to these channels may be changed at any time without installing new crystals. To program the scanner for any of the 4000 public service channels listed in Tennelec's special code book, the number sequence corresponding to the desired frequency is punched into the scanner. The Memoryscan can receive on up to 16,000 frequencies, has FET r-f stages, automatic or manual scan control, channel lockout switches, and squelch. $339.95.

CIRCLE NO. 93 ON FREE INFORMATION CARD

GUTTER-MOUNT CB ANTENNA

A low-profile 27-MHz CB antenna, designed to be installed on any vehicle rain gutter, is now available from Breaker Corp. Known as the "Independence" (Model 10-245), it is 28 inches long; the top whip is



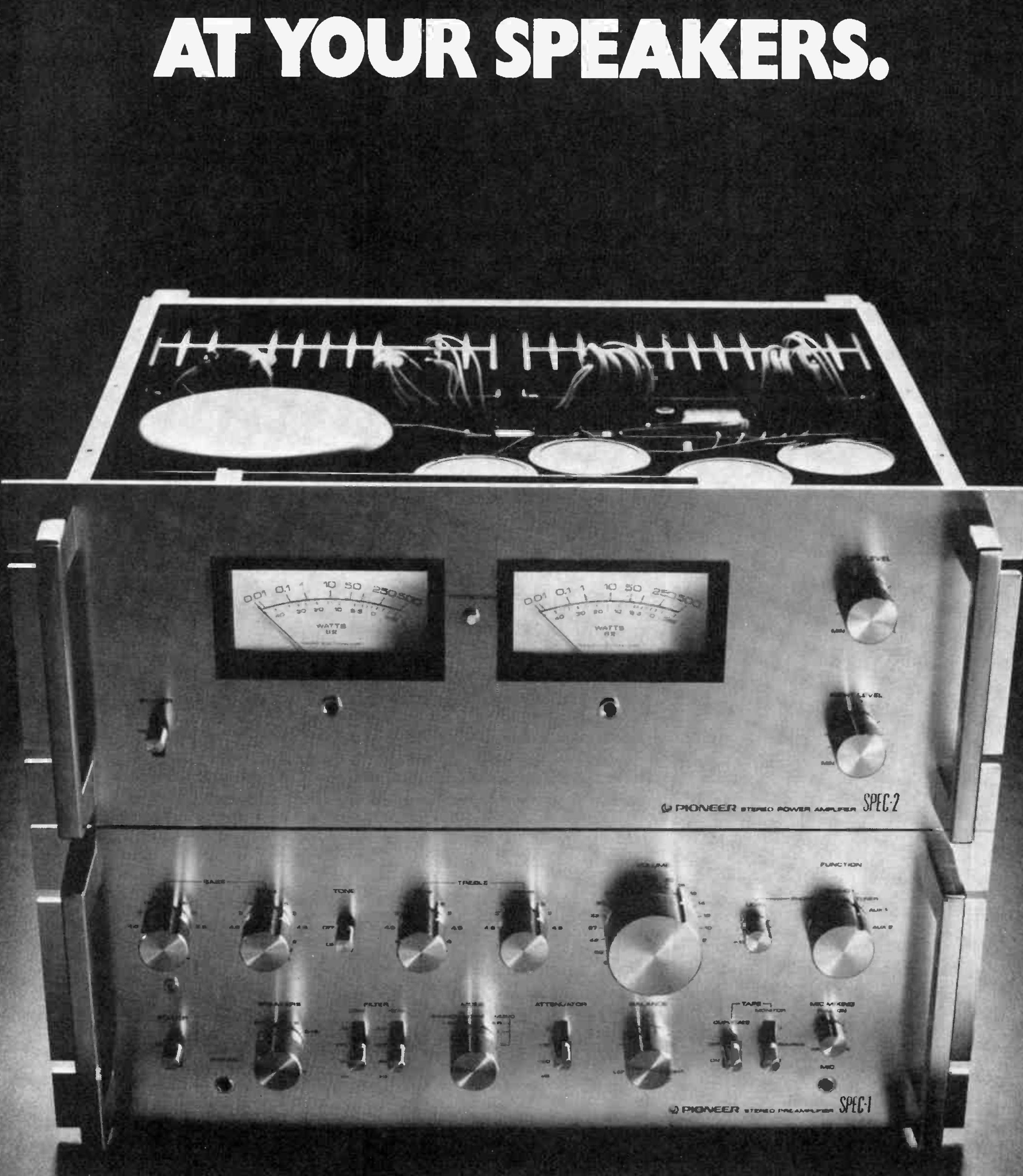
stainless steel and the base chrome-plated brass. The whip includes a static arrester and has a pre-tuned heavy-duty ABS-encapsulated center load coil; an auto-flex, stainless-steel spring relieves whip shock. The antenna comes packaged with Allen wrench for fine tuning, 10-ft coax cable with PL-259 plug, and complete instructions. $22.95.

CIRCLE NO. 94 ON FREE INFORMATION CARD

TEKTRONIX SINGLE-TRACE OSCILLOSCOPE

Tektronix's Model T921 oscilloscope is a single-trace unit with mono time base. Vertical bandwidth is dc to 15 MHz, with 2

PIONEER INTRODUCES AN AMPLIFICATION SYSTEM THAT WILL FORCE YOU TO TAKE A HARD LOOK AT YOUR SPEAKERS.



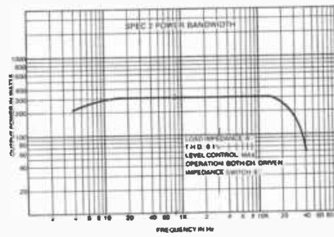
Pioneer's new Spec 1 and Spec 2 are capable of producing a level of high-quality sound most speakers are simply incapable of reproducing.

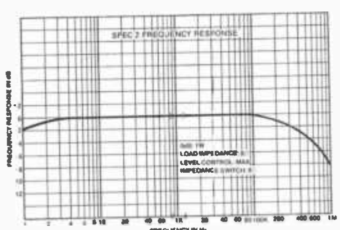
So, unless you're willing to listen to Spec 1 and Spec 2 at something less than their full potential, don't make the decision to invest in them if you're not prepared to invest in a new pair of speakers.

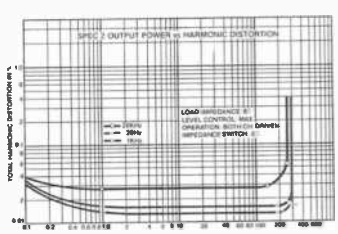
SPEC 2: 250 GOVERNMENT-APPROVED WATTS A CHANNEL

Spec 2 was the first power amplifier designed to deal with the new F.T.C. power regulations. It has a continuous power output of 250 watts per channel minimum RMS. At 4 or 8 ohms. From 20 to 20,000 Hz. With no more than 0.1% harmonic distortion.

Other power amplifiers that used to claim a lot more power can't do that anymore.







WHO NEEDS ALL THIS POWER AND WHY

When you listen to a live performance it can have an average sound level of 84 dB. Which most high fidelity systems can reproduce with half a watt of power. But a sudden musical peak of 110 dB takes four hundred times as much power. Which means you need 200 watts of power to reproduce that peak. If your amplifier doesn't have that much reserve power, you get "clipping." Which doesn't happen during a live performance.

So, if you want your system to be able to give you all the power, all the sheer presence of live performance, you need an amplifier with all the reserve power of the Spec 2.

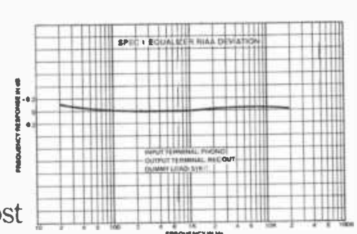
STATE-OF-THE-ART DESIGN

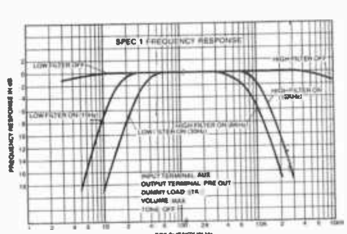
Spec 2 not only produces an uncompromising amount of sound; it does so in a totally uncompromising manner.

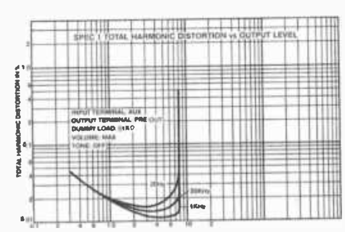
For example, Spec 2 uses an advanced toroidal coil power transformer. It's a more expensive transformer than most amplifiers use. But a more efficient transformer. And one that keeps magnetic flux leakage to an absolute minimum.

Also unlike many power amplifiers, Spec 2 doesn't use fans. Because fans can cause noise. Instead, Spec 2 has massive heat sinks and special Pioneer-developed protective circuitry to keep the operating temperature under control.

Spec 2 even has wattage meters that indicate music output in RMS watts at 8 ohms. These had to be specially designed, too. Because conventional VU meters couldn't give an accurate enough power reading.







SPEC 1: TWICE THE CONTROL OF MOST PREAMPLIFIERS

Most preamplifiers have two tone controls. Some have three. But Spec 1 has four. Each of which is calibrated in 1.5 dB clickstops. All together, they give you a total of 5,929 ways to compensate for any deficiencies in program material or listening area.

And, so you can make sure you've made all the right adjustments, Spec 1 has a "tone off" switch that lets you compare your setting with a completely flat setting.

Spec 1 even has its own microphone amplifier, with its own volume control. So you can mix into any program material without touching the main volume control.

THE BEAUTIFUL SOUND OF NOTHING

One thing Spec 1 doesn't do is add anything to the sound it reproduces. The phono section has a completely inaudible signal-to-noise ratio of 70 dB (IHF, short-circuited A network). All other inputs are rated at 90 dB. Which is even more inaudible. And it has a total harmonic distortion of no more than 0.03%. Which is five times under what your ear is capable of detecting.

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Both Spec 1 and Spec 2 are 19" wide. So you can place them in any standard EIA laboratory rack.

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SPEC 1
SPEC 2

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SOUND/IR/SOUND XMTR

Revox Corp. has released a number of Beyer Dynamic components for sound-to-infrared-to-sound transmissions. The system consists of the IS76 infrared transmitter with ten transmitter diodes in line, specially equipped with back reflectors; IE76 receiver, designed to be used with existing headphones; DT444 infrared receiving headphone; and charging unit for IE76 and DT444. The system can be used for TV, radio, and hi-fi sound pickup where cable-free listening is desired. Carrier frequency is 95 kHz with FM modulation; max. deviation is 30 kHz at 30 mV/100,000 ohms; frequency range is 40-10,000 Hz. IS76 $92.50; IE76 $76.00; DT444 $119.50; charging unit $12.50.

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New Literature

LITTELFUSE INDICATOR LIGHT GUIDE

Littelfuse's line of indicator lights (Littellites) is highlighted in a six-page, four-color product guide. It contains information on cartridge lamps and lampholders, subminiature and miniature lampholders, and snap-mount Plastic Lites. Address: Littelfuse, Inc., 800 E. Northwest Highway, Des Plaines, IL 60016.

METRIC STANDARDS BIBLIOGRAPHY

Up-to-date information on the availability of metric standards is provided in a new edition of the "Bibliography of Metric Standards" of the American National Standards Institute. Among the areas covered are machinery and hardware. More than 1000 standards, recommendations, and amendments are listed. Single copies of ANSI's "Bibliography of Metric Standards," Special Publication 11b, are available on request. Address: ANSI, Sales Dept., 1430 Broadway, New York NY 10018.

MICROPHONE SELECTION & APPLICATION GUIDE

Tips on how to select and use microphones plus guidelines for on-stage miking are compiled in a new brochure, "The Music-Maker's Manual of Microphone Mastery" from Shure Brothers Inc. In nontechnical terms, the booklet describes how to mike voices and instruments, with techniques for handling troublesome sound pick-up situations. Also featured are recommended microphones for specific instrumental and vocal styles, positioning hints, and descriptions of accessories that can be helpful. Address: Shure Brothers Inc., 222 Hartrey Ave., Evanston, IL 60204.

1976 RADIO SHACK CATALOG

Radio Shack's 1976 Electronics Catalog #263, contains 164 pages (100 in full color) describing the company's complete line of products. Among the new items are a special limited-edition bicentennial radio, a 23-channel CB two-way radio with a telephone-type handset, a new line of Radio Shack pocket calculators priced from $16.95, a digital multimeter, a precision belt-drive manual turntable and a new line of Realistic stereo tape cassette recorders. Also included is a coupon for the purchase of a $1.00 Radio Shack metric slide-rule calculator for 25¢. Address: Radio Shack, Dept. R-19, 2617 W. Seventh Street, Fort Worth, TX 76107.

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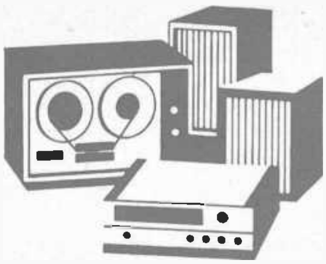

Stereo Scene

By Ralph Hodges

TONE CONTROLS, PLAIN AND FANCY

ONCE again a number of high-quality preamplifiers is being offered without tone controls. The philosophy of the manufacturers involved is, this time, both practical and purist. "You wouldn't want the simplistic bass and treble knobs we'd have to use to keep the design and cost of the product under control," they suggest. "Instead, buy our basic, unadorned preamplifier that contains nothing that will foul up the signal. Then, if you still feel you want tone controls, add a quality equalizer for the desired flexibility." And, of course, as often as not an appropriate equalizer is already on the drawing board of the manufacturer.

Bass and Treble Controls. I can find no fault with the above argument, but as these products fall into my hands from time to time, I realize that I sorely miss the old bass and treble knobs. They helped to provide a frame of reference in a world where equalization of recordings is going in every direction at once. An investigative twitch of the bass control has become almost routine; sometimes there's an additional octave or so of usable low frequencies hiding at the bottom of the spectrum. More often, after a minute or two of listening I'll want to trim the high frequencies in some way, or even run the treble control up full to get a better idea of the noise levels on the recording or the distortion characteristics of a particular phono cartridge. For these purposes, tone controls are cheap and easy. Furthermore, sometimes they are capable of bringing about a genuine sonic improvement in a recording. I am mindful of the purist's admonition against tampering with the sound of the original, but the fact is that the vast majority of commercial recordings come pre-tampered. If you listen only to your own recordings miked in a perfect replication of a Venetian cathedral you can afford to set pretty lofty standards. However, those of us who buy regularly from the major labels need all the help we can get.

Some of the hostility that simple tone controls arouse is understandable. The technically minded note that, since most controls operate within one of the preamplifier's feedback paths, they affect the distortion of the device. The enthusiast who worships at the altar of high fidelity considers them a blatant form of cheating. Often the average listener has found them useless in many situations and so has ignored them. This last is symptomatic of a misunderstanding of what tone controls are likely to be good for, and what they are not.

Occasionally, tone controls are recommended for matching a speaker system's response to the acoustic conditions of the listening room. I have my doubts about this. If the speakers have been placed with reasonable care, a simple shelving of the midrange and treble response to match the bass output should be all that is required. The controls on the speakers should be able to accomplish this, and do it better than most tone controls. For more persistent problems (including a poor speaker to begin with), a tone control's action is usually too gross or too unspecific to make a good correction.

I have always felt that a treble control should be able to ameliorate high-frequency distortion problems that can develop from several sources, but I've never been able to put this theory to work. By the time I've turned down the treble enough to have some effect on the distortion, all traces of musical high frequencies have disappeared. In short, if the music sounds harsh because it is seriously distorted, I wouldn't look to tone controls for a satisfactory remedy.

Bass boost is often useful and often not. Many recordings lack bass because the lows have been sharply rolled off somewhere in production. The typical bass control cannot begin to complement the steep attenuation slope used. Even if the slope is not so steep, the bass control is likely to begin acting at too high a frequency, generating an obnoxious midbass hump in the response. Furthermore, with disc recordings, the low-frequency noise levels that are common will have you playing tag with acoustic feedback as soon as you start advancing the bass knob much beyond its midpoint. Nevertheless, a moderate amount of bass boost can really bring certain recordings to life. Bass cut, on the other hand, is rarely wanted or tolerated except with program material having a restricted frequency response—an unaccompanied male voice, for example.

The opposite is true of the treble control. Turned down, it may be capable of taming many of the over-bright recordings (the British call them "chromium plated") that are always cropping up. Turned up, the treble control generally inundates you with noise—a cure worse than the disease.

Matching the Music. In my experience, tone controls are most useful for "correcting" sins of recording equalization that have been committed by similar circuits. How useful they are in every circumstance is another question. Shown in Fig. 1 is the spectral balance typical of a commercial symphonic recording during a loud orchestral passage. Steady percussion has raised the upper midrange levels somewhat, and the recording is on the bright side, but the overall shape of the curve is representative. Figure 2 shows the same kind of data for a typical pop recording.

(Continued on page 26.)

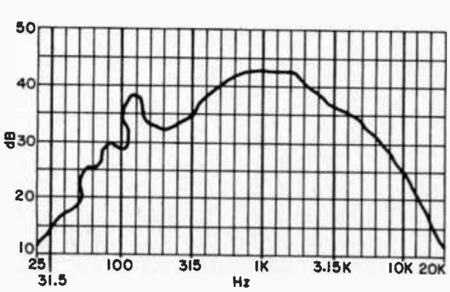

Fig. 1. Dynamic spectrum of a classical recording, measured on a real-time analyzer.

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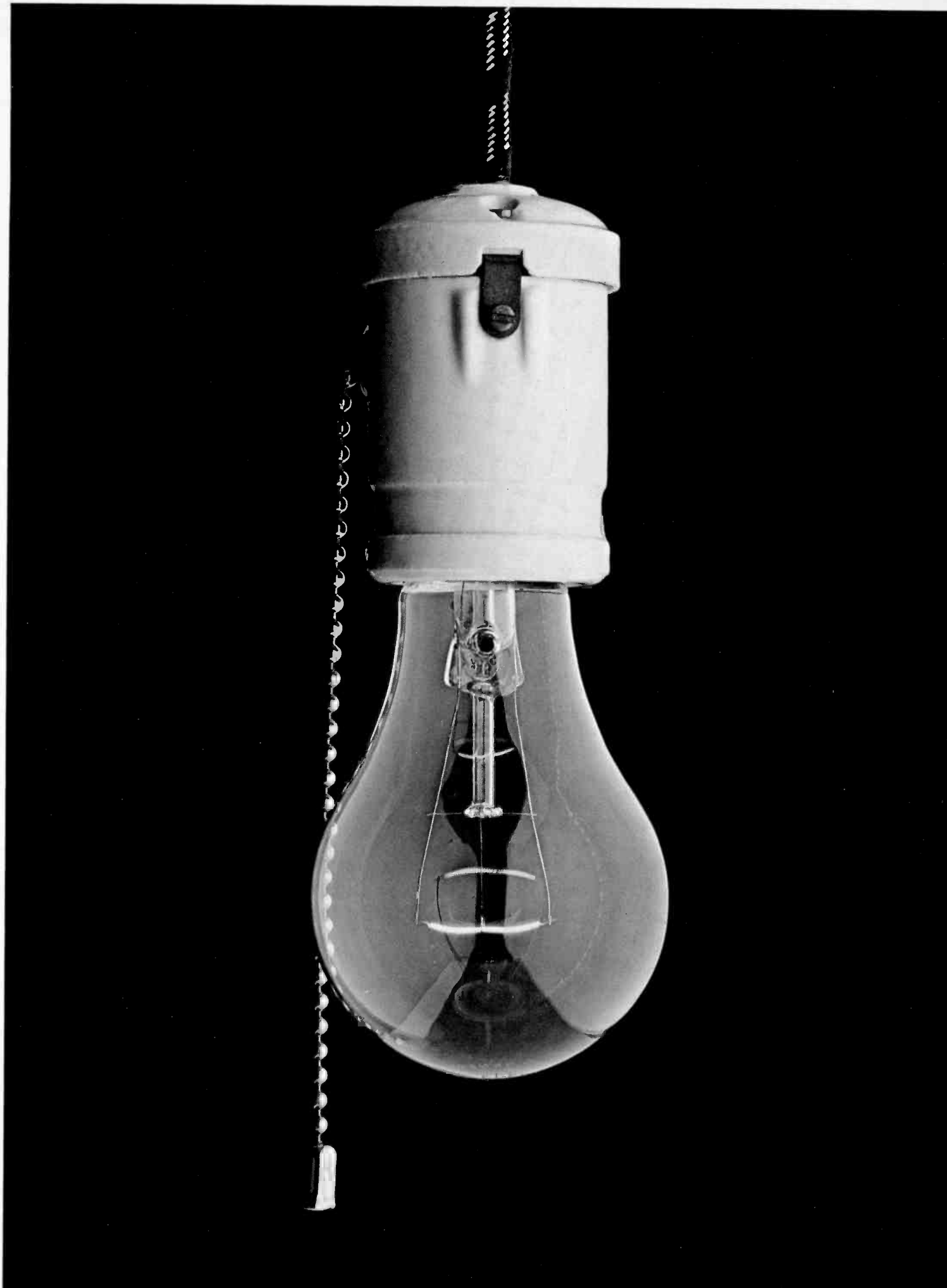

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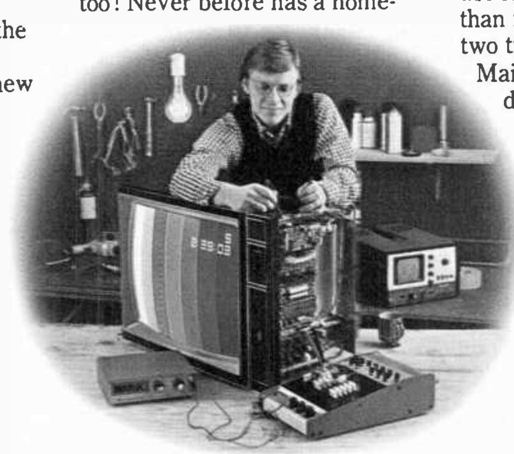

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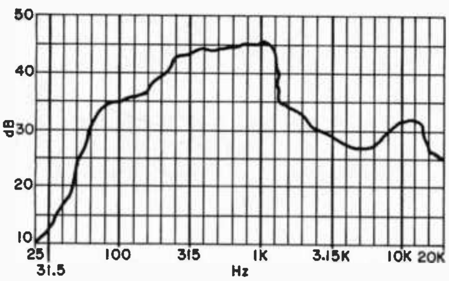

Fig. 2. Dynamic spectrum of a popular recording, measured on the same analyzer as Fig. 1.

At first glance, the family of curves usually available from simple tone controls (Fig. 3) seems like it would fit in well with the classical material if smooth shaping of the final response curve is the object. The pop selection looks too chopped up to be predictable. However, having heard these two recordings, the tone-control correction I'd choose for them would be: do nothing to the treble of the pop selection (which was, after all, meant to sound a little strange and electronic), but add a moderate boost to the deepest bass (which might be handled by the sliding inflection point of the bass control's characteristic). For the classical record, I'd want to tame down the upper register of the violins, which is somewhat strident. Unfortunately, I couldn't do this without applying a greater cut to the extreme high frequencies and losing the attractive sparkle of the percussion. In this case the available tone-control characteristics suit the pop selection better than the classical.

Figure 4 shows the tone-control results for one prominent product on which a great deal of designer concern was lavished. The philosophy was to concentrate most of the controls' effects at the frequency extremes. As you can see (particularly in the treble), the greatest influence occurs at 30 and 20,000 Hz. Sliding inflection points are used for both bass and treble, so that moderate settings leave the range from 100 to 3000 Hz virtually untouched, while greater adjustments move farther and farther into the midrange. During my experience with these controls, I found they were at their best in providing boost. Treble response could be tilted upwards slightly without a great increase in noise between 5000 and 10,000 Hz. But reduced treble was just not as satisfactory, having a muting effect on the extreme highs rather quickly.

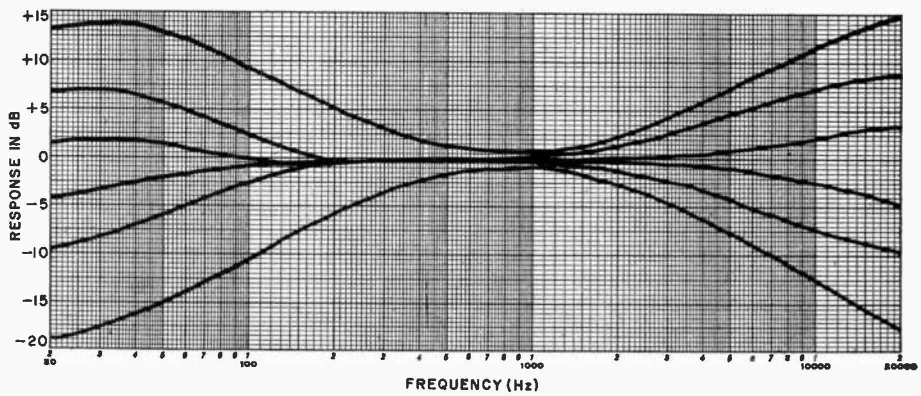

Fig. 4. Tone controls giving these characteristics were designed for maximum effect at frequency extremes.

Another manufacturer follows a different route. His controls really shine when it comes to reducing bass and treble. With a moderate reduction, the treble control ignores the midrange region, but really acts sharply from 2000 to 10,000 Hz to quash the stridency of violins and other high-pitched instruments. At the same time the frequencies above 10,000 Hz are not further reduced, so that much of the sparkle remains. This sort of characteristic will do wonders on, for example, many of the old Bruno Walter recordings from Columbia and its subsidiary labels. At the low frequencies, you can obtain a reasonably sharp bass cut (to reduce rumble and similar noises), but it affects nothing above 60 Hz. If fact, the bass control is generally more satisfactory than the unit's rumble filter for this purpose.

On the boost side, things are less happy. The treble control may readily introduce stridency when all you want is a bit of top-end "tizz," while the bass has excessive effect above 100 Hz.

More Knobs. While some manufacturers are eliminating tone controls, others—especially those in Japan—are giving us more and more. Along with bass and treble knobs, a midrange control (usually centered at about 1000 Hz in its action, and not of a great deal of use in my view) is not unusual. Many tone controls now have switchable inflection or "turnover" frequencies. Perhaps the most useful innovation in terms of precise response shaping is the dual tone-control system, with bass and treble controls for relatively broad-band effect as well as for the frequency extremes (in other words, a total of four controls).

With more controls comes more flexibility but also more complexity of operation, until we get to the paragon, the multi-band equalizer. New equalizers have been appearing in phenomenal numbers of late, and still the surface of design possibilities has barely been scratched. Most current consumer products provide control over fixed frequency bands spaced

(Continued on page 32.)

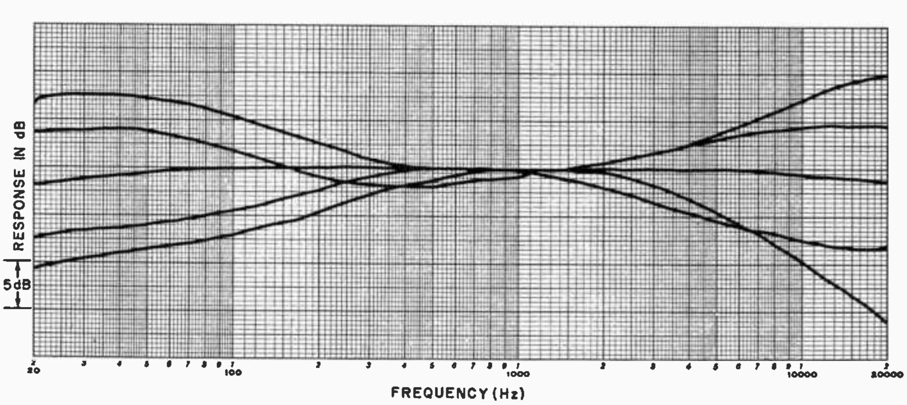

Fig. 3. Typical tone controls affect upper bass and moderate highs as well as extremes.

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Q. What kind of jobs are you talking about?

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Q. But I have a job, and as much as I would like to get into electronics, I can't afford to take time off. How do I get around that?

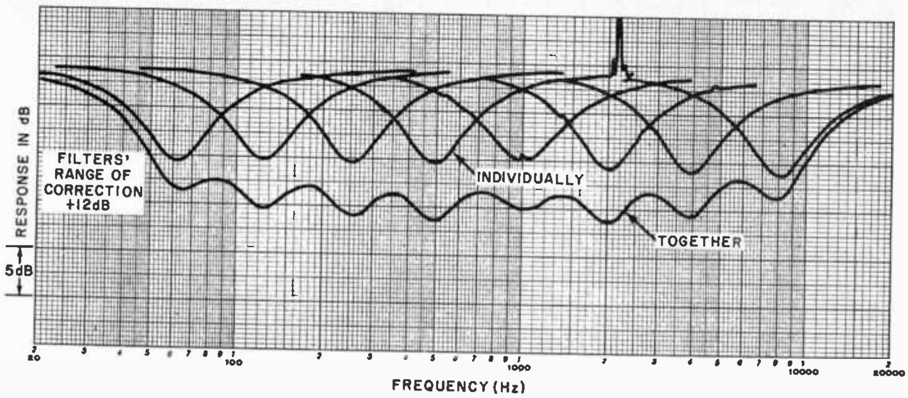


Fig. 5. Combining filters used individually and in concert. Note that the effect of all controls exceeds that of only one.

anywhere from two octaves to 1/3 octave apart, but Technics has demonstrated a prototype with variable band centers and bandwidths. You just tune in on the frequency aberration you want to correct and zap it.

Equalizers are very good in their way—incomparable, in fact, for the purpose for which they are designed. I do not personally find them that much more useful for correcting most individual recordings than simple tone controls. Also, they are much more arduous to use in that application, requiring the finicky adjustment of at least five slide pots for each channel. Most of their appeal lies in the possibility of fine-tuning the loudspeaker/listening-room interaction and making precise, permanent alterations of a system's frequency response. For this sort of use, the simple five-band units with two-octave spacings are rarely versatile enough. The octave-band devices begin to approach the necessary resolution, but the 1/3-octave equalizers are considered much better in most cases.

The more elaborate equalizers (or "filter sets," as they are often aptly called) come in a variety of types: band pass, band rejection, active, passive, boost and cut, cut only, etc. Not all of these are ideally suited to sound-system equalization, but between those that are there is an important distinction to be made: the difference between so-called "graphic equalizers" and the equalizers that use "combining" filters.

The graphic equalizer is the most common type in the consumer area. It apparently got its name because the response curve it introduces can be read roughly from the control settings on the front panel. If the controls are slide pots, their positions form a frequency-response graph that can be interpreted at a glance. The sets with combining filters, of which the best known to consumers is probably the Altec Acousta-Voicette, may look identical to the graphic devices, but their control settings give only the vaguest idea of what's going on inside. Combining filters are intended to interact liberally with neighboring filters, with the result that a variety of slopes, degrees of attenuation, and center frequencies can be obtained by the proper finagling of adjacent filters. This means that even a very complicated response curve can be "dialed in" in great detail. However, the adjustment of the filters is a painstaking process involving careful monitoring with appropriate instruments. A combining-filter set is likely to frustrate even the most expert attempts to use it "by ear." In contrast, the graphic equalizer has fixed center frequencies, and predetermined slopes, and is generally limited to the extremes of boost and cut for each band given in the specifications. Figure 5 shows the effects of combining filters used one at a time and simultaneously. Note that the combining filters together can produce more drastic attenuation than any one filter used individually, and that there is a slight indication in the ensemble curve of the slope variations combining filters can achieve. Figure 6, an actual equalization curve for a sound system, gives a much better idea of how closely a combining filter set can "track" a desired frequency-response curve. A standard graphic equalizer could manage only a very rough approximation.

A final note on elaborate equalizers: they can be enormously useful in "tuning" the overall loudspeaker/listening-room response, as advertised, but they can only be predictably useful under certain well-defined conditions. In a room large enough to support a stable reverberant field (that is, a sound field in which levels and frequency response are almost perfectly uniform throughout), they can equalize that reverberant field with excellent results. Unfortunately, no conceivable home listening room is large enough to qualify.

Conversely, in a smallish room, such as a recording-studio control room, they can equalize the monitoring loudspeakers for any desired response at the ears of some fixed listener. Usually the listener is seated at the mixing console, which is rather close to the speakers; and usually the speakers are quite directional, so that most of their output is beamed right at the head of the listener, with reflected sound contributing very little to what he hears. Should he move away from his favored spot at the mixing desk, chances are excellent that he will hear a significantly different frequency balance, and the same would be true for you at home with your equalized system. This is not to say that equalization can't make great improvements in a

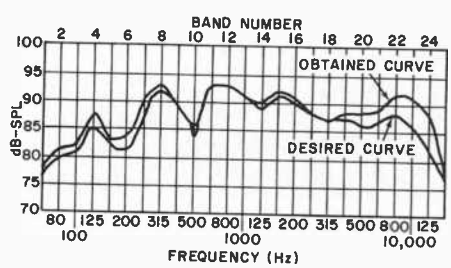


Fig. 6. The interaction of combining filters enables the resulting curve to closely resemble the desired curve.

home sound system. Often it can. But it is in the home environment that it encounters severe limitations.

Syn-Aud-Con. I am indebted to Don Davis for giving me an appreciation of the many nuances of sound equalization. Recently, I attended Mr. Davis's three-day Syn-Aud-Con (Synergistic Audio Concepts) seminar. It is evident that professional sound people are developing some powerful tools in their quest for optimum performance. My hope is that we listeners at home will be able to use these developments to our own benefit. ◈

news HIGHLIGHTS

Digital Watch/Calculator

Time Computer, Inc. has come out with a combination Pulsar quartz timepiece (hours, minutes, seconds, month and date) and microminiature IC calculator. The calculator is capable of providing answers totaling up to 12 figures, displaying the first six significant digits. It has a complete calculator keyboard that enables the wearer to add, subtract, divide, or multiply. It also has a built-in memory, floating decimal point, and percentage key. The unit can be switched from calculator to timepiece at the touch of a single key. The miniature calculator is operated by touching the keys with the retractable plastic tip of a 12-kt gold-filled pocket pen packaged with the unit. The unit is powered by four energy cells, which the company estimates will provide power for as many as 25 calculations and 25 time checks a day for one year. Initial production, limited to a hundred 18-kt gold models, carried a price tag of $3,950. Future models, in less elaborate cases, are planned to sell for considerably less.

Teac To Use dbx NR

Teac has signed a license agreement which will permit it to incorporate dbx noise reduction in its machines in all three tape formats. The system will be the same 2:1 double-ended compression/expansion system presently being marketed by dbx as an outboard accessory and will be compatible with dbx noise-reduction systems now in use.

Back-Up Warning Device

A Japanese firm has developed a vehicular warning device—R-Phone—which talks. Consisting of an IC, waterproof housing, and a plastic speaker, the unit is about the size of an automobile horn. It is designed to be mounted to the rear under-section of any vehicle (motor home, camper, van, auto, truck) and hooked up to the back-up light circuit. When the gearshift lever is put into "reverse," an endless tape repeats the warning, "Watch out, this car is backing up." The device is being imported by Klir, Inc. of Santa Ana, California and will be offered through chain-store outlets and auto accessory stores.

"Instant-On" TV

Beginning January 1, 1977, "instant-on" television receivers will be banned in New York State under a bill Gov. Carey recently signed into law. Designed as an energy-conservation measure, the law applies to units manufactured on or after that date.

Fire Detection Systems

A recent market study by Frost & Sullivan predicts that annual sales of residential alarm devices will grow from $68 million in 1974 to $302 million by 1985. Smoke detectors will be the fastest growing product line, from $12.6 million in 1974 to $107 million by 1985. Other trends include the combination of fire and burglar alarm devices into a single system, the advent of wireless systems and the growing use of solid-state components. Government is stimulating this trend. More and more states are requiring early-warning fire detection devices in new homes. Federal safety standards will soon make smoke detectors mandatory in all new mobile homes. Also, homes underwritten by FHA-sponsored loans must now be protected by smoke detectors.

In a related area, the Protectowire Company (Hanover, Mass.) has developed a line-type detector that is actuated by both radiant and convected heat. The sensor consists of two energized wires encased in a heat-sensitive material. The application of heat anywhere along the line causes the material to yield, and the wires make contact. The resultant current change energizes or releases one or more relays which in turn actuate warning devices. Various sensitivities are available: 155°, 190°, and 280° F (65.2°, 87.5°, and 137.6° C).

Wireless TV Remote Control

A Canadian company, the Keeble Selectra Corp. Ltd., has developed a wireless remote control tuning system which can tune up to 32 vhf channels (including special "cable" channels). The channel control emits an ultrasonic signal (which Keeble claims won't bother your pet), and is roughly the size and weight of a pocket calculator. It can switch a television receiver on or off and change channels from a distance of 20 feet (6 m) and from 45° angles. The receiver unit, called a translator, which sits atop the television, directs the chosen signal from its own tuner to the television's antenna terminals. The translator contains three elements: a mixer, a tuner, and a pc board carrying digital logic and a voltage selector to route the signal to the television. The hand held "channel control" transmitter is battery operated.

Computerized Speech Synthesis

Scientists at the Naval Research Laboratory have developed a computer program that translates English text into synthetic speech. The program applies a limited set of letter-to-sound rules to individual words, and "sounds" them out the way a child does. Thus, it does not require a separate, dedicated computer system, separate storage for a large data base, or computer time to break up and attempt to understand sentences. In an average sample of English text, the system pronounces correctly about 95% of the words, and most errors are obvious enough to be detected by the human operator. In the current system, a commercial speech synthesizer is used.

Popular Electronics®
March 1976

CONSTRUCTION

An LED-Readout Audio Power Meter

BY TIM HENRY

Measures amplifier output, indicates speaker balance, compares speaker efficiencies, and doubles as a VU meter with easy-to-read displays.

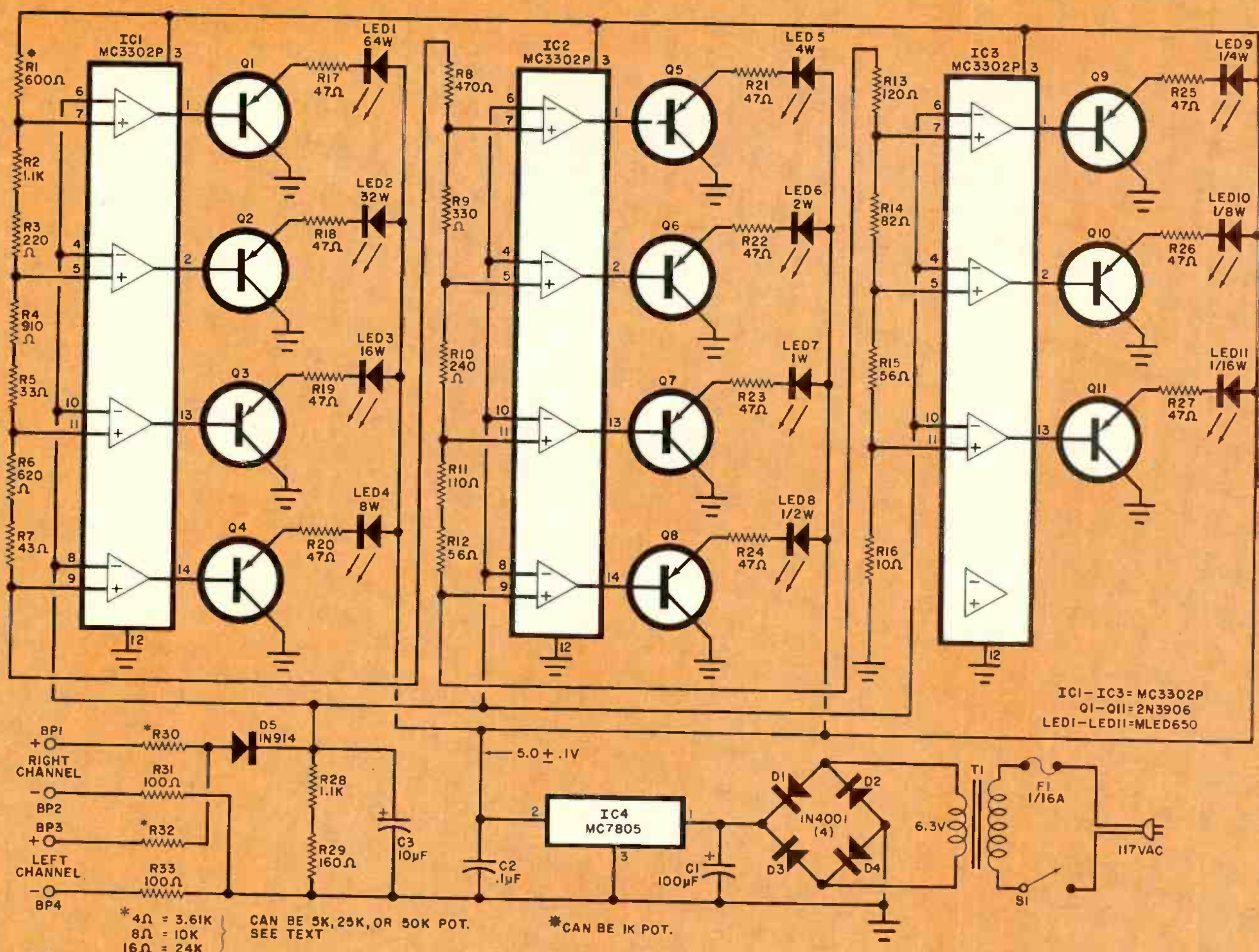
HOW MUCH power does your audio amplifier really put out? How is your stereo channel balance? Which is the more efficient speaker in your unmatched set? These are just a few, among many, questions that are difficult to answer unless you have some very specialized test equipment.

With the audio power meter described here, however, you can get the answers to many questions about your audio system—at a reasonable cost. The meter has an easy-to-read LED display and can also be used as a VU meter. The 11 LED's (light emitting diodes) are arranged in a row and are identified from 1/16 to 64 watts, with each succeeding LED indicating a doubling of audio output power. This means that the lights come on in sequence at 3-dB intervals. (A 3-dB increase means a doubling of power.) Since the human ear has a logarithmic sensitivity, 3 dB is about the minimum change that can be detected.

The meter is capable of operating with 4-, 8-, or 16-ohm speakers simply by changing the values of two resistors. The 0-dB point, or reference, was arbitrarily set at 1 watt.

System Operation. The meter (Fig. 1) is a form of analog-to-digital converter in that it takes the instantaneous voltage across the speaker (an analog signal) and converts it to digital indication to light the LED's. The only difference between this system and conventional A/D conversion is that here there is a nonlinear (logarithmic) relationship between the input and output. The 11 levels are used to create a 2048:1 change, rather than a 11:1 range if the system were linear.

The voltage measured across the speaker terminals is converted to power by using the nonlinear equation $P = E^2R$, where E is the measured voltage and R is the speaker resistance. Then the 11 stages are designed to turn on their respective LED's at the desired power level. Table 1 shows the related values of voltage and power for the 11 steps used in this meter and for three difference speaker resistances. Note that, as the impedance doubles, the voltage values shift up one line. This means that a specific value of voltage, say 2.00, corresponds to a power level



PARTS LIST

BP1 to BP4—Five-way binding post (two red, two black)
C1—100-µF, 25-V electrolytic capacitor
C2—0.1—µF, 100-V ceramic capacitor
C3—10-µF, 15-V electrolytic capacitor
D1 to D4—Diode (1N4001 or similar)
D5—Diode (1N914 or similar)
F1—1/16-A fuse and holder
IC1 to IC3—Quad comparator (Motorola MC3302P)
IC4—5-volt regulator (Motorola MC7805CP)
LED1 to LED11—MLED 650 (or similar)
Q1 to Q11—Transistor (2N3906 or HEP715)
Following resistors are ½-W, 5% unless otherwise specified:
R1—600 ohms (see text)
R2,R28—1100 ohms
R3—220 ohms
R4—910 ohms
R5—33 ohms
R6—620 ohms
R7—43 ohms
R8—470 ohms
R9—330 ohms
R10—240 ohms
R11—110 ohms
R12,R15—56 ohms
R13—120 ohms
R14—82 ohms
R16—10 ohms
R17 to R27—47 ohms
R29—160 ohms
R30,R32—See schematic
R31,R33—100 ohms
S1—Spst switch
T1—6.3-V filament transformer (Stancor P-6465 or similar)
Misc.—Suitable cabinet, line cord, grommets for LED's, press-on type, mounting hardware, etc.
Note—The following are available from MITS, Inc., 6328 Linn, N.E., Albuquerque, NM 87108: printed circuit board only, $6.50; complete kit of parts including pc board but not case, $38.

Fig. 1. As signal input voltage doubles, 11 comparators turn on their associated LED's.

of 1 W across 4 ohms, ½ W across 8 ohms, and ¼ W across 16 ohms. Thus the same circuitry can be used for any of the three impedances simply by changing the values of the input resistors (*R30* and *R32*).

About the Circuit. The input circuit consists of resistors *R30* through *R33*, diode *D5*, and an RC filter consisting of *R28*, *R29*, and *C3*. The filter has a time constant of about 80 Hz. Resistors *R31* and *R33*, in the common (−) inputs, allow the circuit to be used with amplifiers that do not have a common ground for both channels. They provide a low-impedance reference for the circuit but have no effect on the bias of the amplifier.

Resistors *R30* and *R32* reflect a high impedance to the program source because their values are insignificant in parallel with the few milliohms of output impedance of most amplifiers. These resistors take the algebraic average of the voltage across each of the speakers, which causes the power meter to indicate the average power being delivered by the amplifier. This could be extended to use on a four-channel system by adding two more resistors, with all four at 20,000 ohms to maintain a 5:1 ratio.

Diode *D5* prevents the negative half of the audio signal from bringing the comparator inputs below ground and causing possible damage. The diode also rectifies the signal so that the meter can indicate a somewhat average power rather than peak power, which the 80-Hz (low-pass) filter provides. The filter was selected to give good LED response and still provide a reasonably slow LED switching time for the eye to follow.

The eleven differential comparators in *IC1* to *IC3* deliver logic outputs based on the states of their inputs. If a noninverting (+) input is higher than the associated inverting (−) input, the comparator output is high, and vice versa.

The inverting inputs of all comparators are connected together and driven by the input signal. The noninverting inputs are threshold voltages determined by the voltage divider made up of *R1* through *R16*. The divider values are based on the desired power-level increments. Since the inputs to the comparators should not be higher or lower than the supply voltage, the input circuit forms a 5:1 ratio and the corresponding thresholds are similarly reduced. As the output of each comparator switches from high to low, its associated transistor is turned on, causing the LED to glow.

Each LED requires about 20 to 40 mA, while the comparators can sink only 2 mA. Thus the transistors must be used, with series resistors (*R17* to *R27*) to limit the LED current. If more brightness is required, the series resistors can be reduced to 22 ohms.

The power supply is a conventional transformer-diode-filter combination with a voltage regulator (*IC4*) to provide 5 volts. Capacitor *C2* is used for transient suppression.

Construction. The meter circuit can be assembled on perforated board or a pc board (Fig. 2) can be used. Note that the 11 LED's are not mounted on the board. They are connected to the appropriate pads on the board by lengths of insulated wire.

Before installing the comparators (*IC1* to *IC3*), build and test the power supply. (The transformer is not on the board.) Install *IC3*, and the 1/16-watt LED (*LED11*). Connect the positive lead of one of the meter inputs (*BP1* or *BP3*) to the 5-volt dc line and tie the other input leads to ground. When power is supplied, *LED11* should light. If it does not, it may be connected backwards. Remove power from the circuit and install the other two IC's and the remainder of the LED's. The leads for the LED's should be long enough for them to be mounted on the front of the chassis selected.

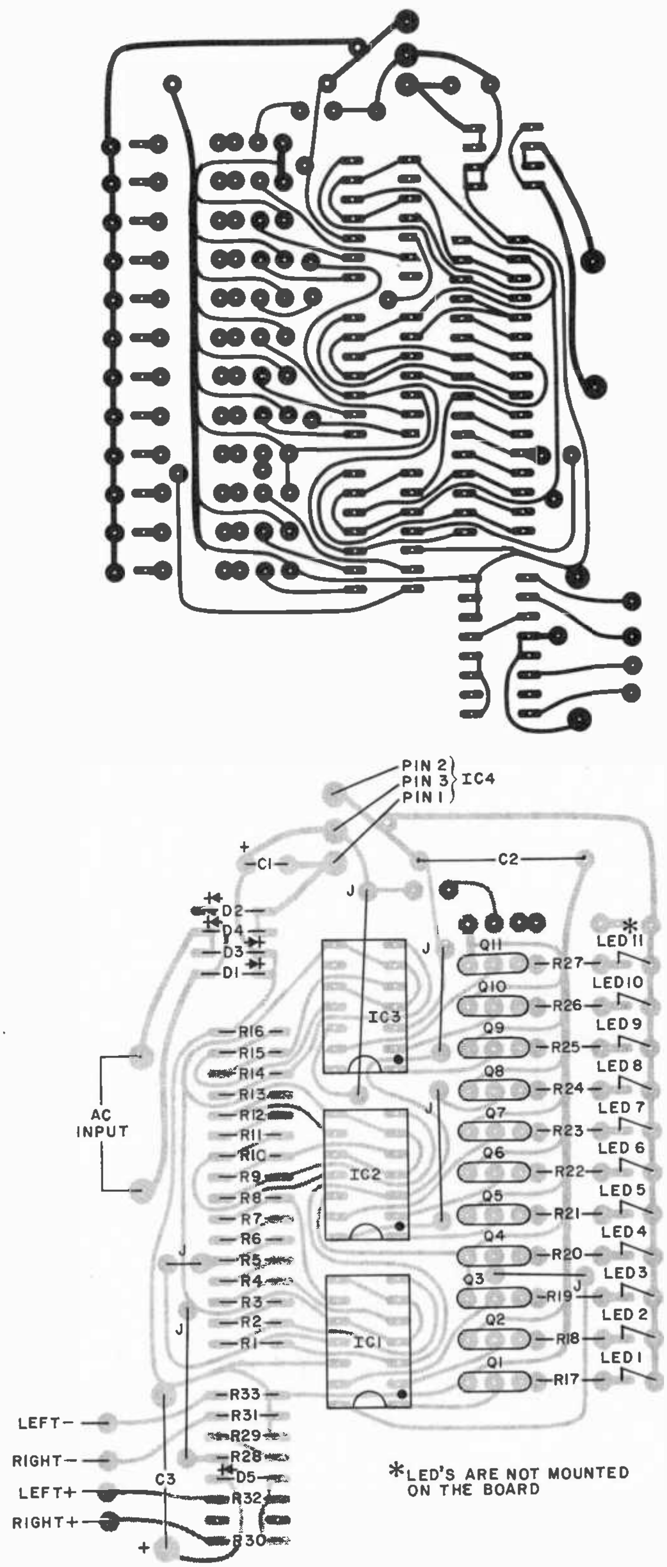


Fig. 2. Foil pattern (top) and component layout for the audio power meter.

With one of the positive inputs to the meter connected to the 5-volt supply, the lowest four LED's should glow. With both positive inputs connected to 5 volts, the lowest six LED's should light. This test indicates whether or not the circuit is operating properly. If desired, the threshold voltages can be checked with Table II, which gives the ideal values—though a 5% tolerance is permitted.

The basic accuracy of the system is directly related to the input divider

TABLE I—VOLTAGES FOR SELECTED POWER LEVELS

Power (watts)	Voltage (across 4 ohms)	Voltage (across 8 ohms)	Voltage (across 16 ohms)
1/16	0.5	0.707	1.00
1/8	0.707	1.00	1.41
1/4	1.00	1.41	2.00
1/2	1.41	2.00	2.83
1	2.00	2.83	4.00
2	2.83	4.00	5.66
4	4.00	5.66	8.00
8	5.66	8.00	11.3
16	8.00	11.3	16.0
32	11.3	16.0	22.6
64	16.0	22.6	32.0

ratio and the voltage levels of the respective thresholds. With 5% resistors, the system has an absolute accuracy of 5%. A potentiometer can be used for *R1* for calibration adjustment. This allows correction for the input divider adjustment of the power supply threshold reference voltage, and setting any particular threshold to its exact value. To calibrate the meter with a potentiometer at *R1*, adjust the pot until the voltage at pin 7 of *IC2* is precisely 0.436 volt. All of the other thresholds should then have an accuracy of 2.5% or better.

If 5% (or even 2.5%) accuracy does not sound good enough, keep in mind that this is a power meter which indicates the continuously changing output of an audio system. It is not a laboratory-grade instrument.

Using the Meter. Besides being used to indicate the instantaneous output of an amplifier, the meter can also indicate channel balance, and response of bass and treble controls. It will also serve as a VU meter for recording and for comparing speaker efficiencies.

Connect the input leads across the amplifier outputs, noting the polarities. If one set of leads is reversed, the LED's will indicate the difference in power being supplied to each channel. This can be used as an indicator of channel balance and/or channel separation.

In bass response testing, the meter will indicate the amount of boost or cut provided by the bass control. For treble control testing, a single frequency should be applied to the amplifier. This is because most of the power is in the lower frequencies, and the presence of higher frequencies in the bass test is insignificant.

Relative efficiencies of speakers can be checked by connecting the meter across the amplifier output and measuring the output power required to deliver a certain "standard" listening level. ◈

TABLE II—IDEAL THRESHOLD VOLTAGES

IC	Pin	Voltage
1	7	0.011
1	5	0.070
1	11	0.153
1	9	0.270
2	7	0.436
2	5	0.670
2	11	1.001
2	9	1.470
3	7	2.133
3	5	3.070
3	11	4.395

BY ALEX BURR

The Care & Feeding of NiCd Batteries

How they work and how to use them correctly

NICKEL-CADMIUM batteries are becoming ever more popular in cordless consumer products and electronics building. Although initial cost may seem to be high, nickel-cadmium cells can be recharged so often that their per-unit-of-use performance actually makes them less expensive than almost any other type of battery in the long run. Aside from rechargeability and reasonable cost, these batteries can often directly replace ordinary disposable carbon-zinc cells.

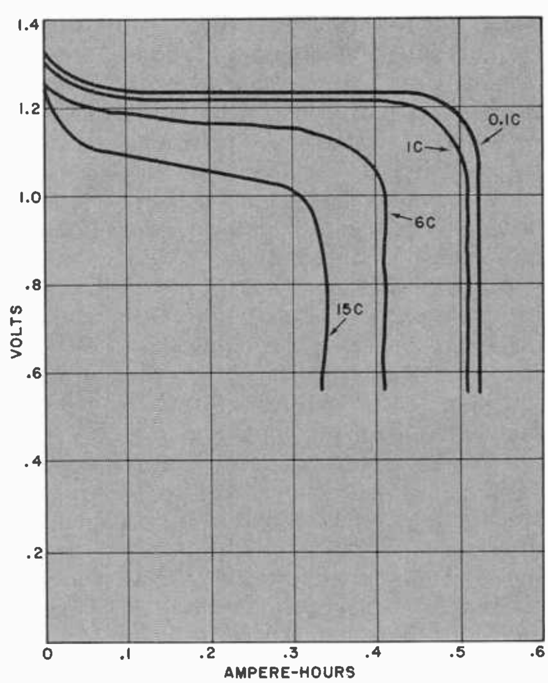
Just as there are differences between bipolar and field-effect transistors (although they are both transistors), there are basic differences between nickel-cadmium cells and other types. Indeed, there are different types of nickel-cadmium batteries, too. Just what are the differences? How do nickel-cadmium batteries work? And where are they best put to use? These and other questions will be explored.

General Details. The energy that a nickel-cadmium battery supplies is stored in the chemical compounds formed in the cell. The active material in the cell is nickel hydroxide in the positive plate and metallic cadmium in the negative plate. During discharge, the cadmium metal supplies electrons to the external circuit and becomes oxidized to cadmium hydroxide, while the nickel hydroxide accepts electrons from the circuit and goes to a lower valence state. The reverse process occurs during the recharging.

Both processes take place in an electrolyte of potassium hydroxide. The cell has a long useful life because the active plates remain as solids and do not dissolve while undergoing charging and discharging. During overcharge, when both plates have all their active metal storing as much energy as they can, gaseous oxygen is released at the positive and gaseous hydrogen at the negative plates.

The manner in which the gases are handled distinguishes the two major types of nickel-cadmium batteries from each other. In *vented* cells, the gas is simply released into the outside air. However, not just gas is released; so is some of the water from the cell. Consequently, more water must be added to the cell eventually, creating a maintenance problem.

The maintenance problem is eliminated in *sealed* cells, but at the price of lower energy density and higher internal resistance. The cells must be cap-



Discharge characteristics for a typical AA cell. They apply, in general, to other NiCd cells also.

TABLE I—TYPICAL CHARACTERISTICS

Size	Capacity (AH)	Internal Resistance (milliohms)	Max. Charge Rate (mA)	1C Rate (A)
AA	0.5	35	50	0.5
C	1.0	10	100	1
D	1.2	7	100	1.2
D*	4.0	5	350	4

*High power.

able of sustaining an overcharge because there is no convenient way of determining when they are fully charged (and also because people who use rechargable cells tend to forget to turn off the chargers).

In sealed cells, the gas problem is solved by making the negative plate's capacity higher than that of the positive plate. When the positive plate is fully charged and releasing oxygen, the negative plate has not yet come up to full charge. The oxygen is permitted to migrate over to the negative plate, where it combines with that plate and prevents it from further charging. Thus, hydrogen gas is never released, and the oxygen is completely used up. This procedure can continue indefinitely as long as it proceeds slowly enough to allow the oxygen time to get to the negative plate. Most sealed cells have an emergency high-pressure relief valve to prevent a heavily overcharged cell from bursting.

For the purposes of this article, our discussion will be limited to the sealed type of nickel-cadmium cell. It is this type of cell that is in most use in electronics.

Sizes and Capacities. There are several varieties of sealed cells. Some are designed to operate over wider temperature ranges than others, some have larger capacities, and others permit faster charging rates. However, all nickel-cadmium cells of the sealed variety are very similar in the general details of their care and use.

The most popular sizes of nickel-cadmium cells and some of their characteristics are listed in Table I. The information given here is very useful, but it does require some clarification. While the AH (ampere-hour) figures listed under "Capacity" might imply that any product of current in amperes and time in hours will yield the correct AH figure for a given cell, this is not strictly the case. A number of variables (like temperature, end voltage, current, and duty cycle) have an effect on the number used to represent the capacity of a cell. Fortunately, these effects are usually very small and can be ignored.

A procedure often used for measuring capacity is to select 0.5 V as the potential at which the cell is declared fully discharged and then select a current that will discharge the cell in one hour. This is termed the 1-hour rate and that current is called the 1C rate, which is the rate to which all other rates are referred.

The AA cell in Table I has a 0.5-AH capacity, which means that the terminal potential will be 0.5 V after a 1-hour drain at the rate of 500 mA. The 1C rate in this particular case is 500 mA. Ideally, this figure would mean that (for example) you could get 1A from the cell for a half hour before the potential drops to 0.5 V. But, as we shall see, this is not quite correct.

If you selected 1 V as the cutoff potential (the voltage at which the cell is considered to be completely discharged), you would expect to obtain less energy from the cell than if cutoff was at 0.5 V. Furthermore, 1 V appears to be a more practical cutoff point than 0.5 V. So, why not use 1 V? The answer is that the voltage characteristics of the cells are such that the 0.5-V figure produces a more reliable number than does a higher cutoff voltage.

Information on how a higher discharge rate and higher cutoff voltage affect the capacity of a typical nickel-cadmium cell is given in Table II. As an example of how to use this table, consider an AA cell that is to supply 5 A until its terminal potential is reduced to 1 V. From Table I, the discharge rate for an AA cell is 500 mA. Therefore, our rate is 10C. Moving along the 10C row in Table II until we get to the 1.0-V column, we find that, at a 10C discharge rate to 1.0 V, 10% of the cell's capacity is not available. We can expect to get only 0.45 AH (about 5 minutes of energy at this high rate) from the cell under these conditions. Because Table II is given in terms of multiples of the 1C rate, it can be used with all sizes of sealed nickel-cadmium cells. The table clearly shows that you can use nickel-cadmium cells at a 10C rate to an end potential of 1.0 V with very little reduction in capacity.

Discharge Characteristics. One of the welcome characteristics of nickel-cadmium cells is their excellent discharge characteristic. Their terminal potential remains a fairly steady 1.2 V until the cell is almost completely discharged, after which it drops off rapidly. The details of the discharge characteristics for an AA cell are shown in the diagram (previous page), which displays the voltage versus AH delivered at various discharge rates. While the plots are for a typical AA cell, they also give the main characteristics of the discharge curves for any sealed nickel-cadmium cell.

Note from the graph that the terminal potential reduces to 0.5 V when the cell has delivered 0.5 AH at the 1C rate. (Because the 1C rate is 500 mA for the AA cell, this will take 1 hour). At the 0.1C rate, which is 50 mA for an AA cell, you will obtain about 0.525 AH, or somewhat more than 10 hours of use because the cell will deliver more power at that slower rate. Similar calculations can be made from the curves for the other cells listed in Table I. The main feature illustrated by the curves is that the terminal voltage of any cell is about 1.2 volts for most of the time it is supplying (a wide range of) current.

TABLE II—INACCESSIBLE CELL CAPACITY AS A PERCENTAGE OF TOTAL CAPACITY TO 0.5 VOLT

Discharge Rate	Cutoff Voltage (V)		
	0.5	1.0	1.1
0.1C	0	3	5
1C	0	3	5
2C	0	4	7
5C	0	5	9
10C	0	10	30-40

Charging Characteristics. Sealed nickel-cadmium cells can be charged under a wide variety of conditions, but the chemical processes do place some limitations on the charging process. A little oxygen is generated at the positive electrode during charge and a lot during overcharge. This oxygen puts both an upper and a lower limit on the charge rate.

Sealed cells are designed to get rid of the oxygen generated during overcharge as quickly as it is generated, as long as the charge rate is kept below 0.1C, which means that current at the rate of 0.1C or lower can be supplied indefinitely to the cell. Higher current rates—up to 20C in special applications—can be accommodated as long as the positive plate of the sealed cell is not overcharged. It is difficult (but not impossible) to tell just when overcharging sets in. (Fast-rate chargers are complicated and expensive to build, which precludes them from this discussion.)

The amount of oxygen generated before the cell is fully charged is small, but it does compete with the desired oxidation of the nickel hydroxide. It is this reaction that defines the minimum charge current that will effectively charge a cell. A charge rate lower than 0.01C results in more current being used to generate oxygen than is used to convert the active material. Hence, currents smaller than 0.01C produce little increase in the charge contained in the cell.

Most chargers supply current at the 0.1C rate. This represents the rate that will recharge the ordinary cell in the least possible time without endangering the life of the battery if accidentally left connected for a long time. It is important to note that, while current at the 1C rate will discharge the cell in 1 hour, more than 10 hours are required to charge it at the 0.1C rate. The oxygen generated and losses in the cell's internal resistance are two reasons. In general, at the 0.1C rate, one must put in about 140% of the energy that the cell can store before a completely discharged cell can be considered fully charged.

There are several other facts about charging nickel-cadmium cells that are useful to know. If you charge at a 1C rate, only about 120% of the cell's capacity can be supplied before overcharging commences. If a 0.05C rate is used, the cell will be difficult to charge above 75% of its capacity. Allowing the temperature of the cell to reach about 50° C will cause difficulties when attempting to charge above 75% of capacity, even with a charge rate of 0.1C. Full charge is assured at 25° C. At very low temperatures, like 5° C, some hydrogen is generated at the negative plate of the cell during charging. There is no rapid recombination reaction to rid the cell of this gas, so it tends to increase the pressure inside the cell. If the cell must be recharged at low temperatures, the only way to overcome this problem is to derate the maximum permissible overcharge rate to 0.02C at −20° C.

Failure Modes. Because nickel-cadmium cells use active materials that are highly insoluble in their alkaline electrolyte, failure modes are few. Most sealed cells are guaranteed for 500 to 1000 charge/discharge cycles. This might appear to be a limited number, but when you consider 1000 cycles at a rate of two cycles per week, these cells will last 10 years.

In the case of sealed cells, the quality of materials used in making them has a marked effect on their useful life. Although failures are rare, they do occur (catastrophically) for two major reasons: internal shorts and loss of electrolyte.

Internal shorts develop when time and temperature cause decomposition of the materials that separate the positive and negative plates of the cell. Shorts are generally a low-charge phenomenon.

Loss of electrolyte reduces the capacity of the cell and increases its internal resistance. The electrolyte is usually lost in some combination of two ways. Even the best of hermetic seals will allow some hydrogen and oxygen to escape. In the case of high-quality seals, 10 years or more will elapse before an appreciable amount of electrolyte is lost. If the cell is abused by excessive overcharging or reverse charging, excessive gas in the cell will cause the safety valve to vent the excess pressure into the atmosphere. Needless to say, the hermetic seal is now broken and evaporation of the electrolyte will be much faster. Even if the safety valve is resealable (quite common), a significant amount of vapor will escape with the excessive pressure and eventually cause the cell to dry out with continued venting.

There are also non-catastrophic failures common to nickel-cadmium cells. These, however, are reversible so that the cell can be restored to full capacity.

One reversible failure mode is due to long and continued overcharging (as when a standby power supply is kept on float charge for a month or more without discharging it). The effect is accentuated by high temperatures. The second reversible failure mode appears in cells used in a regular cycle. If a group of cells is regularly called upon to deliver, say, 25% of their full capacity and then recharged, they will eventually "memorize" that only 25% of capacity will be required of them and become incapable of supplying the remaining 75% of capacity. This phenomenon is most likely to occur if a cell is rarely overcharged, the rate of discharge is great, and/or the temperature is high.

Non-catastrophic failures can be reversed by completely discharging the cell at a low discharge rate and then recharging it at a 0.1C rate for 20 hours at 25° C (80° F). One or two reconditioning cycles like this are generally all that is needed to restore a cell to its full capacity.

Storage Characteristics. Sealed nickel-cadmium cells readily lend themselves to prolonged storage, whether in a partially or fully charged state or completely discharged. If stored in a charged state, the cell will self-discharge, at a rate that depends on cell design and storage conditions. In general, a cell will lose about 1% of its charge per day so that at the end of about three months an initially fully charged cell will be completely discharged. If stored at high temperatures (50° C or higher), the cell will lose up to 5% of its charge per day, with the charge lasting less than a month.

The lack of a charge in a cell when it is put into storage has no effect on the cell's life. The cell can be put back into service after one or two charge/discharge cycles. Over a wide range of temperatures (−50° C to 50° C), nickel-cadmium cells can be stored for years with no significant degradation in performance.

Closing Comment. Sealed nickel-cadmium cells have a number of outstanding characteristics that make them good first choices for everyday use. They are reusable, permitting up to 1000 charge/discharge cycles. Their terminal voltage during discharge holds relatively constant. And they require no special care.

There are, of course, some minor disadvantages. High initial cost is one, although it is counterbalanced by the fact that the cells are reusable. Another is that the typical nickel-cadmium cell, when compared with the same-size carbon-zinc cell, has a lower capacity and a lower terminal voltage (1.2 V as opposed to 1.5 V for the carbon-zinc cell). The balance, however, is in the nickel-cadmium cell's favor when it comes to long life, convenience of use, and reliability. ◈

THEFT ALARM FOR HANDHELD CALCULATORS

BY TOMMY N. TYLER

HANDHELD calculators are a prime target for thieves because they can be quickly picked up and tucked out of sight. Though you could physically fasten the calculator to your desk, this defeats the purpose of its portability. Here's another approach—an audible alarm that sounds off when the calculator is unplugged from its charger.

The Alarm Circuit. Simplicity is the key feature of this alarm. It is inserted between the charger and the calculator, as shown in Fig. 1, and draws a nominal amount of power from the charger. As long as a trickle charging current (at least 100 μA) flows into the calculator, silicon diode *D1* conducts. The forward voltage drop across it keeps germanium transistor *Q1* turned on. Transistor *Q2*, which can be almost any pnp device, is cut off, and the Sonalert alarm is silenced.

However, if the calculator is unplugged, *Q1* turns off, *Q2* turns on, and the Sonalert starts to howl. Obviously, if the charger is unplugged, the alarm will not operate. So, it's important either to hide the charger or secure it in some way so that the thief will not disconnect it. To prevent the alarm from becoming obvious (when it is silenced!), it's a good idea to build the alarm *and* the charger into one small enclosure.

Two variations on the circuit are shown in Figures 2 and 3. The relay contacts can be used to trigger a remote signalling device. Install diode *D2* to prevent destruction of *Q2* by inductive voltage spikes generated by keying the relay. Figure 3 shows a small transistor oscillator which can be used in place of the Sonalert. It can be assembled from junk box parts. (Note *R2* is changed to 2200 ohms.)

Construction. Take care in wiring jack *J1* and plug *P2*, observing correct polarities. Although *D1* will prevent damage to the calculator from reverse current, the unit's batteries will never charge! And, of course, be sure that *P2* and *J1* are the same types as those on the charger and calculator. Either pc or perforated board may be used. Both parts placement and the selection of semiconductors are not critical. Just be sure that *D1* is rated to handle the charger's maximum output (in the event that *P2* is accidentally shorted), and *Q1* is a germanium device. ◈

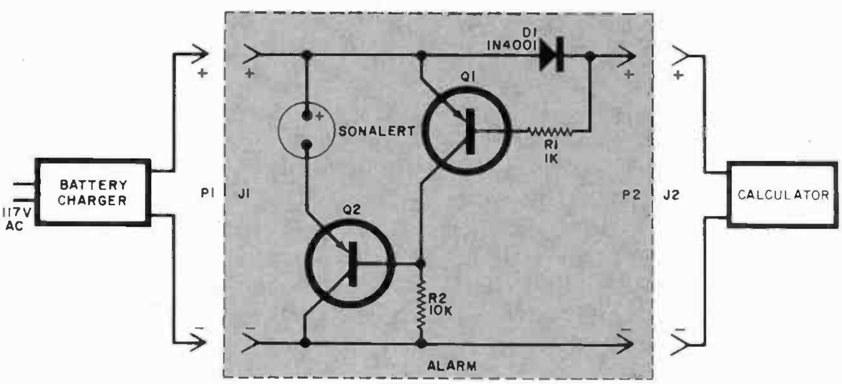


Fig. 1. When trickle current through D1 stops, Sonalert is activated.

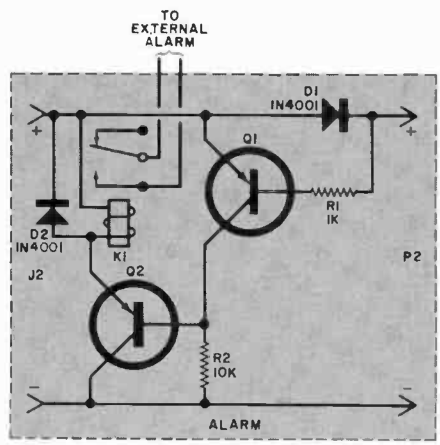


Fig. 2. For a remote alarm, use a relay instead of Sonalert.

PARTS LIST

C1*—1-μF, 15-volt electrolytic capacitor
D1, D2*—1N4001 rectifier
J1—Calculator-type power jack
K1*—6-9 volt, 500-ohm relay (Radio Shack 275-004 or equivalent)
P2—Charger-type power plug
Q1—General-purpose germanium pnp transistor
Q2—General-purpose pnp transistor
R1—1000-ohm, ½-W, 10% resistor
R2—2200-ohm or 10,000-ohm, ½-W, 10% resistor (see text)
Sonalert—Mallory SC628P
Spkr*—3.2-ohm dynamic speaker.
T1*—500- or 1000-ohm/3.2-ohm audio transformer
Misc. Perforated or pc board, hookup wire, solder, suitable enclosure, machine hardware, etc.
*Optional. See text.

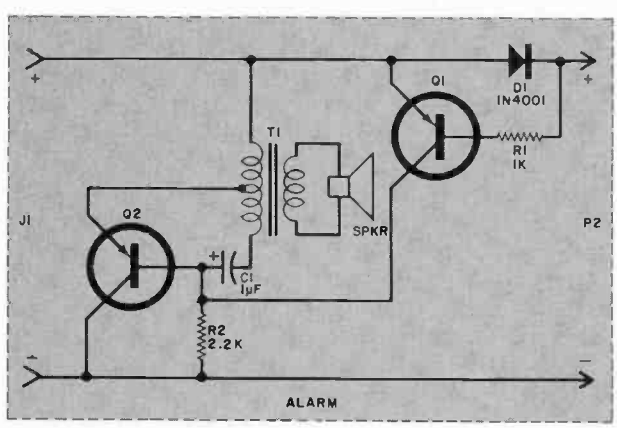


Fig. 3. Audio oscillator can also be used to provide an audible signal.

BY LEE FELSENSTEIN

Build "PENNYWHISTLE" The Hobbyist's Modem

Under-$100 interface for digital data transmission/reception over channels such as telephone or cassette tape.

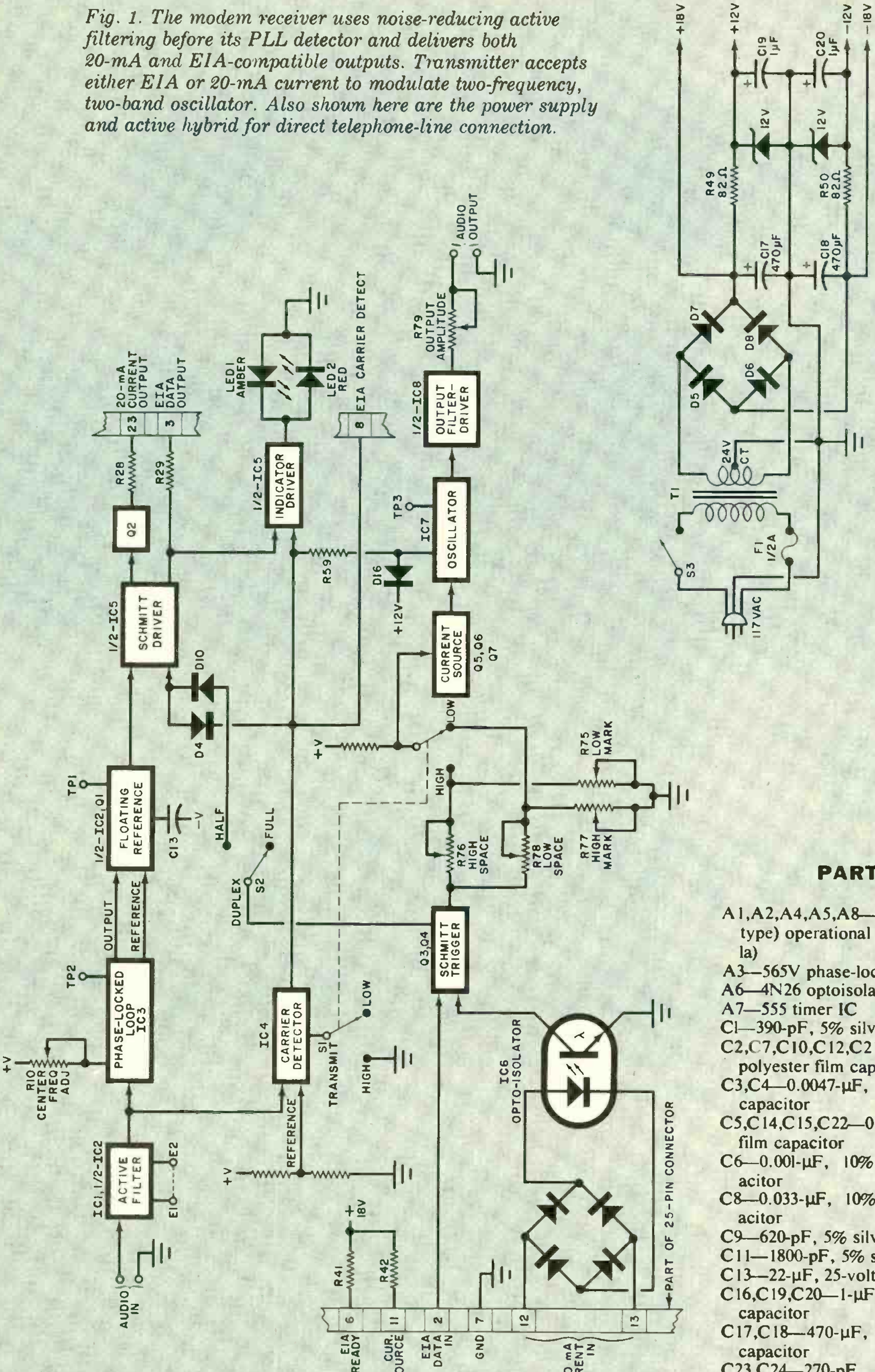
TO TRANSMIT and/or receive digital data—as between two computers, between terminal and computer, etc.—over telephone lines and other limited-bandwidth channels, you need a modem (an acronym for *mo*dulator/*dem*odulator). Most such channels cannot cope with the steep-sided, flat-topped digital pulse without distorting it, much less pass the high baud rate (bits per second) used in computers. The modem translates the pulses into a usable form.

Digital pulses going into a modem at one end emerge as different frequency audio tones that are fed into the transmitting channel. At the other end, another modem translates the tones back to the appropriate digital pulses.

Modems can operate in one direction only (half duplex) or in both directions (full duplex). The under-$100 Pennywhistle modem project presented here offers the user both modes with the flip of a switch.

Although some modems can operate at up to 9600 baud over telephone lines, full-duplex operation usually restricts the maximum speed to 300 baud, or 30 characters/second. Modems in this speed range generally operate with frequency-shift keying (FSK), using four frequencies in two "bands." The 1070-to-1270-Hz low band is used for transmission from a terminal to a central system, while the 2025-to-2225-Hz high band is for transmission in the opposite direc-

Fig. 1. The modem receiver uses noise-reducing active filtering before its PLL detector and delivers both 20-mA and EIA-compatible outputs. Transmitter accepts either EIA or 20-mA current to modulate two-frequency, two-band oscillator. Also shown here are the power supply and active hybrid for direct telephone-line connection.



PARTS LIST

A1,A2,A4,A5,A8—MC1458 (dual 741-type) operational amplifier IC (Motorola)
A3—565V phase-locked loop IC
A6—4N26 optoisolator
A7—555 timer IC
C1—390-pF, 5% silver-mica capacitor
C2,C7,C10,C12,C21,C25—0.1-µF, 10% polyester film capacitor
C3,C4—0.0047-µF, 10% polyester film capacitor
C5,C14,C15,C22—0.01-µF, 10% polyester film capacitor
C6—0.001-µF, 10% polyester film capacitor
C8—0.033-µF, 10% polyester film capacitor
C9—620-pF, 5% silver-mica capacitor
C11—1800-pF, 5% silver-mica capacitor
C13—22-µF, 25-volt electrolytic capacitor
C16,C19,C20—1-µF, 25-volt electrolytic capacitor
C17,C18—470-µF, 25-volt electrolytic capacitor
C23,C24—270-pF, 5% silver-mica capacitor
D1 to D4,D9,D10,D15 to D24 — IN4148 low-leakage diode

D5 to D8,D11 to D14—1N4001 rectifier diode
F1—3AG, ½-ampere slow-blow fuse with pigtails
LED1, LED2—Light-emitting diode (one red, one amber)
J1,J3—Two-conductor, closed-circuit miniature phone jack
J2—Two-conductor, open-circuit miniature phone jack
P1—No. DB25S connector plug
Q1,Q2,Q4,Q5—2N2907 transistor
Q3,Q6,Q7—2N2222 transistor
Following resistors are ¼-watt, 5% tolerance, except as noted:
R1,R51,R80—6800 ohms
R2, R3, R9, R17, R18, R19, R45, R47, R54, R55, R59, R60, R61, R63—10,000 ohms
R4,R5—150,000 ohms
R6,R25,R26—330,000 ohms
R7—20,000 ohms
R8,R14—18,000 ohms
R11,R70—2200 ohms
R12,R13,R53—4700 ohms
R15,R16,R22,R57,R64 to R69—1000 ohms
R20,R21—5100 ohms
R23,R24,R33—15,000 ohms
R27,R40,R46,R48,R58—3300 ohms
R28,R41,R42—1000 ohms (½-watt)
R29,R30,R31—680 ohms (½-watt)
R32—680 ohms
R34—68,000 ohms
R35,R72,R73—220,000 ohms
R36—4300 ohms
R37—1.5 megohms
R38—24,000 ohms
R39—180,000 ohms
R43—8200 ohms
R44,R56—100,000 ohms
R49,R50—82 ohms (½-watt)
R52—22,000 ohms
R62—620 ohms
R71—470,000 ohms
R74—47 ohms
R10,R77—5000-ohm trimmer potentiometer (CTS No. 360S502B or similar)
R75—20,000-ohm trimmer potentiometer (CTS No. 360S203B or similar)
R76,R78—100,000-ohm trimmer potentiometer (CTS No. 360S104B or similar)
R79—1000-ohm trimmer potentiometer (CTS No. 360S102B or similar)
S1,S2,S3—PC-type dpdt toggle switch
T1—24-volt center-tapped, 600-mA power transformer
Z1,Z2—12-volt, 1-watt zener diode (1N4742 or similar)
Misc.—Printed circuit or perforated board and solder clips; sockets for IC's (optional); 2¼"-diameter, 8-ohm loudspeakers (2); suitable enclosure; three-conductor line cord with plug; line cord strain relief; metal spacers; hookup wire; machine hardware; solder; etc.
Note: A complete kit of all Pennywhistle modem parts, including cabinet, is available for $97.50 from M&R Enterprises, P.O. Box 1011, Sunnyvale, CA 94088. Add $1.50 if ordering from Canada. California residents, please add 6% sales tax. Allow 15 days for delivery after receipt of order. Send SASE to above address for free copies (8" × 11") of schematic, etching and drilling guide, and component layout guide.

tion. Modems that transmit on the low and receive on the high band are termed "originate-mode" devices, since they are usually used by a local terminal to call into a remote central computer.

In either band, digital data is translated from 1's and 0's (marks and spaces) to high and low frequencies. Don't confuse this with high and low *band* terminology. The receiving modem translates the tones back to 1's and 0's. Note that the high and low frequencies used in FSK are only 200 Hz apart.

Most originate modems, including the Pennywhistle, employ acoustic coupling to the telephone line via the telephone handset. (Some modems are, however, designed to be directly wired into the phone line.) Acoustic couplers obviate the need for the user to pay installation and rental charges for the devices the telephone company requires for direct-line hookups. The main disadvantage of the acoustic coupler is that it can cause an increase in distortion problems that can increase the error rate.

It is important that you bear in mind that modems do not process the data passed through them. They merely accept a stream of serial bits at one end and deliver the same bit information at the other end. The translation that takes place in between merely makes it possible to have remote-point communication. Also, modems do not generally have UART's built into them; they are designed to be connected to outboard UART's, such as those designed into computers.

Circuit Operation. A block diagram of the modem is shown in Fig. 1, which we will use to explain system operation. (The schematic diagram and etching and drilling and component placement guides are too large to fit on these pages. They are available FREE by sending a stamped, self-addressed 8" × 11" envelope to the source given in the Parts List.)

The audio input to the modem is first applied to a three-stage filter consisting of both parts of *IC1* and half of *IC2*. This prevents most noise and harmonics from passing through the system. The filtered signal is then passed to the *IC3* phase-locked loop, which contains a variable-frequency oscillator and comparator. The PLL always attempts to lock the frequency of its internal oscillator to the incoming signal frequency. The correction voltage supplied by the comparator to the oscillator provides a measure of how far off the incoming signal frequency is from a preset center frequency.

It is difficult for a PLL to discriminate between an input signal of the proper frequency and one of its harmonics or subharmonics. Since the high-band frequencies are almost twice those of the low band, this can present a problem for some modems, which is the reason for preceding the PLL with the three-stage active filter in the Pennywhistle. Potentiometer *R10* is used to set the PLL's center frequency. The PLL itself delivers two outputs: one is a fixed reference voltage from the internal voltage divider, and the other is the actual output of the stage.

One of the lesser problems associated with a loop is that voltages drift with changes in temperature. The Pennywhistle tackles this problem with the floating reference circuit made up of half of *IC2* and *Q1*. This circuit takes advantage of the fact that in asynchronous data transmission, the serial data signal returns to the "mark" condition between every character sent. The floating reference circuit detects the mark and resets its voltage accordingly. If the data goes to and remains at a "space" condition, the circuit slowly readjusts itself and, in about 2 seconds, will claim the new level as a "mark." It readjusts much faster in the opposite direction to correct such a mistaken impression quite rapidly.

The floating reference is fed to *IC5*, a Schmitt trigger, while the data is fed to the other input. The output of *IC5* is an EIA data output which, in turn, drives *Q2* to deliver a 20-mA current output.

The *IC4* circuit is used to detect the presence of an adequate signal level for reliable loop operation. The output of *IC4* provides a positive EIA-type "carrier present" signal to turn on external terminals and hold the data output to the terminal at a mark condition when insufficient carrier is present. Indicators *LED1* and *LED2* are driven by *IC5*. A positive output from the IC turns on *LED2*, while a negative output turns on *LED1*. When no carrier is present, the output of *IC5* is normally negative. With a carrier present, it is positive. Hence, the LED's will alternately light when data is being received, providing a useful indication of modem operation.

The carrier detect signal turns on

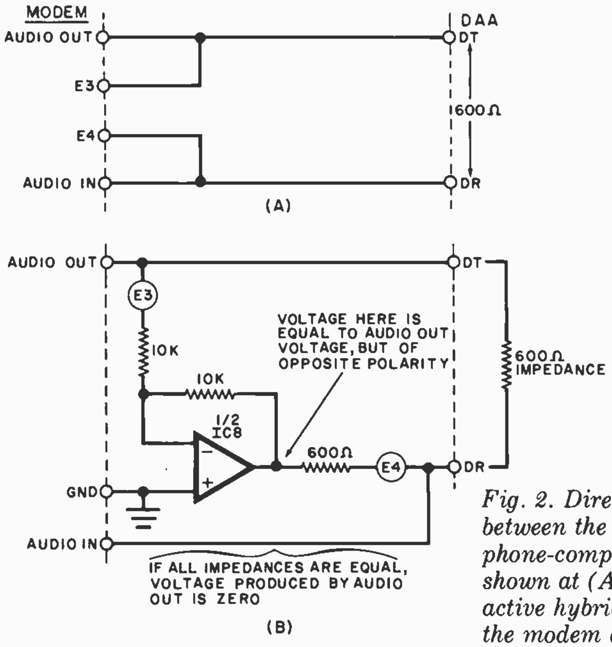


Fig. 2. Direct line connection between the modem and the phone-company supplied DAA is shown at (A). Use of the active hybrid connection between the modem and DAA is shown at (B).

transmitter oscillator *IC7* via *R59*. The TRANSMIT switch *(S1)* has a section that simulates a received carrier to turn on the oscillator. Data is "looped back" from the transmitter to the receiver when DUPLEX switch *S2* is in the HALF duplex position. This provides an echo of data originated at the terminal without requiring that the data travel to the other end and return. Some time-share services require half-duplex operation, which is one reason for including this feature in the Pennywhistle. Another is that it provides a self-test capability for the terminal and modem.

The transmitter is built around *IC7*, a 555 timer chip. The output of *IC7* is fed to the output filter (half of *IC8*), which smooths out the waveform to reduce harmonics and provides enough power to drive a small speaker or the telephone line.

The frequency at which *IC7* operates is determined by *Q5*, *Q6*, and *Q7*, which form a symmetrical current source that keeps the "on" and "off" periods of the oscillator equal, regardless of the operating frequency. Potentiometers *R77* and *R75* set the mark frequency, while *R76* and *R78* determine the space frequency.

The *Q3-Q4* Schmitt trigger circuit accepts data from either the EIA data input (positive or negative levels) or from optoisolator *IC6*, which can be tied into a standard 20-mA teleprinter current loop. Mark data has a negative voltage level at the EIA input or a current of 15 mA or more at the current-loop input. Space data is a positive voltage level at the EIA data input or no current at the current-loop input. With nothing connected to either input, the modem "sees" a space.

TRANSMIT switch *S1* is used to select either the high- or the low-tone band. Normally left in the LOW position, for tape recording or unit-to-unit transmission, it is switched to HIGH.

Construction. The modem lends itself equally well to either printed-circuit or perforated-board wiring. Since the design of the system provides for maximum flexibility, both current-loop and EIA circuits are provided. However, you can omit either of these circuits, depending on the needs of your system.

Capacitors *C2, C7, C8, C10, C12*, and *C22* must operate with a relatively high degree of stability in the circuit. So, it is important that you use only Mylar, polystyrene, or other high-stability capacitors where these are called out.

Do not use wire-wound potentiometers. They can be difficult to adjust with a high enough degree of accuracy. Transistor types are not critical, but it is good policy to use only complementary pnp and npn types for *Q5* and *Q6*. All transistors in the system must be good-quality silicon switching types.

Any 741-type operational amplifier IC will operate in the modem's circuit. The only restriction here is that the op amp you select must be able to operate with a short-circuited output indefinitely with ±18 volts dc applied to the positive and negative pins of the IC. Not all op amps can meet this requirement; check this out on the IC specifications sheet before you buy. Most quad op amps will not meet the requirement. Type 3900 op amps will not work in this circuit because of the radical design changes required.

After wiring the circuit board assembly, mount the two soft-rubber acoustic "muffs" on the cover of the enclosure. Note that all parts, except the muffs and *J1*, *J2*, and *J3*, mount on the pc board. The case supplied with the kit has a stepped area through which the toggles of the switches protrude and holes through which the LED's are visible. Connector *P1* fits along the edge of the board and is held in place by soldering its pins to the foil pads. The connector is then secured to the metal base plate that forms the bottom of the enclosure with machine hardware through its tabs. Mount *J1*, *J2*, and *J3* in holes in the base plate near *P1* and wire them to the board. Secure the power cord with a strain relief after soldering its conductors to the appropriate points in the circuit.

If you buy your parts locally, you'll have to fabricate your own acoustic coupler from a pair of small loudspeakers (see Parts List) and some commonly available materials.

To do this, apply a thin bead of silicone adhesive/sealing compound around the entire front edge of one of the speakers. Make sure the bead is no more than ⅛" (3.2-mm) thick and doesn't bleed onto the cone. Place this speaker, front down, on a square of wax paper atop a flat, level surface. Gently press the speaker so that the silicone cement bead spreads out. Allow the speaker to remain like this for at least 24 hours to permit the silicone cement to cure. At the end of this time, slowly and gently peel away the wax paper. Trim the silicone cement flush with the outside perimeter of the speaker and check that the silicone provides a tight seal to the microphone of a telephone handset.

From a piece of resilient polyurethane foam, cut a "donut" to fit over the rear of this loudspeaker. Solder lengths of stranded hookup wire to the speaker's lugs. Route the wires through the hole in the plastic foam, and cement the latter to the rear of the speaker with silicone adhesive.

Two 2⅝" (6.7-cm) diameter tin cans can be used as "wells" in which to mount the speakers to make good contact with the telephone handset. The cans should be mounted 5¾" (14.6) apart, center to center, and

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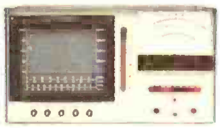

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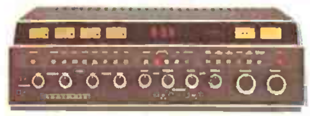

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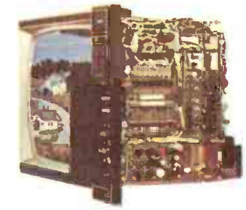

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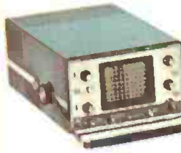

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should have 3/16" (5-mm) thick polyurethane foam lining their sides. Punch a hole in the bottom of each can to allow wires to pass through for connecting the speakers into the circuit. Fashion two circular wedges of polyurethane foam to fit into the bottoms of the cans, where they will hold the speakers the correct distance away from and at the proper angle to assure firm contact with the handset when the handset is placed in the cans. You may have to experiment a bit to get the right wedge shapes. Punch a hole through each wedge. Route the speaker wires through the holes in the wedges and the cans, and silicone cement the wedges in place. Then connect the wires from the speaker with the silicone "gasket" to the output and the wires from the other speaker to the input terminals of the modem.

If you prefer, you can use an inductive pickup at the receiving side of the modem. To do so, you'll have to lower the value of *R19*, (which determines the gain of the last stage of the active filter) to compensate for the lower gain of the pickup. In this way, you eliminate the possibility of external noise pickup.

Test and Adjustment. Set TRANSMIT switch *S1* to LOW and DUPLEX switch *S2* to FULL. Temporarily connect a jumper wire from pin 2 of the 25-pin connector to a voltage source of about −12 volts dc. This can be found at the negative sie of *C2*. Connect a frequency counter to test point *TP3* (at *IC7*) and temporarily connect a jumper across *D16*. This will turn on the transmitter. Now, adjust *R77* for a frequency of 1270 Hz, ±5 Hz. Remove the jumper from pin 2 of the connector and power supply, and adjust *R78* for a frequency of 1070 Hz, ±5 Hz.

Set the TRANSMIT switch to HIGH and replace the jumper from pin 2 of the connector to the negative voltage supply. Adjust *R75* for a frequency of 2225 Hz, ±10 Hz. Remove the jumper and adjust *R76* for a frequency of 2025 Hz, ±10 Hz.

The output of the modem must now be set for −15 dBm (0.14 V rms or 0.39 V p-p) on the telephone line when the handset is in position in the modem's acoustic coupler by adjusting *R79*. Assuming you don't have a standard modem test instrument to perform this adjustment, carefully follow the procedure below.

First, make no measurements of the voltage on your phone line until you have dialed and have a party on the other end. Next, be very careful not to short the telephone terminals, and use an ungrounded meter to make all measurements. If your meter doesn't have an OUTPUT jack, place a 0.1-μF capacitor in series with one of its test probes.

Set the TRANSMIT and DUPLEX switches to the LOW and FULL positions, respectively. Turn on the transmitter by jumpering *D16*. Place the telephone handset into the acoustic coupler. (Make sure the handset is correctly oriented.) Then connect the meter to the telephone connector block. (Do not attempt to use a "keyset" telephone that has lighted pushbuttons.) Adjust *R79* for −15 dBm, 0.14 V rms, or 0.39 V p-p.

Connect a 1000-ohm resistor between the audio input terminal to the active filter and ground. With a 100,000-ohm resistor connected in series with the signal or "hot" output, connect a signal generator to the audio input terminal and the generator's ground lead to the modem's common ground.

Monitoring the output with a frequency counter, set the generator's frequency for 1170 Hz. Connect the

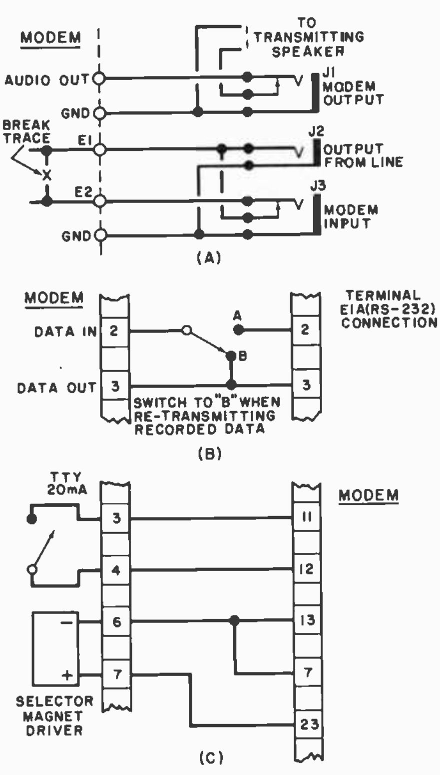


Fig. 3. Ways to connect the modem to tape recorder, an EIA terminal, or a Model 33 TTY Teleprinter.

counter between *TP3* and ground and a dc voltmeter between *TP1* (floating reference) and ground. Adjust *R10* through its entire range, observing where the monitored voltage swings smoothly between positive and negative. This is the lock range of the PLL. Adjust *R10* so that the meter indicates zero within the lock range. Perform this adjustment several times to be sure you haven't adjusted outside the lock range; false indications are possible there.

Direct-Line Hookup. To wire the modem directly to the telephone line, the telephone company requires that you use a DAA (Direct Access Arrangement) to isolate the two. The lowest-cost system available, generally renting for $2 to $5 a month, is the CDT (1001A) coupler. It has a switch that cuts the telephone out and the coupler in when turned on. The wiring diagram for this setup is shown in Fig. 2A.

When the CDT is used, *IC8* is wired as an "active hybrid" circuit that can subtract the output of the transmitter from the input of the receiver, as shown in Fig. 2B. Terminal E3 is connected to the output of the modem, which is also connected to one side of the phone line. E4 goes to the input terminal of the modem and the other side of the phone line. Ideally, *R62* should be the same resistance as the line impedance, specified by the telephone company as 600 ohms, when a DAA is used. However, this resistor's value can be trimmed if "balancing out" adjustments are needed.

Tape Recorder Connections. The phone jacks, *J1*, *J2*, and *J3*, permit the use of the modem with a tape recorder to record data from the terminal or from the phone line, and to play the data back to the terminal for the phone line, or both.

The jacks are wired into the modem as shown in Fig. 3A. Jack *J1* then connects to the transmitting speaker and serves as the interconnect for the microphone input to the tape recorder. Jacks *J2* and *J3* connect between E1 and E2 and ground. (Make sure you break the foil between E1 and E2 on the circuit board if you use this mode.) Jack *J2* goes to E1, which is the output of the first stage of the filter, and also feeds the microphone input of the tape recorder when *J2* is used. Jack *J3* breaks the connection between E1 and E2 and allows the tape recorder to feed a signal into the second stage of the filter.

To record local terminal data, plug the tape recorder's microphone input into *J1* and set the TRANSMIT switch to HIGH. Run the recorder and input data from the terminal.

To record line data, plug the recorder's microphone or auxiliary input into *J2*. Run the recorder for the duration of the desired output. Record a 5-second leader of no-data carrier on the tape before the data.

To play data back to a local terminal, plug the recorder's speaker output into *J3*. Then play the tape. The modem will track with any desired speed variations from the tape. The first point of failure for speed change will occur when the timing of the signal into the terminal goes beyond the limits of its serial receiver circuit.

To play data back to the line, connect a switch between pins 2 and 3 of the 25-pin connector on the modem and pins 2 and 3 of the terminal as shown in Fig. 3B. Using the terminal, set up the proper conditions in the system to receive the data. Make sure that you start the tape in the no-data carrier leader area. Plug the recorder cable into the tape recorder and throw the switch to connect pins 2 and 3 of the connector. Plug the other end of the recorder cable into *J3*. Data will now be feeding into the modem's receiver, looping back to the transmitter section. Simultaneously, the data will appear on the terminal.

Current-Loop Hookup. Teleprinters handle data on a current loop, where 20 mA of current represents a 1 or "mark" and no current represents a 0 or "space." The wiring between the modem and a Model 33 Teletype (TTY) are shown in Fig. 3C. If you have an older teleprinter that has bare coils, use a reed relay between pins 23 and 7 (ground) on the modem. Connect a diode between pin 23 and ground, with the cathode going to pin 23. This diode will prevent inductive "kickback" voltages from damaging current-source transistor *Q2* inside the modem.

Teleprinter keyboards consist of switches that open and close according to a set pattern to control an externally supplied current. Pin 11 of the modem is a source of 18 mA of maximum current. Connect pin 11 to pin 12 and the teleprinter keyboard from pin 13 to pin 7.

EIA Interface. The EIA standard relevant to the modem is RS232C. Any terminal wired according to this specification will mate with the Pennywhistle modem.

EIA signals in the RS232C standard are always more than 3 volts in amplitude and always less than 25 volts open circuit (15 volts when connected). They are positive or negative, depending on the data. Negative is a data 1 (mark), positive a data 0 (space). Control lines are active with a positive signal. EIA signals are not required to drive a load of less than 3000 ohms, but they must be protected from ground and each other.

Final Remark. To communicate between two Pennywhistle modems, the TRANSMIT switch must be set to LOW for receiving, HIGH for transmitting. Keep the DUPLEX switch in the FULL position, and your receiver will come back with what you're transmitting. Bear in mind that communication can be in only one direction when using this scheme. ◈

A BCB LOOP ANTENNA FOR DX'ING

Increases reception range of inexpensive AM radios by inductive linking.

BY NORMAN FALLON

IF YOU'RE anxious to hear distant stations on the AM Broadcast Band—say, to catch blacked-out home-town sports events—then the Broadcast Band Loop is just what you need! When coupled to a good AM transistor radio with a built-in ferrite bar antenna, it will bring in lots of stations you could never copy before—be they TA's (transatlantics), rare "locals," or clear-channel stations from distant cities. It is easy to build and use, fairly small, and inexpensive—total parts cost is about $15 to $20!

About the Loop. The use of a loop antenna is not new, but its advantages are timeless. It has good directivity, and can be easily rotated. Further, the loop works only with the magnetic portion of the radio wave (which contains both electric and magnetic fields), so it is inherently quieter than higher-gain long-wire outdoor antennas. The loop contains no fragile semiconductors and requires no power supply, unlike the "amplified loops" that some MW DX'ers are now using.

A simple loop antenna is shown in Fig. 1. It's an electrically short loop consisting of turns of wire with a total length much less than a wavelength. Medium waves are fairly long, e.g. 500 m (1640 ft) at 600 kHz! Obviously this loop or an outdoor longwire are the only real options.

The loop is really an inductor. When shunted by variable capacitor C, the combination can be tuned to resonance. Its nominal directional pattern (Fig. 1) is a figure eight, with maximum response in the plane of the loop. Turning the antenna broadside to a station will cause an appreciable drop in signal strength.

Selectivity is another loop characteristic. The antenna favors signals at the resonant frequency at the expense of those nearby. Its response gets progressively narrower as its Q increases (which varies directly with the C/L ratio). For our purposes, we'll want as high a Q as possible.

We have adapted the loop to better serve our purpose by eliminating the direct connection between the Loop and the receiver. Experience indicates that unwanted signal pickup occurs when a transmission line is used to couple signals to the receiver's antenna input jack (if there is one). In this design (Fig. 2), signals are coupled inductively, simply by positioning the built-in ferrite bar close to the loop base. This offers the advantage of being able to adjust the degree of coupling between the coils to suit variations in signal strength. Operating the loop and ferrite bar in tandem will yield a cardiod directional pattern due to interaction between the coils.

Further flexibility is afforded by a switch which shorts out one turn of the Loop when closed. This is often desirable when working the high end of the MW band, since a decreased L requires more C for resonance. The result is a higher Q, and slightly less gain. In most cases, though, the effect on signal strength will not be noticed—but the sharpened tuning will be greatly appreciated. It's easy to see that the *L1* and the ferrite bar in the receiver act as an r-f transformer. The "audio circuit" has been included as an operator convenience. To best work DX, headphones should be used. They are more sensitive than loudspeakers, so it will be easier to hear weak signals. The acoustic isolation from background noise will also come in handy—you'll be able to listen without bothering others around you, and vice versa.

To accomplish this, audio will be coupled from the earphone jack on the receiver to jack *J3* by a short patch cord. Make use of the new crop of high-sensitivity, lightweight (Mylar transducer) stereo headphones, which require only a few milliwatts of drive.

It's also wise to use battery power rather than an ac battery eliminator, as hum problems can arise. Of course, if you don't want to use phones or already have a mono miniature/stereo phone jack adapter, the audio circuit can be ignored.

Physical Construction. The Loop's frame will be assembled first, using doweling, two pieces of hardwood, aluminum tubing and aluminum U-channel. Refer to Fig. 3.

First, take two pieces of ½-inch (1.3-cm) ID seamless aluminum tubing, 34" (86.4 cm) long, and flatten the center 1½" (3.8 cm) in a vise as shown in step 1. (Steps are shown in Fig. 3.) Drill a 7/32-inch (5.6-mm) hole in each tube at the center point. Then drill two 5/32-inch (4-mm) holes 6" (15.2 cm) from the center point on each length of tubing. Next, drill two ⅛-inch (3.2-mm) holes 16.5" and 15" (41.9 and 38.1 cm) from the center point on each length of tubing.

Center-drill ½-inch (1.3 cm) holes ¼ inch (6.4 mm) deep on each of three 2⅝-inch (6.7-cm) lengths of ¾-inch

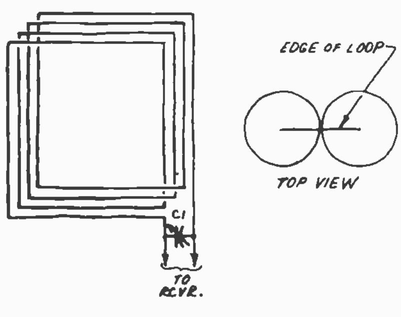


Fig. 1. Loop acts as an LC parallel circuit.

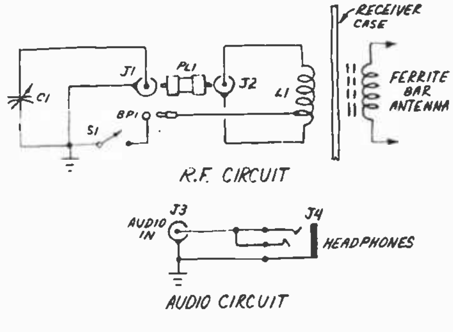


Fig. 2. Schematic shows how loop and radio antenna form r-f transformer.

(1.9-cm) doweling. File six grooves ⅜" (9.5 mm) apart on the dowels, spacing the outer ones ⅜" (9.5 mm) from each end. Take a 12¼-inch (31.1-cm) length of ½-inch (1.3-cm) doweling and drill two ⅛-inch (3.2-mm) holes 1¼" (3.2 cm) and 2¾" (7cm) from one end. Repeat four times. Then, glue the dowels together to form three T-shaped wire supports as shown in Step 2. Save the remaining dowel for later use.

Form a cross by overlapping the two lengths of tubing. Line up the center holes and secure with a ¼-20 × 1 inch bolt, flatwashers, and wing nut. Slide the Tee's into ends B, C, and D of the cross until the holes line up. Secure the Tee's in the tubing with ¼-inch self-tapping sheet metal screws (Step 3). Form four support braces from 9-inch (23.9-cm) lengths of ½" × ½" (1.3 cm × 1.3 cm) aluminum U-channel. Drill two 11/64-inch (4.4-mm) holes ¼" (6.4 mm) from each end. Then fasten the braces to the cross by lining up holes and using 6-32 × 1 inch machine screws, flatwashers, and nuts. Two lengths of channel should be on opposite sides of the tubing at each juncture.

Now prepare the fourth Tee by center drilling a ½-inch (1.3-cm) hole ¼" (6.4 mm) deep on one long side of a 4" × 1¼" × ¾" (10.2 cm × 3.2 cm × 1.9 cm) block of hardwood (Step 4). Drill a 3/16-inch (4.8-mm) hole ⅞" (2.2 cm) from one end of the block for the center conductor pin of *J2*, an SO-239 coaxial connector. Then drill a 3/16-inch (4.8-mm) hole 9/16" (1.4 cm) away on each side of the center conductor hole for two securing screws. File seven grooves ⅜" (9.5 mm) apart, spacing the HOT END groove 5/16" (7.9 mm) from the edge of the block. Drill a ⅛-inch (3.2-mm) hole in the center of both the HOT and GROUND END grooves. Then drill a 3/16-inch (4.8-mm) hole ⅜" (9.5 mm) to the right of the HOT and GROUND END holes on the top (ungrooved) side of the block. Mount solder lugs above each hole, using No. 6 × ½" wood screws.

Referring to Step 5, prepare an SO-239 coaxial jack, cutting two corners with a hacksaw to fit the hardwood block. Solder one end of a 6-inch (15.3-cm) length of hookup wire to the center conductor pin of *J2*, and thread it through the center conductor hole. Then secure *J2* to the wood block using No. 6 × ¼" wood screws, looping one end of a 4-inch (10.2-cm) length of hookup wire under the head of the screw nearest the GROUND END groove. Thread the other end through the hole in this groove and attach to the nearest solder lug (above *J2*). Trim excess. Attach the free end of the center conductor wire to the other solder lug, trimming excess.

Glue the hardwood block to the remaining 12¼-inch (31.1-cm) dowel to form the fourth Tee. Insert the Tee into the remaining corner of the cross (A), lining up the holes. Secure with ¼-inch self-tapping sheet metal screws. Then drill a 3/16-inch (4.8-mm) hole ⅞" (2.2 cm) above the bottom of the vertical tubing (above corner A). Make the hole slightly more than ⅜" (9.5 mm) deep.

Take one end of a 74-foot (22.6-m) length of 18- or 16-gauge (solid or stranded, bare or insulated—enamel or plastic—almost anything will do!) copper wire, thread it through the HOT END hole and solder it to the HOT END solder lug (trimming excess). Then tightly wind the wire around the cross, using the Tee grooves as guides to make six turns in all. Thread the free end through the GROUND END hole and solder to the lug, trimming excess. Remove the insulation (if any) from the wire near corner A on the fifth turn. Solder one end of a 4-inch (10.2-cm) length of hookup wire to this point. Leave the other end free for the moment.

Control Panel Construction. We'll now assemble the Loop's Control Panel. It should be fashioned from a 4.75" (12.1-cm) square piece of 1/16-inch (1.6-mm) aluminum plate. Physical layout is flexible, but use Fig. 4 as a guideline. Form a support bracket from aluminum stock, or use a commercial aluminum angle about 2½" × 1½" × 1½" (6.4 cm × 3.8 cm × 3.8 cm). Install the bracket centered along one side of the aluminum panel. Then drill mounting holes for an SO-239 coaxial jack—this should be set back 1" × 1" (2.5 cm × 2.5 cm) from the corner nearest the notched side of the bracket—and for the main tuning capacitor, switch *S1*, binding post *BP1*, and the RCA phono and headphone jacks (if desired).

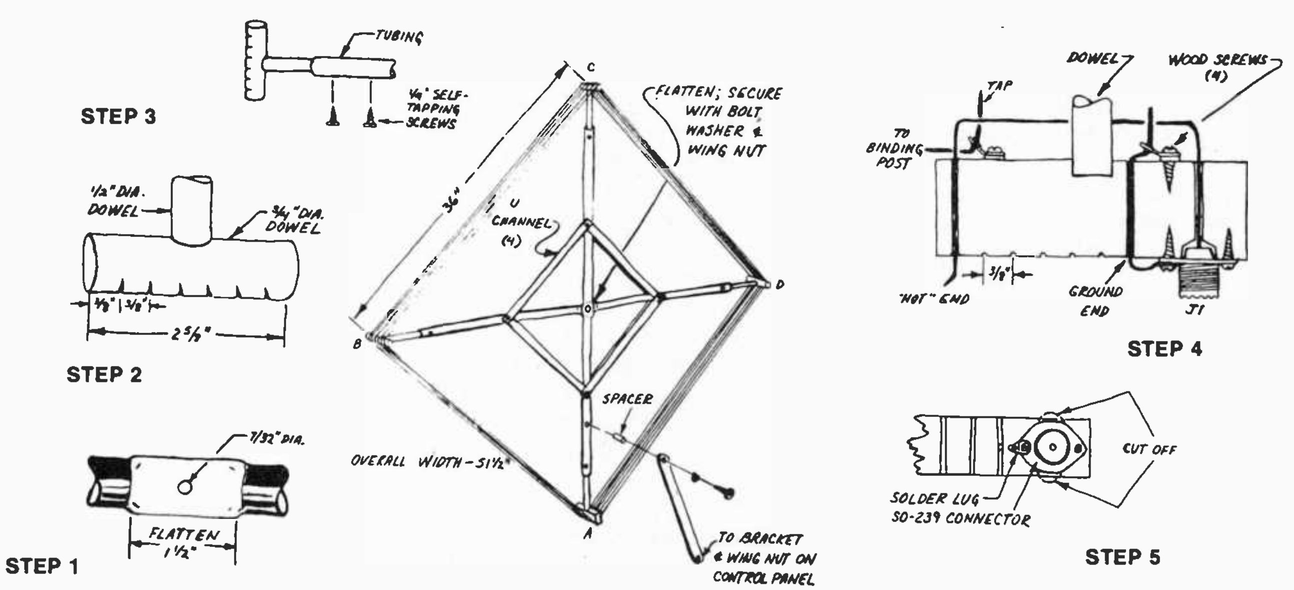


Fig. 3. Above are directions for constructing the frame for the loop. Aluminum tubing, U-channel, and wood dowels are used. Steps 1 to 5 are referred to in the text.

A note about capacitor *C1*—any surplus, multi-gang variable capacitor may be used. Total maximum capacitance should be about 1200 pF. As of press time, Fair Radio Sales, Box 1105, Lima, OH 45802, has several suitable models, with an approximate cost of $3.00. If you have trouble finding a capacitor on the surplus market, buy three 365-pF AM tuning capacitors and gang their shafts together. After installing all components, wire the Control Panel in accordance with the schematic (Fig. 2) using 18-gauge solid hookup wire. Try to keep all leads as short as possible.

The Control Panel should be mounted in a cutout on a rotatable platform—a lazy susan arrangement. The platform should be big enough to accommodate your AM receiver also, since it must be rotated in step with the Loop.

Once the Panel is mounted, drill a 7/32-inch (5.6-mm) hole in the support bracket ⅜" (9.5 mm) down and 1" (2.54 cm) over from the un-notched top corner. Then drill 7/32-inch (5.6-mm) holes along the center line ⅜" (9.5 mm) from each end of an 11¼" × 1" × ⅜" (28.6 cm × 2.5 cm × 9.5 mm) hardwood strip. Attach one end of the strip to the support bracket using a 10-20 × 1" hex head bolt, a hex nut as a spacer between the strip and bracket,

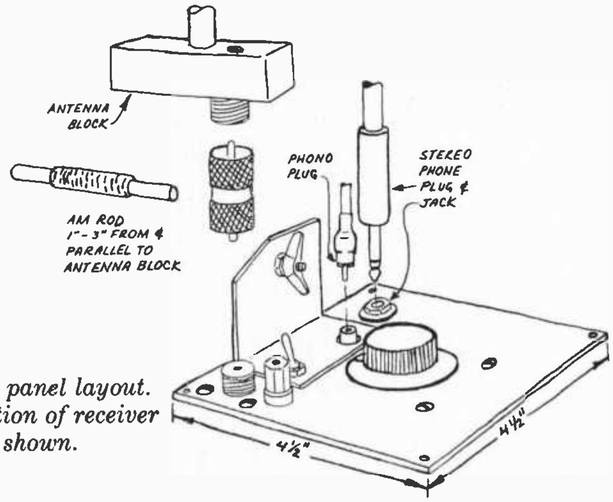


Fig. 4. Control panel layout. Proper orientation of receiver rod antenna is shown.

FRAME BILL OF MATERIALS

2—42 inch lengths of ½" ID thin-wall aluminum tubing
4—14-inch lengths of ½" wood doweling
3—2⅝-inch lengths of ¾" wood doweling
4—12-inch lengths of ½" × ½" aluminum U-channel
1—Block of hardwood 4" × 1¼" × ¾"
1—Strip of hardwood 11¼" × 1" × ⅜"
1—10-32 × 1½" bolt and washer
1—¾-inch spacer to fit above.
1—¼-20 × 1" bolt, washers, and wing nut
4—6-32 × 1" machine screws, flatwashers, and nuts
4—No. 6 × ½" wood screws
8—¼" self-tapping sheet metal screws

PARTS LIST

BP1—5-way binding post
C1—1200-pF (total) multi-gang variable capacitor
J1,J2—Uhf coaxial jack, SO-239
J3—RCA phono jack
J4—Open-circuit stereo headphone jack
L1—6 turns of 16- or 18-gauge copper wire wound on loop frame
PL1—Double male uhf coaxial adapter (Amphenol 83-877, Lafayette 42 69064 or equivalent)
S1—SPST switch
Misc.—4.75" square 1/16-inch aluminum plate, tuning knob, machine hardware, hookup wire, solder, etc.

and wing nut. Keep the wing nut relatively loose. Now secure the other end of the strip to the Loop frame using a 10-32 × 1½" bolt, washer, and a ¾" (1.9 cm) spacer. Use the 3/16-inch (4.8-mm) hole previously drilled above the bottom of the vertical tubing.

Attach the Loop frame to the Control Panel using *PL1*, a double male uhf coaxial adapter (Amphenol 83-877), between jacks *J1* and *J2*. Then connect the free end of the hookup wire from the loop to binding post *BP1*. Tighten the hardware holding the hardwood strip. Leave *S1* open, and position your AM receiver below the Loop, orienting its rod antenna as shown in Fig. 4. The two coils should be about 1" to 3" (2.5 cm to 7.6 cm) apart.

Using the Loop. Tune the receiver down to the low end (540 kHz) of the AM Broadcast Band. Turn *C1*'s tuning knob so that the plates are fully meshed. Then, carefully tune in an audible signal using the receiver's tuning capacitor. Slowly unmesh *C1*'s plates (reduce capacitance) until the signal peaks strongly. You have now tuned the Loop to resonance at this frequency.

It's possible that loading effects by the Loop may "pull" the receiver off its dial calibration. If this occurs, just continue to adjust both *C1* and the receiver's tuning capacitor for maximum intelligibility. You'll probably find that the two controls interlock, but with a little practice you'll be quickly zeroing in on the station you're after. Try rotating the loop to get an even stronger signal. Best results will be obtained when the plane of the loop extends in the direction of the desired signal. You can also use this directivity to null out an interfering station on the same frequency—turn the loop broadside to the offending signal.

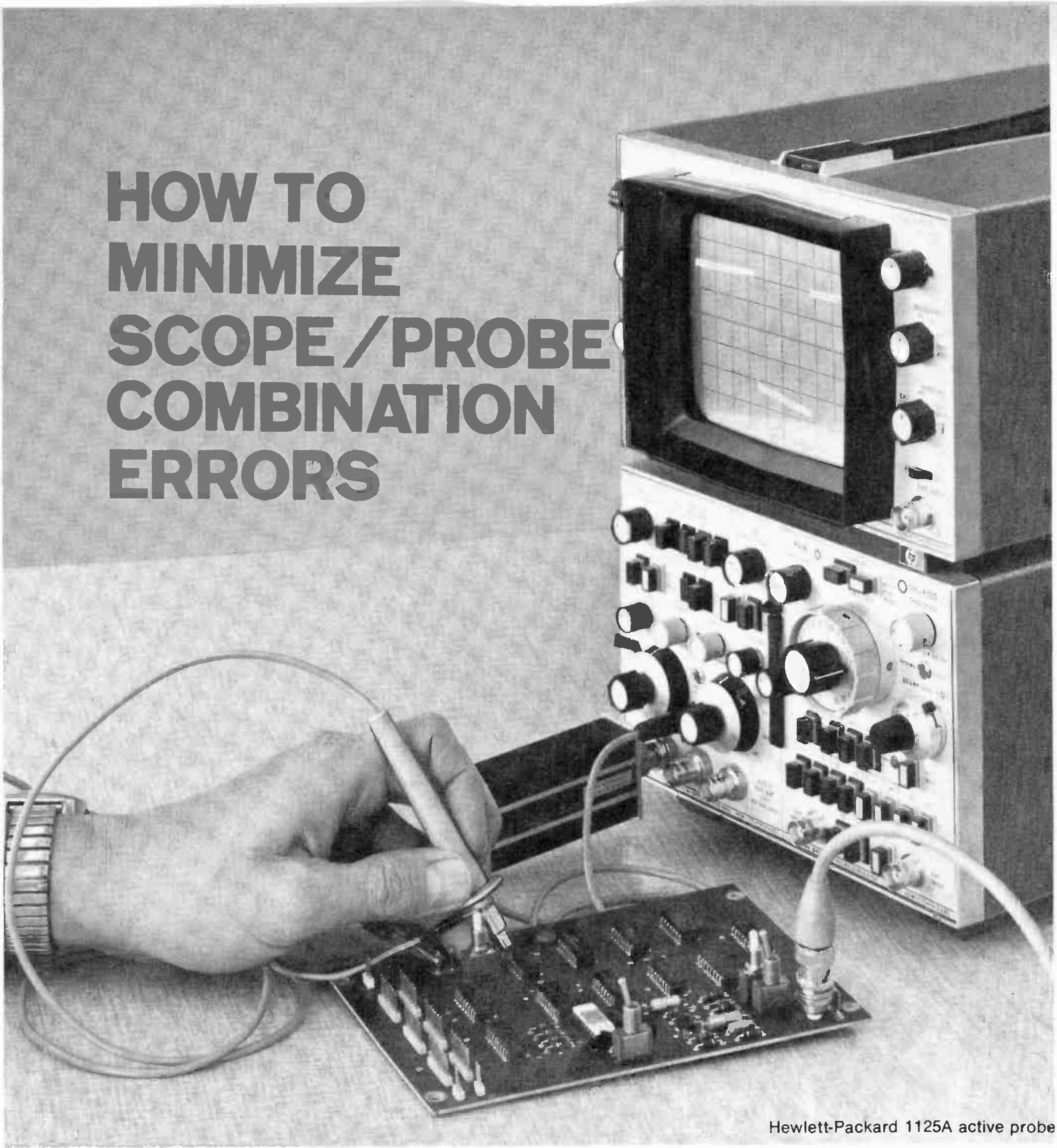
With *S1* open, the Loop can be tuned just about to 1600 kHz. It also has maximum gain in this position. But there are times when a bit more selectivity is desirable over gain—for example, when two fairly strong stations are a few kHz apart. This is particularly true when trying to work the "splits"—foreign stations operating on odd frequencies not multiples of 10 kHz. In situations like this, close *S1*. This shorts out the bottom turn of the loop, giving a higher Q. It also gives you a bit more "room" on *C1* at the top end of the band.

Other Suggestions. The "pulling" action mentioned earlier can cause you to get "lost" in terms of frequency. To prevent this, prepare a list of strong signals in your area, noting them by call letter and frequency. You can then use them as frequency markers to chart your way across the band. It's also a good idea to get a complete list of North American AM stations—especially if you want to DX the band. Several are available, listing stations by call letters, power output, frequency, and geographical location.

Another system variable is the amount of coupling between the Loop and the rod antenna. This should be varied to suit signal strength, but cannot accurately be predicted without experience with your particular receiver. While it should vary between 1 and 3 inches, experiment for best results.

To make tuning easier, a vernier (0 to 100) tuning knob can be used with *C1*. Once you have properly tuned a station in, record its frequency, direction toward which the Loop is turned, position of *S1*, and the amount of capacitance needed. Keep all this information for future reference. ◈

HOW TO MINIMIZE SCOPE/PROBE COMBINATION ERRORS



Hewlett-Packard 1125A active probe.

Choosing the right probe for a particular application can reduce measurement errors 50% or more.

BY THOMAS R. SEAR

MOST of us tend to assume that an oscilloscope display is a "perfect" representation of what is occurring in a given circuit. Actually, when you apply a signal to the input of a scope, you can lose a large percentage of what is really there if the signal source is not carefully matched to the scope's input impedance. Since the main reason for paying big money for a wideband scope is that you need the bandwidth, it is important that nothing be allowed to compromise its performance—least of all something as "simple" as a probe connected to the input.

If you select the wrong type of probe for a given measurement, the signal that reaches the scope may not have some of the characteristics that are of interest to you. Unless certain precautions are observed, especially at high frequencies, getting the signal to the input of the scope may become the most critical part of any measurement you are making.

There are times when a plain piece of wire will suffice for coupling a signal to a scope. Also, the passive types of attenuator probes that are sold with

The Tektronix P6045 probe, with FET isolation stage, provides signal attenuation of 1:1, 10:1, or 100:1 with 1.5-ns rise time.

most new scopes do a fine job most of the time. However, the broad bandwidths of modern scopes and the sophisticated uses to which they are put make it absolutely necessary to match scope to probe if you want accurate and meaningful measurements. Failure to match probe and scope can result in measurement errors of 50% or more.

Impedance Effects. The scope vertical input to which you connect the probe will have either a high impedance or an impedance of 50 ohms (Fig. 1A). In either case, the impedance is a resistance in parallel with a capacitance (values approximately those in the diagram). Any probe can also be represented by a parallel RC circuit (Fig. 1B).

To estimate the effects that a given scope/probe combination will have on the signal, the combination can be simplified schematically as shown in Fig. 1C. Note that the values here are those that would be "seen" from the probe tip. That is, the series resistance of R_P and R_S is typically about 10 megohms (R_{IN}); and the series equivalent of C_P and C_S is about 6.7pF.

As R_{IN} decreases, more current is drawn from the circuit being tested. When R_{IN} approaches the impedance of the signal source, significant errors result because of resistive loading. The amount of error in per cent is $100Z_G/(Z_G+Z_{IN})$, where Z_{IN} is the parallel combination of R_{IN} and the impedance of C_{IN}.

Small amounts of loading decrease the signal amplitude only slightly. Heavy loading, however, may draw so much current from the signal source that the circuit will saturate, become nonlinear, or stop operating completely.

So the first rule for selecting scope/probe combinations Is:

Rule 1: To insure that resistive loading errors are less than 1%, select a scope/probe combination with R_{IN} at least 100 times greater than the source impedance.

The probe capacitor can be troublesome in two ways. First, if not properly adjusted to provide frequency compensation, slight errors will be introduced into your measurements. Second, consider the effects of the combined capacitance (C_{IN}) as a function of frequency. At 1000 Hz, C_{IN} (Fig. 1C) has an impedance of about 23.8 megohms, with no effect on signal measurement. But at 2375 Hz, its impedance will equal R_{IN} and have a definite effect on the signal. Down at 1 MHz, the impedance is only about 24,000 ohms and may load the circuit heavily.

The results of shunt capacitance variations can be amplitude attenuation and abnormal circuit operation. Furthermore, it can cause phase shift, excessive source loading, pulse perturbations, and errors in rise time and propagation-delay measurements.

The effects of shunt capacitance can become a factor almost before you know it. At 100 MHz, impedance of shunt capacitance can be less than 80 ohms for some scope/probe combinations—practically a short circuit in some cases. So, the second rule for probe selection is:

Rule 2: To minimize errors related to frequency, select a scope/probe combination with a shunt capacitance value that is as small as possible.

Rise-Time Error. We have considered the effects of resistance and

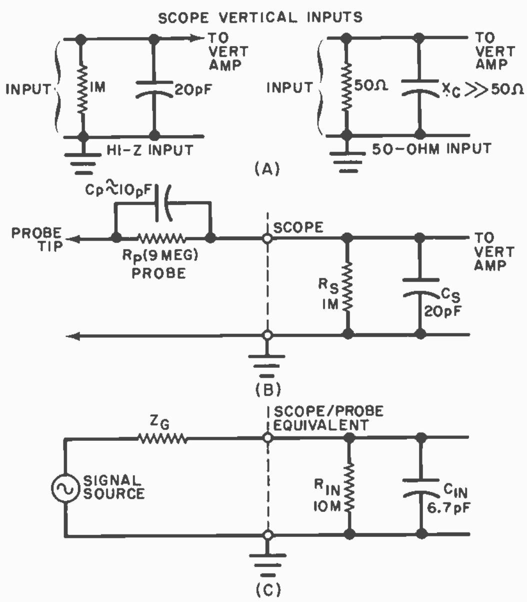


Fig. 1. Typical scope inputs: (A) for high- and low-impedance scopes; (B) with a passive divider probe; (C) equivalent circuit of combination in (B).

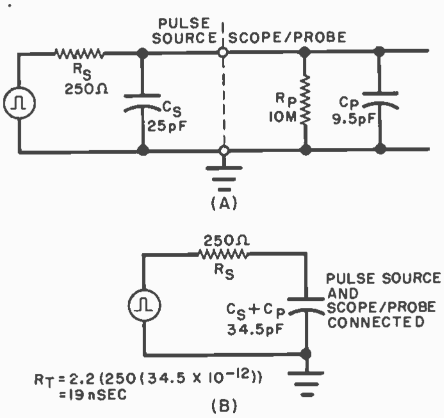
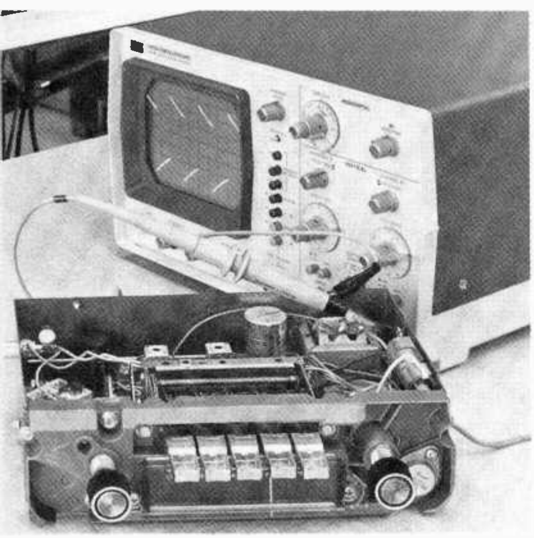


Fig. 2. A pulse source connected to the scope/probe combination in (A) results in equivalent at (B) for rise-time analysis.

capacitance. Now what is their combined effect? Figure 2A shows a typical pulse source, with an internal impedance of 250 ohms and shunt capacitance of 25 picofarads. Assuming a pulse signal with a rise time of zero, the source output rise time would be approximately $2.2R_SC_S$, or 13.8 nanoseconds. The equivalent circuit for the scope/probe and source combination is shown in Fig. 2B. Since R_P is so much larger than R_S, the former can be ignored. The rise time of the signal reaching the scope input will now be about 19 nanoseconds. The loading effect of the probe is the percentage change in rise time or about 37.7%. This is directly related to the difference in capacitance (9.5/25 or 38%) caused by the addition of the probe. So to determine how much error in rise time you are going to introduce by adding a probe, determine the ratio of the capacitances involved.



Hewlett-Packard's 10001A passive probe is rugged and easy to use.

Phase-Shift Error. In making measurements, source impedance is the key parameter. Accuracy requires that the source impedances of the two points being measured be on the same order of magnitude. For example, referring to Fig. 3, consider the effects of various probes on phase measurements between the input and output of the amplifier. The source impedance of the input is 50 ohms; while, for the output, it is 2000 ohms.

If 10-megohm, 10-picofarad scope/probe combinations are connected to the input and output of the amplifier, the source impedances will not be changed and a phase measurement error of about 49 degrees will result.

However, if 1000-ohm, 1-picofarad scope/probe combinations are connected to the input and output, the source impedances will become 47.5 and 667 ohms, and the phase measurement error will be only about 2 degrees. Thus, by loading the input and output circuits of the amplifier, the phase error has been almost eliminated; but the resistive loading error is on the order of 67%.

When phase and amplitude are both of interest, it is necessary to perform two tests—one for phase (using low-impedance probes) and another for amplitude (using high-impedance probes). So the third rule is:

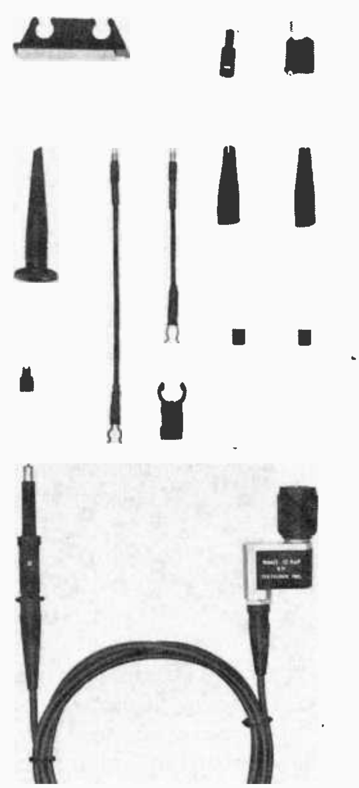
Rule 3: To minimize phase errors, use low-impedance scope/probe combinations.

Types of Probes. In general, there are three basic types of probes available commercially. The types and their characteristics are as follows:

- **High-Resistance Passive.**
  Minimum resistive loading.
  Subject to capacitive loading at frequencies above 200 kHz.
  High input impedance from dc to about 200 kHz.
  High dynamic range (500-600 V).
  Least expensive type.

- **Miniature Passive Divider.**
  Load source more than high-resistance types, but load remains constant to about 100 MHz so loading is easy to predict.
  Minimum capactive loading.
  Most useful when resistive loading is not a consideration.
  Fastest rise time.
  Widest range of voltage division (to 100:1 with changeable divider tips).
  Maximum signal voltage less than high-resistance types.
  Best for measuring fast rise time, phase relationships, and high frequencies if resistive loading is not important.

- **Active Probes.**
  Very little resistive loading.
  Minimum capacitive loading.
  Limited dynamic range (50 V maximum signal).
  Highest input resistance of all types.
  Lowest input capacitance of all types.
  Excellent for high-frequency, low-level signals.
  Best general-purpose probe within its limited dynamic range.
  Slightly greater pulse perturbations than passive-type probes.
  Large physical size.
  Most expensive type.
  Requires some form of external power.



Tektronix active probe has switch to actuate trace-identity function on scope—good for dc to 250 MHz.

Of course the active probe is the "in thing" these days—primarily because it has the least possible effect on the test circuit. It is generally used with scopes having 50-ohm inputs; but it can't really be considered a general-purpose probe since it is expensive and is liable to damage from misuse.

There is a fourth type of probe that doesn't fit any of the other categories. Called a "current" probe, it is ideal for measurements involving very high source impedances, where other probes would put too much load on the circuit. The current probe clips around the wire (or component) carrying a signal so that it does not actually contact the circuit. There is a small amount of insertion impedance (about 0.1 ohm) reflected into the circuit being tested, but this merely means that the source impedance must be at least 5 ohms to minimize errors in amplitude measurement. ◈

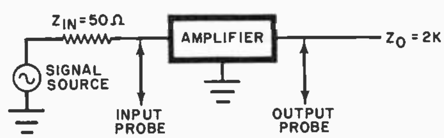


Fig. 3. Scope/probe combination can affect phase-error measurments.

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BY SAMUEL LYLE

CURVE TRACER Checks Semiconductor Quality from Breakdown Voltage to Beta

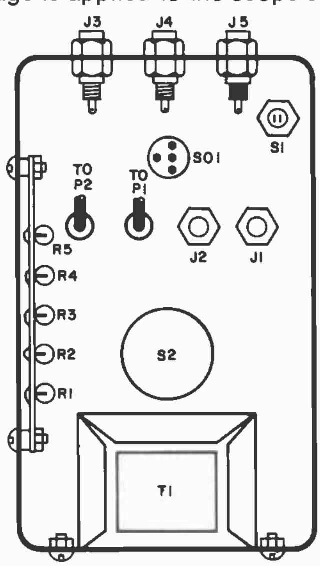
A SIMPLE go/no-go tester will tell you if a transistor will operate, but it will not tell you the quality of operation. For this, you need a curve tracer, which is usually an adapter designed to be used with an oscilloscope. The Experimenter's Assistant tracer/tester described here can test virtually any type of discrete semiconductor device, classify it according to type (npn or pnp) and material (silicon or germanium), and check reverse and forward breakdown voltages and leakage. It can also provide a rough indication of a transistor's beta.

In addition to semiconductor devices, the tester can also check capacitors and inductors. With a little imagination, it can also be used for in-circuit testing. To make testing conditions as safe as possible, the maximum test current is limited to slightly less than 4 mA.

Circuit Operation. The tester provides a simple means of depicting the voltage/current behavior characteristic of the component under test, graphically displaying the characteristic on an oscilloscope screen. The basic circuit shown in Fig. 1 consists of transformer *T1*, resistors *R1* and *R2*, switch *S1*, and component attachment jacks *J1* and *J2*. Note the three connections that must be made from the tester to the oscilloscope's horizontal and vertical inputs and ground. The remainder of the circuit is used for actual semiconductor testing and is connected to the basic circuit by plugging *P1* into *J1* and *P2* into *J2*.

With *S1* open, the 12.6 volts rms at *T1*'s secondary provides the sweep for the scope. Because the input impedance of the scope is virtually infinite, relative to the value of *R1*, the full transformer swing of ±17.82 volts peak-to-peak is applied to the horizontal input of the scope. Since no effective current flows through *R1*, no signal appears at the scope's vertical input. The result is a horizontal trace on the CRT, with the right and left ends of the trace representing +17.82 and −17.82 volts, respectively.

If test leads are connected to *J1* and *J2* and their test tips are shorted together, the full secondary voltage of *T1* will appear across *R1*, while no voltage is applied to the scope's horizontal input. This results in a vertical trace on the CRT, with the top of the trace representing a current of 3.8 mA (17.82 volts/4800 ohms = 3.8 mA).



A typical layout for the curve tracer.

Removing the short between the test leads and depressing *S1* places *R1* and *R2* in the circuit. Now, the scope will display a 45° trace, assuming the horizontal and vertical input channel gains of the scope are properly set. Resistor *R2* and switch *S1* are used for balancing the channel gains. Once the channel gains have been set to display a 45° trace, any component whose resistance is greater than 4700 ohms will produce a more nearly horizontal trace, while component resistances of less than 4700 ohms will produce a more nearly vertical trace. The actual slope of the trace is directly related to $R1/R_{TEST}$, where $R1$ = 4700 ohms and R_{TEST} is the resistance of the component connected across the *J1/J2* test probes.

Construction. You can assemble the tester in any enclosure of a convenient size using a point-to-point wiring technique. Use a terminal strip to mount the five resistors. The best place to mount *SO1*, *S1*, *S2*, *J1*, and *J2* is on the cover of the enclosure.

Connect one end of a 12" (30.5-cm) length of flexible test lead to the C lug on *SO1*, tie a knot in it to serve as a strain relief, pass the free end through a rubber-grommet-lined hole in the top of the case, and terminate the cable with a banana or tip jack (to mate with *J1*). Repeat this procedure with a cable connected to the E lug on *SO1*. These two cables, when plugged into *J1* and *J2*, allow transistors plugged into *SO1* to be tested. For in-circuit tests of transistors and diodes and out-of-circuit tests of transistors that do not fit into *SO1*, separate test cables must be plugged into *J1* and *J2*. Prepare these with appropriate plugs at one end and standard test probes at the other end.

Mount *J3*, *J4*, and *J5* on the rear wall of the case. Prepare three 36" (about 1-meter) test cables with plugs (*P3*, *P4*, and *P5*) to match these jacks on one end and plugs to match the input connectors on your scope at the other end. These last jacks and cables are for interconnecting the tester with a scope. Alternatively, you can connect the cables directly to the appropriate points in the tester circuit and have them exit the case through grommet-lined holes and eliminate *J3*, *J4*, *J5*, *P3*, *P4*, and *P5*.

After wiring the circuit and assembling the case, label the jacks, plugs, switches, and test socket.

Using the Tester. If an "ideal" diode is connected between *J1* and *J2*, it will act as a short circuit for one-half of the ac cycle when forward biased. During the other half-cycle, it will be

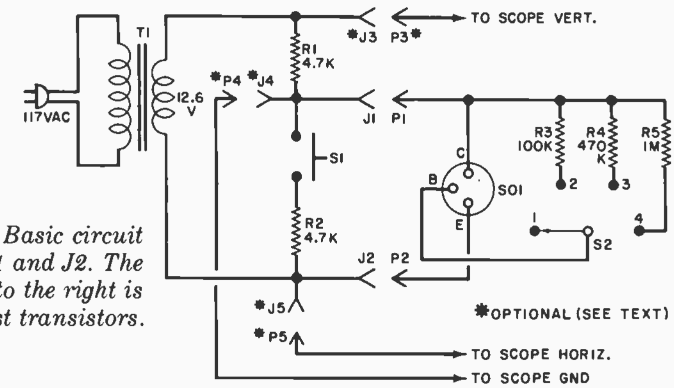


Fig. 1. Basic circuit ends at J1 and J2. The circuit to the right is used to test transistors.

PARTS LIST

J1 to J5—Banana or tip jack (J3, J4, J5 optional—see text)
P1 to P5—Banana or tip plug to match jacks (P3, P4, P5-optional—see text)
R1,R2—4700-ohm, ½-watt, 1% resistor
R3—100,000-ohm, ½-watt, 1% resistor
R4—470,000-ohm, ½-watt, 1% resistor
R5—1-megohm, ½-watt, 1% resistor
S1—Normally-open pushbutton switch
S2—4-position, nonshorting rotary switch
SO1—Transistor socket (chassis mount)
T1—12.6-volt filament transformer
Misc.—Line cord with plug; flexible test-lead cable; control knob; test probes (2); jacks for scope input (3); case (such as Radio Shack No. 270B098—6⅛" × 3¾" × 2"); lettering kit; machine hardware; rubber grommets; hookup wire; solder; etc.

reverse biased and will seem to be an open circuit. Hence, the trace observed on the scope's CRT will form a right angle with one leg horizontal and the other vertical. The intersection of the two legs will be centered on the screen.

Few things in nature are perfect, the diode is no exception. A silicon diode requires about 0.6 volt forward bias before it begins to conduct, germanium about 0.2 volt. Illustrated in Fig. 2A are the differences in forward conduction voltage as "offsets" in expanded horizontal traces. Hence, the tester can identify a diode under test as either silicon or germanium.

If you connect a 5-volt zener diode between the test probes connected to *J1* and *J2*, the resultant waveform will appear as shown in Fig. 2B. Note that the zener's impedance and breakdown voltage can be obtained from an expanded horizontal trace. The zener impedance is equal to the change in voltage divided by the change in current within the linear breakdown region of the trace. Snap-recovery and tunnel diodes also produce their own characteristic traces.

In testing transistors, it is useful to visualize them as variable resistors whose emitter-to-collector resistances are controlled by a minute base current. Within a transistor's operating range, the collector current will approximately double if base current is doubled. The "resistance" of the transistor, as "seen" by its associated circuit components, will decrease by a factor of approximately two.

To use the tester as a transistor checker, the *SO1* portion of the circuit in Fig. 1 must be plugged into *J1* and *J2* or the separate test leads must be plugged into the jacks. Assuming the former, if a transistor is plugged into *SO1* and *S2* is set to position 1, the trace observed should be a continuous horizontal line. (With no base current, the transistor should have an infinite emitter-to-collector resistance.) The trace will be off the horizontal only if there is leakage current within the transistor or the transistor's breakdown voltage is exceeded. These traces are depicted in Fig. 2C.

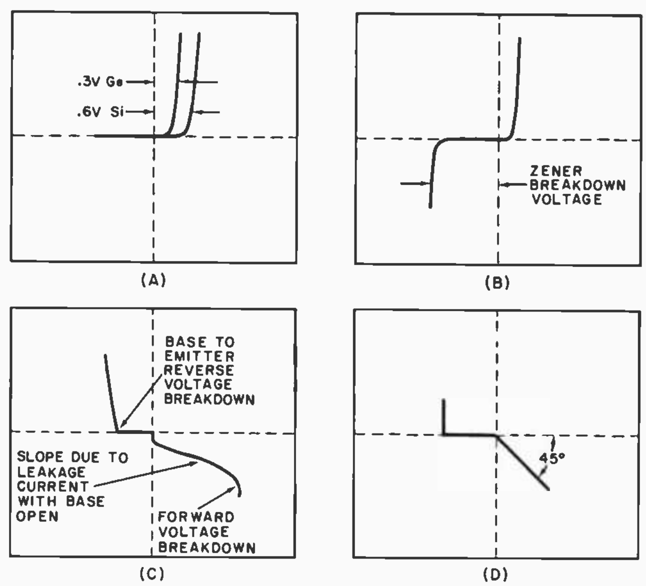


Fig. 2. Typical scope traces: (A) identification of silicon or germanium junction; (B) zener diode curve; (C) transistor with leakage, forward breakdown voltage, reverse breakdown; (D) transistor with a gain of 100.

To perform a beta (β) measurement of a transistor, start with no transistor plugged into *SO1*. Depress *S1* and adjust the scope's controls for a 45° slope to the trace. Insert the transistor in the test socket, observing the proper lead basing, and set *S2* to position 3. If the transistor's β is 100, a 45° trace will be displayed as shown in Fig. 2D.

For most transistors, β can be determined by rotating *S2* until the trace is close to 45°. For the component values shown in Fig.1, and a trace slope of 45°, the β is approximately 21 in position 2 of *S2*, approximately 100 in position 3, and approximately 213 in position 4.

Other Uses. If you connect a good capacitor across the test leads connected to *J1* and *J2*, an elliptical trace will be displayed. This trace will result because of the phase shift at 60 Hz between the vertical and horizontal inputs of the scope due to the RC network. A trace shape approaching a circle is obtained when the capacitive value under test is approximately 0.5 µF. Inductors will produce similar traces, and the tester can also be used to match inductances of home-made toroidal transformer coils.

Since the current through the probes is limited to less than 4 mA, the tester can be used to check most in-circuit components. Connect the test leads across an in-circuit semiconductor, and the resultant trace shape and slope will be determined by the various resistances and reactances associated with the semiconductor. Although the waveform displayed can be greatly distorted, you can check junction operation by looking for the telltale junction discontinuity that is typical at the zero axis. Not only can you check semiconductor junctions, you can also check the qualities of other componants such as resistors, capacitors, and inductors that are common to the transistor stage. ◈

How Multiplexed LED Displays Simplify Circuits

BY PATRICK J. DELANEY III

A CONVENTIONAL digital readout system for LED's consists of a counter to generate a BCD (binary coded decimal) output and drive a seven-segment decoder for each of the seven segments. For several decades of readout, requiring a counter/decoder combination for each digit, the cost and circuit complexity can be very high.

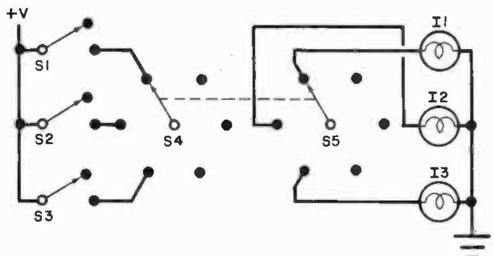


Fig. 1. Basic principle of mechanical multiplexing is a time-sharing scheme.

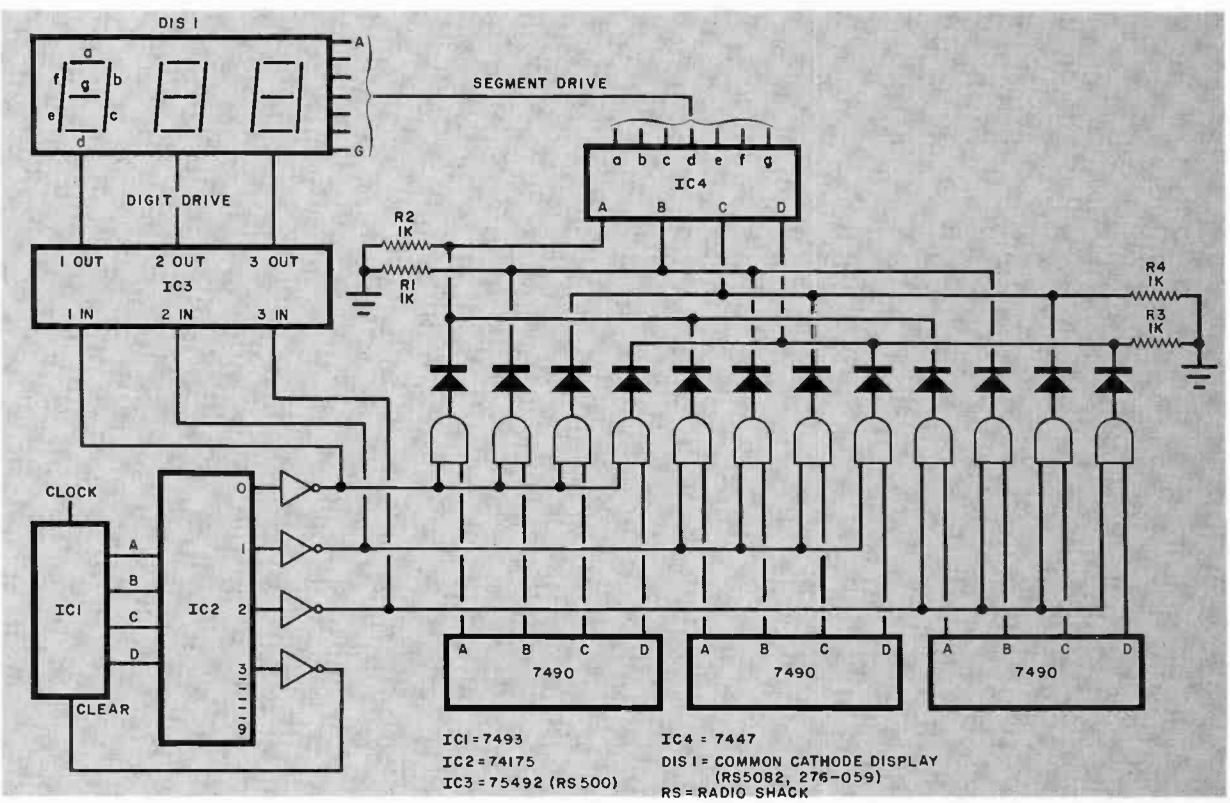
The use of digital multiplexing greatly reduces the number of parts and the size of a digital counter. It also means that inexpensive AND gates can be substituted for seven-segment decoder IC's; low-cost surplus multi-decade readout blocks can be used; and there is lower current drain on the power supply. The amount of wiring required can also be reduced.

How Multiplexing Works. Display multiplexing is based on a time-sharing technique which is shown in a simplified form in Fig. l. If switches *S4* and *S5* are driven from a common shaft, they carry "on" and "off" information from *S1*, *S2* and *S3* to lamps *I1*, *I2*, and *I3* sequentially, so that the lamps respond to the position of each associated switch. That is, *I1* responds only to *S1*, *I2* responds only to *S2*, and *I3* responds only to *S3*.

If *S4* and *S5* were made to switch very rapidly, it would appear to the eye that the lamps were either constantly on or constantly off depending on the position of the controlling switches. (When LED's are used, thermal lag in lamp filaments, which would have some import in incandescent lamps, can be disregarded.)

The actions of the mechanical switches can be duplicated with digi-

Fig. 2. Electronic multiplex can be used to experiment with multi-digit LED readouts—as many as nine digits.



tal electronic circuits as shown in Fig. 2. The components in this circuit can be bought from almost any "blister package" rack. The three 7490 decade counters represent the output stages of a digital instrument. Although only three decades are shown, the circuit can be easily expanded to six decades simply by adding AND gates and diodes or to nine decades by duplicating *IC3*.

In Fig. 2, *IC1* and *IC2* act as the rotary switches of Fig.l. They are driven by *IC1*, which gets a clock pulse to determine the multiplex rate. Each output of *IC2* turns on a single digit of the multi-digit readout by shunting a cathode to ground through *IC3*. Simultaneously, the output signal from *IC2* turns on its set of AND gates to transfer the associated decade counter's BCD output to the common BCD-to-seven-segment decoder *IC4*.

In the digital readout block, all the similar segments are connected in parallel so that (for example) if segment A is driven, all A segments are driven. However, the digit driving circuit has activated only one digit so only the A segment of that digit will glow. The clock pulses then cause *IC2* to switch to its next output so that the second digit is activated. If the clock rate to *IC1* is high enough (above 200 Hz), each digit is strobed rapidly so that the display appears to be motionless. When the states of the 7490 IC's change, the readouts change accordingly.

As a rule, the output of a TTL gate is intended to drive the input of another gate. If the outputs are tied together, it is possible that, when one gate has a high output, one of the others may have a low output. The latter will then try to "sink" the output currents. This causes one gate to overheat and possibly malfunction. The diodes on the outputs of the AND gates in Fig. 2 prevent this problem by isolating the outputs. Resistors *R1* through *R4* provide a return path to ground to insure that the inputs of *IC4* are low if no positive input is present.

The clock signal for *IC1* can be obtained from any source of pulses whose frequency is greater than 200 Hz. If more than three decades are required, select an output from *IC2* that is one digit higher than the number of digits to be displayed. Then invert this signal and apply it to the clear input of *IC1*. Expand the circuit by coupling the diodes to the BCD inputs of *IC4*. Each *IC3* can handle six digits. ◈

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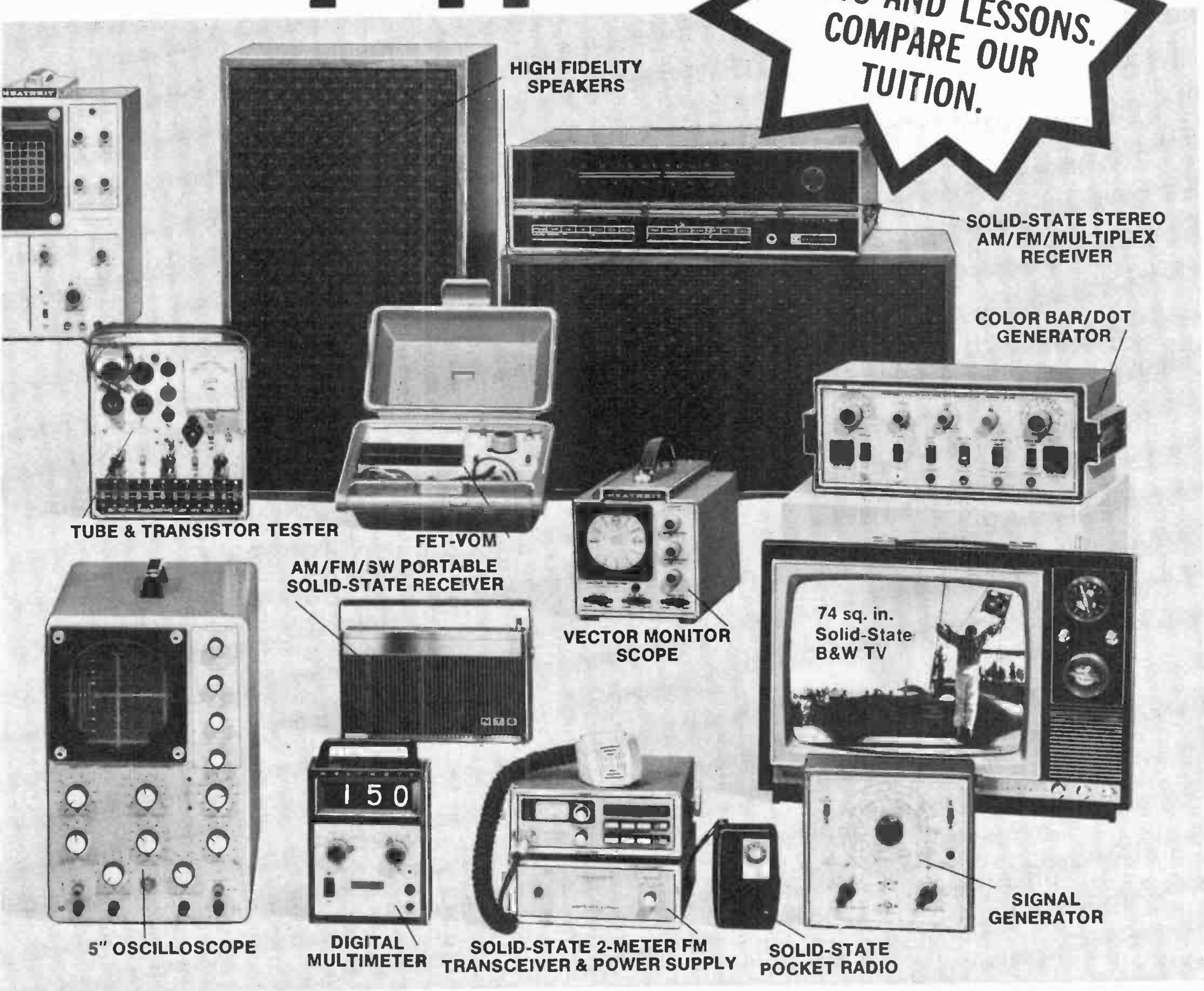

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Product Test Reports

ABOUT THIS MONTH'S HI-FI REPORTS

One of the more versatile models in the new Marantz line of cassette decks is the front-loading 5220, which can also be used to decode Dolby FM broadcasts. It is equipped with bias and equalization selectors for all three basic tape formulations (ferric-oxide, chromium-dioxide, and ferrichrome).

The Onkyo Model TX-220 AM/stereo FM receiver, though relatively low-priced, compares favorably in performance with others costing more—and has most of the same features. It is rated for lower power than some more deluxe units, but there are many compact speakers that it can drive to room-filling levels without strain.

—Julian D. Hirsch

MARANTZ MODEL 5220 STEREO CASSETTE DECK

Front-load tape deck combines fine performance with luxury features.

The Marantz Model 5220 is a front-loading cassette deck whose styling matches that of other audio components in the company's line. More than half of the satin-gold front panel is devoted to a blackout area that corresponds to the dial portion ordinarily found on tuners and receivers. When the power is on, two level meters, (illuminated in blue and red), become visible behind the blackout window.

The cassette compartment occupies the left portion of the panel and is internally lighted to permit visibility of the cassette while playing or recording. The compartment is covered by a tinted plastic window that swings open for inserting or removing the tape and closes by operating a lever near the cassette well.

The deck measures 16⅜"W × 12½"D × 5⅜"H (41.6 × 31.8 × 13.7 cm) and weighs 19½ pounds (8.9 kg). Price is $349.95.

General Description. The deck's control section includes an index counter for the tape, accompanied by pushbuttons to reset the counter and engage a MEMORY feature. When the latter is engaged, the tape automatically stops when the counter reaches 000 in the rewind mode. This is convenient when you want to return to a previously selected point on the tape.

Six levers provide control of the tape transport. They are labelled EJECT, REC, REW, FF, STOP, and PAUSE. Except for REC, any control can be operated at any time without first stopping the tape. At the end of the tape, or if the cassette jams or breaks, the mechanism shuts off and disengages automatically in any operating mode.

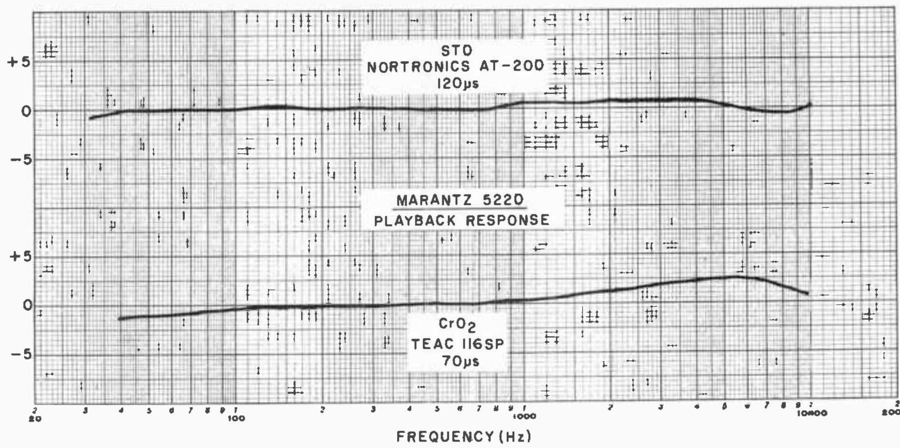
Slide-type controls provide a means for separately adjusting the recording levels for each channel from the microphone and line sources. (The two can be mixed.) A single slide potentiometer serves as the master level control. The playback level is normally fixed, but it can be adjusted via screwdriver controls located in the rear of the deck. The two MIC jacks are located below their level controls, and a stereo jack for 8-ohm headphones is below the power switch.

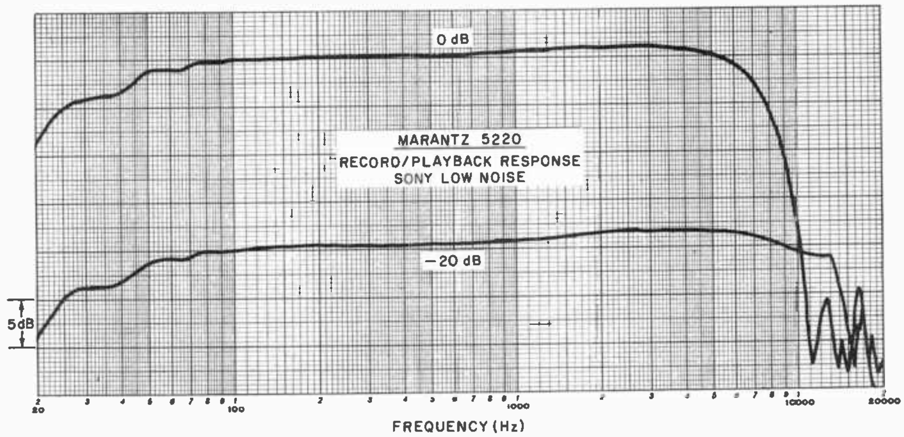
The deck's remaining functions are controlled by seven pushbutton switches located below the gain controls. Two switch in and out the Dolby FM decoding system for listening to broadcasts with the benefits of noise reduction and correct frequency balance. Screwdriver controls on the deck's rear are provided for calibrating the Dolby circuits to a standard level tone transmitted by the FM station by setting the meter pointers to the Dolby (+2-dB) marks on the scales. A slide switch on the rear of the deck can be used to insert a compensating network to convert the normal 75-µs tuner deemphasis to the 25-µs used in Dolby transmissions. (If your tuner has its own 25-µs deemphasis network, this switch should be left in the 75-µs position.)

Another pushbutton turns on and off the Dolby circuits themselves for FM decoding or for recording and playing tapes. Separate pushbuttons for NORMAL (low-noise ferric-oxide tapes), CrO_2, and FeCr tape formulations simultaneously select the correct bias and equalization required for each type of tape. The final pushbutton engages a recording LIMITER that goes into operation at levels above 0 dB to prevent tape saturation and distortion from unexpected high input levels. A red PEAK light, located between the meters, flashes when instaneous recording levels exceed "safe" limits. A REC light glows red when the deck is in the recording mode.

The tape transport employs a servo-controlled dc motor for driving the capstans and tape hubs. Plug-in circuit-board assemblies are used in the deck for easy serviceability, and extra shielding and bias traps keep the 100-kHz bias oscillator signal out of the line outputs when recording. The deck's circuits, including the Dolby noise reduction section, are built with discrete components to reduce distortion at high signal levels. Ferrite tape heads provide long life and wide frequency response.

Laboratory Measurements. The playback frequency response was measured with both 120- and 70-µs test tapes for the NORMAL and CrO_2/FeCr tape selector settings. The





120-µs response was flat to within ±1 dB from 31.5 to 10,000 Hz. The 70-µs response rose slightly in the several thousand hertz range but was within ±2 dB from 40 to 10,000 Hz.

The record/playback frequency response was checked with the three tapes for which the deck had been specifically adjusted. Sony Low Noise (LN) was used as a NORMAL tape, Sony CRO for chromium-dioxide tape and Sony FeCr for the ferrichrome. Response checks were also made with other standard tapes to verify compatibility: Maxell UD and Scotch Classic. (Most CrO_2 tapes have very similar magnetic properties.)

The Sony LN tape yielded a frequency response within ±2 dB from 45 to 13,500 Hz. The CrO_2 tape, as expected, produced a slightly extended response: ±3 dB from 22 to 14,500 Hz. The best response was obtained with the ferrichrome tape: ±3 dB from 23 to 16,500 Hz. The recorder was evidently slightly under-biased for Maxell UD tape, since the response had a gentle upward slope above 1000 Hz. However, it was still quite usable with the NORMAL tape setting. The Scotch Classic ferrichrome has different properties from the Sony ferrichrome, and its output was emphasized below 1000 Hz compared to the high-frequency level. It was still within ±4 dB from 20 to 14,000 Hz.

All response measurements were made at a −20-dB level. At 0 dB, high-frequency response suffers due to tape saturation, with the high-frequency performance improving markedly as we progressed from LN to FeCr tape.

A line input of 58 mV or a microphone input of 0.16 mV was needed for a 0-dB recording level at 1000 Hz. The microphone input overloaded at a very high 95 mV. The playback output depended on the tape used, varying from a low of 0.65 volt with Sony LN to a high of 0.81 volt with CrO_2. The meters had ballistic characteristics close to those of professional VU meters, indicating about 95% of steady-state levels on a 0.3-second tone burst. A Dolby level tape played back with meter indications within 0.5 dB of the Dolby markings.

The NORMAL tapes had the lowest distortion and greatest recording headroom at 1000 Hz. Both Sony and Maxell tapes were quite close in their performance, with the Sony LN having 1.8% distortion at 0 dB and reaching the 3% reference distortion level at +6 dB. Corresponding figures for Maxell UD were 1.6% and +7 dB. The CrO_2 tape saturated at a much lower level, with 3% distortion occurring at +1 dB. The two ferrichrome tapes reached 3% distortion at +2 dB. Since the PEAK light flashed at +7 dB, it can be used as an overload indicator only with ferric-oxide tapes. Other tapes would be driven into saturation long before the lamp would flash.

The signal-to-noise (S/N) ratio was measured with the three tapes relative to the recording level that gave 3% playback distortion. Measurements were made unweighted (wide-band), with IEC "A" weighting to reduce the effect of less audible low and high frequencies, and again with the Dolby system switched in. The three S/N figures for Sony LN tape were 50.8, 56.0, and 62.5 dB. With Sony CRO tape, they were 50.5, 56.0, and 61.5 dB, and with Sony FeCr tape, they were 50.0, 55.0, and 60.5 dB. The Scotch Classic ranked close to the Sony FeCr and the Maxell UD was similar to the Sony LN in their distortion and noise characteristics.

Through the microphone inputs at maximum gain, the noise increased by only 4.5 dB, which is considerably less than the noise added by most cassette recorder microphone amplifiers. The combined unweighted rms wow and flutter was 0.11% in playback only and 0.13% in a combined record/playback measurement. The tape transport required 93 seconds to wind a C-60 cassette in the fast speeds. The recording limiter had a very fast attack and a slow decay. Although it had no effect on signal levels below 0 dB, it virtually eliminated all possibility of overload distortion. (Even a 50-volt input signal, at maximum gain, was held to safe levels.) The headphone output was too low to be really useful with high-impedance (200 ohms) phones, which are much more common these days than the 8-ohm phones for which the recorder was designed. The Dolby circuits tracked well, affecting the overall record/playback response by less than 2 dB at any frequency, at recording levels of −20 and −30 dB.

User Comment. Our tests confirmed the specifications for the tape deck. The Model 5220 is extremely versatile in its ability to use different tape formulations, mix signal sources, and properly decode FM Dolby transmissions with any type of tuner.

We liked the front-loading feature. The cassette can be seen clearly in the compartment if it is close to eye-level. Below eye-level, however, there may be some fumbling encountered in seating the cassette in its support. When the EJECT lever is operated, the door swings up and the cassette slides down to the front of the compartment for easy removal.

Although the meters are accurate and have good ballistic response, their illumination is rather dim. The low-level blue light used for the "safe" portion of the scale provides almost no contrast with the meter pointer. On the other hand, once the level has been set, there is little need to refer to the meter, especially if the limiter is used. When the limiter is switched out, the flashing PEAK light is visible anywhere in the room.

From our distortion and S/N measurements, we conclude that a good low-noise ferric-oxide tape, such as the Sony LN, gives the most satisfactory overall results with this recorder. The distortion and noise for LN were marginally better than for CrO_2 and FeCr tapes, but its frequency response was not quite as wide. These differences are not significant. What we consider important is the extra 4 to 6 dB of recording "headroom" of the ferric-oxide tape. This allows the recording gain to be set for maximum program levels of 0 to −3 dB, with an occasional flash of the PEAK light indicating when a +7-dB level has been reached. With the other tapes, the average maximum recording level should be reduced to between −5 and −8 dB, at which time, the PEAK light conveys no useful information since the tape distortion could be excessive before the light would flash.

Used independently of the transport, the built-in FM Dolby decoder worked very well. Once the level calibrations have been made with the aid of broadcast test tones, they should not require re-adjustment unless a different tuner is used.

All in all, the laboratory and listening results reveal that the Model 5220 represents good value for the money.

ONKYO MODEL TX-220 AM/STEREO FM RECEIVER

Moderately priced unit for budget audio systems.

HIRSCH-HOUCK LABS REPORT

Although it is relatively low powered, the Onkyo Model TX-220 offers several design and operating features not commonly found in AM/stereo FM receivers in its price range. Selling for only slightly more than the lowest priced stereo receivers on the market, the Model TX-220 has integrated circuit (IC) output amplifiers that deliver a conservative 12 watts of power per channel into 8-ohm loads over a frequency range of 50 to 20,000 Hz at less than 1% total harmonic distortion (THD). The outputs can be switched to either or both of two pairs of speaker systems. If the second pair of speakers is placed in the back of the room, a MATRIX 4CH position on the speaker selector switch allows the receiver to drive them with an L−R difference signal to simulate 4-channel programs from a stereo source.

The receiver measures 16⅝"W × 13¾"D × 5⅝"H (42.2 × 35 × 14.3 cm) and weighs 19 pounds (8.6 kg). $219.95.

General Description. The receiver has a bronze satin-finished front panel and gold-colored knobs. Behind a "black-out" window are AM and FM tuning scales, the latter linearly calibrated at 0.25-MHz intervals; a dial pointer that lights up in red; and a single meter for center channel tuning on FM and relative signal strength on AM.

Except for the large TUNING knob to the right of the dial area, the receiver's operating controls form a single row across the lower portion of the front panel. To the right of the SPEAKERS switch and headphone jack are the BASS and TREBLE tone controls and the concentric VOLUME and BALANCE controls. (The BALANCE control is a ring around the VOLUME knob.)

Four pushbutton switches are for the LOUDNESS compensation, mono/stereo MODE, and TAPE MONITOR functions. The last is for two tape decks. Programs can be dubbed from TAPE 1 to TAPE 2 while you are monitoring the playback from recorder number two.

Used in conjunction with the MIC jack on the front panel, a MIC MIXER control allows the output of a dynamic microphone to be mixed with the selected program so that both appear at the speaker outputs. When the MIC MIXER knob is pulled out, the signal also appears at the tape recording outputs.

The last front-panel control is the program, or source, selector. It has positions for AM, FM AUTO, PHONO, and AUX inputs.

On the rear apron of the receiver are located binding post output terminals for four speaker systems, all input and remaining output jacks, and AM and FM antenna terminals. A nonadjustable ferrite rod AM antenna is mounted inside the receiver's cabinet.

The receiver comes with a walnut-grained vinyl-clad metal cabinet.

Laboratory Measurements. The receiver's audio amplifiers clipped at 13.3 watts/channel with both channels driven into 8-ohm loads and a 1000-Hz test signal. The 4-ohm output was 16.4 watts/channel, while the 16-ohm output was 8.4 watts/channel. The receiver easily met its 12-watt/channel FTC output rating. Harmonic distortion measured between 0.1 and 0.2% from 70 to 8500 Hz and less than 0.5% from 40 to 20,000 Hz. At lower levels, the distortion was slightly less, measuring typically less than 0.1% at most frequencies and output power levels.

The 1000-Hz THD, at less than 1-watt

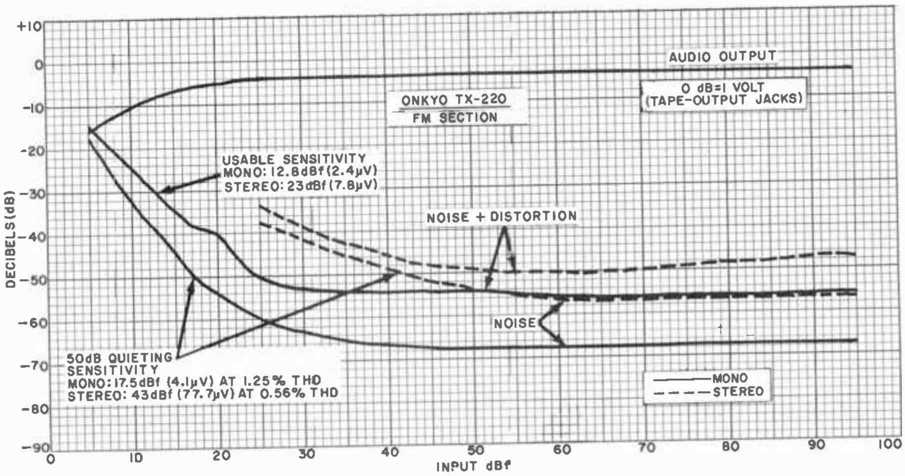
output, measured below the noise level. It was about 0.08% from 3 to 10 watts, and reached 0.6% at 14 watts output. The IM distortion was between 0.1% and 0.2% between 0.1 and 9 watts output, reaching 0.33% at 12 watts. It also rose at very low power levels, achieving 1% at a few milliwatts output.

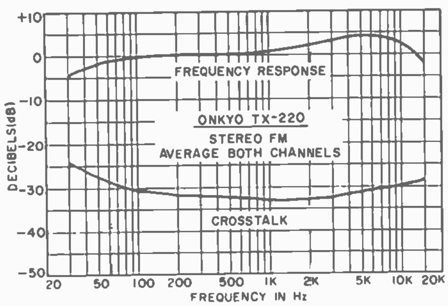
The input sensitivity for 10 watts output was 145 mV through the AUX inputs, 2.1 mV through the PHONO inputs, and 4.5 mV through the MIC input. The respective noise levels were −77.5, −76.1, and −62.5 dB. The PHONO input overloaded at 50 mV, an adequate figure for most cartridges. Microphone overload occurred at a very safe 180 mV.

The characteristics of the TREBLE control were hinged at 1000 Hz, and the BASS control had a sliding turnover frequency that permitted effective compensation at very low frequencies with negligible effect on the response at higher frequencies. The LOUDNESS compensation boosted the low and high frequencies at low VOLUME control settings.

The RIAA phono equalization was accurate to within ± 1 dB from 50 to 15,000 Hz, with a slight low-frequency roll-off to −3 dB at 20 Hz. There was only a minor interaction with cartridge inductance, which increased the output by 1 to 2 dB at frequencies between approximately 8000 and 20,000 Hz.

The FM tuner section had a usable sensitivity in mono of 12.8 dBf, equivalent to 2.4 μV. This is much better than the rated 3.0-μV sensitivity specified by Onkyo. In stereo, the sensitivity was determined essentially by the automatic switching threshold of 23 dBf (7.8 μV). the 50-dB quieting sensitivity





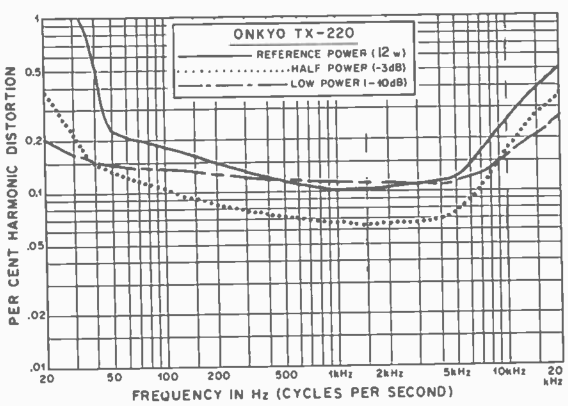
in mono was 17.5 dBf (4.1 μV) with 1.25% THD. In stereo, it was a rather high 48 dBf (77.7 μV) with 0.56% THD. The distortion was very low for a receiver in this price range, measuring 0.16% in mono and 0.32% in stereo. (The rated values are 0.4% and 0.8%.)

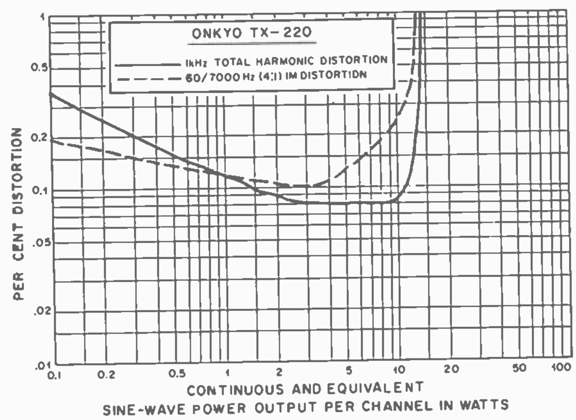
The FM frequency response was ±4 dB from 30 to 15,000 Hz. There was a high-frequency emphasis and a reduced bass response. The channel separation was good at an almost constant 30 to 33 dB from 85 to 8500 Hz. It was better than 25 dB over the full audio range. The FM capture ratio at a 45-dBf (100 μV) input was 1.8 dB, which was slightly better than the rated 2 dB. The AM rejection was a very good 66 dB. Image rejection measured 52.4 dB, bettering the 50-dB rating.

Alternate-channel selectivity, which was almost perfectly symmetrical about the signal frequency, was 53.5 dB, slightly short of the 60-dB rating. The automatic stereo/mono transition occurred smoothly over an input range of 17 to 25 dBf (4 to 10 μV). The 19-kHz pilot carrier leakage was 51 dB down.

The FM tuner was not equipped with interstation noise muting. The AM frequency response was down 6 dB at 70 and 1700 Hz.

User Comment. When used with moderately efficient speaker systems, the Model TX-220 proved to be a very smooth handling and generally fine-sounding receiver. However, it cannot be expected to drive low-efficiency speakers to satisfactory volume levels. The slightly accentuated high-end response in the FM mode added a touch of brightness and was no doubt partially responsible for the 56.5-dB stereo S/N measurement we obtained,





since it tended to exaggerate the tuner's background hiss.

The calibration of the FM dial was very accurate, limited only by the width of the pointer (about 100 kHz wide). We missed having an interstation noise muting circuit, but recognize that the design of such a modestly priced receiver must make some trade-offs. Fortunately in this case, the basic high-fidelity performance characteristics were not sacrificed. In addition, the full control facilities provided for two tape decks and a microphone input that can be used for recording as well as driving the outputs are not often found in this price range. Judging from the "feel" of the tuning, the FM tuner had a small amount of non-defeatable afc, of which no mention was made in accompanying literature.

We didn't evaluate the MATRIX 4CH mode, which operates in a manner similar to other ambience-recovery schemes we have tested in the past. This feature is the least expensive way to enjoy some of the benefits of quadraphonic reproduction by simulating the rear channels from the out-of-phase information contained in many stereo programs. It costs nothing but the simple addition of an extra pair of speaker systems.

The Model TX-220 could certainly serve as the basis for a satisfactory music system for those with limited funds available.

CIRCLE NO. 81 ON FREE INFORMATION CARD

MIDLAND MODEL 13-882B MOBILE AM CB TRANSCEIVER

Boasts high voice intelligibility and antenna-mismatch indicator lamp.

THE MIDLAND Model 13-882B mobile CB tranceiver is designed for AM operation on all 23 channels. Its special feature is a lamp that warns the operator in the event of a mismatch or defective antenna system that might result in damage to the r-f output transistor or cause instability.

Full 23-channel coverage is obtained through the use of a frequency synthesizer. Among the other features to be found in this transceiver are: S/r-f meter, adjustable squelch, switchable noise limiter, Delta tune, external speaker jacks, built-in bottom-facing speaker, nominal 12.6-volt dc (negative- or positive-ground) operation, supply line filter, and dynamic microphone.

The transceiver measures 7⅞"D × 6⅜"W × 2¼"H (20 × 16.2 × 5.7 cm) and weighs 3.8 lb (1.7 kg). It comes complete with mobile mounting hardware. $179.95.

The Receiver. Conventional double conversion is employed in the receiver. The stage complement includes a diode-protected grounded-base r-f amplifier, bipolar transistor first mixer, diode second mixer, ceramic filter, two i-f amplifiers, diode detector and agc, anl, and a three-stage a-f amplifier section that terminates in a push-pull output amplifier.

The measured receiver sensitivity was 0.5 µV for 10 dB (S+N)/N at 30% modulation with a 1000-Hz test signal. Adjacent-channel rejection was nominally 50 dB. The overall audio response was 550 to 3800 Hz at 6 dB, and the maximum audio power available for both receiving and PA operation at the start of clipping with a 1000-Hz test tone was 3 watts at 5% distortion into 8 ohms and 3% distortion into 16 ohms.

Rounding out our receiver measurements, the agc was quite flat, holding the audio output to within 6 dB with an 80-dB r-f input signal change at 1 to 10,000 µV. A 50-µV signal level produced an S9 meter indication. The squelch threshold range was 0.25 to 500-µV. Unwanted- or spurious-signal response was 45 dB down, and measured −50 dB at several points within ±3 MHz of the 11-meter band. Image and i-f signal rejection were 80 and 60 dB, respectively.

Frequency Control. The frequency synthesizer is of conventional design, employing 10 crystals that are combined in specific pairs to produce a local oscillator signal of around 38 MHz at the first mixer that, in conjunction with the CB signal, results in an 11.275-MHz first i-f. A second i-f of 455 kHz is generated by heterodyning the first i-f signal against an 11.730-MHz crystal-controlled signal.

On transmit, the on-channel carrier is generated by heterodyning the synthesizer's output with an 11.275-MHz crystal-controlled signal at a transmitter mixer, using the difference frequencies. Triple-tuned bandpass filtering circuits at both the synthesizer- and transmitter-mixer outputs minimize spurious-signal responses.

The Transmitter. The usual lineup of predriver, driver, and power amplifier with a multi-section 50-ohm output-matching network make up the transmitter. An adjustable TVI trap is included in the design. Collector modulation of the driver and power amplifier stages by the audio section includes automatic modulation control (amc), which is obtained in the usual manner with negative feedback. The functions of each stage are controlled by electronic switching.

Using a 13.8-volt dc source, we measured a 3.75-watt r-f carrier output power. A sine-wave modulation envelope was attainable at 100% modulation with 8% distortion using a 1000-Hz test tone. Raising the microphone input level by 10 dB over that required to initially produce 100% modulation held the distortion to 10% with no evidence of over-modulation.

Under the above conditions, and using a 2500-Hz test tone, the adjacent-channel splatter was 50 and 35 dB down, respectively. With voice signals, the "attack" time was a little slow before the amc took hold, enabling the peaks on the initial rise to slightly square off. Nevertheless, splatter was held to −55 dB or better.

The audio response was 600 to 7000 Hz at 6 dB. The frequency tolerance of the transmitter on any channel was within 225 Hz at 80° F.

The ANT. WARNING lamp is driven by an SWR-sensing circuit. When SWR is greater than about 2.5:1, which may be due to an open or shorted transmission line or to antenna mismatch, a reflected voltage derived from the sensing unit turns the lamp on.

User Comment. The edgewise meter movement used in the transceiver is fairly large and easy to view, due to a high level of illumination. It is quite lively in its action, with indications starting at about a 1-µV signal level.

As may be noted from the audio response measurements for both the receiver and transmitter, the low-frequency rolloff commences at a somewhat higher frequency than usual. This results in a very crisp signal, with the voice energy accentuated where it is needed for high intelligibility.

The DELTA TUNE control has three detented positions. It shifts the receiver frequency in one fixed amount of about 1000 Hz to either side of center.

The anl's performance was very good. It attenuated impulse noise by roughly 50 dB and its effectiveness was most pronounced when receiving weak signals.

CIRCLE NO. 82 ON FREE INFORMATION CARD

HEATHKIT MODEL GB-1201 DIGITAL STOPWATCH

Handheld clock provides seven types of timing functions.

THE NEW handheld digital stopwatch from Heath offers unusual timing versatility. It has the multifunctions, range, and accuracy needed for any split-second timing application one can think of—rallies, photo work, track events, efficiency studies, etc.

The Heathkit Model GB-1201 provides seven timing functions, two of which are programmable. It is housed in a hand-contoured black plastic case and comes with detachable sun shield, neck lanyard, felt-lined Naugahyde® carrying case, built-in rechargeable nickel-cadmium battery pack, and battery charger/eliminator—all for $99.95 in kit form.

The digital stopwatch measures approximately 5⅓" × 2" × 2" (13.5 × 5.1 × 5.1 cm) without sun shield in place. It weighs about 8 oz (0.23 kg).

General Description. The stopwatch is built around an eight-digit, seven-segment LED display consisting of 0.15" (3.8-mm) high numerals. Tens and units of hours and tens and units of minutes are displayed in the upper row, while the lower row indicates tens and units of seconds and tenths and hundredths of seconds from left to right. (Heath also includes a modification that converts the display to read in hours, minutes, and tenths and hundredths of minutes for special applications.)

As configured, the display has a timing range of 99 hours, 59 minutes and 59.99 seconds. With the modification, the timing range is 99 hours, 59.99 minutes, in which case the display employs only six of the eight digits.

There are two miniature slide switches. One is for turning on and off the POWER. The other switch, labelled DISPLAY, allows the user to select a constantly on display or to disable the display (without interrupting the time counting cycle) to conserve battery power when timing long-period events. Two more switches round out the front-panel complement. One of these is the rotary function switch labelled clockwise from 1 to 7. The other is a momentary-action push-button switch marked RESET/ (LOAD).

If you can't go to college for your career in electronics —read this!

CREI brings college-level training to you with eight educational advantages, including special arrangements for engineering degrees

The best way to qualify for top positions and top pay in electronics is obviously with college-level training. The person with such training usually steps more quickly into an engineering level position and is paid considerably more than the average technician who has been on the job several years.

A regular college engineering program, however, means several years of full-time resident training—and it often means waiting several years before *you can even start your career*. This, of course, is difficult if you must work full time to support yourself and your family.

If your career in electronics is limited without college-level training, take a look at the advantages a CREI home study program can offer you.

1. Convenient Training

CREI brings the college to you. Through the convenience of home study, you receive exactly the same level of training you will find in any college or university offering programs in electronic engineering technology. With CREI, however, you can "go to college" whenever you have spare time at home or on the job.

2. Specialized Programs

With CREI, you enjoy the advantage of *specialized* training. That is, your program will include only those courses directly applicable to your career in electronics. We omit such courses as English, social studies and other subjects, which are usually required in resident schools. Therefore, with CREI, you move ahead faster to the more interesting and useful part of your training.

3. Practical Engineering

CREI programs give you a *practical engineering* knowledge of electronics. That is, each part of your training is planned for your "use on the job." By using your training, you reinforce the learning process. And by demonstrating your increased knowledge to your employer, you may qualify for faster career advancement.

4. Engineering Degrees

CREI offers you a number of special arrangements for earning engineering degrees at recognized colleges and universities. You can earn college credit while you are taking your CREI program or apply later, whatever is best for your career plans.

5. Unique Laboratory

Only CREI offers you the unique Electronic Design Laboratory Program. This complete college laboratory makes learning advanced electronics easier and it gives you extensive practical experience in many areas of engineering, including design of electronic circuits. No other school offers this unique program. It is a better "Lab" than we have found in many colleges. And the professional equipment included in the program becomes yours to keep and use throughout your professional career.

6. Wide Program Choice

CREI gives you a choice of specialization in 14 areas of electronics. You can select exactly the area of electronics best for your career field. You can specialize in such areas as computer electronics, communications engineering, microwave, CATV, television (broadcast) engineering and many other areas of modern electronics.

7. Prepared by Experts

Experts in industry and technical organizations of government develop CREI programs. Each part of your training is developed by a recognized expert in that area of electronics. That means you get the most up-to-date and practical instruction for your career.

8. Industry Recognition

That CREI training is recognized by industry and government is evident from the fact CREI provides training to advanced technical personnel in over 1,700 technical organizations. Many subsidize the training of their employees with CREI. If there is any question about the advantages of CREI training for you, ask your employer or any engineer to evaluate the outline of a CREI program for you.

Other Advantages

Of course, there are many other advantages to CREI training. For example, throughout your training, CREI's staff gives you personal instruction for each step of your program. And in many industrial areas, both in the U. S. and abroad, CREI Field Service Representatives provide a number of important personal services for your training and your career.

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CREI programs are approved for training of veterans and servicemen under the G.I. Bill.

The timing functions available take some explaining to understand how they differ from each other. Let us take a function-by-function look at them.

In function 1, the stopwatch is used as a start/stop elapsed time indicator. It can be used to time any one or more events, displaying the time it takes for each successive event to complete while counting the total elapsed time of all events separately. Only the particular event being timed is normally displayed. Then you press a button to display the total elapsed, excluding any times out or delays between events. This mode is excellent for timing periods in basketball games.

In function 2, the stopwatch becomes a sequential timer. This lets you time each part of a given continuous event, such as separate lap times in an auto race or the times between handoffs in relay footraces. Meanwhile, the stopwatch times the period of the overall event.

Function 3 is for total activity timing. This function is similar to the first, displaying the elapsed time for a series of events, minus times out between events. Where it differs is that, with the press of a button, you can also display total elapsed time, *including* the times out.

In function 4, the stopwatch operates in a split mode. The display gives the cumulative time to each "split" point in an event while timing the overall event separately.

Setting the function switch to position 5 sets the stopwatch up as a stop/start activity timer. In this mode, the stopwatch gives separate times for each event as well as the total time of all events.

Functions 6 and 7 are unique. They let you count up to or down from a preprogrammed time, respectively, over a 9 hour, 59 minute, 59.99 second range. To operate in these modes, the display must be set to the reference time by first operating the RESET switch to display all zeros. Then the function switch is set to each of positions 1 through 5 and simultaneously with the pressing of the S/S (start/stop) and F/S (final stop) switches located on the left and right of the case. Once the reference time is established on the display, you switch back to function 6 to operate the RESET/(LOAD) switch to program the internal counter.

After loading the program, you either stay in function 6 to count up from zero to the reference time or switch to function 7 to count down from the reference time to zero by pressing the S/S switch. When the stopwatch completes the counting cycle, all counting stops. If a signalling device is plugged into the alarm jack at the top of the case, an alarm will sound at the termination of the count. (The kit's assembly manual provides full details for connecting various types of alarm devices.)

There are two more jacks on the top of the case. One is for plugging in the battery charger/eliminator, and the other is for operating the start/stop function remotely (either manually or by automatic trip devices). The start/stop jack is wired in parallel with the S/S switch.

Two PMOS LSI chips are used inside the stopwatch for all counting operations. A quartz crystal provides an accurate, stable time-base reference.

About the Kit. The stopwatch ranks as a one-evening kit project for the experienced kit builder. Even a newcomer can assemble and start using the stopwatch in little more than seven or eight hours. This is possible because all of the complex circuits are contained in the two counter IC's. There are very few discrete components to be wired to the two screened, double-sided printed-circuit boards.

The LED displays come in lensed DIP cases, and they and the IC's plug into sockets. This eliminates the possibility of heat damage during soldering and makes it easy to troubleshoot and replace defective components should the need arise.

There are no critical steps to perform during assembly. However, because the LSI chips are MOS devices, safe-handling precautions must be exercised (see assembly manual).

User Comment. Heath claims an accuracy of ±0.006% when the stopwatch is adjusted without instruments and better than ±0.003% with instruments. We tried both ways and obtained better than ±0.003% in both cases. Just as important, the long- and short-term stabilities were excellent. We used a 15-minute short-term test and observed no significant drift. At the end of a 25-hour (long-term) test, operating the stopwatch on the battery charger/eliminator, we observed a difference of 4.31 seconds when compared against a WWV calibrated timer.

These results were obtained with the stopwatch aligned without instruments. After aligning with instruments and repeating the 25-hour test, there was a discrepancy of less than 1 second between the stopwatch and reference timer, which in all likelihood was due to reaction time lag when both were started and stopped.

This is a very easy stopwatch to use and operate. With the S/S and F/S buttons located on either side of the display, it is not limited to either right- or left-handed operation. Also, the grasp is comfortable. A nice final touch is the sun shield, especially useful when reading the LED display under high ambient lighting conditions.

CIRCLE NO. 90 ON FREE INFORMATION CARD

TRI-STAR "TIGER SST" CD IGNITION SYSTEM

Capacitive-discharge kit system for autos.

MANY different circuits have been designed to increase the performance of automotive engines by upgrading the ignition system. One of these is the capacitive-discharge system (CDI) which boosts the voltage applied to the primary of the ignition coil. The Tri-Star "Tiger SST" is such a CDI circuit. It is triggered by the existing breaker points and is fully compatible with stock as well as "breakerless" ignition systems.

The Tiger SST is available factory-wired for $42.95 and in Simpli-Kit form for $31.95.

General Description. The ignition system utilizes a two-transistor multivibrator whose operating frequency is set at about 8000 Hz. This frequency is high enough to prevent the synchronization problems that plagued earlier CDI system designs.

The multivibrator converts the 12-volt vehicle electrical system potential to a square-wave ac signal. A transformer then steps up this signal and passes it to a full-wave rectifier-diode bridge to convert it to pulsating dc. Following the bridge is a 2.2-μF storage capacitor that begins to charge up from the bridge's output signal.

A signal from the vehicle's breaker points triggers an SCR in the CDI system. This permits the storage capacitor to discharge its stored 400 volts through the car's ignition coil. A special RC network in the CDI system prevents the SCR from triggering during contact bounce.

With 400 volts applied to the ignition coil's primary, the output potential across the coil's secondary can reach 45,000 volts at idle and 30,000 volts during cranking and at high engine speeds. The duration of the spark is about 310 µs, and about 0.15 joule of energy is contained in each pulse. This assures a very hot, short-duration spark that provides reliable ignition and long life for the vehicle's points, capacitor (condenser), and spark plugs.

The system has a built-in switch that allows the user to select CDI or standard ignition.

About the Kit. It took us about an hour to assemble the kit version of the Tiger SST. This time included preliminary voltage checks.

The multivibrator transistors arrived already riveted to a metal plate that serves as their heat sink. This plate assembly must be force-fitted into a channel at the top of the system's case. The heat-sinking action with this setup allows the transistors to operate very cool. All other components, except the STD/CDI switch, mount on one printed circuit board. The switch comes already riveted to one of the end plates of the case. Exiting through the same end plate is a four-conductor ribbon cable.

Installing the system into an automobile required only a few minutes of work. First, we had to drill four holes, which permitted us to mount the compact 5"D × 4½"W × 4½"H (12.7 × 11.4 × 11.4-cm) unit on the engine side of a wheel well with self-tapping sheet metal screws. We then made the five necessary connections to make the system functional. The case of the unit was connected to chassis ground.

After this, we wired conductors from the CD ignition system to a +12-volt point in our car's electrical system, the vehicle's points, and to the positive (+) and negative (−) terminals on the car's ignition coil.

Performance Results. The difference between the standard and capacitive-discharge systems was quickly evident. (We installed the system in a 1974 car that has a full complement of anti-smog devices that rob power and make operation balky.)

With the CDI system installed and switched on, our car's engine turned over immediately and warmed up quickly. Putting the transmission in gear, the engine seemed to call upon power reserves we never knew it had. And the engine began to run more smoothly than it had previously.

Having lived with the Tiger SST CD ignition system for over a year, we can make some long-range observations. We noted some increase in fuel economy, but we must caution that this will not necessarily occur with all cars or all drivers.

The car has now been driven with the CDI system switched in for more than 20,000 miles. Points and plugs are still in excellent condition, and the ignition coil and condenser have been given a clean bill of health. Moreover, the car's engine "catches" in less than a second of cranking, even after overnight exposure to wet weather and winter temperatures. Also, the engine never balks under load, even in high gear and on hills with moderately steep grades.

CIRCLE NO. 83 ON FREE INFORMATION CARD

Solid State

By Lou Garner

OPTING FOR OP AMPS

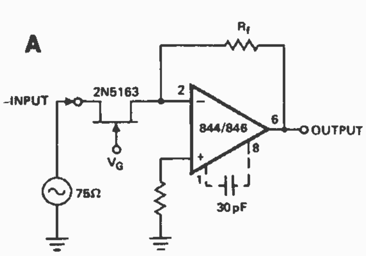
CONSIDERED as a class, operational amplifiers are perhaps the most versatile of all integrated circuits. Depending on terminal interconnections, feedback, load, and similar factors, they can perform many different tasks. Op amps typically appear as differential amplifiers, voltage comparators, phono and microphone preamps, clippers, control amplifiers, voltage followers, pulse-width modulators, phase inverters, function generators, instrumentation amplifiers, multivibrators, pulse generators, summing amplifiers, integrators and differentiators, active filters, voltage or current regulators, peak detectors, buffers, sample-and-hold circuits, logarithmic converters, anti-log generators, and VCO's. And that's not a complete list!

These devices were among the first linear IC's to be produced commercially in large quantities. Although introduced back in the mid-sixties, many of the 'first generation" types are still available and have, to a degree, become industry standards. Semiconductor manufacturers often describe their newer devices by comparing them with such familiar old-timers as the 741. Teledyne Semiconductor's latest quad op amp, the 836, for example, is offered as an inexpensive, wide-band replacement for four 741's with similar general specifications, but more than twice the operating speed (i.e., slew rate).

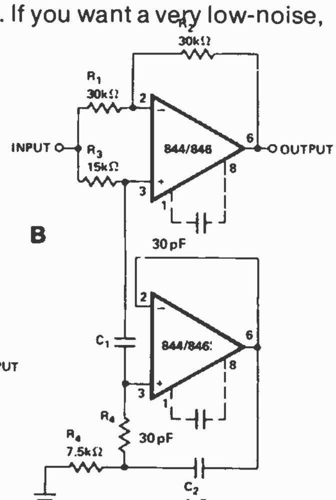
When first introduced, op amp IC's were quite expensive, often costing more than similar circuits duplicated using discrete devices. Today, however, manufacturer's surplus types are available for less than a dollar, with even greater savings possible through the use of multiple units, such as quad devices (see "Applications for Quad Op Amps." "Experimenter's Corner," POPULAR ELECTRONICS December, 1975). Despite the relatively low cost of many popular general-purpose op amps, one can still invest a handful of cash in these units. If you want a very low-noise, high-gain, extremely stable precision device with low drift and a broad temperature range (such as National Semiconductor's LH0044A), you could pay as much as thirty to forty dollars, or more, for a single op amp!

Fig. 1. Op amp applications: (A) gain-controlled amplifier; (B) notch filter.

A



B



Interestingly, there are a number of applications in test and control instrumentation as well as in medical electronic equipment where the use of such expensive devices can be justified. Typically, precision op amps are used in strain-gauge bridges, thermocouple amplifiers, and ultrastable reference amplifiers.

There are a number of excellent sources for op amp application data, including magazine articles and standard reference texts. Among the top sources are the technical specification bulletins and application notes issued by the various semiconductor manufacturers. For example, the five op amp applications illustrated in Figs. 1 and 2, can be found among a total of twenty-seven in the 12-page data bulletin for the 844/846 Series, published by Teledyne Semiconductor (1300 Terra Bella Ave., Mountain View, CA 94043). Among the other applications offered in the bulletin are clipping, instrumentation, and summing amplifiers; Wien bridge oscillators; an anti-log generator; integrators and differentiators; a bandpass filter; and several current sources.

Available in 8-lead TO-type metal cans, plastic miniDIP's, and standard 14-lead ceramic DIP's, the 844/846 devices are general-purpose op amps fabricated on a single monolithic silicon substrate using planar epitaxial technology. Suitable for use as plug-in replacements for such popular types as the 741, 107, and 101, the devices offer a guaranteed slew rate of 1.0 V/µs (min.), an input bias current of 30 nA max., maximum input offset current of 5 nA, and offset voltage of 2 mV. The 844 is internally compensated, but the 846 is not, permitting the user to tailor the circuit's frequency response to meet application requirements. Both devices offer typical large-signal voltage gains of 300 V/mV and can supply output voltage swings of better than ±12 volts with a ±15-volt dc source. Internal power dissipation ratings range from 500 mW with metal can packaging to 670 mW for the ceramic DIP version.

Typical Circuits. With potential applications in audio systems, electronic music, test equipment, and radio transmitters and receivers, the gain-controlled amplifier illustrated in Fig. lA employs a 2N5163 n-channel FET in conjunction with an 844/846 op amp. (Note: for both circuits of Fig. 1, a 30-pF compensation capacitor is required if the type 846 is used). Pin connections are identified for the TO-type can and miniDIP packages, with the bipolar 12-volt supply connections made to pins 4 (−) and 7 (+). The circuit's gain control characteristics are determined by the size of the feedback resistor, which can range in value from 10 to 47 kilohms. With a value of 10 kilohms, overall gain will vary from approximately 5 to 38 dB as the FET's gate voltage is shifted from −0.5 to −5.0 volts. With 47 kilohms, the range is from 20 to 52 dB using a similar control voltage.

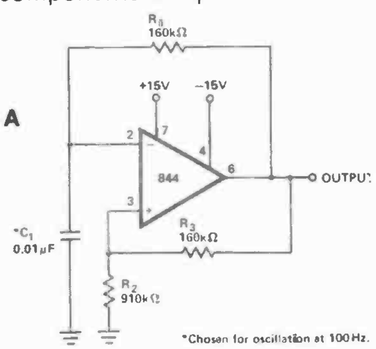
The notch filter circuit given in Fig. 1B employs the 844/846 op amp as a gyrator. It can be used in audio test circuits, electronic music instruments, and similar applications. The filter's center frequency is determined by *C1*, ranging from about 20 Hz with a 1.0-µF capacitor to 2 kHz with 0.0001 µF.

An astable multivibrator and low frequency square-wave generator employing the 844 are shown in Figs. 2A and 2B, respectively. The two circuits are designed for operation on bipolar 15-volt dc supplies. In addition to the op amp, the square-wave generator utilizes a pair of zener diodes (*D1* and *D2*) to provide a clamped output signal. In both designs, the operating frequency is determined by *C1*.

Finally, a sine-wave oscillator using a pair of 846 op amps is illustrated in Fig. 2C. With a specified distortion level of less than 0.4%, this circuit could be used as an audio-signal generator, as a tone source for electronic music, or any similar application. The oscillator's output frequency is determined by *R3* and the values of feedback capacitors *C1* and *C2*. If 0.47-µF capacitors are used, the minimum and maximum frequencies are 18 and 80 Hz, respectively. With 0.1-µF capacitors, the coverage is 80 to 380 Hz, while 0.022-µF components will provide a 38- to

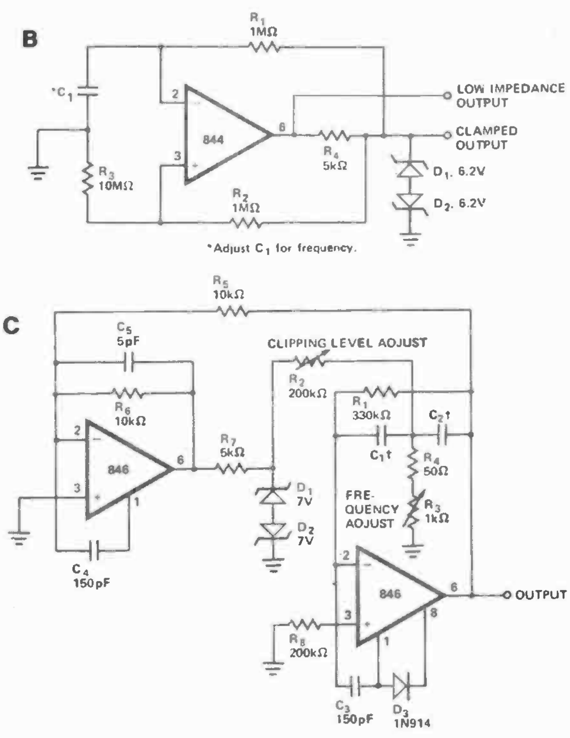
Fig. 2. An op amp used as an astable mutivibrator (A); square-wave generator (B); and sine-wave generator (C).

A



B

C



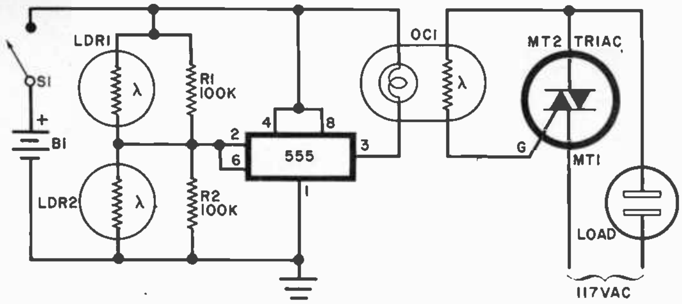


Fig. 3. An opto-coupler controls triac gate current.

1700-Hz range. Increasing the operating frequency is easily accomplished by further reducing capacitance.

Reader's Circuit. Add a dash of imagination and chances are you can think of a hatful of projects for the light-controlled switch shown in Fig. 3. Contributed by reader Ted Reiter (1442 Brook Dr., Titusville, FL 32780), the circuit utilizes a number of different solid-state devices—ligh-dependent resistors (LDR's), a 555 IC timer, an optocoupler and a power triac. When activated by external light sources such as a flashlight or the sun, the circuit can be used for remote control applications as an intruder alarm or an automatic light or appliance switch (hot coffee with the rising sun, perhaps?).

The 555 serves as a bistable switch controlled by a pair of light dependent resistors, *LDR1* and *LDR2*. When the IC is in its high state, output terminal 3 is connected to the dc source, but in the low state, pin 3 is grounded. The battery-powered control circuit is effectively isolated from the ac line by *OC1*.

In operation, light striking one of the LDR's will switch the 555 from a high to a low state, or vice versa. If high initially, light striking *LDR1* causes a positive input pulse which switches the IC, activating *OC1* which in turn supplies a gate signal to the triac, switching this device on and applying ac power to the external load. If the IC is low, light striking *LDR2* will switch the device to high, deactivating *OC1*, thus removing the triac's gate signal and switching off the load.

In describing his circuit, Ted did not specify the type numbers of the LDR's or triac installed in his original model, indicating that a variety of devices can be used. Obviously different applications require varying sensitivity, while load requirements will vary with the nature of the switched device. Depending on the nature and intensity of the light source, either CdS or CdSe photocells could be used as sensing elements, but identical types should be used for both *LDR1* and *LDR2*. Ted suggests that a standard 100-V, 8-A triac is more than adequate for most applications, but it should be heat-sinked if used near its maximum ratings. Resistors *R1* and *R2*, are used to balance the LDR characteristics but if the LDR's are closely matched, the resistors will not be needed. At the user's option, either a 6- or 12-volt dc source can be used with the control circuit.

Neither lead dress nor layout is critical and the circuit can be assembled on pc or perf board or even on a small chassis. Some care is required in placing and mechanically mounting the LDR's, of course, so that both are not activated simultaneously by the light source. Small tubes, opaque shields, masks, or lenses can be used, depending on the specific application.

Device/Product News. Responding to the increasing use of microprocessors and memory IC's, the Vector Electronic Co., Inc. (12460 Gladstone Ave., Sylmar, CA 91342) has developed a new DIP plugboard designed specifically to accommodate those devices. The board accepts two supply voltages, is copper clad on both sides for shielding and to supply primary power (positive on one side, negative on the other), with interwoven zig-zag lines (also on both sides) to facilitate power distribution. Designated as the Model 4350, the board will hold 63 14- or 16-pin DIP's or five 24-pin microprocessors and 45 DIP's. The 4350 is priced at $14.95 each in unit quantities and is available from both local and mail order outlets.

A lever-actuated solid-state switch of interest to experimenters and hobbyists is now available from Optron, Inc. (1201 Tappen Circle, Carrollton, TX 75006). Identified as the type OPS 100 Optical Limit Switch, the device does not use mechanical switch contacts. Instead, the lever arm operates a shutter which interrupts a light beam between a GaAs infrared LED and an npn phototransistor, the latter generating an output signal (See Fig. 4). It can be used as either a normally open or normally closed spst switch, depending on a simple mechanical adjustment. A dc source is required for the LED.

The Fairchild Camera and Instrument Corp. (464 Ellis St., Mountain View, CA 94042) has announced a 2048-bit static n-channel RAM ideally suited for use with microprocessors. The new product, type 3539, is organized as 256 x 8 bits, and is available in two versions with maximum access times of 650 and 500 ns. Two separate chip-select inputs allow direct expansion to 512 bytes of memory. The device has a power dissipation rating of less than 500 mW, requires a single 5-volt power supply. It comes in a standard 22-pin DIP. The 3539 also features TTL-compatible inputs and outputs.

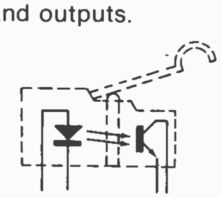


Fig. 4. Optron's OPS 100 optical limit switch provides bounceless electronic switching.

Fairchild's East Coast Imaging Systems Division (300 Robbins Lane, Syosset, NY 11791) has developed a third-generation charge-coupled-device (CCD) television camera offering considerably improved resolution over earlier models. The Model MV-201 has 244-line resolution and a bandwidth of 1.86 MHz. It is sensitive to as little as 0.000125 footcandle of illumination at the CCD elements. The camera weighs only 12 ounces and is 2" H × 2.5" W × 3.75" L. Interfacing directly with conventional TV monitors, the MV-201 requires only 4 watts at 12 volts.

If you're interested in the design and assembly of electronic musical instruments, you'll find it worthwhile to investigate the standard IC's offered by American Microsystems, Inc. (3800 Homestead Road, Santa Clara, CA 95051). Among the interesting devices available are the S2555 and S2556 top-octave synthesizers, the S2566 rhythm generator ROM, the S8890 rhythm generator, the S2567 resettable rhythm counter, the S2470 six-stage frequency divider, the S50240 series of top-octave synthesizers, and the S2193 seven-stage frequency divider. Unit prices range from $4.50 for the frequency dividers and S2567 resettable rhythm counter to $22.50 for the S8890. ◈

Test Equipment Scene

By Leslie Solomon

USING YOUR OSCILLOSCOPE

MUCH of my mail has to do with questions about oscilloscopes and their use. Here are some common problems and, hopefully, their solutions.

Rise Time. How do you determine the rise time of a scope to find out how well it will work in making measurements in digital circuits?

First, you have to find the upper frequency at which the scope is 3 dB down. This can be done either by checking the manufacturer's specifications in the user's manual or by applying a signal and, after determining a graticule level at some intermediate frequency, raising the input frequency until the display is about 30% smaller. This will be the approximate 3-dB point.

Assume that the scope has a bandpass of about 5 MHz at 3 dB down. Since the period is the reciprocal of the frequency ($T=1/f$), the period comes out to 0.2 microsecond at 5 MHz, and a third of this at the 3-dB down point or 0.06 microsecond. This means that the scope will display a rise time of 0.06 microsecond. So you can see why most people want a scope that will go to about 10 MHz.

Ringing and Overshoot. Some people apply square waves to an oscilloscope to try to establish the rise time. However, they notice "spikes or wobbles" along the upper and lower portion of the waveform. This effect is called "overshoot" or "ringing." In many cases, overshoot is followed by ringing, but not always. Other times, overshoot occurs only at one edge. However, no matter how you slice it, overshoot and ringing produce signal distortion.

The amount of overshoot can be determined by making a calculation based on the type of trace shown on your scope. With a square-wave input at some known value (as measured on the scope), determine the overshoot level. Divide the amount of overshoot by the main signal level and multiply by 100 to find the per cent of overshoot. The scope with the smallest overshoot is the best.

Amplifier square-wave response may often show overshoot coupled with ringing, overshoot with tilt, and overshoot with both ringing and tilt. In many cases, overshoot is the price paid for trying to improve the rise time, while ringing is usually caused by inductance in the signal path (such as occurs with peaking coils in broadband amplifiers). In many low-cost scopes and many TV receivers, the high-frequency response of an amplifier is extended by inductors.

Linearity. What if the vertical and horizontal amplifiers in your oscilloscope don't "work" together the way they should? This is particularly important when checking phase relationships with Lissajous figures.

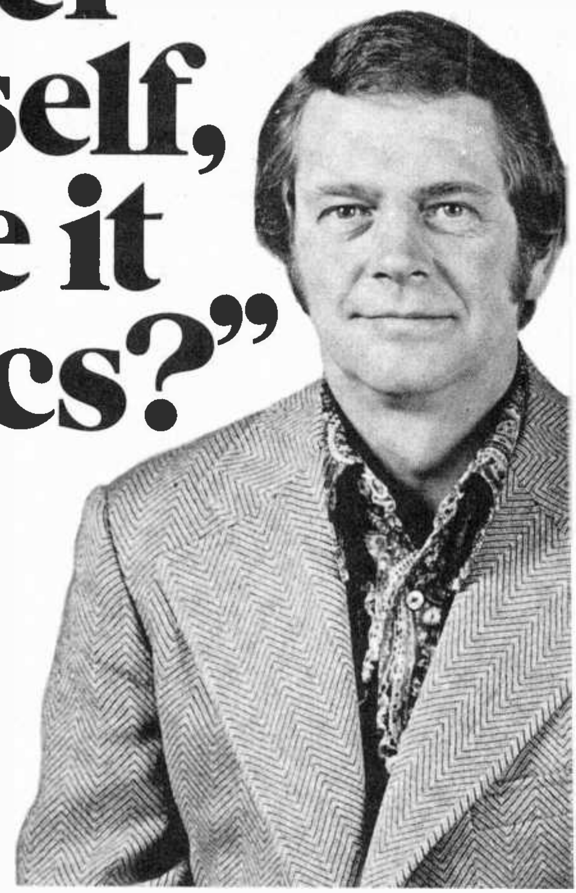
To find out, connect the scope ground to an audio signal-generator ground. Then connect the hot lead of the signal generator to both the vertical and horizontal inputs (use external horizontal input on the scope). Adjust the scope's vertical and horizontal gains for a balanced diagonal line around the graticule zero crossing. If this line is straight, the scope amplifiers are linear and can be used for phase measurements. If, however, the line has a bend in it, the scope amplifiers are nonlinear, and this fact can affect phase measurements.

Light Emitting Diodes. Changing the subject slightly, we have also been asked whether it is possible to use a LED as a voltage dropper in a piece of test equipment instead of a conventional diode.

The idea, of course, is to obtain the voltage-dropping function and, at the same time, have a power-on pilot light. This can be done, but there is a small catch. What is the drop across the LED?

To find out, assemble a series circuit of a 5-volt dc power supply, a couple of 100-ohm resistors for current limiting and a holder for inserting an LED. Measure the voltage across the LED when it is glowing. (You may have to vary the series resistor to get the amount of glow you want.) Try this on several different LED's from different manufacturers and of different colors. You will note that the voltage drop can be as high as 3 volts. ◈

Have you ever asked yourself, "Can I make it in Electronics?"



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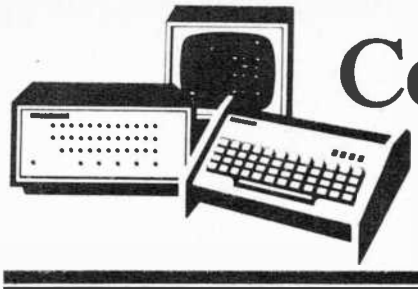


Computer Bits

By Robert M. Marsh

COMPUTER USERS TAPE SYSTEM

THE LACK of standardization is the bane of many industries. For example, three basic four-channel audio systems (SQ, QS, and CD-4), instead of a universal system, have impeded progress in that field. The same holds true for computer hobbyists, where a host of methods for exchanging programs or data have been introduced, including the HIT system published in POPULAR ELECTRONICS, September 1975.

Rather than stifle this user-created "program explosion," a group of hobby computer manufacturers and other interested parties (POPULAR ELECTRONICS, among them), met in Kansas City, MO, last November to explore standardization in general and hopefully to agree on a single method of recording data. There was general agreement that cassette tape represented the best route to go for a hobbyist computer-data exchange system. These tapes are low-cost and widely available, and cassette machines are owned by most people.

The use of inexpensive cassette recorders was not viewed as a serious limitation as long as the record/playback exchange method adopted allowed for certain inherent machine deficiencies. The two most common considerations with low-cost cassette machines are: (1) the automatic level control incorporated in some machines, and (2) variations in average speed, nominally 1⅞ inches/second. Both drawbacks could be easily overcome, it was decided.

Another important consideration in using low-cost cassette tapes is that some tapes would likely cause dropouts (momentary loss of signal) due to a lack of uniform distribution of oxide particles. At this time, the user would have to "certify" the best tape brand and model for him to use. There are also "data cassettes" certified by tape manufacturers. Prices are not too much higher than those for consumer premium tapes.

Cassette Data Recording Methods. Various methods have been used by computer enthusiasts and manufacturers to record data on audio cassette recorders. These fall into five categories: (1) simple tone burst, (2) pulse-width modulation such as used in the POPULAR ELECTRONICS HIT program, (3) frequency shift keying (FSK) as used in radioteletypewriter or phone-line communications modems, (4) double-frequency pulse recording as used in most floppy disc systems, and (5) phase encoding as used in ANSI standard magnetic tape transports of all major computer manufacturers.

Most of these methods record data serially; that is, one bit after another. Serial recording requires a conversion from parallel to serial form (and vice versa) when used with a computer. Fortunately, most computers and terminals already have a standardized serial communications channel that transmits in a form called "non-return to zero" (NRZ), shown in Fig. 1A.

Tone-burst (or cw) recording may be the simplest way of recording data, where data "1" is the presence of a tone and data "0" the absence of a tone, as shown in Fig. 1B. Because this system is basically an amplitude-modulation scheme, and very susceptible to noise, reliability suffers above 150 bits per second.

Pulse-width modulation may be recorded in its pure form (Fig. 1C) or as a burst of tone with varying duration, as used in the HIT system (Fig. 1D). Both methods are self-synchronizing and are highly independent of speed and amplitude variations. However, in the original HIT proposal, data was recorded synchronously so that each data word had to follow the previous word immediately, thus making HIT impractical for use with stand-alone asynchronous terminals such as TV typewriters and teleprinters. In addition, "pure" pulse-width modulation is patented as a data recording method, which might be seen as a drawback by manufacturers.

Ordinary *frequency shift keying* (FSK), shown in Fig. 1E, is by far the most common method used to transmit data over phone lines and radio links. It would be a useful feature of a cassette recorder interface if it could transmit data over phone lines as if it were a FSK Bell-103 compatible modem. However, while FSK is fairly insensitive to AM noise and level changes, it is susceptible to loss of data when overall frequency changes exceeding ±5% of the nominal value occur. The 5% frequency, or speed tolerance is not sufficient for reliable data storage on many cassette re-

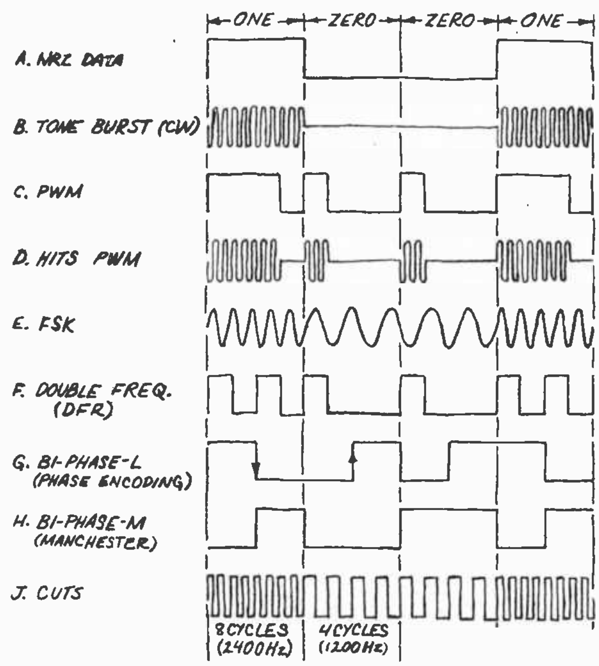


Fig. 1. Methods of recording data on cassette recorders.

corders. In addition, FSK is more expensive to implement than many other methods.

Double-frequency recording (DFR), shown in Fig. 1F, is often used on disc memories at high data rates. When used on a cassette, however, it requires a relatively high bandwidth for a given data rate. This method is insensitive to speed variation since each bit is self-clocked, but it is only moderately free from problems created by noise and amplitude changes. DFR is, therefore, not as reliable as other methods at data rates higher than 500 bits/second, making future expansion and improvement difficult.

Phase encoding has many variants and has been in use in many different types of magnetic tape data systems for many years. The most common forms are Bi Phase-L, usually called "phase encoding," and Bi Phase-M, often called "Manchester" code. Both methods are self-clocking and, at first glance, resemble simplified FSK. In fact, phase modulation does create a form of frequency modulation. All phase-encoded methods are independent of frequency changes over a wide range, and can be made highly resistant to AM noises and level shifts.

Bi Phase-L is shown in Fig. 1G. You can see that there is a transition in the middle of each bit cell and that the polarity of the transition determines whether the bit is a logic 1 or 0. Bi Phase-M, or Manchester, shown in Fig. 1H, has a transition at the beginning of each bit cell. Logical 1's have another transition in the middle of the cell, whereas logical 0's do not.

Manchester code is extremely easy to generate, decode, and synchronize, and is the basis for the CUTS (Computer Users Tape System) recording method proposed as an outgrowth of the meeting in Kansas City.

The CUTS method employs a variation of the Manchester code in which a

COMPARISON CHART

	Level, Noise Tolerance	Frequency, Speed Tolerance	Self clocking	Cost*	Future Upgrading**	Remarks
CW (Fig. 1B)	Poor	Poor	No	Very Low	No	Susceptible to noise. Reliability suffers over 150 baud.
PWM (Fig. 1C)	Good	Very Good	Yes	Low	To 1500 Baud	Patented. Requires higher bandwith than Bi-phase for same baud rate.
HITS (Fig. 1D)	Good	Very Good	Yes	Low	To 600 Baud	Requires higher bandwidth than CUTS for same baud rate (see PE, Sept. 1975).
FSK*** (Fig. 1E)	Very Good	Poor-Fair	No	Moderate	To 450 baud (with Bell 103 tones)	Can be transmitted over phone lines to any modem.
DFR (Fig. 1F)	Moderate	Good	Yes	Low to Moderate	To 800 Baud	See "Computer Hobbyist" Vol. 1, No. 5, 6, 1975.
Bi-Phase-L (Fig. 1G)	Very Good	Very Good	Yes	Low to Moderate	To 1500 Baud	Proposed ANSI standard. Subject to phase inversion.
Bi-Phase-M (Fig. 1H)	Very Good	Very Good	Yes	Low to Moderate	To 1500 Baud	Widely used. Easily decoded.
CUTS (Fig. 1J)	Very Good	Very Good	Yes	Low	To 1200 Baud	Very easily decoded. Can be transmitted by phone to other CUTS units.

*Cost is estimated for devices which do not require a CPU for reading and writing. Cost may be quite low if CPU decodes mostly by software.

**Future upgrading implies minimal hardware modification at low cost.

***Especially Bell-103 compatible.

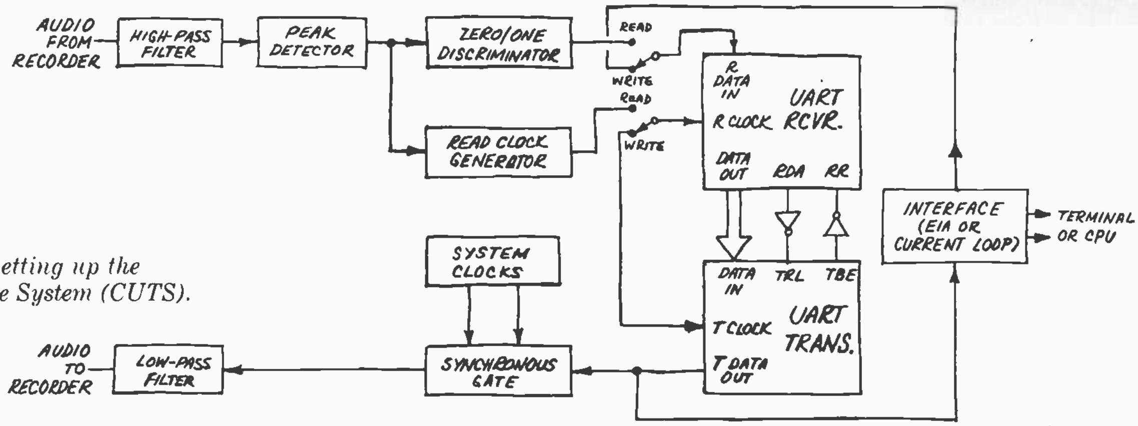


Fig. 2. One way of setting up the Computer Users Tape System (CUTS).

logical 1 consists of eight cycles of 2400 Hz, and a logical 0 is four cycles of 1200 Hz. A 4800-Hz clock is derived from the recorded data itself as the tapes are read, and is used to clock a UART (Universal Asychronous Receiver Transmitter) which performs the serial/parallel and parallel/serial conversions necessary to interface with the computer's data bus. It is not necessary to use a UART. Also, in some simple applications, a less expensive circuit can be used.

The standard data rate is 300 bits/second, and can be expanded to 600 or even 1200 bits/second with slightly higher error rates. Each bit is self-synchronizing because every bit time frame starts with a positive transition and contains an even number of tone cycles. Each data character is resynchronized by a logic 0 start bit that precedes the data bits. Therefore, data can be transferred asynchronously from any computer, terminal or modem with a serial data channel,as long as the serial channel is set up for 300 bits/second, eight data bits, and two "stop" bits.

Recording Method. The following specifications were adopted with the goal of optimizing versatility, reliability, low cost, and future expandability.

Mode: asynchronous by character.

Character Format: 11 bits; one start bit (a 0); least significant data bit first (if less than 8 bits are used as with Baudot 5-level code, then all bits not specified by the code will be set to 1). The interval between characters, if any, will be 1's.

Modulation Method: 1's will be 8 cycles of 2400 Hz; 0's will be four cycles of 1200 Hz tones. Sine-wave signals are preferred, although not always necessary.

Leader: Five seconds of continuous 2400 Hz (all 1's) will precede any block of valid data. At least 30 seconds of continuous 2400 Hz should be recorded at the beginning of each cassette. When multiple blocks are recorded, there will be a 5-second gap between them.

Motor Control: The interface should provide for switching the tape recorder motor so that the computer can start and stop the machine under program control.

Basic Circuit. One suggested approach to mechanizing the CUTS system is shown in Fig. 2. In the write mode, data is accepted from a terminal EIA/current loop interface and converted from serial to parallel by the UART receiver. The parallel data is transferred to the UART transmitter when a complete data character is received. The UART transmitter then converts the signal to serial form to gate either a 2400-Hz tone for 1's or a 1200-Hz tone for 0's. The tones are then passed through an output filter which rounds off the waveform and reduces the output level to about 0.5-volt peak-to-peak. This signal is then passed to the tape recorder auxiliary (or microphone) input for recording on the cassette.

In the read mode, the output from the recorder earphone jack is filtered to remove any low-frequency noise, and the waveform is squared up and synchronized with the system clock by the zero/one discriminator. The clock signal for the UART receiver is derived from the recorded information itself by the read clock generator. Parallel data from the UART receiver is transferred to the UART transmitter when a complete character is received. The reconverted serial data is then coupled to the terminal or CPU via the appropriate EIA or current loop.

Data transmitted from the computer or terminal could be sent directly to the synchronizing gate during write operations, but successive serial/parallel and parallel/serial conversions guarantee an accurate 300 bits/second data rate. This type of conversion and reconversion effectively eliminates the possibility of cumulative speed errors when duplicating tapes, and makes for a cleaner and more precise signal whether reading or writing.

Based on observations made at the meeting, most manufacturers agreed to shelve their personal systems for the good of the industry, although some might still offer their systems, with CUTS made available as an alternative.

More Hobbyist Clubs. Here are additional computer hobbyist clubs reported to us.

California

Bay Area Microprocessor Users Group, 4565 Black Ave., Pleasanton, CA 94566.

29 Palms Area, Sgt. Wesley B. Isrigg, 74055 Casita Dr., 29 Palms, CA 92277 (address change).

Colorado

Denver Amateur Computer Society, P.O. Box 6338, Denver, CO 80206.

Georgia

Atlanta Area Microcomputer Hobbyist Club, Jim Dunion, Pres., 421 Ridgecrest Rd., Atlanta, GA 30307.

Illinois

Computer Hobbyist Exchange, P.O. Box 36, Vernon Hills, IL 60061

New Jersey

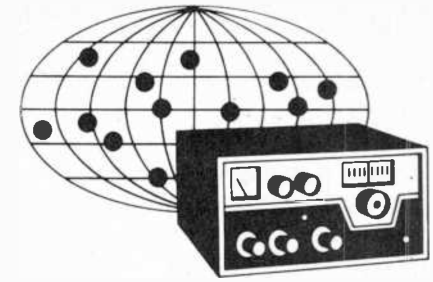
Amateur Computer Group of New Jersey, Union County Technical Institute, 1776 Raritan Road, Scotch Plains, NJ 07076

New York

Long Island Computer Club, c/o Popular Electronics, One Park Ave.,New York, NY 10016

Texas

El Paso Computer Group, Jack O. Coats, Jr., 213 Argonaut, Apt. 27, El Paso, TX 79912. ◈



DX Listening

By Glenn Hauser

SHORTWAVE NEWS FROM ALL OVER

DX LISTENERS in western North America have long felt frustrated by their inability to hear one of the nearest radio countries—Turks & Caicos Islands (in the Bahamas chain). VSI Radio's afternoon show on 4.788 MHz—in a band requiring darkness between transmitter and receiver—usually ends not later than 0030. (All times are GMT.) But now, Marlin Field in Michigan reports a morning program around 1130, when propagation is possible to the farthest shores of the Pacific. Whether 750 watts will cut through the QRM is another matter.

Radio Swan de Honduras started out on 6.185 MHz, but Jack Jones who discovered them, reports a switch to 6.000 MHz—obviously to strengthen their tenuous ties to the original Radio Swan, which used that channel. Radio Swan may be just the vanguard of growing SW activity in that country. Visiting Honduras, Scott Reeves learned that a leading Honduran presidential candidate was planning to add 6.145 MHz to his Radio Ceiba outlet early this year, and put his other stations on SW too. Jones reports another Honduran on 4.870 MHz.

Colombia-watcher Adam Gaffin of Brooklyn, N.Y., says the Colombian government is cracking down on what was once one of the most free-wheeling broadcasting scenes in Latin America. If the 60-meter band becomes a bit tamer, it may be because Colombian stations have been forbidden to criticize government or church officials.

Mexico, Colombia and Venezuela have all staked out channels on the 19-meter band, but only Venezuela has shown signs of a truly international approach, with an occasional Arabic program at 1300-1400, and English at 2200-2300 on Radio Nacional, 15.400 MHz. Colombia relays its official domestic program on 15.336 MHz; and Radio Mexico's English programming on 15.384 MHz has been limited to appeals for reception reports. John Fischer, Jr., of New York theorizes they do this from time to time to prove to their funding agency that they have an audience abroad. Meanwhile, reception reports pile up, unanswered, as a contact of John Tuchscherer's found when he visited the station.

Brazil has big plans for international broadcasting. Eight 250-kW transmitters are being built in strategic locations, and Brazilian commercial stations expect to have to turn over some of their frequencies to Radio Nacional—Brasilia. So far, RNB has only one on the air at 11.780 MHz (with 15.245 and 9.605 MHz as alternates) with an English hour at 2100. Among the feature programs are: Mon. Science on the March; Tue., Travelling Through Brazil; Wed., The Versatile Guitar; Thurs., Strange & Curious Aspects of Brazil; Fri., People & Events; Saturday Special; Sun., Retrospective —per a schedule sent to David Snyder in Brooklyn.

New Zealand also is contemplating going big time with 250 kW instead of 7.5 kW—but, even so, Radio New Zealand is surprisingly well heard on their beam toward Hawaii and Alaska at 0500-0745 on 9.540 and 11.780 MHz. Check for the Mailbag program, Fridays at 0615. Times change to an hour later in March.

Belgium has announced plans to cease broadcasting to the western hemisphere after the first week in March. Although the 20-minute English program was just a token successor to their 1958's World's Fair Radio, and was hard to receive in the interior, Jackie Marshall's friendly voice will be missed. But we've already gained a new English broadcast to North America, from the Voice of Greece—also tough to hear, but try for 15 minutes at 1215, 1515, 0015 or 0215 on 9.520 MHz.

Those who prefer English-language programs must sometimes make do with language lessons from stations not otherwise broadcasting in English—such as Algeria, which has "Brush Up Your English" Wednesdays around 1420 GMT on 17.825, 11.910 and 9.510 MHz—all frequencies likely to vary greatly. For Spanish from Algiers, tune to the clandestine "Voz de la Resistencia Chilena" program at 2300-2400 on 7.1431 MHz.

North Korean clandestine "Voice of the Revolutionary Party for Reunification" ambitiously has begun English broadcasts at 0530-0600 and 2300-2330 on 4.5515 MHz, as monitored by Kouji Yamada in Tokyo, but not likely to be heard here. Realizing that 1230-1250 is an ideal hour to reach North America, VRPR has a Thursday program for "our compatriots in the US", also on 4.115 MHz—in Korean.

Tirana's tirades make it a station most Americans avoid with a passion. But Kim Andrew Elliott of Minneapolis has found a way to *enjoy* listening to Radio Tirana! He recommends the musical portions of the incomprehensible Albanian-language program at 0030-0100 on 6.200, 7.300 or 9.790 MHz—especially *Tosk* music, raspy *a cappella* chanting, not to be confused with more conventionally Balkan *Geg* music.

DX-Program aficionados find Soviet-bloc versions rather dull. Unlicensed SWL'ing and DX'ing is suspect, so DX programs from the USSR, Bulgaria and Romania take the amateur angle—which is licensed and permitted. But Radio Budapest exercises more freedom, reading lists of DX loggings, including even evangelical stations. Though admitting its main aim is political, Radio Kiev encourages listener feedback on programs, and hopes to expand to daily English broadcasts, says Mike Barraclough of England who paid them a visit. Try for the Kiev DX program on the second Monday of each month (following Tuesday GMT). Radio Tashkent, Uzbek SSR, is reported to have begun a ham-type DX program on the second Sunday of the month at 1215—currently on 6.025, 9.540, 9.600 and 11.925 MHz.

Another DX program you're likely to miss if you aren't careful is from Deutsche Welle. Strangely, their one English segment is broadcast during its *German* transmissions, in consecutive translation. Check the second Saturday of the month at 2350 on

6.145 MHz and many others, repeated at 0350 on 6.085 and 9.605 MHz, among others.

Odds and Ends. If you're just getting started in SWL'ing, most of your questions are answered in the new book, *DX According To NASWA*. You can order it postpaid for $3.00 (in North America) from North American Shortwave Assoc., Box 13, Liberty, IN 47353.

Updating some items in the 1976 Communications Handbook: Now there's evidence the Spanish numbers spout from Cuba, rather than the USA. Several DX'ers report hearing the ciphers mixed with Radio Habana audio, which points to a common transmitter site—unless ionospheric cross modulation is involved. And the "4Y" Ocean Weather Stations have been closed down. ◈

ENGLISH-LANGUAGE SHORTWAVE BROADCASTS FOR MAR. & APR.

By Richard E. Wood

TO EASTERN NORTH AMERICA

TIME—EST	TIME—GMT	STATION	QUAL*	FREQUENCIES, MHz
6:00-6:30 a.m.	1100-1130	Tirana, Albania	F	9.48, 11.985
6:00-7:00 a.m.	1100-1200	London, England	G	15.07
6:00-9:00 a.m.	1100-1400	**VOA, Washington, U.S.A.	G	5.955, 9.73
6:15-7:15 a.m.	1115-1215	Montreal, Canada	G	5.97
6:15-7:45 a.m.	1115-1245	Melbourne, Australia	G	9.58
7:00-7:30 a.m.	1200-1230	Jerusalem, Israel	F	15.10, 17.815
7:00-7:55 a.m.	1200-1255	Peking, China	F	11.685
7:00-8:15 a.m.	1200-1315	London, England	G	15.07
7:15-7:30 a.m.	1215-1230	Athens, Greece	P	9.52
		HCJB, Quito, Ecuador	G	11.745
7:30-8:00 a.m.	1230-1300	Stockholm, Sweden	G	15.305
7:30-11:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
8:15-8:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
9:00-9:30 a.m.	1400-1430	Stockholm, Sweden	G	15.305
		Helsinki, Finland	G	15.185
10:00-11:15 a.m	1500-1615	London, England	G	17.84 (via Ascension)
3:00-3:55 p.m.	2000-2055	Jerusalem, Israel	G	5.90, 7.395, 9.815
4:15-5:45 p.m.	2115-2245	London, England	G	9.58 (via Ascension), 11.78, 15.26 (via Ascension)
4:30-5:50 p.m.	2130-2250	Hilversum, Holland	G	9.715, 11.73 (Sun.: Dutch)
5:30-6:00 p.m.	2230-2300	Vilnius, U.S.S.R.	G	5.94, 7.31, 7.355, 7.44 (Sat./Sun.)
5:30-6:20 p.m.	2230-2320	Johannesburg, S. Africa	G	5.98, 9.585, 11.90, 11.97
5:45-11:30 p.m.	2245-0430	London, England	G	5.975, 7.325, 9.58 (via Ascension)
5:55-6:15 p.m.	2255-2315	Brussels, Belgium	G	9.73 (subject to cancellation)
6:00-6:30 p.m.	2300-2330	Stockholm, Sweden	F	6.035, 9.605, 11.705
6:00-7:30 p.m.	2300-0030	Moscow, U.S.S.R.	G	5.94, 7.105, 7.115, 7.15, 7.205, 7.355, 7.40, 7.44, 12.05, 15.14, 15.18, 15.455, 17.72
6:45-7:45 p.m.	2345-0045	Tokyo, Japan	F	15.27, 15.30
7:00-7:25 p.m.	0000-0025	Tirana, Albania	G	7.065, 9.78
7:00-7:30 p.m.	0000-0030	Oslo, Norway	P	6.18 (Sun.)
7:00-7:55 p.m.	0000-0055	Peking, China	F	11.945, 15.06, 15.52, 17.673
		Sofia, Bulgaria	F	9.70
7:00-9:00 p.m.	0000-0200	**VOA, Washington, U.S.A.	G	6.13, 9.65, 11.71, 15.205
7:15-7:30 p.m.	0015-0030	Athens, Greece	P	9.52
7:30-8:00 p.m.	0030-0100	Kiev, U.S.S.R.	G	6.02, 7.15, 7.26, 9.78, 12.05, 15.14, 15.18, 15.455 (Mon./Thu./Sat.)
		Vilnius, U.S.S.R.	G	5.94, 7.355, 9.53, 9.685 (Sat./Sun.)
		HCJB, Quito, Ecuador	G	6.095, 9.56
7:40-8:00 p.m.	0040-0100	Brussels, Belgium	G	6.08 (subject to cancellation)
8:00-8:15 p.m.	0100-0115	Vatican City	G	5.995, 6.165, 9.605
8:00-8:20 p.m.	0100-0120	Rome, Italy	G	6.01, 9.575
8:00-8:45 p.m.	0100-0145	Berlin, Ger. Dem. Rep.	P	9.73
		Madrid, Spain	F	6.065, 11.925
8:00-8:55 p.m.	0100-0155	Peking, China	G	7.12, 9.78 (via Tirana), 11.685, 11.945, 15.06, 15.52
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 11.99
8:00-9:00 p.m.	0100-0200	Montreal, Canada	G	6.085
8:00-9:00 p.m.	0100-0200	Moscow, U.S.S.R.	G	5.94, 6.07 (via Sofia), 7.105, 7.15, 7.205, 7.355, 7.44, 9.505, 9.53, 9.78, 11.86, 12.05, 15.14, 15.455

8:00-10:30 p.m.	0100-0330	Havana, Cuba	G	11.725, 11.93
8:00- p.m.-12 mdt.	0100-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.91 (includes some Eskimo)
8:30-8:50 p.m.	0130-0150	Cologne, Ger. Fed. Rep.	G	6.01, 6.04, 6.10 (via Malta), 9.565, 9.69, 9.745, 11.865 (via Malta)
8:30-8.55 p.m.	0130-0155	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
8:30-9:25 p.m.	0130-0225	Bucharest, Rumania	F	5.99, 9.57, 9.68, 11.775, 11.94
8:45-9:15 p.m.	0145-0215	Berne, Switzerland	G	5.965, 6.135, 9.725, 11.715
9:00-9:30 p.m.	0200-0230	Budapest, Hungary	G	6.00, 7.22, 9.833, 11.91 (Ex. Sun.)
		Lisbon, Portugal	F	6.025, 11.935
		Oslo, Norway	P	6.18 (Sun.)
9:00-9:45 p.m.	0200-0245	Madrid, Spain	F	6.065, 11.925
9:00-9:55 p.m.	0200-0255	Peking, China	F	11.965, 12.055, 15.06
9:00-10:00 p.m.	0200-0300	Moscow, U.S.S.R.	G	5.94, 6.07 (via Sofia), 7.105, 7.115, 7.205, 7.26, 7.355, 7.44, 9.61, 9.78, 11.86, 12.05, 15.14
9:00-10.20 p.m.	0200-0320	Hilversum, Holland	G	6.165 (via Bonaire)
9:00-10:30 p.m.	0200-0330	Cairo, Egypt	G	9.475
9:00-11:00 p.m.	0200-0400	Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815 (mixed Polish/English)
9:30-10:00 p.m.	0230-0300	Beirut, Lebanon	P	9.545 (subject to change)
10:00-10:30 p.m.	0300-0330	Budapest, Hungary	G	6.00, 7.22, 9.833, 11.91
		Kiev, U.S.S.R.	G	5.98, 6.02, 7.245, 7.26, 7.40, 9.78, 11.86 (Mon./Thu./Sat.)
10:00-10:45 p.m.	0300-0345	Madrid, Spain	F	6.065, 11.925
10:00-10:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana)
10:00-11:00 p.m.	0300-0400	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 11.99
		Moscow, U.S.S.R.	G	5.94, 6.07 (via Sofia), 7.115, 7.205, 7.355, 7.44
10:30-10:55 p.m.	0330-0355	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
10:30-11:30 p.m.	0330-0430	London, England	G	5.975, 9.58 (via Ascension)
10:30-11:50 p.m.	0330-0450	Havana, Cuba	G	11.725, 11.76, 11.93
11:00-11:15 p.m.	0400-0415	Budapest, Hungary	G	6.00, 7.22, 9.833, 11.91 (Tue./Fri.)
11.00-11:25 p.m.	0400-0425	Bucharest, Rumania	F	5.99, 9.57, 9.68, 11.775, 11.94
11:00-11:30 p.m.	0400-0430	Oslo, Norway	P	6.18, 9.61 (Sun.)
11:00-12 mdt.	0400-0500	Moscow, U.S.S.R.	G	5.94, 7.115, 7.15, 7.205, 7.355, 7.40, 7.44
11:50 p.m.-1:00 a.m.	0450-0600	Havana, Cuba	G	11.725, 11.76
12 mdt. 12:15 a.m.	0500-0515	Jerusalem, Israel	G	5.90, 5.950, 7.395, 9.009
12 mdt.-2:00 a.m.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56

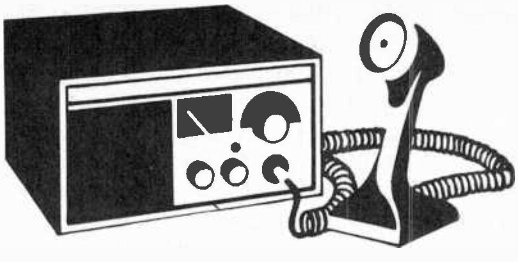
TO WESTERN NORTH AMERICA

TIME-PST	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
4:00-5:30 a.m.	1200-1330	London, England	G	5.99 (via Sackville) (opens 1300 Sun.)
4:15-4:30 a.m.	1215-1230	HCJB, Quito, Ecuador	G	11.745
4:30-8:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
5:00-5:15 a.m.	1300-1315	Tokyo, Japan	G	5.99
5:00-8:00 a.m.	1300-1600	**VOA, Washington, U.S.A.	G	6.11, 9.76, 11.715
5:57-8:54 a.m.	1357-1654	Manila, Philippines	F	9.58 (closes 1554 Sun.)
6:00-6:30 a.m.	1400-1430	Tokyo, Japan	G	5.99
7:00-7:30 a.m.	1500-1530	Tokyo, Japan	G	5.99
7:00-8:15 a.m.	1500-1615	London, England	G	17.84 (via Ascension)
8:00-8:15 a.m.	1600-1615	Tokyo, Japan	G	9.505
8:00-8:30 a.m.	1600-1630	Oslo, Norway	P	11.895 (Sun.)
8:42-8:51 a.m.	1642-1651	Hilversum, Holland	G	11.82, 15.19 (via Bonaire; mixed English/Dutch)
9:00-9:15 a.m.	1700-1715	Tokyo, Japan	G	9.505
9:00-10:30 a.m.	1700-1830	London, England	G	15.365 (via Sackville)
10:00-10:15 a.m.	1800-1815	Tokyo, Japan	G	9.505
10:00-10:30 a.m.	1800-1830	Oslo, Norway	F	11.895 (Sun.)
11:00-11:15 a.m.	1900-1915	Tokyo, Japan	G	9.505
12 noon-12:15 p.m.	2000-2015	Tokyo, Japan	G	9.505
12 noon-12:55 p.m.	2000-2055	Jerusalem, Israel	F	9.815, 11.645
1:00-1:15 p.m.	2100-2115	Tokyo, Japan	G	9.505

1:15-3:00 p.m.	2115-2300	London, England	G	15.26 (via Ascension)
2:00-2:15 p.m.	2200-2215	Tokyo, Japan	G	15.105
3:00-3:30 p.m.	2300-2330	Tokyo, Japan	G	15.105
3:00-4:30 p.m.	2300-0030	London, England	G	6.175, 9.51 (via Sackville), 9.58, 15.26 (via Ascension)
		Moscow, U.S.S.R.	G	12.05, 15.21, 17.72, 17.775, 17.90
4:00-4:15 p.m.	0000-0015	Tokyo, Japan	G	15.105
4:00-6:00 p.m.	0000-0200	**VOA, Washington, U.S.A.	G	11.76, 15.21, 17.79
4:30-7:30 p.m.	0030-0330	London, England	G	6.175 (via Sackville), 9.51 (via Greenville), 9.58, 15.26 (via Ascension)
5:00-5:15 p.m.	0100-0115	Tokyo, Japan	G	15.105
5:00-5:30 p.m.	0100-0130	Moscow, U.S.S.R.	G	12.05, 15.21, 17.72, 17.775, 17.90 (via Soviet Far East)
5:00-5:55 p.m.	0100-0155	Peking, China	G	11.945, 11.965, 12.055, 15.06, 15.52
5:00-7:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
5:00-9:00 p.m.	0100-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.91 (includes Eskimo)
5:30-6:00 p.m.	0130-0200	Moscow, U.S.S.R.	G	12.05, 15.21, 17.72, 17.90 (via Soviet Far East)
5:30-6:30 p.m.	0130-0230	Tokyo, Japan	G	15.195, 15.235, 17.725, 17.825
6:00-6:15 p.m.	0200-0215	Tokyo, Japan	G	15.105
6:00-6:55 p.m.	0200-0255	Peking, China	G	11.455, 11.965, 12.055, 15.06, 17.855
6:00-7:00 p.m.	0200-0300	Moscow, U.S.S.R.	G	12.05, 15.21, 15.245, 17.72, 17.90 (via Soviet Far East)
6:00-8:50 p.m.	0200-0350	Taipei, Taiwan	F	11.86, 15.125, 17.72
6:15-6:30 p.m.	0215-0230	Athens, Greece	P	9.52
6:30-7:00 p.m.	0230-0300	Stockholm, Sweden	P	9.695, 11.705
7:00-7:15 p.m.	0300-0315	Tokyo, Japan	G	15.105
7:00-7:30 p.m.	0300-0330	Seoul, Korea	P	15.335
		Kiev, U.S.S.R.	G	12.05, 15.21, 15.245, 17.72 (Sat./Mon./Thu.) (via Soviet Far East)
7:00-7:45 p.m.	0300-0345	Madrid, Spain	P	6.065, 11.925
7:00-7:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana), 11.445, 12.055, 15.06, 15.385, 17.735, 17.855
7:30-8:15 p.m.	0330-0415	Berlin, Ger. Dem. Rep.	P	5.955, 6.08, 9.73
7:30-8:30 p.m.	0330-0430	London, England	G	6.175 (via Sackville), 9.58 (via Ascension)
7:30-9:30 p.m.	0330-0530	Moscow, U.S.S.R.	G	7.17, 7.18, 7.26, 9.54, 9.58, 9.735, 11.69, 15.14 (via Soviet Far East)
8:00-8:15 p.m.	0400-0415	Tokyo, Japan	G	15.105
8:00-8:30 p.m.	0400-0430	Sofia, Bulgaria	P	9.70
		Budapest, Hungary	F	6.00, 7.22, 9.833, 11.91 (Tue., Fri.)
8:00-9:00 p.m.	0400-0500	Montreal, Canada	G	6.135, 9.655
8:30-9:00 p.m.	0430-0500	Lisbon, Portugal	P	6.025, 11.935
		Berne, Switzerland	F	6.045, 9.725
		Vienna, Austria	P	6.015
9:00-9:15 p.m.	0500-0515	Tokyo, Japan	G	9.505
		Jerusalem, Israel	F	7.412
9:00-10:00 p.m.	0500-0600	Montreal, Canada	G	6.135, 9.655
9:00-10:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.715 (via Bonaire)
9:00-11:00 p.m.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56
9:30-9:50 p.m.	0530-0550	Cologne, Ger. Fed. Rep.	F	6.10 (via Malta), 6.185, 9.545
9:30-11:30 p.m.	0530-0730	Moscow, U.S.S.R.	G	7.15, 7.17, 7.26, 9.54, 9.58, 9.61, 9.735, 9.78 (via Soviet Far East)
10:00-10:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
10:00-10:30 p.m.	0600-0630	Oslo, Norway	P	9.645, 11.87 (Sun.)
10:00-11:00 p.m.	0600-0700	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
10:30 p.m.-12 mdt.	0630-0800	Havana, Cuba	G	9.525
11:00-11:15 p.m.	0700-0715	Tokyo, Japan	G	9.505
12 mdt.-12:15 a.m.	0800-0815	Tokyo, Japan	G	9.505
1:00-1:15 a.m.	0900-0915	Tokyo, Japan	G	9.505
2:00-2:15 a.m.	1000-1015	Tokyo, Japan	G	5.99
2:00-2:50 a.m.	1000-1050	Pyongyang, D.P.R. Korea	G	9.415, 9.535
3:00-3:15 a.m.	1100-1115	Tokyo, Japan	G	5.99

*Reception quality, East Coast (West Coast) location: G-good, F-fair, P-poor
**Not intended for North America, but receivable satisfactorily

Frequencies are accurate as of press time, but subject to change.



CB Scene

By Ray Newhall

IS YOUR STATION READY FOR AN EMERGENCY?

MUCH has been written about the public safety potential of the many CB radio stations spread across the country. Equally publicized is how CB'ers have responded to past large- and small-scale disasters. But a well-executed assist does not "just happen." It is planned in advance and is practiced over and over until both equipment and operators are ready to handle the emergency when it occurs.

Hundreds of CB clubs have organized emergency communications systems, and many of the more successful organizations have expanded to nationwide scope. REACT, ALERT, and REST Marine are typical of these emergency networks. However, in spite of these admirable efforts, many CB'ers are still not equipped to handle emergency communications. Are you?

What's an Emergency? The FCC defines an emergency that deserves channel priority as one which, "involves . . . the immediate safety of life . . . or the immediate protection of property." Only when a situation meets these requirements can the band be cleared for priority traffic or the international distress signals (MAYDAY for voice transmissions) be used. Then operating restrictions can be abandoned *if necessary* to initiate and direct rescue operations. However, misuse of priority or distress procedures can result in very heavy fines, imprisonment, or both—not to mention widespread confusion!

Less grave situations do not qualify for priority or distress traffic, but they may be conducted on the emergency channel 9, or any of the other 21 "free" class D channels. Channel 11 should be avoided, if possible, as it is set aside for contact ("call and switch") transmissions only. But in any event, as soon as contact is made on either channel 9 or 11, you should move to another one to keep these calling channels open.

Being Prepared. Public safety communications facilities should have reliable equipment, local maps and a list of needed phone numbers, a telephone, and most of all trained and dedicated operators.

Every CB'er is aware of equipment requirements—a good transceiver and a high-performance antenna. The rig should be checked regularly to make sure it's in top shape and to be certain that all channels are on frequency. Preventive maintenance schedules should be followed. To make a transceiver truly useful for emergency, it should be provided with a power source independent of the commercial power lines. For mobile units, which are powered by the car battery or alternator, there's no problem. But base stations are a different story. Obviously, if a real disaster occurs which knocks out the power lines, you won't be able to do much with a dead base transceiver.

Many transceivers, especially those of the "base/mobile" variety, will accept 12 volts dc as well as 117 volts ac. With such equipment, fully-charged automotive storage batteries will provide the back-up power you might need. But the batteries must be charged. A trickle charger permanently attached to the power line will keep the battery topped up.

A relay can be used for automatic, instantaneous switching when the ac line fails as shown in the diagram. For extended operations, more than one battery might be required. If needed, the additional batteries can be simply placed in parallel with the primary battery. But be sure to observe standard safety procedures for handling and charging lead-acid storage batteries. For ac-only base transceivers, a battery/ac inverter combination or an emergency generator will be needed.

Although not required, auxiliary equipment will be useful. This includes a vhf/FM scanner with local Public Service channels and (if you live near the shore) vhf/FM marine channels 2, 16, and 22. A tape recorder and a phone patch might also prove handy, but I hardly ever use my patch unless the band is unusually quiet. This equipment should also have a back-up power source.

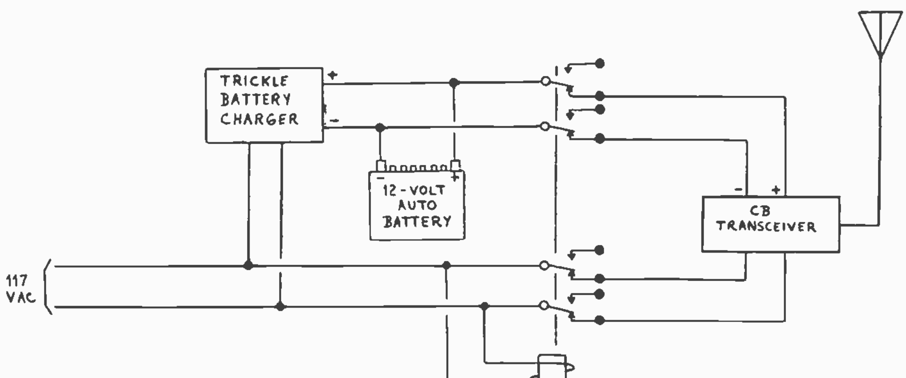
Other items that should be included are:

- Pencils, notepads and a logbook.
- Land-line phone within easy reach.
- City street listing and maps of your monitoring area.
- Telephone numbers for all local public safety agencies.

Training Yourself. As I mentioned earlier, all this equipment is of little value unless the operator is properly trained and can use it efficiently. In emergency communications, effectiveness is essential. The guidelines for emergency traffic handling can be summed up in the "Four C's."

Be Calm. No matter what the emergency, a calm, professional attitude will help cool the situation and instill confidence. Remember that the person reporting the emergency is likely to be excited, and might even be abusive or irrational in his anxiety.

Be Courteous. Persons seeking assistance sometimes expect the



Circuit to use with a trickle battery charger.

service of a professional operator. Try to act the part. No matter what the provocation, you *must* be courteous.

Be Concise. When you receive an emergency message, jot down all the essential data needed to identify the nature of the incident, its exact location, the number and identity of persons or vehicles involved, and the nature and extent of injuries, if any. Make your transmissions as brief and clear as possible.

Be Correct. Before you relay a message, try to get confirmation from a second source, if possible. Note the call signs of reporting stations, vehicle registration numbers, etc.—any information which will identify the victim(s) and the caller. Be particularly careful to confirm the exact location of the incident. Excited informants are often confused about their exact whereabouts. Keep in mind that your information can do more harm than good when you direct emergency teams to the wrong location!

It's not easy to follow these four commandments in the heat and excitement of an emergency, but that's precisely the time when they are most necessary to get the message through. Play it cool. Keep all emotion out of your voice. Remember—this takes self discipline and *practice*.

Whom to Notify. Generally, when you receive an emergency call at your base location you will be asked to relay a message to police or marine safety agencies. But you must know the jurisdictions of each organization so you can alert the proper one. For example, don't deliver a message to your *local* police concerning an accident on an interstate highway patrolled by state authorities. However, if you need an ambulance, a call to your local police (or to the 911 emergency service if available) may be your best bet.

If you monitor marine activity, you should know what marine safety groups are active in the area. Do the local police maintain a marine patrol, or is there an active Coast Guard Auxiliary Flotilla in your area? If you call the Coast Guard directly, chances are that they will refer your call to one of these other agencies. Precious time will be lost in the process. The best way to find out whom you should call for each situation is to visit these groups at their own bases of operations and see for yourself how they operate. Normally, they will appreciate your interest and efforts to learn. You will also find out which, if any, of the organizations operate CB equipment of their own and how they can be contacted directly on the Citizens Band. (Most are far too busy to maintain a continuous CB watch, but might monitor one individual channel.) This knowledge is of particular value when you are reporting an emergency from your mobile unit.

The best way to handle emergency communications on the local level is to organize a CB monitor-and-assist team. Even if you're not presently associated with the local REACT, it's good practice to know the other emergency operators in your area. Perhaps your local CB club has an organized net. If not, try and form one yourself. Through an organized approach, you can quickly establish a working relationship with public safety agencies and such groups as the Red Cross. Also, a local emergency net can hold drills and simulated emergencies to sharpen operating skills.

Channel Usage. Remember that channel 9 is to be used only for emergency traffic. Don't conduct simulated message relays over it, or use it for the *administrative* purposes of your local emergency team. Now that many truckers have moved their highway communications to channel 19, channel 9 is much less susceptible to heavy "bleed-over." But you might hear an emergency message about a highway accident first on channel 19 via the truckers. Marine messages might first be heard on channel 13, which is used by shipboard CB'ers.

If you are monitoring channel 9 and scofflaws are using it for nonemergency purposes, don't argue with them. The experienced operator avoids a confrontation of this sort because he knows that a response usually just compounds the problem. The FCC is stepping up its efforts to indict illegal operators, and will appreciate your efforts to provide them with positive identification. Sometimes, signals from Latin America will "skip" in on channel 9. These operators are not governed by U.S. regulations, and their transmissions are all quite legal. It's just one of the annoyances that CB'ers must tolerate. ◈

Hobby Scene

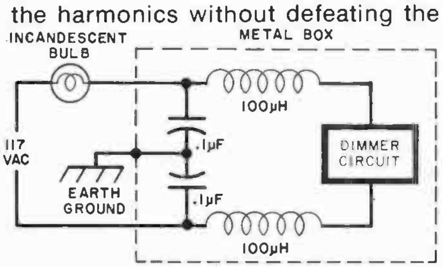
By John McVeigh

DIMMER RFI

Q. ***I replaced several of my wall switches with triac dimmers, but now experience severe interference to AM broadcasts. I tried a 0.1-µF capacitor, which reduced but did not eliminate the noise. How can I lick this problem?***

—William Conover, Clinton, TN

A. The fast switching action of thyristors produces voltage and current waveforms with abrupt on and off transitions, which contain loads of harmonics extending into the hf region. A lowpass filter will take care of the harmonics without defeating the



purpose of the dimmer. Construct two low-pass filters (one for each side of the line) from 100-µH coils and 0.1-µF, 200-V ceramic capacitors. Mount the filters and the dimmer inside a metal box, and bond the box to a good earth ground. That should clear up your AM reception.

DIGITAL IC DATA

Q. ***I am looking for a handbook on the 7400 series of digital integrated circuits. Is there any volume out that can serve as a basic reference guide?***

—Galen Tackett, Newark, CA.

A. The 7400 Series Pinout Handbook will probably help you. It includes pin connections, functional specs, truth tables, and a cross-reference. It's available for $2.95 plus $0.30 postage from IMS Associates, 1298 E 14th St., San Leandro, CA 94577.

EUROPEAN/US AC CONVERTER

Q. ***I am serving with the Canadian Armed Forces in Europe and have purchased several appliances which I want to take home with me. Is there a simple way to convert the 50-Hz, 220-V ac power to 60-Hz, 110-V service we have in North America?***

—Keith L. Webber, Lahr, Germany

A. A simple 2:1 transformer will take care of the voltage problem, and it works both ways. If you want to convert 110 V to 220 V, take a transformer like the Thorardson Type 23V74, attach a power plug to the secondary and a receptacle to the primary. When 110 V is applied to the "secondary," 220 V will appear across the "primary." To step down 220 V to 110 V, reverse this procedure. It is *not* an easy job, however, to convert the 50 Hz to 60 Hz line frequency or vice versa. You would have to rectify the ac to dc, and then use a dc/ac transistor converter running at the desired line frequency. A sample circuit was shown in PE, 5/69, page 65. We've had many inquiries about these dc/ac circuits, but they all share several disadvantages. They tend to be inefficient, require bulky, expensive transformers, or ones you have to roll for yourself. Most of them have limited power capacities, and their outputs are square-wave ac. This makes them unsuitable for use with induction motors, refrigerators, air conditioners, etc.

Operation Assist

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

Freed-Eisemann FM-AM radio chassis Model CH155. Schematic. Sylvania part #241-0002 horizontal scanning output choke. Need part. Charles L. Pierce, Hwy. 180, Suches, GA 30572.

RCA Institutes Multimeter. Schematic of ac section. 6.667 ohm/V ac shown on meter face. Tom Stanton, Box 224, 902 Bayshore Dr., Terra Ceia, FL 33591.

Lavoie Labs. WWV Receiver LA800D. Automatic Electric Intercommunication Type 1-A-T, Drg. No. GH78025-1. Operation and maintenance manuals. Julian A. Harris, Jr., 1900 N. Barcelona St., Pensacola, FL 32501.

Military AN/UPM-1 Radar Test Set, Instruction manual. John Landa, S. Tallulah Fls., Clarkeville, GA 30523.

LeSabre 10-transistor AM-FM portable radio. Service manual with schematic. Dana G. Frisbee, 490 Commonwealth Ave., Boston, MA 02215.

Hallicrafters Model S-40 receiver. Schematic and/or service information. Mike Turner, Box 85, Fletcher, NC 28732.

Collins R105/ARR-15 (51H3) Radio Receiver. Air Force manual AN 16-30-ARR15. Felix M. Marshall, 9339 E. Magdalena St., Tucson, AZ 85710.

Avia FMR-150 Radio. Schematic and/or service manual. Richard Kindred, 902 Rainbow Dr., Blackwell, OK 74631.

Navy surplus receiver. Need transformer N17-T-73701-5366, UTC G-5551A, RCA 8889252-1, TF 1A 03 YY. Reynaldo Rodriguez, 8412 Georgian Dr., Austin, TX 78753.

Varo Receiver Model R-663A/TRC-42. Any information. Bernard Gnat, 1565 Hollywood N.E., Warren, OH 44483.

Precision Apparatus, Series EV-20 VTVM and Multi-Range Test Set. Schematic. Jesse G. Williams, 1833 Waycross Dr., Winston-Salem, NC 27106.

Magnecord Tape Recorder, Model PT6-A. Schematics of motor and amplifier sections. Robert Faris, Rt. 25, Brookfield, CT 06804.

Channel 11 mini-TV transmitter schematic needed. R. Greenwade, 211 Cherry Lane, Monmouth, OR 97361.

Monarch SA60 Stereo Amplifier. Schematic. John Mutchler Jr., Rte. 3, Box 304, Grand Rapids, MN 55744.

ITT 4-trace Oscilloscope Model KP-404, Serial No. 7027. Schematic and/or service manual. Sam Lay, 6771 Bonnie Dr., Huntington Beach, CA 92647.

Hammarlund HQ-129X Receiver. Schematic and/or service manual. James Smythe, 5158 W. 135th St., Hawthorne, CA 90250.

Surplus Transponder AN/APX-6A with Radio Receiver/Transmitter RT 279/APX-6A. Schematic. J.P. Vanags, 505-1111 Beach Ave., Vancouver, B.C. Canada.

Gibson Guitar Amplifier Model Minuteman GA-20RVT. Schematic and instruction manual. Carl McCormick, 1502 Debra, Bossier City, LA 71010.

Skyline Radiophone Model 1A30. Schematic and/or owner's manual. Fred Caughlin, 11094 71st Ave. N.E., Brooks, OR 97305

Vivitar Model ICR-007 FM-AM Radio. Schematic. Rico Liu, 110-19 65th Ave., Forest Hills, NY 11375.

Electro-Voice EVR-2A Stereo Receiver, Serial #134,257. Schematic and/or operating manual. Henry L. Black, 2411 E. Gage Ave., Huntington Park, CA 90255.

Gorler Varactor FM Tuner No. 4-1969 312-0512. Schematic. Paul G. Kazmierski, 9146 Forrer, Detroit, MI 48228.

United Cinephone U.S. Army Signal Corps Test Oscilloscope TS-100/AP, Order #368-DAV-45-RA. Operator's manual, service information. Chester A. Browning, 219 Hanover St., Providence, RI 02507.

Electronics Library

INTERNATIONAL DICTIONARIES OF SCIENCE AND TECHNOLOGY: SOUND

edited by R.W. Stevens

Scientists and technologists of eight European nations and the USA have collaborated to produce this multilingual dictionary which provides coverage of the ways in which sound is important in modern technology. Included are physical concepts relating to mechanical vibrations as well as thorough treatment of such topics as architectural acoustics, audio circuits, disc, magnetic and optical recording, sound editing and broadcasting, telephony, ultrasonics, underwater and musical acoustics. There are also transliterations of entries into English, French, German, Italian, Portuguese, Spanish and Russian. *Published by Halsted Press, Div. of John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10016. 853 pages. $37.50 hard cover.*

RCA SOLID-STATE DEVICES MANUAL

A manual on the theory and applications of solid-state devices, including discrete types and monolithic IC's, has been published by RCA. The Solid-State Devices Manual (SC-16), successor to the RCA Transistor, Thyristor, and Diode Manual, covers silicon diodes, bipolar transistors (low-, medium- and high-frequency types), MOSFET's, thyristors, and monolithic IC's (bipolar and COS/MOS types) for linear and digital applications. It provides information on basic operation, technology, ratings and characteristics, circuit applications, packages, and handling and mounting considerations, as well as an up-to-date listing of commercial types available from RCA. Many projects, including schematics, parts lists, and descriptions are included. *Published by RCA Solid State Division, Box 3200, Somerville, NJ 08876. 752 pages. $5.00 soft cover.*

DM-1A DIGITAL INTEGRATED CIRCUITS MANUAL (THIRD EDITION)

This updated digital IC reference manual contains listings by type numbers (old and new), and by figure (pinout) numbers (old and new). Included are most IC's the hobbyist is likely to encounter in the TTL, DTL, ECL, MOS and C/MOS families. Covered are simple combinational gates, flip-flops, shift registers, RAM's and arithmetic chips. *Published by Electronetics, Box 127, Hopedale, MA 01747. 48 pages (8½" × 11"). $6.95 soft cover.*

Experimenter's Corner

By Forrest M. Mims

PERCUSSION INSTRUMENT SYNTHESIZER

THANKS to John Simonton, and Don Lancaster, this magazine has featured articles on virtually every aspect of electronic music over the past several years.

Recently the electronic music bug bit me. Having tinkered with several of the basic circuits, I'm convinced that voicing circuits are by far the most challenging—and the most fun. Of course, they can be very difficult to implement, but the successful electronic synthesis of the unique "voice" or timbre of a particular musical instrument is quite rewarding.

Percussion instruments are among the simplest to simulate, so let's jump into electronic music by putting a percussion synthesizer together. Since percussion instruments include the bell, gong, cymbals, triangle, xylophone, tambourine, and drum, a successful percussion synthesizer has lots of uses!

The first step of a successful design is to study the waveforms produced by the instrument to be synthesized. If you're new to electronic music, be prepared for a surprise! "Ordinary" musical instruments produce some very extraordinary waveforms. To make matters even worse, the amplitude (signal strength) of the waveform during the first 100 milliseconds or so is usually irregular and often unique. For example, the cello has a gradual, slow amplitude rise time, but the tuba has a fast rise time in the form of a high-amplitude spike followed by the remainder of the sound "envelope." See Don Lancaster's article "Imitating Musical Instruments with Synthesized Sound" (POPULAR ELECTRONICS, August 1975, p. 37) for more information on the sound envelopes of these and other nonpercussion instruments.

Fortunately, percussion instruments produce a fairly orderly sound envelope. Figure 1 is a somewhat simplified version of the waveform

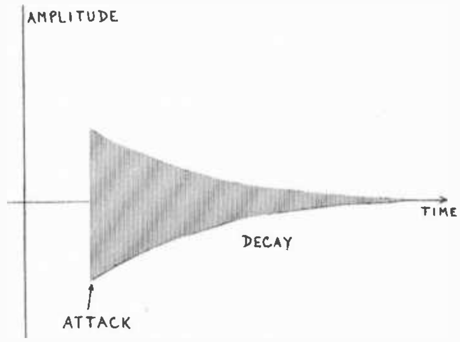


Fig. 1. In percussive waveform, rise is fast and decay slow.

produced by a typical percussion instrument. The waveform consists of a strong, fast rise-time "attack" followed by a gradual "decay." In the case of a bell, the attack is the initial high-amplitude sound produced when the bell is struck by its clapper. The decay is the ringing sound representative of the bell's natural resonant frequency.

Now that we've defined the frequency and amplitude relationships of the sounds we wish to simulate, we can start designing a circuit. Fortunately, our task is easy because "ringing," the effect we want to simulate, is a common and even pesky problem in many electronic circuits!

An active notch filter happens to make an excellent ringing circuit since it has a natural resonance frequency and can be adjusted to a critical point where oscillation can be externally stimulated and internally damped. As you may know, an active filter uses transistors or, better, one or more op amps to simulate a conventional filter. The active filter is superior to a passive filter since it has internal gain which replaces the losses of passive filters and since it can be made with a very high input impedance (very desirable) and a low output impedance (also very good).

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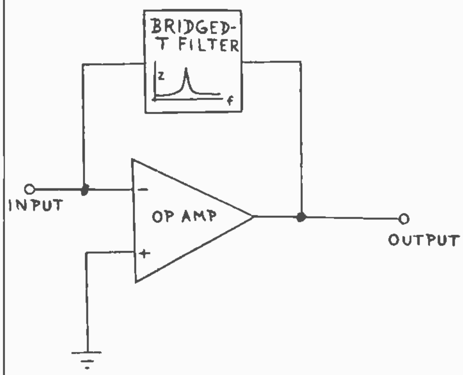

Fig. 2. Notch filter with maximum impedance at center frequency.

Figure 2 is the block diagram of a typical active notch filter which uses a single op amp, and Fig. 3 shows a working circuit. The filtering action takes place in the twin-T network formed by *R1*, *R2*, and their associated components. The twin-T notch filter is an old standby and is often used to block 60-Hz line noise in amplifiers and other circuits. The op amp provides restorative gain and interfacing to external circuits. You can operate the circuit as it is by connecting a miniature speaker to the output through a matching transformer (a unit with a 1000-ohm primary and an 8-ohm secondary), but you will have best results by connecting the circuit to an external audio amplifier.

The circuit works like this. The potentiometer is adjusted so that the filter just begins to oscillate and is then backed off until oscillation ceases. After this adjustment is made, a tiny input signal at pin 2 of the op amp will stimulate an oscillating attack followed by a gradual decay as the oscillation is dampened. How do you apply an input signal? Simple—just touch the touch plate (which can be a scrap of bare hookup wire) with a finger. The LM308, a precision op amp, has a typical input resistance of 40 megohms and readily accepts the small noise voltage from your body.

The frequency pattern of the circuit is very similar to Fig. 1, and the result is a very effective and realistic percussion simulator. You will probably have to make several adjustments of the pot for best results. If the circuit continues to oscillate without decaying, back off on the pot.

When *R1* and *R2* are about 100,000 ohms each, the circuit produces a very realistic bell sound when pin 2 is briefly touched. You can change the resonance frequency to simulate many other percussion instruments by

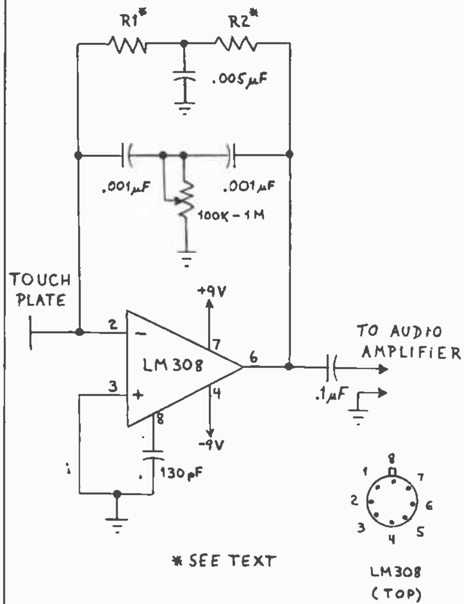

Fig. 3. Damped percussive waveform appears at filter output when touch plate is "struck."

changing *R1* and *R2*. Of course you will have to readjust the pot to obtain the best voice for each instrument. Try these values for various effects:

Instrument	R1 and R2
Triangle	33K
Small bell	47K
Medium bell	150K
Large bell	470K
Drum	1M

A narrow tuning range will help you adjust the circuit for optimum voicing, so you will want to use as small a value for the pot as possible. If 100,000 isn't enough, use values of up to 1M.

Incidentally, you can use various op amps in this circuit, but they may not respond to a touch input signal. If this occurs, just connect a resistance of a few thousand ohms between the positive power-supply lead and pin 2 of the op amp through a momentary contact spst (normally open) pushbutton switch. Press the switch to ring the bell, strike the drum, or whatever. For a ding-dong effect, insert a small (about 0.001-µF) capacitor in place of the resistor. Pressing the switch gives a sharp "ding" and releasing it gives a resonant "dong." This hookup makes a great doorbell circuit!

Finally, if this introductory project turns you on to electronic music, try building a complete percussion synthesizer from several filters adjusted to simulate various instruments. You can even build a realistic xylophone by building up a separate filter for each note. ◈

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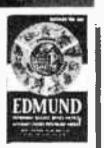

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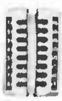

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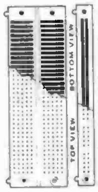

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QT18S Socket	2.4"	2.1"	36	4.75
QT12S Socket	1.8"	1.5"	24	3.75
QT8S Socket	1.4"	1.1"	16	3.25
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7403N	.15	7445N	.77	74105N	.50	74170N	2.05
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7405N	.19	7447N	.72	74109N	.74	74174N	1.25
7406N	.29	7448N	.80	74110N	.72	74175N	.94
7407N	.29	7450N	.14	74111N	1.20	74176N	.90
7408N	.18	7451N	.14	74116N	2.00	74177N	.90
7409N	.20	7453N	.14	74121N	.36	74178N	.90
7410N	.16	7454N	.14	74122N	.38	74179N	2.50
7411N	.24	7459N	.20	74123N	.70	74180N	.80
7412N	.33	7460N	.14	74125N	.47	74181N	2.39
7413N	.44	7470N	.26	74126N	.53	74182N	.70
7414N	.95	7472N	.26	74128N	.84	74184N	1.84
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7423N	.37	7482N	.98	74150N	1.00	74194N	1.10
7425N	.23	7483N	.70	74151N	.80	74195N	.74
7426N	.23	7484N	3.00	74152N	1.40	74196N	.99
7427N	.25	7485N	.90	74153N	.79	74197N	.78
7428N	.33	7486N	.34	74154N	1.40	74198N	1.60
7430N	.20	7489N	2.20	74155N	.97	74199N	1.60
7432N	.24	7490N	.48	74156N	.95	74200N	5.60
7433N	.36	7491N	.78	74157N	.74	74221N	1.50
7437N	.29	7492N	.49	74158N	1.60	74251N	1.75
7438N	.29	7493N	.49	74160N	1.24	74278N	2.45
7439N	.38	7494N	.72	74161N	.99	74279N	.94
7440N	.16	7495N	.80	74162N	1.25	74293N	1.00
7441N	.87	7496N	.70	74163N	.99	74298N	1.98

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74H00N	.33	74H20N	.33	74H52N	.36	74H73N	.80
74H01N	.25	74H21N	.33	74H53N	.36	74H74N	.80
74H04N	.33	74H22N	.33	74H54N	.36	74H76N	.75
74H05N	.33	74H30N	.33	74H55N	.36	74H102N	.75
74H08N	.40	74H40N	.36	74H60N	.36	74H103N	.90
74H10N	.33	74H50N	.36	74H71N	.75	74H106N	.95
74H11N	.33	74H51N	.36	74H72N	.75		

LOW POWER TTL

74L00N	.24	74L10N	.24	74L51N	.34	74L90N	1.62
74L02N	.24	74L20N	.33	74L73N	.43	74L93N	1.51
74L03N	.39	74L42N	1.33	74L74N	.90	74L95N	1.62
74L04N	.33						

74LS

74LS00	.39	74LS27	.45	74LS109	.92	74LS163	2.25
74LS01	.56	74LS30	.39	74LS112	.65	74LS170	5.80
74LS02	.39	74LS32	.45	74LS113	.92	74LS174	2.20
74LS03	.39	74LS38	.53	74LS114	.92	74LS175	2.40
74LS04	.45	74LS51	.39	74LS138	1.89	74LS181	6.00
74LS08	.39	74LS54	.55	74LS139	2.00	74LS194	2.25
74LS09	.57	74LS55	.39	74LS151	1.55	74LS195A	2.25
74LS10	.39	74LS73	.65	74LS153	1.89	74LS196	2.76
74LS11	.42	74LS74	.65	74LS157	1.55	74LS251	2.06
74LS15	.57	74LS76	.65	74LS158	1.68	74LS253	2.42
74LS20	.39	74LS78	.92	74LS160	3.06	74LS257	1.89
74LS21	.56	74LS95	2.30	74LS161	3.06	74LS258	2.06
74LS22	.60	74LS107	.65	74LS162	2.25	74LS260	.55

SCHOTTKY TTL

74S00	.44	74S32	.80	74S113	1.60	74S174	3.30
74S01	.76	74S40	.65	74S114	1.20	74S175	2.90
74S02	.60	74S50	.76	74S133	.80	74S181	6.00
74S03	.75	74S51	.80	74S138	2.20	74S189	4.40
74S04	.55	74S60	.80	74S139	2.20	74S194	3.30
74S05	.76	74S64	.80	74S140	.80	74S195	3.30
74S08	.80	74S65	.80	74S151	2.20	74S251	2.20
74S09	.76	74S74	.90	74S153	3.40	74S253	2.40
74S10	.55	74S76	1.15	74S157	2.40	74S257	2.40
74S11	.65	74S78	1.16	74S158	2.00	74S258	2.40
74S15	.76	74S85	6.10	74S160	3.90	74S260	1.20
74S20	.65	74S86	2.50	74S161	4.70	74S280	5.70
74S21	.76	74S112	1.00	74S172	6.00	74S289	4.00
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LM301AH	.50	LM318M	2.40	LM715CD	4.60
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LM307M	1.50	LM340-12K	2.60	LM747CN	.90
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4008AE	1.79	1.65	4040AE	1.58	1.50	4077AE	.70	.69
4009AE	.59	.51	4041AE	1.82	1.75	4078AE	.38	.35
4010AE	.50	.49	4042AE	.78	.75	4081AE	.25	.23
4011AE	.24	.23	4043AE	.85	.80	4082AE	.34	.31
4012AE	.24	.22	4044AE	.80	.75	4095AE	2.00	1.99
4013AE	.45	.40	4047AE	2.75	2.70	4098AE	1.30	1.29
4014AE	1.45	1.34	4048AE	1.43	1.42	4099AE	2.90	2.89
4015AE	1.24	1.23	4049AE	.58	.53	4507AE	.60	.55
4016AE	.50	.49	4050AE	.58	.53	4508AE	2.20	2.19
4017AE	1.15	1.07	4051AE	1.49	1.48	4510AE	1.45	1.44
4018AE	1.24	1.23	4052AE	1.49	1.48	4514AE	5.00	4.99
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4020AE	1.45	1.34	4055AE	1.95	1.94	4516AE	1.75	1.74
4021AE	1.38	1.25	4056AE	1.99	1.98	4518AE	1.28	.98
4022AE	1.05	.99	4063AE	2.50	2.49	4529AE	1.28	.98
4023AE	.24	.22	4066AE	1.10	1.09	4528AE	1.59	1.45
4024AE	.88	.80	4068AE	.50	.49	4585AE	2.05	1.89
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7523N	1.75
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7525N	4.50

TWO-PHASE MOS CLOCK DRIVER
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DECODED READ/WRITE RAM
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1-24 2.40
25 up 2.30

BIPOLAR MEMORY

C3101	6.50
P3101	4.90
C3101A	7.30
P3101A	5.80
IM5501CDE	7.30
IM5501CPE	5.80
MM5560D	7.30
MM5560N	5.80
DM8599N	5.80
93403PC	5.80

1024-BIT N-Channel RAM

C2102	5.00
P-2102	2.85
C2102-1	5.00
P-2102-1	3.90
C2102-2	6.00
P-2102-2	3.00
P-2102A	8.00
P-2102A-2	9.50
P-2102A-4	6.00
2601-1	4.00
2601-21	11.40
2602B	3.80
2602-1B	4.40
2602-2B	4.00
MK4102P	11.40
7552-1CPE	6.00
7552-2CPE	6.00
TMS4033JL	9.00
TMS4033NL	4.20
TMS4034JL	9.00
TMS4034NL	4.20
TMS4035JL	9.00
TMS4035NL	4.20

MM

MM404H	12.00
MM405H	23.00
MM406H	6.50
MM407H	6.50
MM451H	11.40
MM454F	18.00
MM500H	2.00
MM506H	3.20
MM507H	3.20
MM550H	5.90
MM551H	5.60
MM558H	5.60

MOS-LSI

1402AN	3.80
1403AH	4.00
1403AN	3.80
1404AH	4.50
1404AN	2.90
1405A	4.00
1406	8.40
1407	8.40
1506	3.00
1507	3.00
1602	33.00
P2101	5.00
P2101-1	5.50
P2101-2	4.90
P2111	5.80
P2111-1	6.00
P2111-2	5.90
P2112	5.00
P2112-2	5.90
P2401	9.90
P2405	9.70
2505K	3.30
2512K	4.00
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2525V	3.50
2533V	7.90
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2804PC	4.00
2807PC	2.70
2808PC	4.00
TMS3114J	9.40
TMS3120JC	7.00
TMS3120NC	6.00
TMS3133NC	7.50
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3341APC	7.00
3347DC	5.80
3347PC	4.60
4102	4.95
7552	4.95
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7552-2	5.50
MM4055D	12.00
MM4056H	9.70
MM4057D	13.00
MM5025N	20.00
MM5026N	20.00
MM5027N	20.00
MM5055N	5.50
MM5056N	5.50
MM5057N	5.50
MM5058N	5.50

IC SOCKETS

SOLDER-TIN DIP

PIN	1-24	25	100
8	.21	.19	.17
14	.25	.22	.20
16	.28	.25	.23
24	.67	.61	.55
28	.88	.80	.72
36	1.09	.98	.89
40	1.24	1.12	.92

WIRE-WRAP GOLD

PIN	1-24	25	100
14	.45	.41	.37
16	.54	.49	.44

SOLDER - GOLD

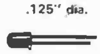
14	.34	.31	.28
16	.37	.34	.31

TEFLON TO-5

3 PIN	.55 EA
4 PIN	.65 EA
6 PIN	.90 EA
8 PIN	1.10 EA
10 PIN	1.40 EA

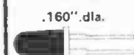
LEDs

.125" dia.



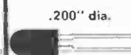
209	RED	$.25
209	YELLOW	.35
209	GREEN	.35

.160" dia.



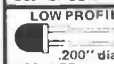
216	RED	$.25
216	YELLOW	.30
216	GREEN	.30

.200" dia.



220	RED	$.25
220	YELLOW	.30
220	GREEN	.30

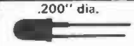
LOW PROFILE



.200" dia.

226	RED	$.25
226	YELLOW	.30
226	GREEN	.30
226	ORANGE	.30

.200" dia.



5053	RED	$.35
5053	YELLOW	.40
5053	GREEN	.40
5053	ORANGE	.40

MV50 RED $.30

216 = MV5024
5053 = MV5053

DISPLAYS

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SLA11	GREEN	3.50	XAN52	GREEN	2.00

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DL81	RED	6.00	DL402	RED	4.00
DL10	RED	6.00	DL701	RED	3.40
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DL33	RED	4.00	DL747 RED	2.50	2.40

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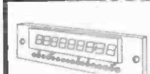

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COM2017H	25.00	20.00
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COM5016	12.00	9.60
KR2376-ST	20.00	17.50
KR3600-ST	20.00	17.50
NMX5010	12.00	9.60
CAL1022	60.00	52.00

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TAA611812	6-15	1.15	8	1.60
TAA621A12	6-27	1.40	8	2.00
TAA641811	6-18	2.20	4	3.00
TBA800	5-30	4.70	8	2.20
TBA810AS	4-20	2.50	4	3.00
TBA820	3-16	0.75	4	1.70
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TCA940	6-24	6.50	8	4.40

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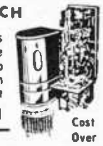

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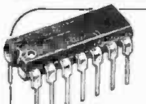

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7403	.21	7476	.32	74177	.79	4007	.23	4082	.23
7404	.21	7480	.70	74180	.70	4008	.79	4502	.79
7405	.21	7482	.70	74181	2.15	4009	.44	4510	1.14
7406	.25	7483	.70	74182	.79	4010	.44	4511	1.05
7407	.25	7485	.89	74184	2.19	4011	.23	4514	2.80
7408	.21	7486	.28	74185	2.19	4012	.23	4515	2.80
7409	.21	7489	2.19	74188	3.50	4013	.40	4516	1.23
7410	.21	7490	.44	74189	3.50	4014	.96	4518	1.14
7411	.21	7491	.70	74190	1.23	4015	.96	4520	1.14
7412	.21	7492	.44	74191	1.23	4016	.40	4527	1.68
7413	.25	7493	.44	74192	.88	4017	1.05	4528	.88
7414	.89	7494	.70	74193	.88	4018	1.05	4585	1.23
7416	.25	7495	.70	74194	.88	4019	.23	LM309K	1.80
7417	.25	7496	.70	74195	.88	4020	1.14	LM324N	1.28
7420	.21	74100	1.28	74196	.88	4021	1.14	LM340T-5	1.25
7421	.25	74107	.30	74197	.88	4022	.96	LM340T-6	1.25
7423	.35	74109	.33	74198	1.49	4023	.23	LM340T-8	1.25
7425	.35	74121	.35	74199	1.49	4024	.84	LM340T-12	1.25
7426	.25	74122	.44	74251	1.09	4025	.23	LM340T-15	1.25
7427	.33	74123	.61	74279	.58	4026	1.68	LM340T-18	1.25
7428	.28	74125	.40	74365	.67	4027	.40	LM340T-24	1.25
7430	.21	74126	.40	74366	.67	4028	.89	LM3900N	.88
7432	.25	74132	.70	74367	.67	4029	1.14	NE536T	3.24
7433	.30	74141	.88	74368	.67	4030	.23	NE540L	2.04
7437	.25	74145	.70	75150	1.31	4033	1.51	NE555V	.48
7438	.25	74147	1.63	75450	.88	4034	3.50	NE556A	.88
7440	.21	74148	1.30	75451	.61	4035	1.14	NE560B	3.83
7441	.88	74150	1.16	75452	.61	4040	1.14	NE561B	3.83
7442	.53	74151	.70	75453	.61	4041	.79	NE562B	3.83
7443	.63	74153	.65	75454	.61	4042	.79	NE565A	1.25
7444	.63	74154	1.03	75491	.81	4043	.70	NE566V	1.28
7445	.70	74155	.70	75492	.84	4044	.70	NE567V	1.36
7446	.70	74156	.70	75493	1.09	4046	1.86	uA709CV	.44
7447	.70	74157	.70	75494	1.19	4049	.40	uA710CA	.44
7448	.70	74160	.88	8093	.40	4050	.40	uA711CA	.53
7450	.21	74161	.88	8094	.40	4051	1.26	uA723CA	.60
7453	.21	74162	.88	8095	.67	4052	1.26	uA741CV	.44
7454	.21	74163	.88	8096	.67	4053	.72	uA747CA	.70
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7470	.30	74166	1.26	8098	.67	4066	.79	MC1458V	.53
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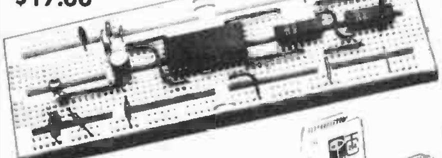

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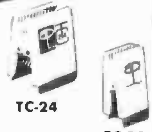

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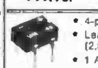

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XAN74	RED	C.C.	XAN674	RED	C.C.
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2.2uf/50v	.08	.65/10	2.2uf/50v	.12	.90/10	100uf/16v	.17	1.30/10
3.3uf/50v	.08	.65/10	3.3uf/35v	.12	.95/10	100uf/25v	.20	1.55/10
4.7uf/25v	.08	.65/10	3.3uf/50v	.12	1.00/10	100uf/50v	.29	2.30/10
4.7uf/50v	.08	.70/10	4.7uf/25v	.11	.90/10	220uf/16v	.20	1.55/10
10uf/25v	.08	.65/10	4.7uf/35v	.12	.95/10	220uf/25v	.29	2.35/10
10uf/50v	.10	.75/10	10uf/16v	.11	.90/10	330uf/16v	.29	2.35/10
22uf/25v	.09	.70/10	10uf/25v	.12	1.00/10	330uf/25v	.32	2.55/10
22uf/50v	.12	1.00/10	10uf/50v	.14	1.15.10	470uf/16v	.32	2.55/10
100uf/6.3v	.09	.75/10	22uf/16v	.12	1.00/10	470uf/25v	.37	3.00/10
100uf/16v	.11	.85/10	22uf/25v	.13	1.05/10	1000uf/16v	.39	3.15/10
100uf/25v	.13	1.10/10	33uf/16v	.12	1.00.10	1000uf/25v	.56	4.50/10
			33uf/25v	.14	1.15/10	2200uf/16v	.62	4.95/10
			47uf/16v	.14	1.15/10			

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100pf/500v	.04	.36/10
220pf/500v	.04	.36/10
470pf/500v	.04	.36/10
1000pf/500v	.04	.37/10
2200pf/500v	.04	.37/10
4700pf/500v	.04	.32/10
.01ufd/500v	.06	.50/10
.01ufd/50v	.03	.24/10
.022ufd/25v	.03	.28/10
.047ufd/25v	.05	.42/10
.1ufd/25v	.08	.62/10

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1N5227B	3.6v	.15	$11/C	1N5237B	8.2v	.15	$11/C
1N5228B	3.9v	.15	$11/C	1N5238B	8.7v	.15	$11/C
1N5229B	4.3v	.15	$11/C	1N5239B	9.1v	.15	$11/C
1N5230B	4.7v	.15	$11/C	1N5240B	10v	.15	$11/C
1N5231B	5.1v	.15	$11/C	1N5241B	11v	.15	$11/C
1N5232B	5.6v	.15	$11/C	1N5242B	12v	.15	$11/C
1N5233B	6.0v	.15	$11/C	1N5243B	13v	.15	$11/C
1N5234B	6.2v	.15	$11/C	1N5244B	14v	.15	$11/C
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14 Pin Solder Tab	.20
16 Pin Solder Tab	.22
18 Pin Solder Tab	.29
24 Pin Solder Tab	.38
28 Pin Solder Tab	.45
40 Pin Solder Tab	.63
8 Pin Wire-Wrap	.24
14 Pin Wire-Wrap	.26
16 Pin Wire-Wrap	.30
18 Pin Wire-Wrap	.60
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8-32 3/8 Screw	.90/C	5.85/M
2-56 Hex Nut	.55/C	3.60/M
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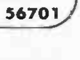

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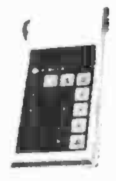

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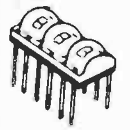

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7808-16c	7475-65c	74161-99c
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7413-49c	7483-85c	74164-1.89
7420-16c	7490-69c	74165-1.49
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7437-39c	7495-75c	74181-2.75
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CD4012 24	CD4023 24	CD4040 . . .1.59	74C107 . . . .1.29
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75492 Hex digit dr. - 39c

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Silver plated copper circuit board 3-3/16" x 5-1/16". 2 rows of 27 holes for DIP IC's • space for transistors, resistors & capacitors. Versatile and simple for breadboarding IC circuitry $1.50 ea.
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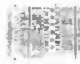

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4 Large Digits • AM-PM. Complete kit includes TMS 3834 chip — green flourescent panel with .5" digits — PC board — alarm speaker — all necessary components — case — schematic and instructions.
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Jumbo red dome .15

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7425	$.13	7473	$.17	74121	$.21
7430	.10	7475	.28	74123	.42
7441	.49	7483	.39	74151	.39
7442	.38	7490	.29	74153	.49
7446	.46	7495	.39	74180	.45
7447	.44	7496	.39	74193	.60
7448	.52	74107	.20		

MARKED — NO FACTORY LOGO GUARANTEED FUNCTIONAL

7400	$.07	7420	.08	7460	.08
7402	.07	7437	.17	7474	.17
7403	.08	7440	.08	7493	.30
7404	.09	7445	.44	7496	.39
7406	.17	7450	.08	74195	.44
7408	.09	7453	.08		
7410	.08	7454	.08		

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74S20	.38
74S22	.38
74S32	.52
74S74	.38

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74LS04	.36
74LS08	.38
74LS10	.36
74LS20	.36
74LS32	.38
74LS40	.45
74LS42	1.40
74LS74	.59
74LS90	1.30
74LS93	1.30
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74LS107	.59
74LS164	2.20
74LS193	2.50
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INCLUDES:
MM314 clock circuit
6 FND70 LED displays (.250" red 7 segment)
All necessary transistors, resistors & capacitors
1 double sided PC board accommodates LED's & clock circuitry
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2513	64 x 8 x 5 character generator	$11.00
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2.2 mfd	35V	.30 ea.	33 mfd	10V	40 ea.
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7525	Dual core mem. sense AMPL DIP	.98
MC1310	FM stereo demodulator DIP	1.95
CA3046	Transistor array 14 pin DIP	.89

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		7492	.71
7400	$ .14	7493	.60
7401	.16	7494	.94
7402	.15	7495	.79
7403	.16	7496	.79
7404	.19	74100	1.30
7405	.19	74105	.44
7406	.35	74107	.40
7407	.35	74121	.42
7408	.18	74122	.45
7409	.19	74123	.85
7410	.16	74125	.54
7411	.25	74126	.63
7413	.55	74141	1.04
7416	.35	74145	1.04
7417	.35	74150	.97
7420	.16	74151	.79
7422	.26	74153	.99
7423	.29	74154	1.25
7425	.27	74155	1.07
7426	.26	74156	1.07
7427	.29	74157	.99
7430	.20	74158	1.79
7432	.23	74160	1.39
7437	.35	74161	1.25
7438	.35	74162	1.49
7440	.17	74163	1.39
7441	.98	74164	1.59
7442	.77	74165	1.59
7443	.87	74166	1.49
7444	.87	74170	2.30
7445	.89	74173	1.49
7446	.93	74174	1.62
7447	.89	74175	1.39
7448	1.04	74176	.89
7450	.17	74177	.84
7451	.17	74180	.90
7453	.17	74181	2.98
7454	.17	74182	.79
7460	.17	74184	2.29
7464	.35	74185	2.29
7465	.35	74187	5.95
7470	.30	74190	1.35
7472	.30	74191	1.35
7473	.35	74192	1.25
7474	.35	74193	1.19
7475	.57	74194	1.25
7476	.39	74195	.89
7483	.79	74196	1.25
7485	1.10	74197	.89
7486	.40	74198	1.79
7489	2.48	74199	1.79
7490	.59	74200	5.90

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307	Op AMP (super 741)	mDIP	.26
308	Micro Pwr Op Amp	mDIP	.89
309K	5V 1A regulator	TO-3	1.35
310	V Follower Op Amp	mDIP	1.07
311	Hi perf V Comp	mDIP	.95
319	Hi Speed Dual Comp	DIP	1.13
320T	Neg Reg 5, 12, 15, TO-3		$1.39
320K	Neg Reg 5.2, 12 TO-3		1.39
324	Quad Op Amp	DIP	1.52
339	Quad Comparator	DIP	1.58
340K	Pos. V reg. (5V, 6V, 8V, 12V, 15V, 18V, 24V)	TO-3	1.69
340T	Pos. V reg. (5V, 6V, 8V, 12V, 15V, 18V, 24V)	TO-220	1.49
370	AGC/Squelch AMPL	DIP	.71
372	AF-IF Strip detector	DIP	2.93
376	Pos. V. Reg	mDIP	2.42
380	2w Audio Amp	DIP	1.13
380-8	.6w Audio Amp	mDIP	1.52
381	Lo Noise Dual preamp	DIP	1.52
550	Prec V Reg	DIP	.89
555	Timer	mDIP	.89
556A	Dual 555 Timer	DIP	1.49
560	Phase Locked Loop	DIP	2.48
562	Phase Locked Loop	DIP	2.48
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739	Dual Hi.Perf Op Amp	DIP	1.07
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1304	FM Mulpx Stereo Demod	DIP	1.07
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1458	Dual Comp Op Amp	mDIP	.62
1800	Stereo multiplexer	DIP	2.48
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8038	V contr. osc	DIP	4.95
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75150	Dual Line Driver	DIP	1.95
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75452	Dual Peripheral Driver	mDIP	.35
75453	(351) Dual Periph. Driver	mDIP	.35
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75492	Hex Digit Driver	DIP	.80

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1101	256 bit RAM MOS	$ 1.50
1103	1024 bit RAM MOS	3.95
2102	1024 bit static RAM	5.55
5203	2048 bit UV eras PROM	17.95
5260	1024 bit RAM	2.49
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7489	64 bit ROM TTL	2.48
8223	Programmable ROM	3.69
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5005	12 DIG 4 funct w/mem	4.95
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MM5736	18 pin 6 DIG 4 funct	4.45
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MM5311	28 pin BCD 6 dig mux	4.45
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LED'S

MV10B	Red TO 18	$ .22
MV50	Axial leads	.18
MV5020	Jumbo Vis. Red (Red Dome)	.22
	Jumbo Vis. Red (Clear Dome)	.22
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		4015A	1.49	4049A	.59
		4016A	.56	4050A	.59
4000A	$ .26	4017A	1.19	4066A	.89
4001A	.25	4020A	1.49	4068A	.44
4002A	.25	4021A	1.39	4069A	.44
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4007A	.26	4023A	.25	4072A	.35
4008A	1.79	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
4010A	.54	4027A	.59	4078A	.39
4011A	.29	4028A	.98	4081A	.26
4012A	.25	4030A	.44	4082A	.35
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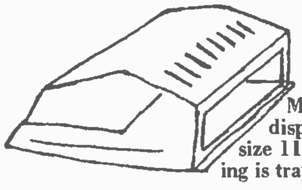

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2SC482	1.75	2SC773	.85	2SC013	1.50	2SC475	1.50	40082	3.00
2SC495	1.10	2SC774	1.75	2SC1014	1.50	2SC1678	5.50	2SC608	4.85
2SC502	3.75	2SC775	2.75	2SC1017	1.50	2SC1679	4.75	SK3046	2.15
2SC517	4.75	2SC776	3.00	2SC1018	1.50	2SC1728	2.15	SK3047	3.75
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2SC699	4.75	2SC781	3.00	2SC1243	1.50	2SF8	3.00	2SK19	1.75
2SC710	.70	2SC789	1.00	2SC1306	4.75	HEP-S3001	3.25	2SK30	1.00
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2SC756	3.00	2SC802	3.75	2SC1307-1	6.00	4004	3.00	3SK40	2.75
2SC765	9.50	2SC803	4.00	2SC1377	5.50	4005	3.00	3SK45	2.75
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2SA316	.75	2SB235	1.75	2SC460	.70	2SC828	.75	2SC1756	1.25
2SA473	.75	2SB303	.65	2SC478	.80	2SC829	.75		
2SA483	1.95	2SB324	1.00	2SC491	2.50	2SC830	1.60	2SD30	.95
2SA489	.80	2SB337	2.10	2SC497	1.60	2SC839	.85	2SD45	2.00
2SA490	.70	2SB367	1.60	2SC515	.80	2SC945	.65	2SD65	.75
2SA505	.70	2SB370	.65	2SC535	.75	2SC1010	.80	2SD68	.90
2SA564	.50	2SB405	.85	2SC536	.65	2SC1012	.80	2SD72	1.00
2SA628	.65	2SB407	1.65	2SC537	.70	2SC1051	2.50	2SD88	1.50
2SA643	.85	2SB415	.85	2SC563	2.50	2SC1061	1.65	2SD151	2.25
2SA647	2.75	2SB461	1.25	2SC605	1.00	2SC1079	3.75	2SD170	2.00
2SA673	.85	2SB463	1.65	2SC620	.80	2SC1096	1.20	2SD180	2.75
2SA679	3.75	2SB471	1.75	2SC627	1.75	2SC1098	1.15	2SD201	1.95
2SA682	.85	2SB474	1.50	2SC642	3.50	2SC1115	2.75	2SD218	4.75
2SA699	1.30	2SB476	1.25	2SC643	3.75	2SC1166	.70	2SD300	2.50
2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
2SA705	.55	2SB492	1.25	2SC681	2.50	2SC1172B	4.25	2SD315	.75
2SA815	.85	2SB495	.95	2SC684	2.10	2SC1209	.55	2SD318	.95
2SA816	.85	2SB507	.90	2SC687	2.50	2SC1213	.75	2SD341	.95
		2SB511	.70	2SC696	2.35	2SC1226	1.25	2SD350	3.25
2SB22	.65			2SC712	.70	2SC1243	1.50	2SD352	.80
2SB54	.70	2SC206	1.00	2SC713	.70	2SC1293	.85	2SD380	5.70
2SB56	.70	2SC240	1.10	2SC732	.70	2SC1308	4.75	2SD389	.90
2SB77	.70	2SC261	.65	2SC733	.70	2SC1347	.80	2SD-390	.75
2SB128	2.25	2SC291	.65	2SC739	.70	2SC1383	.75	2SD437	5.50
2SB135	.95	2SC320	2.00	2SC715	1.75	2SC1409	1.25		
2SB152	4.50	2SC352	.75	2SC762	1.90	2SC1410	1.25	C106B1	.50
2SB173	.55	2SC353	.75	2SC783	1.00	2SC1447	1.25		
2SB175	.55	2SC371	.70	2SC784	.70	2SC1448	1.25		
2SB178	1.00	2SC372	.70	2SC785	1.00	2SC1507	1.25		
2SB186	.60	2SC394	.70	2SC793	2.50	2SC1509	1.25		

POWER-TRANSISTORS HIGH-VOLT. TV. TYPE

BU204	1300V	3.90	BU207	1300V	5.40	2SC1172B	1100V	4.25
BU205	1500V	4.70	BU208	1500V	6.25	2SC308	1100V	4.95
BU206	1700V	5.90	2SC1170	1100V	4.00	2SC1325	1100V	4.95

OEM SPECIALS

1N270	.10	2N960	.55	2N2219A	.30	2N2913	.75	2N3740	1.00	2N4401	.20
1N914	.10	2N962	.40	2N2221	.25	2N2914	1.20	2N3771	1.75	2N4402	.20
		2N967	.50	2N2221A	.30	2N2916A	3.65	2N3732	1.90	2N4403	.20
2N173	1.75	2N1136	1.35	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.20
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25
2N327A	1.15	2N1302	.25	2N2270	.40	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1305	.30	2N2322	1.00	2N3055	.75	2N3856	.20	2N4441	.85
2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90
2N338A	1.05	2N1420	.20	2N2324	1.35	2N3247	3.40	2N3903	.20	2N4443	1.20
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.50	2N3904	.20	2N4852	.55
2N404	.30	2N1540	.90	2N2326	2.85	2N3375	6.50	2N3905	.20	2N5061	.30
2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.20	2N3906	.25	2N5064	.50
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75
2N652A	.85	2N1554	1.25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5294	.50
2N677C	6.00	2N557	.15	2N2712	.18	2N3442	1.85	2N3958	1.20	2N5296	.50
2N706	.25	2N1560	2.80	2N2894	.40	2N3553	1.50	2N4037	.60	2N5306	.20
2N706B	.40	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5354	.20
2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	2N5401	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.15	2N4142	.20	2N5457	.35
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.15	2N4143	.20	C103Y	.25
2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45	C103D	.40
2N930	.25	2N2218A	.30	2N2907	.25	2N3730	1.50	2N4234	.95	C106B1	.50
2N956	.30	2N2219	.25	2N2907A	.30	2N3731	2.75	2N4400	.20	C106D1	.75

SILICON UNIJUNCTIONS

2N2646	.50	2N2160	.65
2N2647	.60	2N4870	.50
2N6027	.55	2N4871	.50
2N6028	.70	2N4891	.50
D5E37	.25	2N4892	.50
		2N4893	.50
		2N4894	.50
		MU10	.40

INTEGRATED CIRC.

UA703C	.40
709C OP. AMP.	.25
741C OP. AMP.	.25
7400	.15
7404N	.18
7430N	.19
74L00J	.35
74H55N	.35

RECTIFIERS

	10	100
IN4001	.60	5.00
IN4002	.70	6.00
IN4003	.80	7.00
IN4004	.90	8.00
IN4005	1.00	9.00
IN4006	1.10	10.00
IN4007	1.20	11.00

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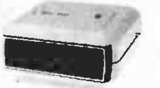
CIRCLE NO. 36 ON FREE INFORMATION CARD

CRYSTALS

Part #	Frequency	Case Style	Price
CY1A	1.000 MHz	HC33/U	$4.95
CY2A	2.000 MHz	HC33/U	$4.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

— AVAILABLE IN THESE FREQUENCIES ONLY —

CLOCK CASES

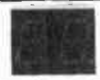


Nicely styled cases complete with red bezel for use in such applications as desk clocks, car clocks, alarm clocks, instrument cases.
DIMENSIONS: W-4", L-4½", H-2"
$5.95

SEMICONDUCTOR SUPER SPECIALS

2N2222	Low Power 2N2222A	7/$1.00
MJ3055	Same as T03 2N3055 but with solder lugs on leads	.59
1N4308	Fast 1N4148 Si Switch	20/$1.00
MCT2E	Si NPN Photo Trans./Opto Isolator	2.95
MV5025	.4 MCD, 20 mA LED with Mounting	.79
MV5377	Low Profile Yellow LED	3/$1.00
XC526R	RED .185" dia. LED	7/$1.00

DL728



The DL728 is a dual 0.5" common cathode red display. It is ideal for use with clock chips, as segments are already multiplexed. **$2.95**

CALCULATOR CHIPS AND DRIVERS

MM5725	8 DIGIT 4 FUNCTION	$1.98
DM75491	SEGMENT DRIVER	.79
MM5736	6 DIGIT 4 FUNCTION	1.95
DM75492	DRIVER FOR 5736	.89
MM5738	8 DIGIT 5 FUNCTION	2.95
DM8864	DRIVER TYPE 1	2.00
DM8865	DRIVER TYPE 2	1.00

CLOCK CHIPS

MM5311	6 DIGIT W/BCD	$4.95
MM5312	4 DIGIT W/BCD	4.95
MM5313	6 DIGIT W/BCD	4.95
MM5314	6 DIGIT CLOCK	3.95
MM5316	ALARM CLOCK	4.95
CT7001	CAL/CLOCK CHIP	5.95

DIGITAL WATCH READOUT

FOR USE WITH WATCHES, DVMS, COUNTERS, ETC. $1.95

HP-5082-7300

HP 5082-7300
.3" Dot Matrix type numeric readouts with decoder/driver/latch built on the chip. Only 8 pins (BCD in, DP Latch, +5v, ground).
HP 5082 7300 **$5.95**

HP 5032 7304 +1 version of 7300 **4.95**

1¼" x 1½" XFMERS — P.C. Mount

That were designed for clock type applications. 110 Vac primary @ 60 Hz.
Secondaries: 8-10 Vac @ 30 mA-50 mA
50 Vac @ 30 mA-50 mA
Excellent for miniature power supplies & gas discharge displays

SPECIAL $.79

1/16 VECTOR BOARD

0.1" Hole Spacing P-Pattern

	Part No.	Length	Width	Price 1-19	Price 20-49
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord®. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire. **$9.50 ea.**

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	(Green)	$2.40
W36-3-B-Pkg. 3	(Red)	$2.40
W36-3-C-Pkg. 3	(Clear)	$2.40
W36-3-D-Pkg. 3	(Blue)	$2.40

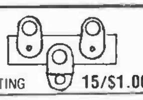
9V BATTERY CLIP

STANDARD CLIP FOR USE WITH 9V TRANSISTOR BATTERIES WITH 4" LEADS

9/.99

TERMINAL STRIPS

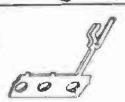
THREE TERMINAL STRIPS, WITH CENTER TERMINAL USED FOR MOUNTING



15/$1.00

AMP TERMINAL PINS

TERMINAL PINS FOR MOUNTING COMPONENTS ALSO PERFECT FOR USE WITH BOARD CONNECTORS AND SUBASSEMBLIES



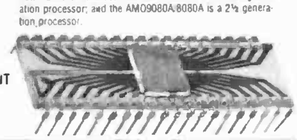
$1.00/100 PCS.

MICROPROCESSOR COMPONENTS

CENTRAL PROCESSOR UNITS

Each processor feature 2μs instruction cycles and are brand new from the manufacturer. The TMS8080 is and 2nd generation processor; and the AMD9080A/8080A is a 2½ generation processor.

T.I 8080 $29.95
DIRECT REPLACEMENT FOR INTEL C8080

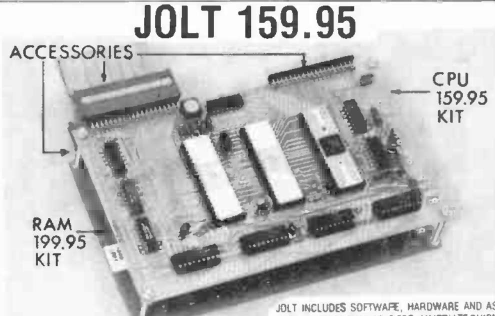


AMD 8080A $39.95
DIRECT REPLACEMENT FOR INTEL C8080A

CPU'S		
8008	8 Bit CPU	$19.95
8080	Super 8008	$29.95
8080A	Super 8008A	$39.95
SR'S		
2504	1024 DYNAMIC	$9.00
2518	HEX 32 BIT	7.00
2519	HEX 40 BIT	4.00
2524	512 DYNAMIC	2.95
2525	1024 DYNAMIC	6.00
2527	DUAL 256 BIT	3.95
2529	DUAL 512 BIT	4.00
2532	QUAD 80 BIT	3.95
2533	1024 STATIC	7.95
3341	FIFO	6.95
74LS670	16X4 REG.	3.95
UART'S		
AY-5-1013	20K BAUD	$4.95
ROM'S		
2513	CHAR. GEN.	11.00
7488	RANDOM BITS	3.50

RAM'S			
1101	256X1	STATIC	$2.25
1103	1024X1	DYNAMIC	2.95
2101	256X1	STATIC	6.95
2102	1024X1	STATIC	2.49
2107	4096X1	DYNAMIC	19.95
2111	256X4	STATIC	7.95
7010	1024X1	MNOS	29.95
7489	16X4	STATIC	2.49
8101	256X4	STATIC	7.95
8111	256X4	STATIC	7.95
8599	16X4	STATIC	3.49
91L02	1024X1	STATIC	2.75
74200	256X1	STATIC	6.95
93410	256X1	STATIC	1.75
5262	2048X1	DYNAMIC	2.95
PROMS			
1702A	2048	FAMOS	15.95
5203	2048	FAMOS	14.95
8223	32X8	BIPOLAR	3.00
74S287	1024	STATIC	7.95

JOLT 159.95



The JOLT system consists of a set of modular microcomputer boards which can be used singly or tied together to produce any desired microcomputer system configuration. The minimum system is one CPU board, which alone constitutes a viable computer system complete with central processor, I/O, interrupts, timer, read-write memory, and a complete software debug monitor in read-only-memory.

JOLT INCLUDES SOFTWARE, HARDWARE AND ASSEMBLY MANUALS. AVAILABLE FOR IMMEDIATE SHIPMENT. $159.95 in kit form . . . $249 assembled.

JOLT SYSTEM DESCRIPTION

JOLT RAM Card — Fully static 4,096 bytes of RAM with 1 microsecond access time and on-board decoding. Hardware and assembly manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $199.95 kit . . . $285 assembled.

JOLT Power Supply — Operates at +5, +12 and −10 voltages. Supports JOLT CPU, 4k bytes of RAM and JOLT I/O card — or, CPU and 8 I/O cards. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $99.95 kit, $145 assembled.

JOLT Accessory Bag — Contains enough hardware to connect one JOLT card to another. Such necessary items as flat cable, connectors, cord spaces, hardware, etc. AVAILABLE FOR IMMEDIATE SHIPMENT. $39.95.

JOLT I/O Card (Peripheral Interface Adapter) — 2 PIA LSI chips, 32 I/O lines, four interrupt lines, on-board decoding and standard TTL drive. Fully programmable. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $95.50 kit . . . $140 assembled.

JOLT Universal Card — Same size (4¼" x 7"), same form factor as other JOLT cards. Completely blank, drilled to accept 14, 16, 24 or 40 pin sockets. Used for additional user memory or I/O control panels, TV interfaces, keyboards, LEDs, or other interface logic. AVAILABLE FOR IMMEDIATE SHIPMENT. $24.95

JOLT +5V Booster Option — Fits onto JOLT Power Supply card. Supports CPU, 16k bytes of RAM — or, CPU and 8k bytes RAM and 8 I/O cards — or, CPU and 4k bytes RAM and 16 I/O cards. Manuals included. AVAILABLE FOR IMMEDIATE SHIPMENT. $24.95

64 KEY BOARD

There high quality keyboards, which were originally made by a large computer manufacturer. Each keyboard has 64 keys, which are brought out on unencoded pins. They utilize magnetic reed type switches, and are new in appearance. $29.95

HD0165 Keyboard Encoder ROM $7.95

WIRE WRAP WIRE

AWG	COLOR	25 FT. MIN.	50 FT.	100 FT.	1000 FT.
30 AWG	WHITE	$2.10	$2.75	$3.50	$24.00
30 AWG	YELLOW	2.10	2.75	3.50	24.00
30 AWG	RED	2.10	2.75	3.50	24.00
30 AWG	GREEN	2.10	2.75	3.50	24.00
30 AWG	BLUE	2.10	2.75	3.50	24.00
30 AWG	BLACK	2.10	2.75	3.50	24.00

RIBBON CABLE

Conductors	1-9ft/ft	10-24ft/ft	25-99ft/ft	100ft
10	.39	.29	25	23
20	59	.49	.45	43
30	.79	.69	.65	62
40	99	.89	.85	80
50	1.19	1.09	1.05	1.00

6' 2 CONDUCTOR POWER CORDS 125V @ 5A

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THREE CONDUCTOR POWER SUPPLY CORDS

NUMBER	LENGTH	AWG	O.D.	RATING	COLOR	PRICE
17236	6	18(41X34)	.265	1250W 10A-125V	BLACK	Special .79 ea.
17237	6	18(41X35)	.253	1250W 10A-125V	GREY	1.25
17238	8	18(41X34)	.265	1250W 10A-125V	BLACK	Special .99 ea
17239	8	18(41X34)	.253	1250W 10A-125V	GREY	1.30
17000	4	18(41X34)	.253	1250W 10A-125V	BLACK	.59

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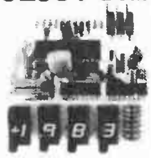
JE SERIES KITS

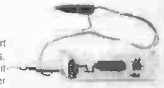
JE801 DVM



The JE801 is a three and one half digit, auto polarity digital voltmeter, in a kit form. It features several options not available in any commercial digital voltmeter. Its low cost is perhaps the most important feature, which is achieved by offering it in a kit form. A kit allows the unit to be used by small OEM's where cost effectiveness is an important factor, and by the hobbyist who has to be concerned with cost. The unit also features on card regulators, allowing it to be operated off a single plus and minus fifteen volt, unregulated power supply. The unit has a small size of three inches width, three and three quarters of an inch length, and one and a quarter inch height.

$39.95 Per Kit printed circuit board

JE803 PROBE



The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families. TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (H) - 1 (LOW) - o (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit printed circuit board

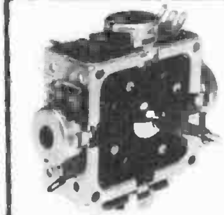
JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip. $19.95

12 or 24 Hour

115 VAC—
$19.95 per kit
$29.95 assembled

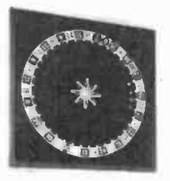
JOYSTICK



These joysticks feature four 100K potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

$9.95 ea

ELECTRONIC ROULETTE



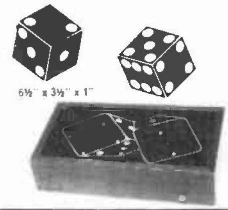
Complete kit with all components case and transformer

$29.95 Per Kit

115 VAC

Dimensions: 6½" x 6½" x 1½"

ELECTRONIC CRAPS



6½" x 3½" x 1"

Complete kit with all components case and transformer.

$19.95 Per Kit

Dimensions: 6½" x 3½" x 1½"

CONTINENTAL SPECIALTIES $15.95

PROTO BOARD 6

The PB-6 lets the user test and build circuits without soldering or patch cords, all interconnections between components are made with common #22 AWG hook-up wire. This quality breadboarding kit inludes 630 component tie points at less than 2.5c each. It measures 6" long by 4" wide. Designed specially to Breadboard Microprocessor Circuits. $15.95

PROTO BOARD 100

A low cost, big 10 IC capacity breadboard kit with all the quality of QT sockets and the best of the Proto Board series . . . complete down to the last nut, bolt and screw. Includes 2 QT-35S Sockets; 1 QT-35B Bus Strip; 2 5-way binding posts; 4 rubber feet, screws, nuts, bolts; and easy assembly instructions.
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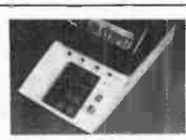

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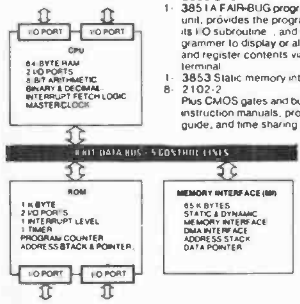

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600	.11	.30	.70	1.80
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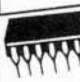

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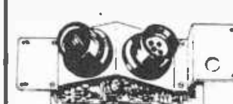

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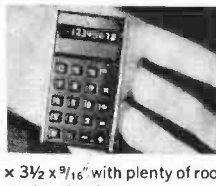

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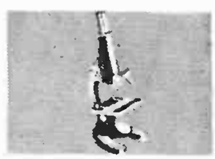

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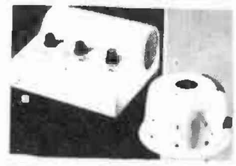

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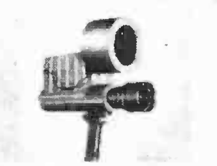

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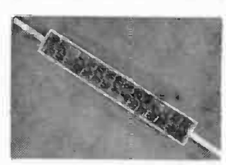

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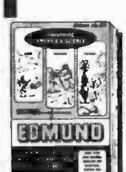

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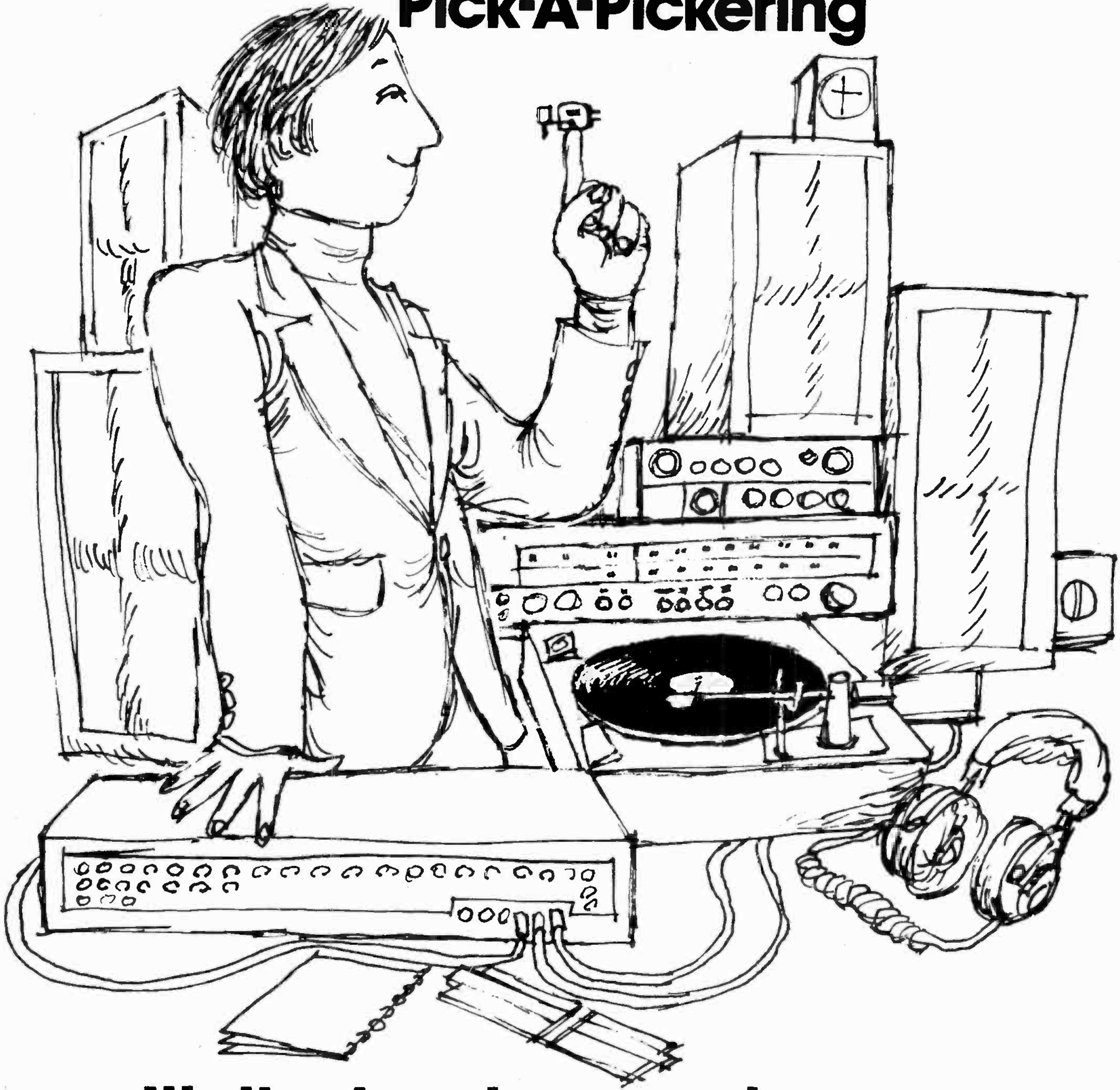

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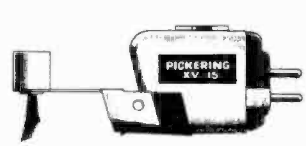

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The Dual 1249.

It will give you more reasons than ever to own a Dual.

For several years, independent surveys of component owners—audio experts, hifi editors, record reviewers, readers of the music/equipment magazines—have shown that more of them own Duals than any other turntable. This is quite a testimonial to Dual's quality performance, reliability and fully automatic convenience.

We believe the new 1249 will add even more serious music lovers to the roster of Dual owners, as it provides every feature, innovation and refinement long associated with Dual turntables plus some new ones. And all in a newly designed chassis that complements the superb design and meticulous engineering of the 1249.

The low-mass tubular tonearm pivots in a true four-point gyroscopic gimbal suspended within a rigid frame. All tonearm settings are easily made to the exacting requirements of the finest cartridges. The tonearm is vernier-adjustable for precise balance; tracking pressure is calibrated in tenths of a gram; anti-skating is separately calibrated for conical, elliptical and CD-4 styli.

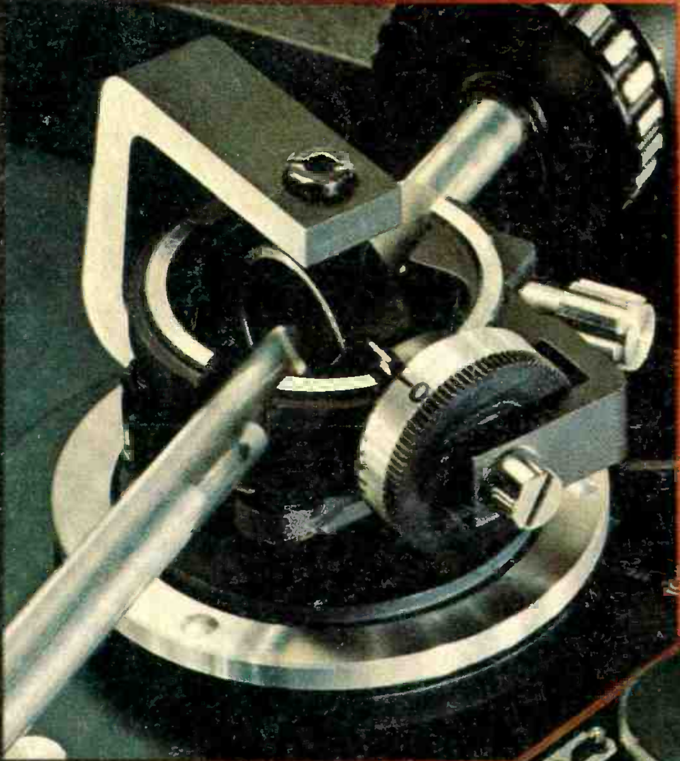
Tracking is flawless at pressures as low as a quarter of a gram. In single-play, the tonearm parallels the record to provide perfect vertical tracking. In multi-play, the Mode Selector lifts the entire tonearm to parallel the center of the stack.

All operations are completely flexible and convenient—and they are foolproof. The tonearm can be set on the record manually or by using the viscous-damped cue-control or by simply pressing the automatic switch. You also have the options of single-play, continuous-repeat, or multiple-play.

The dynamically-balanced cast platter and flywheel are driven by an 8-pole synchronous motor via a precision-ground belt. Pitch is variable over a 6% range and can be conveniently set to exact speed by means of an illuminated strobe, read directly off the rim of the platter.

Of course, if you already own a current Dual, you won't really *need* a new turntable for several years. However, we would understand if you now feel you must have nothing less than the new 1249. Less than $280, less base.

Still, we should advise you of two other models in our full-size, belt-drive series. The 601, single-play, fully automatic, less than $250. (CS601, with base and cover, less than $270.) The 510, single-play, semi-automatic, less than $200.



Tonearm of Dual 1249 pivots in four-point gyroscopic gimbal, suspended within a rigid frame. Each gimbal is hand-assembled, and special gauges assure that each will conform to Dual's stringent specifications.

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