# Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE APRIL 1975/75c

## HOW TO LISTEN TO OUT-OF-STATE AM BROADCASTS

## A LOW-COST COMPANDER FOR HI-FI

## CAREER GUIDE: FAA ELECTRONICS TECHNICIAN

## MINIVOLTER WITH 500μV FULL-SCALE

## LAB TEST REPORTS

Realistic STA-250 Stereo Receiver

Kensonic C-200 Stereo Preamplifier

Stanton 681EEE Stereo Phono Cartridge

Hy-Gain 623 AM/SSB CB Base Station

EL Instruments PG-2 Pulse Generator

PORTABLE

# Analog/Digital Memory Translator

PE TESTED

USE WITH ANY TAPE RECORDER

# At Pioneer, we listen.

Bobby Colomby of Blood, Sweat & Tears is a musician's musician. So when he told Pioneer what he was looking for in the way of features in a tape deck, we listened. And our engineers came up with the new RT-1020L stereo tape deck.

This 3-motor, 3-head unit has virtually every feature a professional like Bobby looks for, yet it's completely simple to use for home recording.

Take the pushbutton control system. It's solid state electronics with full logic. This means you can switch from Record to Fast Rewind, for instance, without using the Stop button. Bobby appreciates it because there's no clicking or popping noises. And it's completely jam-proof; it will never spill tape.

Bobby especially wanted long range record/playback capability. The RT-1020L provides 12 hours on a single 10½-inch reel.

"With so many types of tape on the market," said Bobby, "it's a drag when you have to look for one special tape. The RT-1020L plays every tape with optimum sound reproduction." (That's because it has a 3-step tape bias selector.)

And if you're recording from old records, the equalizer selector helps to revitalize their highs. The improved sound will amaze you.

The RT-1020L has the widest array of features ever built into a tape deck — 2 & 4-channel playback, pause control, sound-on-sound, mono mixing, plus much more. At nine hundred dollars it would be a great value. At $649.95, it's unbeatable.

Pioneer thanks Bobby. And so will you. At Pioneer, we listen.

U. S. Pioneer Electronics Corp.
75 Oxford Drive, Moonachie,
New Jersey 07074.
West: 13300 S. Estrella, Los Angeles,
Cal. 90248 / Midwest: 1500
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**PIONEER**
when you want something better


CIRCLE NO. 40 ON READER SERVICE CARD

# MITS

## BUILDING YOUR OWN COMPUTER WON'T BE A PIECE OF CAKE.

**(But, we'll make it a rewarding experience.)**

Chances are you won't be able to assemble the *Altair 8800 Computer* in an hour or two. But, that's only because the *Altair* is a real, full-blown computer. It's not a demonstration kit.

The *Altair Computer* is fast, powerful, and flexible. Its basic instruction cycle time is 2 microseconds. It can directly address 256 input and 256 output devices **and** up to 65,000 words of memory.

**Thanks to buss orientation** and wide selection of interface cards the *Altair 8800* requires almost no design changes to connect with most external devices. Up to 15 additional cards can be added inside the main case.

The *Altair Computer* kit is about as difficult to assemble as a desktop calculator. If you can handle a soldering iron and follow simple instructions, you can build a computer.

You see, at *MITS*, we want your experience with our kits to be rewarding. That's why we take such pains to write an accurate, straight-forward assembly manual. One that you follow step-by-step. (We leave nothing to the imagination.)

**Some electronic kit companies are experts** at cutting the corners. They promise you the sky and deliver a box full of surplus parts and a few pages of faded instructions run off on their copying machine.

We're experts at **not** cutting the corners. Our *Altair Computer* has been designed for both the hobby and the industrial market. It has to be constructed of the finest, quality parts. And it is.

That's why we give you double-sided boards, gold-plated connectors, a 10 Amp power supply (enough to power 15 additional cards), toggle switches and an all aluminum case complete with sub-panel and detachable dress panel.

That's why we give you three manuals (Assembly, Operator's and Trouble-shooting) in a hard-cover, 3 ring binder plus an Assembly Hints manual.

Buy our computer and we'll automatically make you a member of the *Altair User's Group*. You'll have access to a whole range of custom software designed exclusively for the *Altair 8800*.

**We're quite serious about making computer power available to you at a price you can afford.**

## BASIC ALTAIR AND OPTIONS

The basic *Altair 8800 Computer* includes the CPU, front panel control board, front panel lights and switches, power supply and expander board (with room for 3 extra cards) all enclosed in a handsome, aluminum case.

Options now available include 4K dynamic memory cards, 1K static memory cards, parallel I/O cards, three serial I/O cards (TTL, RS232, and TTY), octal to binary computer terminal, 32 character alpha-numeric display terminal, ASCII keyboard, audio tape interface, floppy disc system, and expander cards.

Software now available includes an assembler, text editor and system monitor.


## PRICE

Altair 8800 Computer: **$439.00 kit**
**$621.00 assembled**

## SAVE $45.00!

For P.E. readers only! The Basic *Altair 8800 Computer* plus 256 words of static memory. $542.00 value. Now, only $497.00. Check the appropriate box in the coupon below. *

Warranty: 90 days on parts and labor for assembled units
90 days on parts for kits
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**MITS/6328 Linn N.E., Albuquerque, N.M., 87108, 505/265-7553**

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CIRCLE NO. 27 ON READER SERVICE CARD

APRIL 1975 VOLUME 7, NUMBER 4

# Popular Electronics®

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE

## FEATURE ARTICLES



## CONSTRUCTION ARTICLES



## COLUMNS



## PRODUCT TEST REPORTS



## DEPARTMENTS



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Western Office
9025 Wilshire Boulevard, Beverly Hills, CA 90211
213 273-8050; BRadshaw 2-1161
Western Advertising Manager, BUD DEAN

Japan: James Yagi
Oji Palace Aoyama; 6-25, Minami Aoyama
6 Chome, Minato-Ku, Tokyo 407-1930/6821,
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# Editorial

## CHICAGO IN THE WINTER

During a jet flight home from the 1975 Winter Consumer Electronics Show in Chicago, I reflected on what I had seen and heard. This bi-annual major exhibit could, perhaps, be summed up: few new product introductions, domination by calculator manufacturers and a general economic outlook that's best described as hopeful.

A handful of new product entries caught my attention, some of which were prototypes that may never reach the marketplace. • Panasonic, for example, displayed a military-styled, portable FM/AM radio (Model RF-1300) with an integrated rhythm maker that features eight rhythms from waltz to rock; drums, cymbals, etc., combined with two microphone/guitar mixing inputs. • Toshiba revealed its $1800 ST-910 digital frequency synthesizer FM stereo tuner, which includes muting-level and signal-level indicators, seven memory stations and automatic/manual scanning. Of special interest to PE readers is the tuner's electronic component makeup—32 transistors, 9 FET's, 100 diodes, 96 IC's and 24 LED's. • A British manufacturer, Lecson, hoping to enter the hi-fi market here, introduced a novel (to look at) basic power amplifier that's encased in a heat-dissipating, fluted, die-cast cylinder. (Thought it was a high-intensity lamp base when I first saw it.) • Rhoades showed a TV audio tuner, a $169 unit that plugs into a stereo system's AUX input for better TV sound. • A new turntable—in a microwave oven—from Sharp attracted hungry onlookers. It revolves during the cooking cycle to assure even cooking.

A host of electronic digital clocks and watches were displayed, including large wall clocks. Outstanding were a thin (1½-inch) 10¼-inch square wall clock with a choice of red LED or orange gaseous displays from Infinity, and Ashley-Butler's clocks with LCD digits almost two inches high, housed in a variety of decorator cases. From ADD-A-Sound was an audio-frequency transmitter/portable speaker system that employs two different carriers for remote stereo use without running wires around the house. And Quantum displayed speaker systems expressly designed for four-channel use. Control panels on each speaker regulate sound projection path, with up to 20 settings possible. The FCC's office of Chief Engineer was represented at the Show, too, urging home entertainment manufacturers to incorporate protective measures in designs to avoid audio equipment pickup of radio signals. The EIA Consumer Electronics Group has already recognized the problem and describes some preventive methods in its November 1974 Engineering Bulletin No. 7, "Audio Rectification."

Hi-fi equipment was not heavily represented at the Show, which wasn't surprising since it's the Summer CES Show that traditionally serves as the big springboard for the new model introductions. It was at the 1971 SCES, in fact, that four-channel equipment was first introduced. With over 300 FM stations transmitting some form of 4-channel broadcast and nearly 700 quadraphonic discs available as software right now, plus advances in equipment design, the second half of 1975 is expected to show an upswing of public interest in the four-year-old four-channel format.

Hi-fi notwithstanding, the array of varied electronic equipment shown at WCES, which also included TV, auto radio, CB, and even a home video game at $299, proved that electronics continues to invade more and more avenues of our daily life.

Art Salsberg

# Letters

## STATUS OF PAY TV

Shel Kagan's "Pay TV Status Report" (December 1974) was well researched and well written. It represents a most impressive summary of the state of the art.

Incidentally, your readers might be interested to know that the Federal Communications Commission has adopted new regulations that will continue to hold back the full potential of pay TV. The FCC has not listened to the CATV industry's arguments for more than two years. Apparently, the only step remaining is for the public to express its opinions about marketplace development of pay TV to the FCC Commissioners and to the members of Congress.

GARY H. ARLEN
Public Information Manager
National Cable Television Association
Washington, D.C.

## NOD OF APPROVAL

Congratulations on the content of "Blazing Speakers" ("Stereo Scene," November 1974). The article is a clear, no-nonsense treatment of a subject that has been poorly handled in the past and about which serious misunderstandings have existed for a long time.

JIM LONG
Marketing Manager
Electro-Voice, Inc.
Buchanan, Mich.

## MINICOMPUTER MAKES MAXISPLASH

As a result of the Altair 8800 minicomputer article in the January issue, I have decided to subscribe to PE. Now, I'm looking forward to an article on building a CRT terminal and would like to see another article about using a cassette deck with the mini for additional memory.

DAVID WILSON
Highland Park, Mich.

The world's largest-selling electronics magazine has outdone even itself this time with simultaneously publishing construction plans for both the Altair 8800 minicomputer and "An Under-$90 Scientific Calculator" (January 1975).

LOUIS H. LENERT
Educational Technologies
Reynoldsburg, Ohio

Congratulations on being the first magazine to present a truly advanced minicomputer construction project. However, I must point out that the text contains several errors:

First, the price of the complete Altair 8800 will be about $760 when one adds the needed Intel 8080 IC to the basic $400 price. Secondly, the number of subroutines available could not possibly be 65,000 when there are only 65k words of memory. Third, a minicomputer cannot handle more than one program at a time. If a second program is to be executed, the current program must be interrupted. Fourth, the Intel 8008 chip is not "designed for use as a buffer." Finally, for anything more than very simple programs, an assembler is required for programming the computer.

In spite of the errors cited, I am very pleased that POPULAR ELECTRONICS has chosen a truly state-of-the-art minicomputer for a construction article.

ROBERT BROWN
Livonia, Mich.

*The cost of the entire kit (with 256 words) included the Intel 8080 IC. When the article was published, this price was $397. It is now $495 (as of March 1, 1975). (The supplier informs us that the increase was necessitated by production-model improvements such as increased power supply, synchronization, and edge-connection* boards. These improvements were included at the old price until March 1.) A basic processor without memory is also available for $439.

The maximum number of two-word subroutines is 32k. But subroutine nesting is almost unlimited; and is certainly more than sufficient, since how many times are you going to want to do more than a 10-level program? Although the computer cannot work two programs simultaneously (as you said), it works so fast that it appears to be doing so. The 8008 is described as a "communication processor," which is a fancy name for "buffer." It has, of course, been used as a CPU; but it is not a powerful one, exhibiting slow speed and interrupt handling problems, among other shortcomings. Finally, part two of the article (in the February 1975 issue) explained the need for an assembler during programming.*

The Altair 8800 computer project has really pleased me. It certainly beats some of the competition. But a minicomputer with only 256 steps is only a toy with lots of potential. How much will each memory block of 4k words cost?

EDWARD LORING TOTTLE
Baltimore, Md.

*Each kit of 4k memory costs $264. Before March 1, the price was $198.*

### THE CALCULATOR EXPLOSION

The "Under-$90 Scientific Calculator" in the January 1975 issue is outdated before anyone can even build it. Right now, assembled calculators with identical capability are being sold for $90. Your construction articles should be ahead of the pack if they are to be of any use to your readers. The timeliness of the Altair 8800 minicomputer is more like what I mean.

S. LIEBERMAN
Los Angeles, Calif.

*The material that appears in* POPULAR ELECTRONICS *must be planned several months in advance of its publication date. Ordinarily, the timeliness of our articles goes unaffected as a result of our keeping on top of the latest developments in electronics. On rare occasions, events occur so quickly (as they have in the calculator field in the last few months) that we are caught unawares. This is what happened with our calculator article. However, even when compared to competitively priced assembled calculators, ours is still a good buy, especially for those people who like to build their own electronic devices.*

### DIRECT CONVERSION

Many thanks for publishing construction plans for "A Direct-Conversion AM/SSB Project" (November 1974). I should have had a receiver like this a number of years ago when teaching amateur radio novices.

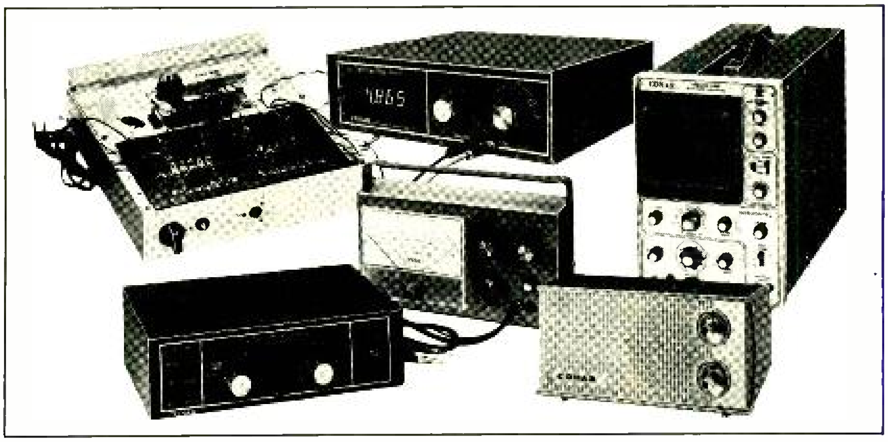
DAVID WELTY
Monterey, Calif.

# Where do the pros get their training?


**Almost half of the successful TV servicemen have home study training and with them, it's NRI 2 to 1.**

It's a fact! Among men actually making their living repairing TV and audio equipment, more have taken training from NRI than any other home study school. More than twice as many!

Not only that, but a national survey,* performed by an independent research organization, showed that the pros named NRI most often as a recommended school and as the first choice by far among those who had taken home study courses from *any* school. Why? Perhaps NRI's 60-year record with over a million students...the solid training and value built into every NRI course...and the designed-for-learning equipment originated by NRI provide the answer. But send for your free NRI catalog and decide for yourself.



### Two Famous Educators... NRI and McGraw-Hill.

NRI is a part of McGraw-Hill, world's largest publishers of educational material. Together, they give you the kind of training that's geared for success...practical know-how aimed at giving you a real shot at a better job or a business of your own. You learn at home at your convenience, with "bite-size" lessons that ease learning and speed comprehension. Kits designed to give you practical bench experience also become first-class professional instruments you'll use in your work.

**Summary of survey results upon request.*

### 25″ Diagonal Color TV... Professional Instruments

As a part of NRI's Master Course in TV/Audio servicing, you build a big-screen solid state color TV with every modern feature for great reception and performance. As you build it, you perform stage-by-stage experiments designed to give you actual bench experience while demonstrating the interaction of various stages of the circuitry. And your TV comes complete with console cabinet, an optional extra with other schools. Likewise, NRI's instruments are a cut above the average, including a 3½ digit precision digital multimeter, triggered sweep 5″ oscilloscope, and integrated circuit TV pattern generator. They're top professional quality, designed to give you years of reliable service. You can pay hundreds of dollars more for a similar course and not get a nickel's worth extra in training and equipment.

### Widest Choice of Courses and Careers.

NRI doesn't stop with just one course in TV/Audio servicing. You can pick from five different courses (including an advanced color course for practicing technicians) so you can fit your training to your needs and your budget. Or, you can go into Computer Technology, learning on a real, digital computer you build yourself. Communications with famous Johnson transceiver. Aircraft or Marine Electronics. Mobile radio, and more.

### Free Catalog... No Salesman Will Call.

Send the postage-paid card for our free color catalog showing details on all NRI electronics courses. Lesson plans, equipment, and career opportunities are fully described. Check card for information on G.I. benefits. No obligation, no salesman will call. Mail today and see for yourself why the pros select NRI two to one!

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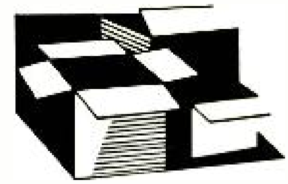


# New Products

*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.*

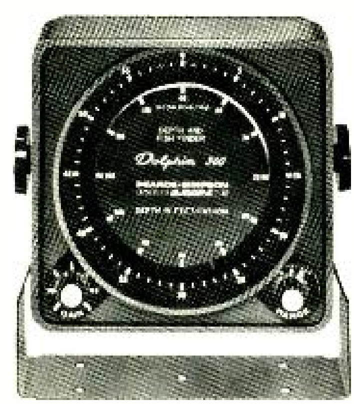
### COURIER 4-CHANNEL PORTABLE SCANNER

The Cop-Scan uhf scanning monitor is a 4-channel portable unit covering the 450-to-475-MHz band. It features a flexible antenna, dual-conversion superhet circuitry, ceramic and crystal filters, LED displays, adjustable squelch and volume. Automatic or manual scanning is switch-selected. Jacks are provided for an earphone, power supply and recharger for optional NiCd battery back. The receiver is housed in a high-impact plastic case.

CIRCLE NO. 70 ON READER SERVICE CARD

### PEARCE-SIMPSON DEPTH SOUNDER

The Dolphin 360 depth sounder by Pearce-Simpson is a solid-state unit with a claimed range of 60 feet/60 fathoms (selectable). Operating frequency is 200



kHz; beam width, approximately 15 degrees. It includes a sunshield for easy viewing, a transducer for transom mounting, power leads, and a stainless steel transom mounting bracket. For through-hull installations, a bronze transducer is available as an option. Requires Supply voltage of 12.6 V dc, 0.5 A. The Dolphin 360 measures 7 2/3" x 4 7/12" x 8 1/3" (19.3 x 11.5 x 20.9 cm) and weighs 3 lb (1.4 kg).

CIRCLE NO. 71 ON READER SERVICE CARD

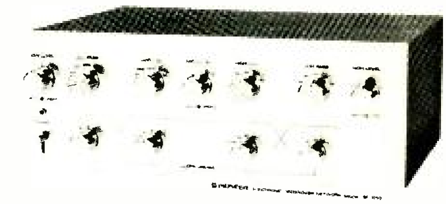
### MARANTZ ELECTROSTATIC HEADPHONES

The Marantz Model SE-1S headphones use electrostatic transducers, have a claimed frequency response of 20 to 20,000 Hz, and a weight of 14 oz. (397 g). Distortion at 100-dB SPL is said to be less than 0.5% from 40 to 20,000 Hz, and 1.5% at 20 Hz. Impedance is 30 ohms, and required power is 3 watts rms/channel. Included with the SE-1S headphones is the EE-1 Energizer with built-in headphone/speaker switching. It also features protective circuitry for drive levels, and facilities for an additional set of headphones. $129.95.

CIRCLE NO. 72 ON READER SERVICE CARD

### PIONEER ELECTRONIC CROSSOVER NETWORK

Pioneer's new Model SF-850 Electronic Crossover Network provides variable passbands for the bass, midrange, and treble regions. As many as ten different



crossover points are possible (125, 250, 500, 700, and 1000 Hz for low-mid ranges; 1000, 2000, 4000, 6000 and 8000 Hz for mid-high ranges). Independent selection of crossover points is provided for low, mid, and high channels. The Pioneer SF-850 also allows selection of three different slope characteristics—6, 12, and 18 dB/octave. The mid slope selectors provide flat positions to facilitate 2-way/multi-way amplifier configurations. Independent channel level controls are coaxial, allowing separate adjustments for left and right signals. The SF-850 measures 13-25/32 in. by 5-15¹/32 in. by 12-31/32 in. (35 by 13.8 by 32.9 cm) and weighs 12.3 lb (5.6 kg). $199.95.

CIRCLE NO. 73 ON READER SERVICE CARD

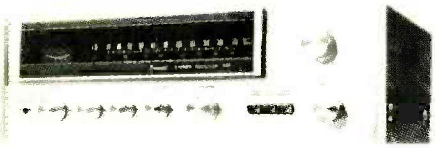
### WAHL THERMAL-SPOT TESTER

The Thermal-Spot Tester by the Wahl Clipper Corp. provides a concentrated jet of hot air that can be directed to a specific component without physical contact. Many components will not malfunction until they reach operating temperature. The Thermal-Spot will allow examination of individual parts without waiting for the entire circuit to warm up. The compact Thermal-Spot heats the jet of air to about 125°C (260°F). It can also be used with heat-shrink tubing, for drying epoxies and cements, and to quickly dry out tuners after spray cleaning.

CIRCLE NO. 74 ON READER SERVICE CARD

### SANSUI LOW-COST RECEIVER

Making heavy use of ICs, the Model 441 AM/FM stereo receiver's tuner front end has a low-noise, dual-gate MOSFET to improve sensitivity and S/N ratio. Other tuner features include two ceramic filters, high-density ICs in the i-f and FM demodulator sections, and a tuning meter. The amplifier



section uses a direct-coupled hybrid IC final amp delivering 11 W rms/channel into 8 ohms over a bandwidth of 40 to 18,000 Hz. THD is less than 1% and IM less than 0.8%, at rated power. Frequency response is 30 to 15,000 Hz, i-f rejection better than 75 dB at 98 MHz, and S/N is better than 65 dB. Stereo separation is better than 40 dB at 1000 Hz. Two pairs of speaker outputs are provided, as well as antenna inputs for 75- and 300-ohm transmission lines. $219.95.

CIRCLE NO. 75 ON READER SERVICE CARD

### ACOUSTIC RESEARCH AR-10π

The AR-10π is a three-way system employing a "woofer environmental control" for proper bass response, according to Acoustic Research. The woofer control is said to compensate for the effects of speaker placement on bass radiation. A three-position switch tailors woofer action for 1π (in front of a wall on the floor), 2π (wall-mounted) and 4π (in the middle of a room) speaker positions. All controls of the AR-10π are located behind a front panel, above the foam grille. A 12-inch (30.1-cm) woofer, 1½-inch (3.8-cm) dome midrange, and ¾-inch (1.9-cm) dome tweeter are used. Nominal impedance is 8 ohms, and minimum power requirement is 25 W. Crossover frequencies are 525 Hz and 5000 Hz. System resonance is 42 Hz. The AR 10π weighs 55 lb (25 kg) and measures 25" x 14" x 10¼" (62.8 x 35.1 x 25.7 cm). $350.00.

CIRCLE NO. 76 ON READER SERVICE CARD

### E.F. JOHNSON HANDSET BASE STATION

The Messenger 132, a 23-channel CB base-station transceiver, incorporates a handset in its "radiotelephone" design.

This feature permits private listening, and, Johnson claims, increased clarity of transmissions in noisy environments. Received signals can also be heard through a built-in or external speaker. An illuminated meter doubles as a received signal-strength and relative r-f output indicator. Squelch and volume controls are included. A PA function allows paging through an external speaker. A back-lighted channel selector changes from white to red when the Messenger 132 is in the transmit mode.

CIRCLE NO. 77 ON READER SERVICE CARD

### HICKOK PORTABLE SEMICONDUCTOR TESTER

Hickok's new Model 215 Semiconductor Tester is a pocket-size, self-contained test instrument capable of checking npn's, pnp's, FET's, diodes, SCR's and UJT's in or out of circuit. The Model 215 automatically determines proper lead configuration, and indicates by LED displays if the device is GOOD or BAD. If GOOD, it further identifies which lead is the base (gate for FET's) and whether npn or pnp. The CMOS circuitry improves reliability and provides long life for the two 9-volt batteries.

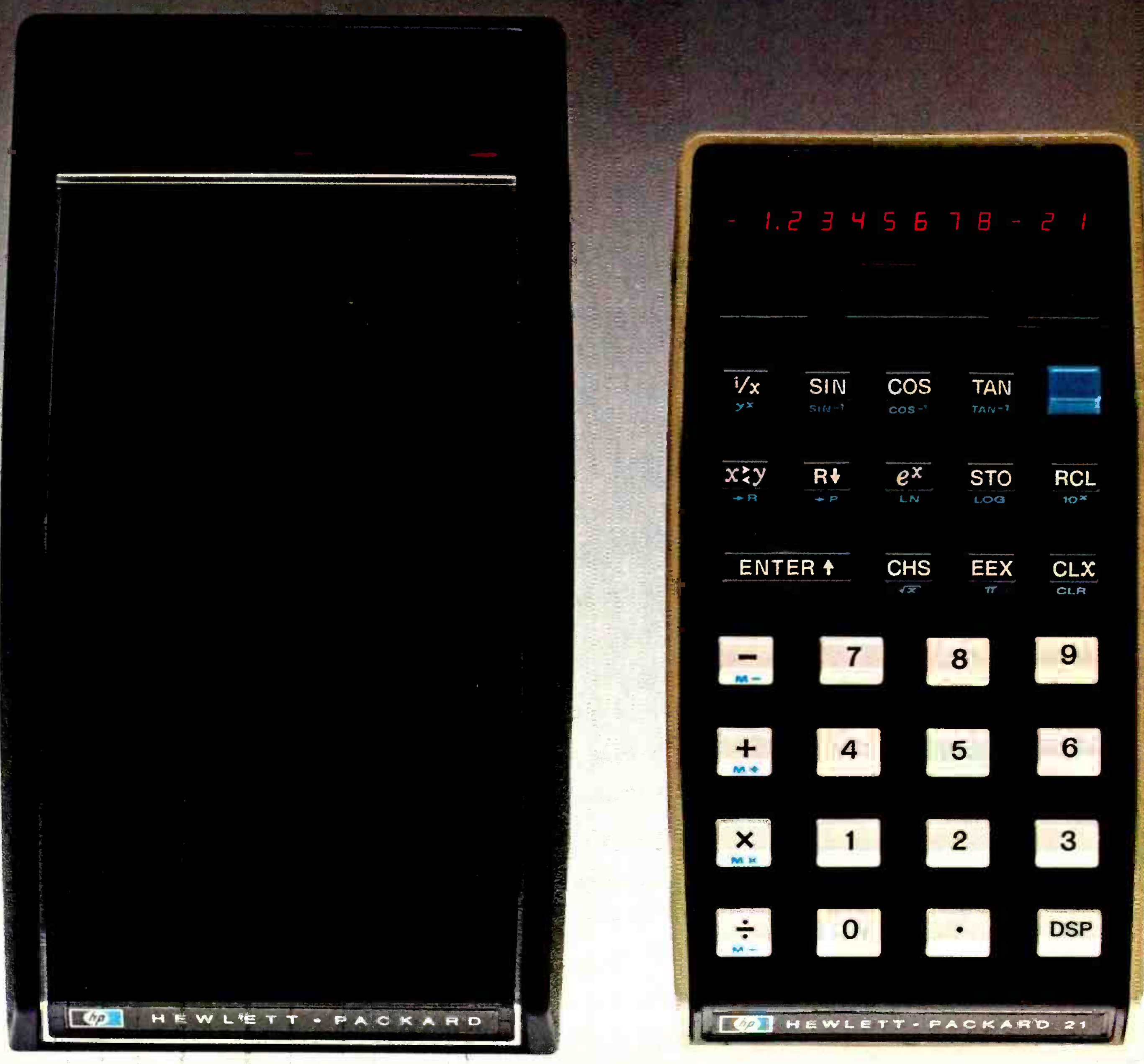
CIRCLE NO. 78 ON READER SERVICE CARD

### ASCOM FIELD STRENGTH METER

A very compact field strength meter, the Model ASM-105, has been introduced by Ascom Electronic Products. The field strength meter can be put to many uses: field checks of antenna radiation, antenna tuning, and comparative tests of various transmitters and antennas. The Model ASM-105 requires no internal power, and covers the frequency range of 27 MHz to 225 MHz. $15.95.

CIRCLE NO. 79 ON READER SERVICE CARD

# Hewlett-Packard introduces a smaller uncompromising calculator,



# the new HP-21 Scientific. $125.00*

Now $125.00 buys:

- **More power than our HP-35.** 32 pre-programmed functions and operations, including rectangular/polar conversion, register arithmetic and common log evaluation.
- **Smaller size.** 6 ounces vs. 9 ounces for our HP-35.
- **Display formatting.**
- **H-P's unique and efficient RPN logic system.**
- **H-P's quality craftsmanship.**
- **An unbeatable price:performance ratio.**

Here are the details:

**32 pre-programmed functions and operations.** The HP-21 performs all log and trig functions, the latter in radians or degrees. It's our only calculator short of the HP-45 that lets you:

- convert polar to rectangular coordinates, and back again (→P, →R);
- do full register arithmetic (M+, M−, M×, M÷);
- calculate a common antilog (10x) with a single keystroke.

The HP-21 also performs all basic data manipulations($1/x, y^x, \sqrt{x}, \pi$) and executes all pre-programmed functions in *one second or less.*

**Full display formatting.** The Display key (DSP) allows you to choose between fixed decimal and scientific notation and lets you control the number of places displayed. (The HP-21 always uses all 10 digits internally.)

When a number is too large or small for fixed decimal display, the HP-21 switches automatically to scientific, so you never have to worry that the calculator will confuse a smaller number with zero.

Finally, if you give the HP-21 an impossible instruction, the Display spells E-r-r-o-r.

**RPN logic system.** Here's what this unique time-and-error-saving logic system means for you:

- You can evaluate *any* expression without copying parentheses, worrying about hierarchies or re-structuring beforehand. Your calculator remembers what's where—automatically.
- You can solve *all* problems your way—the way you first learned in beginning algebra, the way you now use when you use a slide rule.
- You solve *all* problems—no matter how complex—one step at a time. You *never* work with more than two numbers at once.
- You get continuous and immediate feedback. You see *all* intermediate answers *immediately*, because your calculator executes each function immediately after you press the function key. *You watch it happen.*
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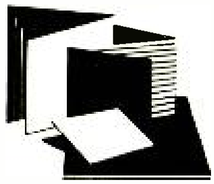

# New Literature

### CROWN HIGH-FIDELITY BROCHURE

Crown International offers a new four-color brochure describing the company's complete line of hi-fi amplifiers, preamplifier, speaker system, control centers and tape recorders. The brochure quotes some specifications, but up-to-date spec sheets and laboratory test reports are also available upon request. Address: Crown International, 1718 W. Mishawaka Road, Elkhart, IN 46514.

### RCA PICTURE TUBE PRODUCT GUIDE

A revised product guide describing RCA picture tubes for the renewal market has been announced by RCA Electronic Components. The guide includes an interchangeability directory that lists RCA replacements for 975 (including 85 foreign) industry types. Its characteristics charts contain data on all types for which RCA has a replacement. The product guide also includes basing diagrams, pictorial views, and keys to tube sizes in the old, new, and foreign designation systems. Address: RCA Electronic Components, Commercial Engineering, Harrison, NJ 07029.

### MULTIMETER BROCHURE

A 6-page brochure describing a 4½-digit Multimeter is available from Data Precision Corporation. The publication describes the Model 1450 which utilizes Data Precision's Tri-Phasic™ A/D conversion technique, Isopolar reference system and Ratiohmic™ resistance measuring system. Address: Data Precision Corporation, Audubon Road, Wakefield, MA 01880.

### EDMUND ENERGY-SAVING BULLETIN

"Tips and Things for Beating the Energy Crisis" is an informative 8-page bulletin offered free by the Edmund Scientific Company. It shows how to save on heating and air conditioning both in the home and plant. Hints are given for making the best use of energy in the kitchen—on and in the stove, refrigerator/freezer, and other electrical appliances. Also included is information on energy-saving devices such as a windmill generator, solar cells, and plans for a Solar House. Address: Edmund Scientific Co., 555 Edscorp Bldg., Barrington, NJ 08007.

### KURZ-KASCH KNOB CATALOG

A two-color, 20-page catalog of knobs and equipment enclosures is offered free by Kurz-Kasch, Inc. Many varieties of knobs are illustrated, including spinner knobs and pointer, dual-control, and skirted models. Address: Kurz-Kasch, Inc., Dayton, OH 45401.

### KESTER SOLDER SLIDE RULE

A handy slide rule published by Kester Solder provides flux selector data and solder alloys guides on flip sides. The pocket-size slide rule gives flux choices for 22 metals; and 36 solder alloys and their melting points are listed. Address: Kester Solder, 4201 Wrightwood Ave., Chicago, IL 60639.

### NATIONAL SPECIAL FUNCTION CATALOG

A new 200-page Analog and Digital Special Function Catalog is now available from National Semiconductor Corp. The new catalog contains design and application information on amplifiers, comparators, analog switches, MOS clocks and digital drivers, and power supply modules. The catalog contains a cross reference guide, product selection guides, and detailed technical information on National's special function IC's. Address: National Semiconductor Corp., Marketing Services Dept., 2900 Semiconductor Dr., Santa Clara, CA 95051.

# Stereo Scene

By Ralph Hodges

## A SHORT HISTORY OF FOUR CHANNEL

An engineering chief from GE had asserted that, on a dollar-for-dollar basis, more satisfactory performance could be obtained from four channels than from two.

I listened very carefully then to the GE spokesman's reasoning, but didn't understand a great deal of it, I'm afraid. When the press briefing ended, I was left with the impression he had said something about four channels not having to "work" as hard (per channel) as two for equivalent loudness levels, and that a four-channel system's greater distribution of actual sound sources produces a greater (better) distribution of room-mode effects.

That was almost two years ago. Since then, if the audiophile community has come to believe that an $800 four-channel system is better than an $800 stereo (two-channel) system, there is precious little sign of it. Sales of four-channel equipment, while not as lackluster as they are sometimes reported, have been a disappointment to some of those companies who thought they sniffed a major revolution in the wind during the early Seventies. The promise based on the 4-channel premise is still there, although the word "quadraphonic" is not yet on the lips of the man on the street. What is to blame? Ineffective demonstrations, of course; and there is also the confusing multitude of available or proposed systems. Extravagant claims made for systems still very much in the development stage greatly contributed, I believe. Finally there is the view—an astute one, perhaps—of Andy Petite of the Advent Corp., once seriously involved with four channel: four channel, even more than stereo, has never been successfuly defined or described itself. Does it surround you with sound like some unfortunate caught between the artillery barrages of opposing armies? Is it a world apart, where you float in a sensation never before experienced by mortal man? Or does it bring you correctly reproduced, reflected sound?

Much of this confusion is expected to be eliminated in the future. The IHF has observed that only 1% of the market has ever heard of 4-channel sound. And most of this minuscule group have not been properly exposed to the format. Manufacturers recognize that they face a public education challenge to bring the concept of quadraphonic sound to the fore, illustrating the enormous improvement of sound reproduction achieved with the latest systems (rather than fighting each other over who has the best system).

**The Beginnings.** Multi-channel (more than two) stereo is not particularly new. In the 1950's, Marvin Camras conducted one of the earlier and more famous experiments by ringing a room-size area of various acoustic environments with outward-facing microphones and recording acoustic events on twelve tracks. For playback, twelve speakers replaced the microphones and the listener(s) was put in the middle. No one I have talked to who attended the (much later) demonstration of these experiments was disappointed, but neither was anyone ecstatic. Perhaps they never imagined they were hearing more than a laboratory curiosity.

However, by the time of the late 1960's, Acoustic Research had begun its portentous investigations into multi-channel sound. AR used artificial reverberation devices, as well as live recordings. For the latter, four microphones (or the equivalent) and four playback loudspeakers were used, placed in the now-traditional rectangular pattern of front and rear pairs. The choice of four was mostly an arbitrary one. Otherwise, the technique did not differ much from the one Camras had used.

Several of the tapes AR made and later demonstrated sounded spectacular to the ears of audiophile listeners. They also served to arouse speculation as to the viability of four channel as a consumer medium.

**Creation of Space.** By and large these first forays into quadraphonics were pragmatic rather than theoretical; in other words, they proceeded from the notion that if it were possible to set up one credible stereo "stage" in front, it should be possible to add three more to encompass the listener. Not much thought was given to what was necessary and what irrelevant to produce the desired aural illusion, especially since so little was known about the requirements for "fooling" the ear-brain mechanism in this way. But in almost every case, the illusion these early experimenters were after

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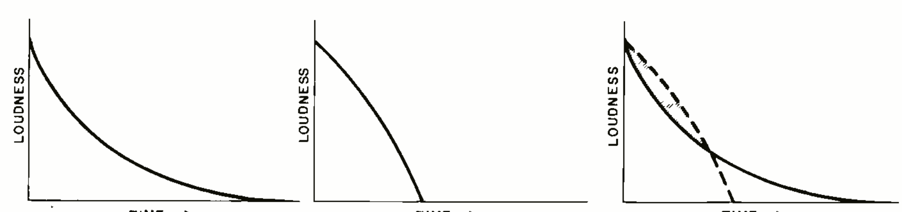
was the same: they wanted to create a pseudo concert hall—the impression of a large enclosed space in which the music from recordings could exist and "breathe."

Anyone can roughly judge the size of a room, even in pitch darkness, by simply making some kind of noise in it. The sound reflections (reverberation) then give it away. The reverberation patterns of large rooms (halls and auditoriums) and small, illustrated in Fig. 1, are characteristic. In a small room, sound coming directly from the source is followed almost instantaneously by rather strong reflections from nearby surfaces. This sonic bombardment continues until the sound energy escapes or is absorbed, mostly by collision with those same surfaces that reflect part of it. In a confined space the collision rate is high, so absorption takes over rather quickly.

In a large room, the first reflections are later in arriving, having had to traverse greater distances. They are also somewhat weaker. However, the sound may "hang on" considerably longer since collisions with walls and ceiling are less frequent, and this accounts for the concert-hall "bloom" that is so flattering to certain types of music.

Two-channel stereo had proved itself less than completely effective in portraying this rich reverberant field; the reverberation was audible on many recordings, but it rarely gave the listener the feeling that he was *in* it. The four-channel solution was to add rear speakers so that reverberation could come at him from all directions. Furthermore, during recording, this reverberation would be miked just as if it were the direct sound from the musicians. Stereo microphone arrays were aimed at the sides and back of the concert hall, as well as at the stage. All this sonic information was assigned to appropriate tracks on the tape, and rendered back through four encompassing speaker channels. One thing that was not really considered—or perhaps it was beyond considering—was the effect that the acoustics of the *listening* room would have on all this. By superimposing the curves of Fig. 1 to produce Fig. 2, we can see that, for a brief time after the cessation of the direct sound, the reverberant field of a small room is considerably stronger than that of a large hall. The result, theoretically, would be a momentary masking of the hall reverberation (on the record) by the listening room acoustics. You can get an idea of what this sounds like, I believe, by playing the final note of any loud symphonic or organ passage on a conventional stereo system. As the note ends, there is the briefest instant of disorientation before the reverberant tail of the sound (from the record) is heard through the speakers. How much this phenomenon would affect the four-channel illusion was, and still is to a large extent, an open question.

**Moving On.** The idea of four-channel reproduction had by now reached the outside world, and there was widespread interest in how the technique could be adapted to the phonograph disc, or even stereo FM. Then up popped Peter Scheiber of Audiodata with an answer of sorts. Scheiber's answer was complex and became more so as time went on. At the heart of it was the relatively simple concept of matrixing, which rapidly became almost a household word, as did the term "separation," since that was where matrix systems had their problems. Conventional matrix techniques applied to a two-channel medium (with no increase in frequency bandwidth allowed) provided only very limited separation between four channels; if you distributed the available separation equally you got 3 dB between each speaker pair. Not excitingly good! Scheiber knew this and concentrated on sophisticated subsequent signal processing to improve




(A) (B)

*Fig. 1. Curve (A), left, shows reverberation characteristics of a large hall; (B) is for small listening room. Fig. 2, right, combines them to show how time curve (B)'s acoustics dominate recorded ambience.*

matters, as did others shortly after. He had a fair measure of success, but the economic realities of the equipment grew unmanageable (and still were when Scheiber was last spoken to).

The matrix concept promptly engendered what seemd like a thousand variations: Dynaquad, Electro-Voice, Sansui, (the latter marketing a device that also phase-shifted and equalized channels), and many others more obscure. About all you could say for them was that the cheapest (Dynaquad) was capable of sounding as good as the costliest. And most of them emphasized the effect that could be obtained from synthesizing four channels from two-channel material. This was astonishingly good with some recordings, but it also laid bare the fact that software for any of the systems was virtually nonexistent. Then CBS demonstrated a somewhat more complicated matrix system with subsequent signal processing that the company called "logic." It worked very well if all you asked of it was the silencing of three channels when only the fourth was supposed to be playing. More than a year would pass before "full-logic" decoders for the system became generally available, but at least Columbia's entry meant that four-channel recordings (intended for SQ decoding) would be widely obtainable. To top this, a short time later RCA announced that it would go with the technologically difficult technique developed by JVC: an ultrasonic carrier on the disc to contain the needed extra information.

**Echo Chambers.** Throughout this period there were those who held that if you wanted reverberation, you might as well get it the way the recording studios often do: by using delay lines. The only device of this type intended for "four-channel" applications that ever came close to being marketed was a device sponsored by Harman-Kardon. It employed mechanical springs that were carefully equalized to subdue their various resonant nastinesses. Others experimented with tape loops and even acoustic delay lines. A number of these systems fed reverberation only to the rear channels—theoretically unacceptable, although the effect didn't always sound that bad.

The king of the delay-line systems was built by Horrall and Watters at Bolt Beranek and Newman for the purpose of studying auditorium acoustics. The

*Fig. 3. BB&N simulator has AR amps, 4x speakers and AKG reverberation unit.*

artificial reverberation is generated by a high-speed tape loop with eight stereo playback heads (16 tracks), as well as a real room-type echo chamber. At the time I visited, the system, called the "Auditorium Acoustics Simulator," was in temporary quarters at the firm's Waltham, Mass., offices, and a high-quality spring-type delay line had been substituted for the echo room. Otherwise the operation was unmodified. It works as follows.

A 1/24-scale model of the auditorium is constructed and measurements are made in it of impulse sound with a small microphone capsule pointed in various directions. After the results have been adjusted for frequency/wavelength effects (due to the model's smaller scale), computer programs are written for twelve channels, corresponding to twelve microphone directions. The contents of the channels are assembled, according to the programs, by mixing, in various proportions, the outputs of a (virtually) reverberationless recording of a symphony orchestra and the various delay mechanisms. The channels are then fed to twelve speaker systems carefully positioned about an acoustically dead listening room of average size (see Fig. 3). The way the bass is handled is especially interesting. Below 150 Hz it is all fed to two 12-inch acoustic-suspension woofers. The woofers are then placed so that the room modes activated by one are not activated by the other. And finally, each woofer is limited in bandwidth to the range over which its response is essentially flat. The frequencies that one woofer cannot reproduce uniformly are handled by the other. This works because low frequencies are presumably nondirectional; the woofers could theoretically be anywhere in the room (during my visit they were close together and off to one side) and still sound right stereophonically.

When I heard it, the BB&N system performed magnificently, providing an uncanny sense of hall sound and a somewhat remote orchestra. Unfortunately, the simulator is not and was never intended to be a consumer product.

**The Present.** In the ensuing several years, all four-channel systems either became technically better or disappeared. CBS went beyond its full-logic decoder to add "variable blend," an electronic cancellation technique that can work when all four channels are supposed to be "on." RCA grappled with a myriad of hardware and software problems, at least holding its ground and, sporadically, even seeming to move ahead. And Sansui essentially dropped its rather weird Quadraphonic Synthesizer somewhere along the way and came up with Vario-Matrix, perhaps the most refreshing solution to matrix separation shortcomings that has been seen to date.

Unfortunately, much of this progress fell on deaf or jaded ears. The carefully nurtured expectations of consumers had been disappointed too often already, and much of the available software was still bland, engineered for quadraphonic effects with a frequently lead-heavy hand.

At present, RCA is finding out that today's prevailing standards of disc-record manufacture are not quite up to the technical demands of its CD-4 systems, theoretically flawless though the system is. CBS continues to hold the upper hand with the SQ matrix, which enjoys the greatest degree of acceptance from record and equipment manufacturers. Ironically, however, the great progress being made in SQ decoders might even be a drag on sales; some prospective buyers seem to be holding off until the system is "finished." For example, the Tate SQ separation enhancer, demonstrated to high acclaim at last summer's Consumer Electronics Show (and not really seen since), has whetted the appetites of many for still better SQ performance than is available now.

Running gamely in third place is Sansui, which has lately adopted a somewhat different strategy: aggressively selling its QS matrix system to FM broadcasters. There is actually some method in this madness, since the Sansui equipment's capability for synthesizing a four-channel effect from stereo material enables FM stations to maintain a consistent format. They simply "presynthesize" everything they play and throw it on the air—full-time "four-channel" broadcasting. QS-processed material of any kind is generally compatible, giving results on two-channel systems that are as good as stereo material yields. (Often better. As Peter Scheiber claimed some years ago, the abundant random-phase—and even anti-phase—content of four-channel matrix recordings tends to produce a "spacier" stereo image on two-channel equipment, often seeming to extend beyond the two speakers).

Fortunately, nobody is fussing too much about the compromised mono compatability, which probably isn't that problematic in most cases anyway. But unfortunately, Sansui still refuses to sell a separate QS decoder. So anyone who wants QS Vario-Matrix but doesn't want a Sansui four-channel amplifier for whatever reason, will have to wait until the QS licensees, of which there are a good many by now, fill the gap in some way.

Informed reports indicate that there is still a serious limitation to the best configurations of the current matrix systems. As good as they can be for surround-type four channel, for subtler effects like rear-channel ambience there is still a tendency for instruments to sneak back behind the listener. This seems to be an artifact of the old separation problem again. I would suspect that a major factor responsible is confusion of arrival times for what is supposed to be the direct sound source.

In a reverberant environment the ear depends heavily on the earliest impinging sound to judge the direction of the source; the later sonic arrivals will presumably all be reflections. In a properly made *discrete* four-channel recording these ambient reflections will be appropriately delayed; and, of course, any system using artificial reverberation will involve delays. But when leakage between channels occurs in a matrix system there is no delay, so the sound of the instrument arrives simultaneously from several directions.

It appears just as certain as ever that we are ultimately destined to have a four-channel system or systems. And as for those views that four channel will soon disappear without trace —not very likely. ◈

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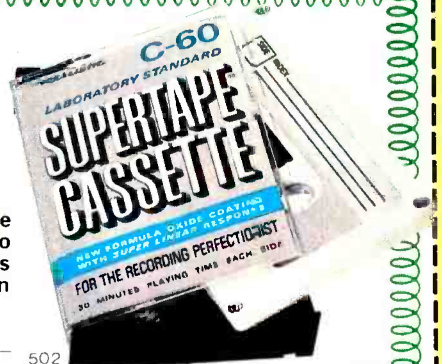


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BY JOE SULMAR AND JAY EISENBERG

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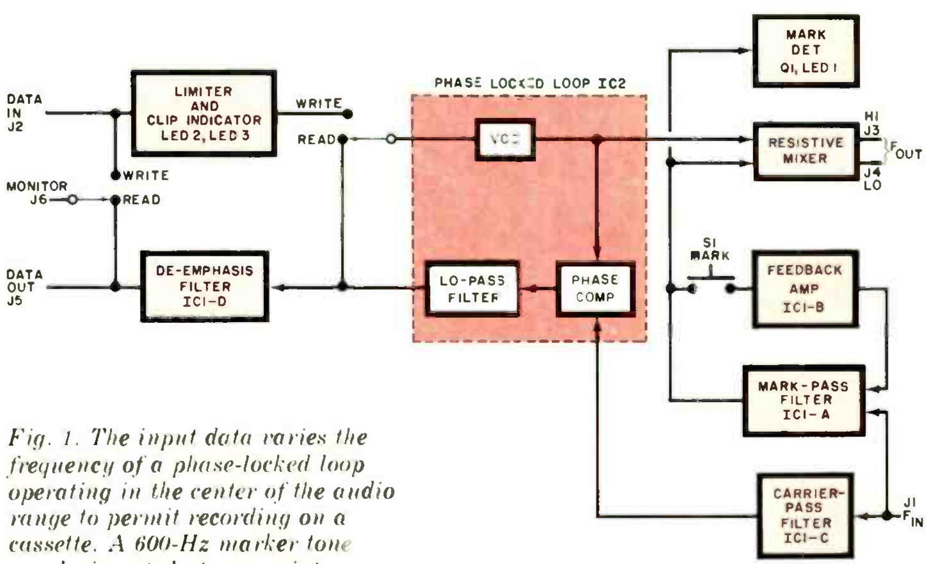


*Fig. 1. The input data varies the frequency of a phase-locked loop operating in the center of the audio range to permit recording on a cassette. A 600-Hz marker tone can be inserted at any point.*

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C13—1000-pF capacitor
C14, C16—5700-pF capacitor (see text)
C15—500-pF capacitor
C18, C20—300-μF, 10-V electrolytic capacitor
D1 to D4—1N4148 diode
D5, D6—5.6-V zener diode
IC1—Quad op amp (National LM324N)
IC2—Phase-locked loop (RCA CD4046)
J1 to J6—Phono connectors
LED1 to LED3—Red light emitting diode
Q1, Q2—Transistor (Motorola MPSA05)
Q3—Transistor (Motorola MPSA70)
Following resistors are all ¼-watt, 10%:
R1, R10, R15, R21, R23—47,000 ohms
R2—680,000 ohms
R3—2000 ohms
R4—1000 ohms
R5, R8, R9, R19—10,000 ohms
R6, R7—200,000 ohms
R11—100,000 ohms
R12—39,000 ohms
R13, R16—82,000 ohms
R14—510 ohms
R17—330,000 ohms
R18—300 ohms
R20—1 megohm
R22, R28, R29—24,000 ohms
R24—22 ohms
R25—240,000 ohms
R26—150,000 ohms
R27—33,000 ohms
S1—Spst normally open pushbutton switch (Alco MSPS-103C or similar)
S2—4pdt, on-none-on subminiature toggle switch (Alco MST405N or similar)
S3—Dpst miniature toggle switch (Alco MST-205N or similar)
Misc.—Suitable chassis, battery holders, rubber feet (4), mounting hardware, wire, solder, etc.

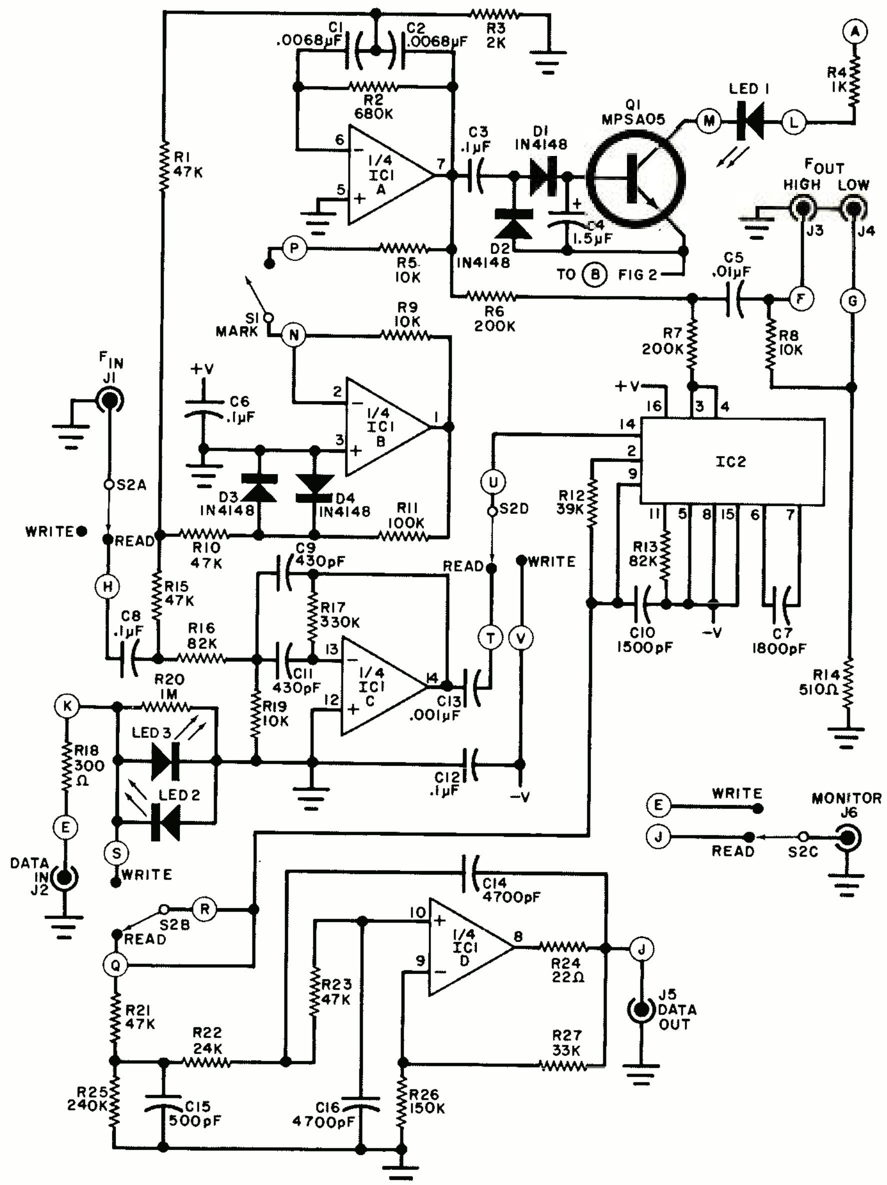



*Fig. 2. Schematic of the translator. Letters in circles indicate connections between board and other components.*

Note—The following are available from Electronics Research Group, 22 Mill St., Arlington, MA 02174: complete kit of all parts including case, excluding batteries (ER-MT-1) at $69.95 plus $2 shipping and handling; pc board alone (MTPC-1) at $7.50 postpaid; chassis, front panel and hardware (CP1) at $15.00 postpaid.

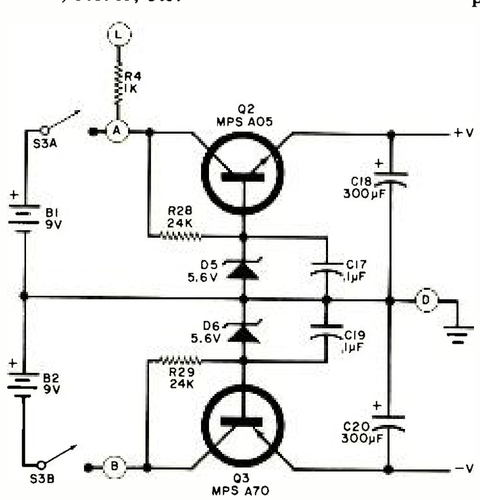



*Fig. 3. Power supply can be mounted on pc board with the exception of batteries.*

**How It Works.** Since tape recorders are relatively insensitive to low-frequency audio inputs, it is necessary to convert the data into high-frequency tones. The block diagram in Fig. 1 shows how this is done.

The data input at *J2* is first applied to a level limiter and clip indicator. Light emitting diodes *LED2* and *LED3* are illuminated when negative and positive (respectively) peaks exceed the diode breakdown (1.5 V). With the system in the WRITE mode, the input is then applied to a phased-locked loop

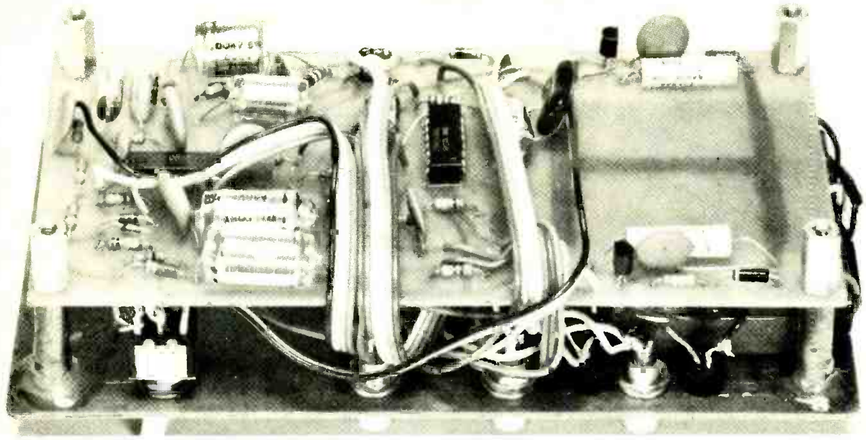


*Photo of the prototype shows the pc board connected to the front panel with spacers. Batteries are located between board and panel.*

*(IC2)*. The frequency of the internal vco is about 7 kHz when the input signal is zero. Positive and negative variations of the input cause instantaneous frequency deviations of the vco output. The latter is applied to the tape recorder through the output terminals *J3* and *J4*. Connector J3 is a 400-mV rms output for the tape recorder's line input, while *J4* delivers a 30-mV rms signal for the recorder's microphone input. The FM output swings between 5000 and 9000 Hz so it is suitable for low-cost recorders.

With the system in the READ mode, the input *(J1)* from the recorder goes through a carrier-pass filter *(IC1C)* that protects the phase-locked loop from unnecessary noise (especially the 600-Hz marker). The signal from the recorder varies the frequency of

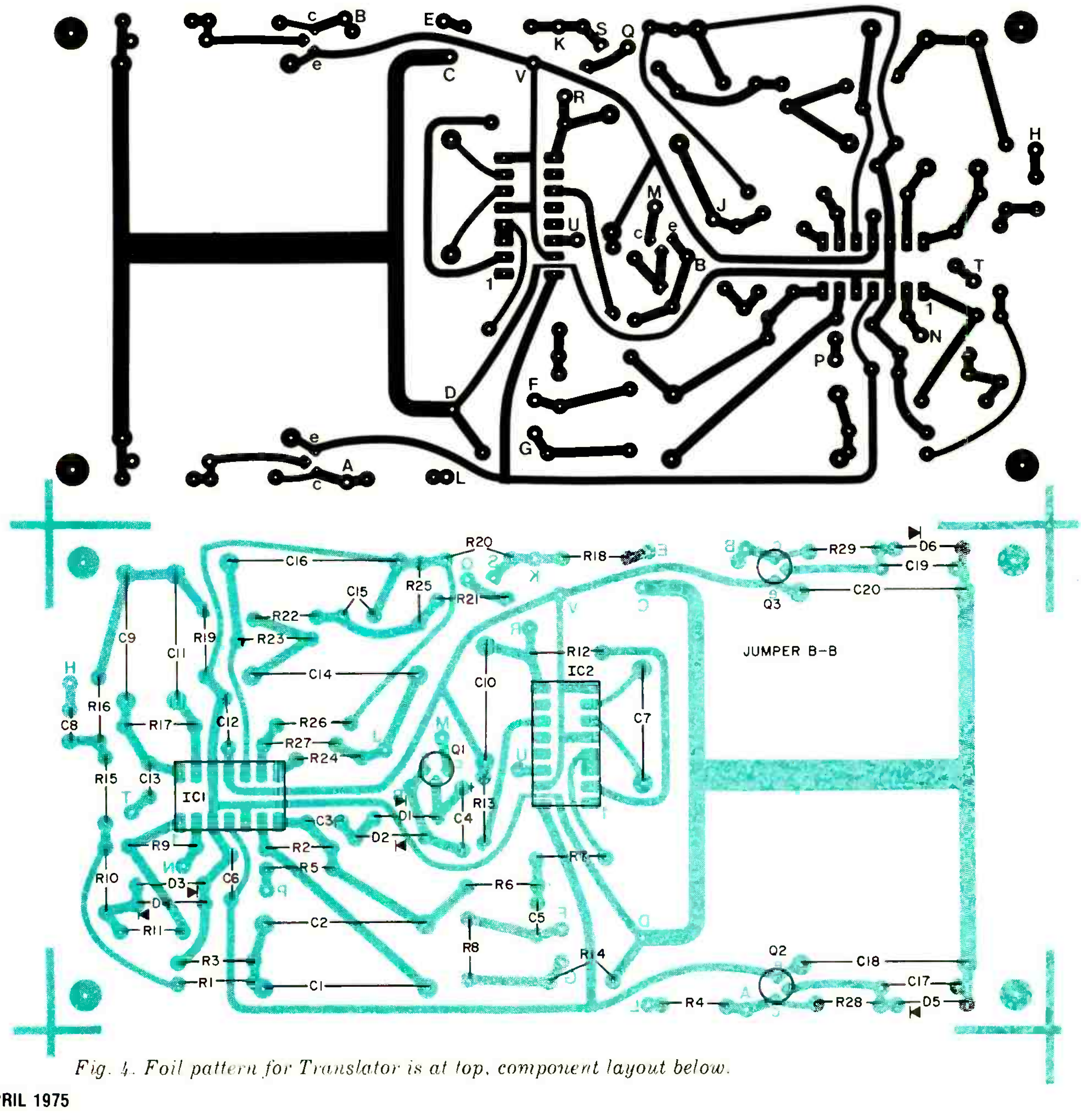



*Fig. 4. Foil pattern for Translator is at top, component layout below.*

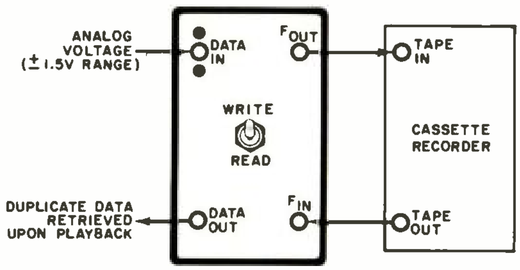



*Fig. 5. Use this setup to connect Translator to a tape recorder.*

the PLL and the de-emphasis filter *(IC1D)* removes the carrier from the signal. The input from the tape recorder should be about 100 mV rms for dependable data reading.

The mark-pass filter *(IC1A)* is an active, high-Q, 600-Hz bandpass filter. In the WRITE mode, depressing *S1* introduces the filter into the feedback circuit of amplifier *IC1B*, causing it to oscillate at 600 Hz. This tone is resistively added to the main signal output for modulation on the tape. At the same time, the marker is indicated by the lighting of *LED1* through *Q1*.

In the READ mode, the 600-Hz marker pulse recorded on the tape is detected by the mark-pass filter to energize *Q1* and light *LED1*.

The complete schematic of the Translator is shown in Fig. 2 and the power supply circuit is shown in Fig. 3. Note that connections to components not located on the pc board are made to points identified by letters on the schematic.

**Construction.** The foil pattern for the pc board and component layout are shown in Fig. 4. Be sure to use precision capacitors for *C1*, *C2*, *C7*, *C9*, *C10*, *C11*, and *C14*. Also, *C7* must be a polystyrene type to assure temperature and humidity stability. The insulated jumper must be installed between the two points marked B in Fig. 4. Observe the polarities of the electrolytic capacitors and semiconductors and the notch-and-dot codes of the IC's. Use a low-power soldering iron and fine solder.

The case used in the prototype was 6½" by 3½" by 1¾" (16.5 x 8.9 x 4.5 cm). The cover should be metal. Using the front-panel photograph as a model, drill twelve ¼-in. holes to mount the front-panel components. Note that these are laid out in logical order. That is, the two LED's used to indicate clipping are mounted next to the input connector; *LED1* is adjacent to *S1*, etc.

Use spacers in attaching the pc board to the front panel, leaving enough room to accommodate the two 9-V batteries.

**Operation.** A typical arrangement for low-frequency analog recording is shown in Fig. 5. To record data, place the MODE switch in WRITE, turn on the tape recorder and the Translator. Operate the MARK pushbutton to denote any desired special point in the recording. Use the same interconnection to read the data back, but with the MODE switch on READ.

The system is linear with unity gain for input levels of ±1.5 volts.

Fluctuating voltage for the purpose of programming electronic equipment can be stored for later use. For example, the sound level of a speaker or the intensity of a light can be preprogrammed for displays or demonstrations. The absolute temperature of an oven can be controlled as long as the tape runs. The operation of servo motors and solenoids can also be programmed.

Two Memory Translators can be used to form a voice scrambling link. The output of the transmitting Translator will be a modulated 7-kHz tone which can be transmitted by radio or telephone to the second Translator which unscrambles the tone into an intelligible voice. In addition, cassettes containing confidential information can be filed and stored, to be decoded only by another Translator.

Two Translators can also be coupled to provide remote data communication. In this case, the Translators are acoustically coupled to telephone handsets and data is transmitted through the line. In this type of operation, it is better to change the carrier frequency from 7 kHz to about 2 kHz. To do this, change *C2* and *C7* to 1500 pF, *C9* to 4700 pF, *C10* to 5000 pF (polystyrene) and *C12* and *C14* to 0.0.2 µF.

To interface TTL with the tape recorder, use the arrangement shown in Fig. 6. A dual 741 op amp can be used. The circuit consists of a level translator for the TTL input and a Schmitt trigger to provide clean logic edges on the playback. Since the maximum recording rate is 500 bits per second, 600,000 bits can be recorded on a 20-minute tape, 900,000 bits on a 30-minute tape, etc. ◈

### CHART RECORDINGS BY MAIL

If you need a chart recording, but the cost of a high-quality pen recording machine is too high, the Memory Translator provides an easy solution.

Record the data on a conventional tape cassette. Mail the cassette to R.I.E.P. Inc., 29 Ware St., Cambridge, MA 02139 and you will get a professional 100-Hz bandwidth chart recording. (Cassette will also be returned.)

The charge is $3.50 per cassette side, plus 10¢ per minute of recorder time.

In making the cassette tape, observe the following guidelines: begin with an initial marker, followed by 15 seconds of grounded data input. Then put in another marker before the beginning of the data. This will allow voltage offset compensation for the difference between your Memory Translator and the master Memory Translator at the chart recorder. Insert six markers to indicate the end of the data.

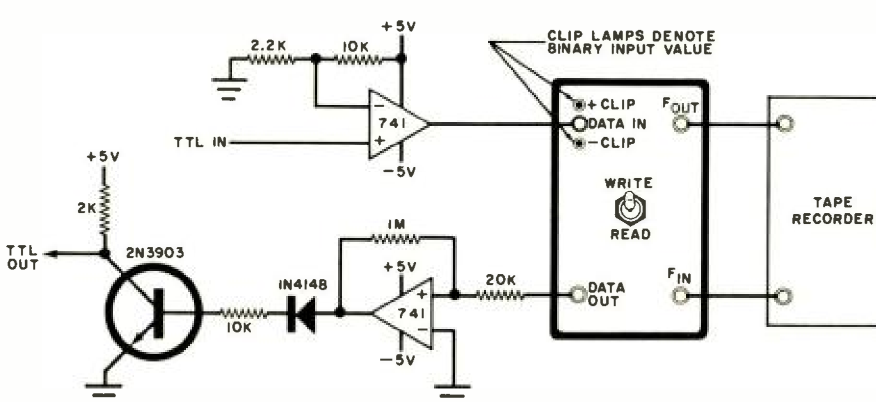



*Fig. 6. Two op amps can be used in an external circuit to make the Translator compatible with TTL.*

# How to Listen to Out-of-State AM Broadcasts

*DX'ing the medium-wave band is a fascinating hobby that can be pursued with a minimum of equipment.*

BY THOMAS R. SUNDSTROM

LISTENING to distant, or out-of-state, stations in the medium-wave band (DX'ing the medium waves) is an excellent hobby which requires a minimum of radio equipment and is a good springboard to the more sophisticated shortwave DX'ing. Listening to stations a thousand or more miles away may be done with only a small portable AM radio or the nearest table radio. Therefore, one can DX the medium-wave band (535 to 1605 kHz) even on a very limited budget.

At the other end of the equipment spectrum, several hundred MW DX'ers in two MW-oriented listener clubs use sophisticated receivers, frequency calibrators, tape recorders, and a variety of specialized equipment to extract intelligence from the ether.

There's more to MW DX'ing than just trying to see how many stations can be heard or how far away a station might be heard. For example, my wife and I are avid National Hockey League fans and particular games, occuring elsewhere in the country, often have a bearing on the standing of our local favorite. So our enjoyment of this spectator sport is enhanced by our being able to listen (with top-notch equipment) to all but three or four of the stations that broadcast games of other teams in the league. With use of a medium-grade portable, that number increases to only six or so that can't be heard. For sports enthusiasts, we've listed here the prime or feed (if a network) station carrying broadcasts of the four major sports.

By international agreement, the broadcast band (BCB) in North America consists of 107 frequency allocations between 540 kHz and 1600 kHz. There are three major types: clear, regional, and graveyard.

*Clear channels* are the easiest on which to hear distant stations. The clears are assigned to 540, 640-780, 800-900, 940, 990-1140, 1160-1220, and 1500-1580 kHz. Although there may be many daytime-only stations operating on clear channels between sunrise and sunset, at night there are only one (class I-A) or two (class I-B) stations operating, usually with a maximum power of 50,000 watts. Forty-one states and the District of Columbia have at least one station operating on a clear channel. There are some exceptions to the only-station-on-the-frequency-at-night concept, identified in the FCC rules as class II stations, and these may operate on the clears at night but usually with lower power and restricted directional antenna patterns in order to protect the class I operations.

*Regional channels* have class III stations operating daytime-only or unlimited (day and night) with a maximum power of 5 kW, intended to serve a major population center and the rural area adjacent thereto. Power at night may be as little as 500 watts, and directional antenna patterns may be employed during the day or the night, or both, in such a manner as to minimize interference on the same or adjacent frequencies. The regional channels are 550-630, 790, 910-980, 1150, 1250-1330, 1350-1390, 1410-1440, 1460-1480, 1590, and 1600 kHz.

*Graveyard channels*, the third category of frequencies, is the smallest in number of channels, but the largest in terms of number of stations per frequency. Accordingly, with upwards of 150 stations each, all low-power and local service, these probably provide the greatest challenge to listeners specializing in domestic (U.S. and Canadian) DX'ing. The class IV stations have virtually unlimited hours, running 1 kW during the day and 250 watts at night, with a nondirectional antenna pattern. There are six graveyard, so named because of the congestion, channels: 1230, 1240, 1340, 1400, 1450, and 1490 kHz.

**Listening Tips.** When to listen? The old axiom of "the best time to listen is when you have the time" is most appropriate here. Actually, there are three variables to consider: daily, yearly, and the sunspot 11-year cycle.

The nighttime hours, as I'm sure you have already noted through casual listening, provide the best long-range reception. This is due to skywave reception; off the E-layer in the ionosphere, the best signals are from about 1000 miles distant. In New Jersey, for instance, stations in Chicago, St. Louis, and Cuba dominate the clear channels at night. Groundwave reception (that is, signals traveling along the surface of the earth) is enhanced, too, increasing from an average 100 miles during the day to 500 or so at night.

The transitional hours of sunrise and sunset also provide enhanced reception. Daytime-only stations offer an excellent source of good DX catches and, depending on the frequency, daytimers can be heard up to a 1000 miles away during these twilight hours.

As it gets dark first in the East, daytimers on the East Coast are the first to go off the air each day. As the sunset zone moves west, stations to the west sign off at 15-minute intervals, removing more and more *interfering* stations. For example, 1580 and 1550 kHz are two excellent sunset frequencies. With only one Canadian clear on each to cope with, daytimers can be heard signing off up to two hours beyond my local sunset time; by this time, daytimers in the Midwest and South-central states are the ones being heard, playing "The Star Spangled Banner." DX'ing the regional frequencies at sunset does not provide much range, as there are a greater number of unlimited-hour stations remaining on the air, but a range of 400 miles (in New Jersey) is not an unreasonable expectation. Stations in the South Atlantic and Gulf states dominate sunset DX-ing on the regional channels here.

Sunrise DX'ing provides an equally good opportunity to log daytimers to the east of the listener. With the receiving point in darkness, daytimers will sign-on to the east and, as the sun rises, fade into the noise level as closer stations encounter their local sunrise and proceed to sign on. These, too, are at 15-minute intervals. Dx'ers in the Midwest are almost ideally situated for sunrise and sunset DX'ing since they can cover the entire continent.

DX'ers on the West Coast usually have to limit twilight DX'ing to the sunrise period and, accordingly, have to be early risers. Six a.m. EDT, of course, means a 3 a.m. PDT session at the dials.

Sometimes it is possible to succeed at sunrise and sunset DX'ing even though you're in the "wrong" part of the continent. For example, WQXR on 1560 kHz in New York City normally signs on at 6 a.m. Eastern time, but on Sundays the station is quiet until 7 a.m. Accordingly, with the late winter sunrise, DX'ers on the East Coast have 30 to 45 minutes of sunrise DX'ing in the twilight hours without interference.

Determining operating schedules of local stations is a useful exercise and often good DX can be found on clear or regional channels when the local is silent. An example is the unlimited-hour WBUD-1260 Trenton, New Jersey, that dominates the daytime dial . . . except on Sundays when sign-on time is 7:30 a.m. Several other daytimers have been added to the log of "heard" stations by listening between 6 and 7:30 a.m.

# STATIONS FOR SPORTS BROADCASTS

**HOCKEY STATIONS (National Hockey League)**

| | | | |
|---|---|---|---|
| Atlanta Flames | WGST-920 | Montreal Canadians | CFCF-600 (English) |
| Boston Bruins | WBZ-1030 | | CBF-690 (French) |
| Buffalo Sabres | WGR-550 | New York Islanders | WMCA-570 |
| California Seals | KEEN-1370 | New York Rangers | WNEW-1130 |
| Chicago Black Hawks | WMAQ-670 | Philadelphia Flyers | WCAU-1210 |
| Detroit Redwings | WJR-760 | Pittsburgh Penguins | KDKA-1020 |
| Kansas City Scouts | WDAF-610 | St. Louis Blues | KMOX-1120 |
| Los Angeles Kings | KFI-640 | Toronto Mapleleafs | CKFH-1430 |
| Minnesota North Stars | WCCO-830 | Vancouver Canucks | CKNW-980 |
| | | Washington Capitals | WTOP-1500 |

**FOOTBALL STATIONS (National Football League)**

| | | | |
|---|---|---|---|
| Atlanta Falcons | WQXI-790 | Miami Dolphins | WIOD-610 |
| Baltimore Colts | WCBM-680 | Minnesota Vikings | KSTP-1500 |
| Buffalo Bills | WKBW-1520 | New England Patriots | WBZ-1030 |
| Chicago Bears | WGN-720 | New Orleans Saints | WWL-870 |
| Cincinnati Bengals | WLW-700 | New York Giants | WNEW-1130 |
| Cleveland Browns | WHK-1420 | New York Jets | WOR-710 |
| Dallas Cowboys | KRLD-1080 | Oakland Raiders | KNBR-680 |
| Denver Broncos | KOA-850 | Philadelphia Eagles | WIP-610 |
| Detroit Lions | WJR-760 | Pittsburgh Steelers | WTAE-1250 |
| Green Bay Packers | WTMJ-620 | St. Louis Cardinals | KMOX-1120 |
| Houston Oilers | KILT-610 | San Diego Raiders | KDEO-910 |
| Kansas City Chiefs | KCMO-810 | San Francisco 49'ers | KSFO-560 |
| Los Angeles Rams | KMPC-710 | Washington Redskins | WMAL-630 |

**BASEBALL STATIONS**

| **American League** | | **National League** | |
|---|---|---|---|
| California Angels | KMPC-710 | Atlanta Braves | WSB-750 |
| Baltimore Orioles | WBAL-1090 | Chicago Cubs | WGN-720 |
| Boston Red Sox | WHDH-850 | Cincinnati Reds | WLW-700 |
| Chicago White Sox | WMAQ-670 | Houston Astros | KPRC-950 |
| Cleveland Indians | WWWE-1100 | Los Angeles Dodgers | KABC-790 |
| Detroit Tigers | WJR-760 | Montreal Expos | CFCF-600 (English) |
| Kansas City Royals | KMBZ-980 | | CKAC-730 (French) |
| Milwaukee Brewers | WTMJ-620 | New York Mets | WHN-1050 |
| Minnesota Twins | WCCO-830 | Philadelphia Phillies | WCAU-1210 |
| New York Yankees | WMCA-570 | Pittsburgh Pirates | KDKA-1020 |
| Oakland Athletics | KEEN-1370 | St. Louis Cardinals | KMOX-1120 |
| Texas Rangers | WBAP-820 | San Diego Padres | KOGO-600 |
| | | San Francisco Giants | KSFO-560 |

**BASKETBALL STATIONS (National Basketball Association)**

| | | | |
|---|---|---|---|
| Atlanta Hawks | WSB-750 | Kansas City-Omaha Kings | KMBA-980/ KLNG-1490 |
| Boston Celtics | WBZ-1030 | Los Angeles Lakers | KFI-640 |
| Buffalo Braves | WBEN-930 | Milwaukee Bucks | WTMJ-620 |
| Capital Bullets | WWDC-1260 | New York Knicks | WNEW-1130 |
| Chicago Bulls | WIND-560 | Philadelphia 76'ers | WCAU-1210 |
| Cleveland Cavaliers | WERE-1300 | Phoenix Suns | KTAR-620 |
| Detroit Pistons | WJR-760 | Portland Trail Blazers | KOIN-970 |
| Golden State Warriors | KEEN-1370 | Seattle Supersonics | KOMO-1000 |
| Houston Rockets | KPRC-950 | | |

Daytime DX'ing is useful to the beginning DX'er. It is important to know what stations are regularly heard, and which are daytime-only and which are operating on unlimited hours. Daytime DX'ing is usually defined as that which occurs between two hours after sunrise and two hours before sunset when reception is 99% limited to groundwave only. (Note, however, there can be some weak skywave reception during the daylight hours . . . given a quiet frequency. Most daytime skywave reception is noted during the short winter days and on the clear channels.)

With a directional receiving antenna (notice the directional effects of the ferrite loop antenna in your AM portable radio), it is possible to dig "behind" your locals and find secondary stations. A marginally dominant graveyard local can be eliminated, and several other stations can be heard. Often, such "nulling" of the dominant station on a regional channel will also yield one or two others during the daylight hours and sometimes at a considerable distance.

The second variable factor that BCB DX'ers have to consider is the annual variation of reception conditions. We all know that summertime means high noise levels and thunderstorms. Further, the increased daylight hours cause changes in the several ion layers in the ionosphere which tend to inhibit skywave propagation. The atmospheric crescendos are deafening and, as a result, many BCB DX'ers forego the hobby from May to September. However, there are some noise-limiting circuits around that help the persistent DX'er through all but the most severe problems.

The summertime conditions of noise and lack of long-range skip is a blessing in disguise for the enthusiast pursuing graveyard DX. There is a definite lack of clutter from inaudible class IV's. During the winter they "skip" in and add to the clutter, but during the summer are "masked" out. For those with patience and the willingness to monitor a graveyard frequency for an hour or two at a sitting, you may be rewarded with an exceptional catch. Most of the time, all that will be heard is a jumble of unintelligible audio. But on the average, during each hour something will float to the top for a few seconds or a few minutes, and you might be lucky enough to have an identification included. The most productive hours seem to be in the midnight to 2 a.m. block of time when sign-offs are most frequent. If you have a communications-type receiver that lets you switch off the AVC (automatic volume control) do so and use the sensitivity control to adjust the audio level. The AVC cannot follow, without introducing distortion, the rapid changes in signal level which can be on the order of 20, 30, or 40 dB.

And, finally, the third variable in our scheme of things is the sunspot cycle which varies over an 11-year period. At the minimums, one of which we are in now, the various ion layers increase in density. This includes the F-layer, which is about 120 miles up and normally comes into play in a discussion of shortwave propagation. A single hop via the F-layer is good for about 3000 miles and multiple hops off the F-layer can, and do, bounce BCB signals around the world. (BCB DX'ers who specialize in pursuing reception of signals from outside the North American continent have upwards of 100 different countries to their credit—from as far distant as Australia and New Zealand, South Africa, and the Middle East.)

Thus far we've dealt with natural variables, but there are several man-made factors, too. FCC rules allot the hours from midnight to 6 a.m. local time for experiments and both daytimers and unlimited-hour stations are authorized to conduct tests within those hours. There are two kinds of tests: frequency checks and equipment tests. Sometimes it is a bit hard to tell the difference due to the station's method of performing each, but the frequency check (FC) is usually of 15-minute duration with a 1000 or 800 Hz tone and one or two identifications. A few FC's use music and a few, especially in the south, use the telephone dial tone as modulation. The vast majority of FC's are run on a monthly basis on a fixed day-of-the-week schedule. For example, Montana can be heard on a FC each first Monday of the month at 2:45-3:00 a.m. EDT on KGHL-790 Billings, using a 1000-Hz tone. The purpose of a frequency check is to have an outside engineering firm check (to the nearest hertz) the precise transmitting frequency to insure its stability, as required by the FCC.

Equipment tests usually run longer than 15 minutes and, if major equipment and antenna changes are being made, such testing could run for the full time of the experimental period.

### DX REFERENCE MATERIAL

**National Radio Club Domestic Log.** Price, about $7.00; its prime listing is by frequency with a secondary cross-index by call. Additional data includes mailing address, antenna pattern notes, PSA powers, and operating schedules of unlimited-hour stations. Accuracy, with updaters, is excellent. National Radio Club, Box 127, Boonton, New Jersey 07005.

**Broadcasting Yearbook,** published as the first issue of the year (albeit not available until late March) of the trade journal "Broadcasting". The 1975 annual is priced at $15 ppd. Before spending this kind of money, the beginning DX-er may wish to look at a copy at a local radio or TV station, or local library. Broadcasting Publications, Inc., 1735 DeSales St., N.W., Washington, D.C. 20036.

**World Radio TV Handbook (WRTH).** The BCB and SW DX'er alike should have this standard reference in his or her personal library; a new edition is available early in January each year at the approximate price of $9.00. Gilfer Associates, Box 239, Park Ridge, New Jersey 07656.

Sometimes tones are used and sometimes records are played. Some stations make an equipment test sound like "regular schedule" without commercials and shout the identification loud and clear, soliciting phone calls from far-distant listeners. In any case, equipment tests (ET's) also provide a chance to log otherwise impossible-to-hear daytimers and unlimited-hour stations that do not otherwise operate beyond midnight local time. The only trouble is that ET's are not scheduled on a regular basis and the DX'er has to hunt them on a random basis.

However, a man-made convention helps the DX'er in this regard. The bulk of the 24-hour non-stop operations do come to a halt once a week on Monday mornings. Fortunately, this includes the giant 50,000-watt stations on the clear channels and some good DX can be found. Daytimers operating on the clears often test during the silent period (SP) of the class I, and with the open frequency span the continent. While FC's and ET's are found on any and all mornings, many do take place on Monday mornings. Saturday mornings seem to be a second favorite choice of engineers for ET's, and Sunday mornings seems to be the low-water mark for experimental period operations.

**How To Get Started.** With a little planning the beginning DX'er should be able to log 400 or 500 stations in his or her first year of listening.

The first step is to take an inventory of the local stations operating during the day and evening hours. Make note of the operaing schedules, if possible, because later on you'll want to listen during the dominant local's silent period. A methodical approach to this study should take one or two months and account for 150 to 200 stations that can be classified as "regulars."

Step two should be an effort to listen "behind" the dominant local, again both during the daylight and evening hours. One or two more stations will probably be added per regional and graveyard channel, depending upon the area of the country you are in. Probably a minimum of 50 stations can be added in this way, and now the total "heard" should be in the neighborhood of 250 stations.

Step three should be a study of the clear channels at night, and a minimum of 50 stations should be counted upon completion of this study, which should take two to four weeks. Your total stations heard should now be around 300.

These steps should result in a total population of stations that will regularly be present when looking for the new and unusual loggings. Your knowledge of what is "normal" is a key to spotting band openings and stations not normally heard. These 300 or so stations will become "pests" over the long run and it is best to get a fix on operating schedules so that you can listen during the silent periods of the various stations.

Step four is to begin scanning the bands on Monday mornings, and check out each FC or ET that you find. The test tone is characteristic and it is best to stop at each one when it obviously is not a local. ID's come at the strangest times, so pay attention.

It is impossible to predict the completeness of the ID in the ET or FC as it varies from just one set of call letters to a complete ID including frequency, power, address, telephone number, and ownership. For this reason it is often useful to have a tape recorder running whenever DX'ing, as a missed ID can be replayed and deciphered, if necessary, until understood.

Step five is to get your feet wet in sunset and sunrise DX'ing. The easiest way to get into this is to DX the regular clear-channel daytimers to get their locations. Follow the same pattern on the regionals to get you a clue as to where the garbled ID in the jumble on the regional channel came from. Virtually every daytimer who wants one now has a PSA (pre-sunrise authority). This allows him to operate at a specified low-power level (no more than 500 watts), sometimes with a directional antenna system, between 6 a.m. local time and sunrise. Accordingly, 6 a.m. local time is a key to hearing the sign-ons of many stations on both regional and clear channels.

Steps four and five can be implemented simultaneously. Over the remaining six to eight months of our mock one-year time-table, an average of four new stations per Monday morning and two new stations per day (one each from sunrise and sunset) for 20 days per month should work out to about 50 stations per month. Six months would account for 300 new stations, added to our base of 300 "regulars," yields over 600 stations for the first year of effort. Not bad, eh?

In this effort, you'll probably find the count of states heard to be around 40 or so without any special difficulty. The last ten will be the hardest. For those on the East Coast, Oregon, Idaho, Wyoming, and Alaska will be the most difficult. For those out West, the New England states of Maine, New Hampshire, and Vermont, plus Delaware and New Jersey will be a challenge.

In all of this, you are probably going to run across some French and Spanish speakers in the dark hours. Excepting 840 kHz, which is either Haiti or St. Lucia (both in the Caribbean), it is almost a certainty that the French-speaking stations logged will be from Canada. Spanish-speaking stations can be from anywhere in Latin America, but for the beginning DX'er noting those with the strongest signals, it would be reasonably safe to say that the East and Midwest DX'ers are dealing with the high-powered Cubans, and the West Coast DX'ers are contending with the Mexicans. Very little English is spoken south of the border in Latin America, but that which is most often heard is 4VEH 1035 Cap Haitien, Haiti; Radio Paradise-1265 St. Kitts; and XERF-1570 Villa Acuna, Mexico. Note that some stations (exemplified by Haiti and St. Kitts) do operate on "split" frequencies, i.e., between the nominal even-10 kHz assignments.

Also observe that East Coast listeners have Europeans to contend with during the winter months, and these operate on 9-kHz spacings. Accordingly, many are on "split" frequencies and can be heard regularly. Perhaps one of the easiest for even a beginning DX'er is the BBC outlet on 1088 after WBAL-1090 Baltimore goes off the air at 1 a.m. on a Monday morning. Equally, West Coast DX'ers have to contend with myriads of Japanese, Korean, and mainland Chinese stations, but the bulk of these operate on the even-10 kHz spacings.

The subject of foreign DX'ing is a world unto itself and, given the proper equipment, it is more challenging than DX'ing the shortwave bands.

To DX the BCB effectively, it is important that you have some reference material handy. Of greatest importance is a log of domestic U.S. and Canadian stations (see box). Joining a medium-wave DX Club is another worthwhile move.

As you can imagine, medium-wave DX'ing is a fun hobby. And since you don't need fancy equipment, it's easy to get started. So join us down here in the BCB; you'll like the "waves." ◈

BUILD A

# BLACKLIGHT LANTERN

***Battery-powered, long-wave ultraviolet lamp reveals color patterns of many substances. Doubles as camp lantern.***

BY W.E. McCORMICK

THERE are many things in nature that, in natural light, look pretty dull. When illuminated by ultraviolet light, however, they take on the appearance of colorful gems. The minerals in rocks, sand, even dirt and some insects fluoresce with beautiful colors under UV light. You can see it all with the aid of the portable blacklight lantern described here.

The ultraviolet fluorescent lamp can also be replaced by a 6-watt daylight fluorescent lamp to provide normal light if desired. If you have a source of 117-volt ac, a simple connector change permits the lantern to be used as a light source, while the batteries are being recharged. The lantern uses a 6-volt rechargeable wet-cell; and, since the drain is only about 1.75 amperes, quite a few hours of operation can be obtained from a single charge.

**Circuit Operation.** As shown in Fig. 1, transistors *Q1* and *Q2* are arranged as a power oscillator. Resistor *R1* determines the turn-on voltage and *R2* determines the frequency of oscillation. With the components specified, the frequency is in the low audio range, but high enough to minimize lamp flicker. Resistors *R1* and *R2* actually form a voltage divider to bias the transistors into conduction before oscillation starts.

The alternating currents in the two halves of the collector winding induce a voltage in the secondary of *T1*. Capacitor *C1* reduces voltage spikes that might damage the transistors. With no load, the voltage is 135 V, which drops to about 110 V (a square wave) with a 6-watt load.

With *S1* in the BATTERY position, the ac voltage lights indicator lamp *I2* and is applied to *I1* through a ballast. Closing switch *S2* completes the lamp filament circuit to heat up the filament. When *S2* is released, the ballast generates an inductive kick to strike an arc in the lamp. This method of lamp starting is used for two reasons: glow-type starters do not work well with the square wave involved here, and such starters may be unreliable at low temperatures.

With *S1* in the AC position, the oscillator is disabled and conventional 117-volt ac can be applied to *J1* through *P2*.

**Construction.** The transformer used for *T1* must be modified for this application. Begin by removing the metal mounting-binding strap from around

### ULTRAVIOLET LIGHT AND FLUORESCENCE

There are hundreds of relatively common substances that are usually quite drab under conventional visible light, but are quite brilliantly colored when illuminated by ultraviolet light. For example, when illuminated with ultraviolet at 3560 Angstroms (as provided by this project), a common, dirty-white mothball becomes a vibrant purple.

Roughly half of the substances that fluoresce strongly enough to be seen by the unaided eye, react to longwave (3560 A) ultraviolet. The remainder react to shortwave (2535 A) ultraviolet, while some react to both wavelengths. Some exhibit a color shift when the wavelength is changed, and others undergo a complete color reversal.

Many substances have a pronounced phosphorescence and continue to glow either the same color or a different one, after the excitation is removed. This can make it possible to differentiate between many materials that have the same fluorescence.

Shortwave ultraviolet lamps can produce sunburn and are dangerous to the eyes. When using an instrument of this type, goggles should be worn at all times. (Window glass or clear acrylic plastic, which are opaque to the wavelength, will suffice.) Longwave lamps provide no sunburn hazard and are optically safe.

Geologists are now using ultraviolet light in oil prospecting. They lay out a grid covering the area under investigation and take core samples at various points from a depth of about six inches. The oil does not have to be near the surface since the hydrocarbons brought up by leaching, capillary action, and evaporation promote the growth of micro-organisms (*bacillus methanicus* and *bacillus ethanicus*) which fluoresce blue under longwave ultraviolet.

This method not only locates oil. It produces an outline of the underground pool on the grid. With a little knowledge of the local shale strata and oil sand, the pool's depth can be determined; and the amount of oil to be expected can be determined from the size of the area that fluoresces. The quality of the oil is indicated by color saturation—high sulfur content shifts the color toward yellow and paraffin content shifts it toward pale blue. Other minerals, in suspension, can also be detected. By color matching, it is possible to tell if the pool is a new strike or leakage from an adjacent field.

Longwave ultraviolet is widely used in criminology to detect forged paintings, altered documents, and the authenticity of antique glass and china.

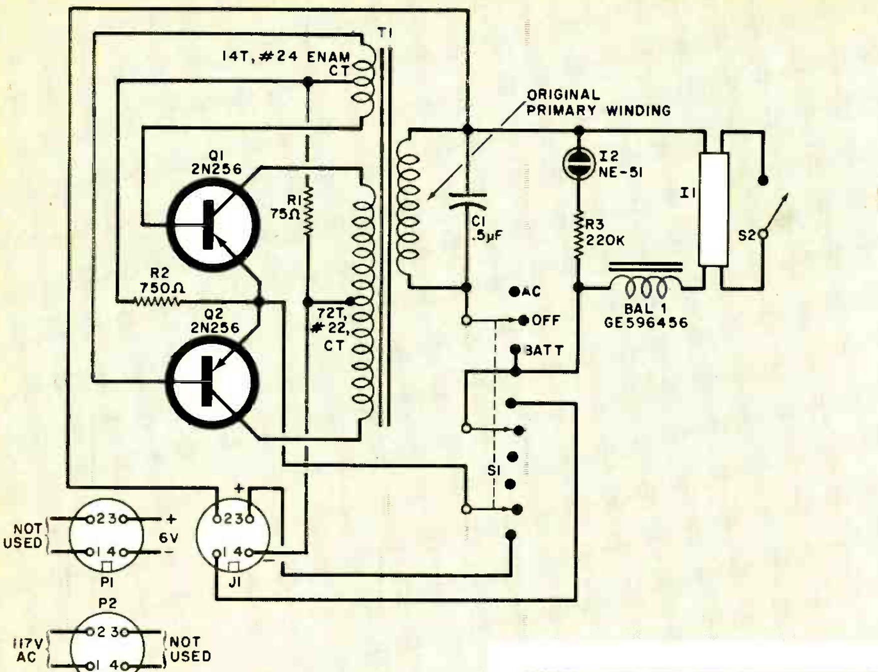



*Fig. 1. Two-transistor power oscillator generates approximately 110 volts for ultraviolet lamp.*

## PARTS LIST

BAL1—Ballast inductor (GE 596456 or similar, available through electrical supply houses)
C1—0.5-µF, 400-volt capacitor
I1—Fluorescent lamp (6 watts): either ultraviolet (GE F6T4/BLB or similar, available from Edmund Scientific, 300 Edscorp Bldg., Barrington, NJ 08007, Cat. No. 60,124, $4.75.) or standard daylight (GE F6T5/CW, available through electrical supply houses)
I2—NE-51 neon lamp
J1—4-pin male plug (H.H. Smith 86CP4 with 12-001-003 adapter plate)
P1,P2—4-pin female connector (Amphenol Series 86-PF4)
Q1,Q2—2N256 power transistor
R1—75-ohm, 10-watt, 10% resistor
R2—750-ohm, ½-watt resistor
S1—4pdt, 3-locking position anti-capacitance switch (Radio Shack 275-600 or similar)
S2—Spst normally open pushbutton switch
T1—117-volt primary; 12.6-volt, 1.2-A secondary filament transformer (Radio Shack 273-1505, modified as per text. Do not substitute.)
Misc.—Plastic case (Bud AC403); metal plate (Bud BPA1590), fluorescent lamp holder (one pair, miniature flush mount, GE 78-X715 or similar); power transistor mounting kit (two, HEP450 or similar); six-foot line cord with plug; three-foot battery cable (#18 stranded); 6-V, 6-A battery (Olson BA-200, $3.49, or PolyPaks, P.O. 942, S. Lynnfield, MA 61940, Cat. No. 92CU1516, $4.95); grommets; decals; mounting hardware; etc.

the core. Then use a thin-bladed knife to loosen the individual laminations and remove them. Be careful not to cut any wires.

Peel the insulating tape from the coil and set it aside for later use. Carefully strip off the secondary (green leads with yellow center tap) and save the wire. Leave the existing primary (black leads) and cover it with a single layer of the insulating tape.

In winding new turns, be sure all winding is made in the same direction. You can wind either way around the core; but once started, everything must be in that direction.

Put the winding (#22 wire) for the collector circuit on first. Color code the start of the winding using a 4" length of spaghetti. Anchor the winding under one of the bobbin flanges by using a small piece of tape. Start wind-

### COLOR AND LOCATION OF MINERALS

| Minerals | Color under visible light | Color under longwave UV | Where commonly found |
|---|---|---|---|
| Adamite (basic arsenate of zinc) | Pale green | Green | Southwestern U.S. and Mexico |
| Amber (a hydrocarbon) | Usually yellow, sometimes brown or white | Blue-white | Widely distributed U.S. |
| Argonite (calcium carbonate) | Indiscernable in mineral mass | Green<br>Orange<br>Brilliant red | New Mexico<br>Sicily<br>Australia |
| Barite (barium sulphate) | Gray | White, cream or yellow<br>Bright golden Orange | Widely distributed U.S.<br>N. Carolina only |
| Calcite (calcium carbonate) | White coating in rock seams | Blue<br>Pale yellow<br>Bright Orange in association with red | Widely distributed U.S.<br>N. Jersey, Texas California |
| Celestite | Colorless crystals<br>Blue crystals | White, blue-white<br>White with green after-glow | Ohio, Midwestern U.S.<br>Ohio only |
| Cerussite (lead carbonate) | Yellowish gray<br>Dull gray | Yellow | Lead mining regions |
| Corundum (aluminum oxide) | Red | Deep red | N. Carolina, N. Jersey |
| Deweylite (magnesium silicate) | Mottled dull green usually in serpentine formation | White | Maryland, Pennsylvania |
| Diamond | Clear or faintly tinted (any color) | Most commonly blue, but can be almost any color | Africa, Arkansas, U.S. |

ing adjacent turns across the bobbin, keeping the turns snugly against each other. At 36 turns, make a 4"-long twisted loop and use a piece of colored spaghetti to insulate and identify it. Bring this out to one side. Wind another 36 turns, fasten it down with tape, and bring out a 4" end identified with colored spaghetti. Place a single layer of tape over the completed winding.

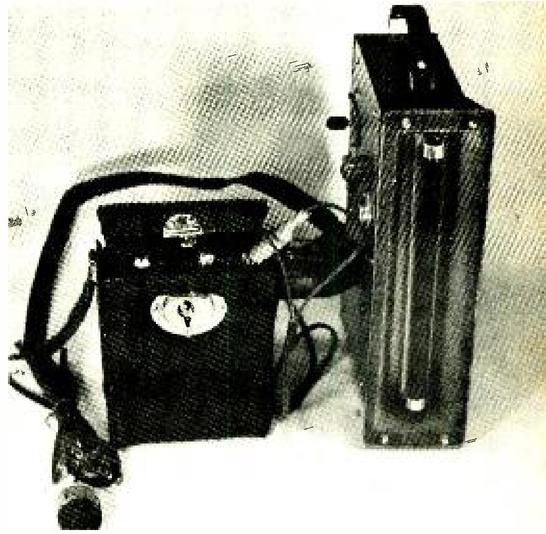
For the base circuit winding, use the #24 wire saved from the original secondary. Use a 4" length of colored spaghetti to identify the start. Wind seven turns, make a center tap as before, and add seven more turns. After all winding is complete, place a layer of tape over the assembly.

Before trying to reassemble the core (laminations), scrape any excess varnish off them. Otherwise, it may be difficult to fit them back on the bobbin. With laminations reassembled, replace the mounting strap, being careful not to pinch the lead ends.

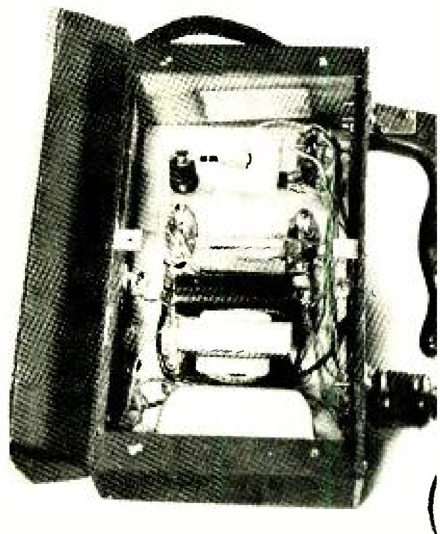
In the prototype, a 5" by 9½" by 2½" (12.7 x 24.1 x 6.4 cm) plastic box with a metal cover was used. The two transistors are mounted on the outside of the cover using a kit (socket, mica insulator, and insulating hardware) so that the cover provides a heat sink. Be sure the collectors are not making electrical contact with the cover. Switch *S1* and *I2* are mounted on the same cover.

The transformer is mounted in the enclosure, while *S2* and *J1* are on one of the sides. Drill a small hole for the four leads to the fluorescent lamp. The lamp reflector can be made of sheet aluminum with wooden end pieces. The lamp holders are attached to the end pieces. The reflector can then be attached to one long side of the case. A pistol-grip handle can be attached to the case if desired.

The 6-volt battery can be carried in a shoulder holder (cassette case, binocular case, etc.) with a two-lead cable to plug *P1*. A conventional 117-volt lamp cord can be connected to *P2*. ◈



*Batteries can be carried in cassette or binocular case with shoulder strap.*



*Internal layout of prototype.*

| | | | |
|---|---|---|---|
| Diopside (silicate of calcium and magnesium) | Masked by pyroxene mass | White, blue-white | N.Y., N. Jersey |
| Fluorite (calcium fluoride) | Purple, green or yellow. Occasionally, blue | Blue, dark red | Widely distributed U.S. |
| Opal (hydrous silica) | Variegated | Green | Western U.S. |
| Scapolite (complex silicate of calcium, sodium and aluminum) | White, greenish yellow | Brilliant yellow, red | Quebec, Canada |
| Sodalite (a silicate of sodium containing aluminum and chlorine) | Usually nondescript | Golden brown | N. Hampshire, N. Jersey |
| Sphalerite (zinc sulphide) | Often indiscernable in mass | Golden orange, blue | N. Jersey, Colorado, Arizona |
| Tremolite (calcium magnesium silicate) | Colorless crystals or a dull talc | Pink, red, fire-red, orange, gray-green or cream | New York; Ontario, Canada only |
| Willemite (zinc silicate) | Usually indistinguishable, sometimes apple-green, dark brown or red | Yellow-green Blue-white | Arizona, N. Jersey |
| Wollastonite (calcium metasilicate) | Gray or white | Weak orange or yellow (Blue-white if associated with barite or green with Willemite) | N. Jersey, Arizona |
| Zircon (zirconium silicate) | Clear, blue Red | Dirty yellow Dirty red | California, N. Carolina |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CONSTRUCTION

# LOW-COST COMPANDER ENHANCES HI-FI RECORDINGS

BY CRAIG ANDERTON

*Simple accessory expands or compresses playback's dynamic range.*

Since the dynamic range of live music is usually greater than the range that discs and tapes can handle, it is standard practice to introduce a certain amount of level compression when a recording is made. Unfortunately, this compression limits many crescendoes and percussive transients that add to the enjoyment of the music. Thus, it is desirable, on playback, to expand the volume to replace the missing peaks. On the other hand, it is sometimes necessary to eliminate loud level changes when using music as a background.

To provide either expansion or compression of the sound, the simple compander described here can be

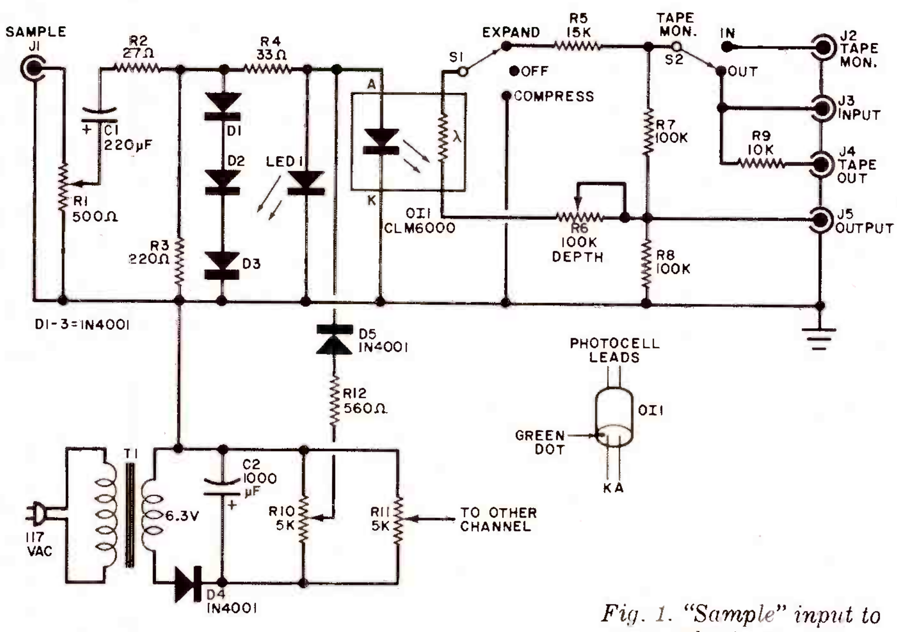



*Fig. 1. "Sample" input to compander is same as input to the speaker.*

## PARTS LIST

C1—220-μF, 50-volt, electrolytic capacitor*
C2—1000-μF, 15-volt, electrolytic capacitor
D1 to D5—1N4001 diode (or similar)*
J1 toJ5—Phono jack*
LED1—MV50 light emitting diode (or similar)*
OI1—Optical isolator (Clairex CLM6000 or similar)*
R1—500-ohm linear taper potentiometer*
R2—27-ohm, 5%, ¼-watt resistor*
R3—220-ohm, 5%, ¼-watt resistor*
R4—33-ohm, 5%, ¼-watt resistor*
R5—15,000-ohm, 5%, ¼-watt resistor*
R6—100,000-ohm linear taper potentiometer*
R7,R8—100,000-ohm, 5%, ¼-watt resistor*
R9—10,000-ohm, 5%, ¼-watt resistor*
R10,R11—5000-ohm linear taper potentiometer
R12—560-ohm, 5%, ¼-watt resistor*
S1—Spdt (center off) switch*
S2—Spdt switch*
T1—6.3-volt filament transformer
Misc.—Perforated board, mounting clips, suitable chassis, lettering, line cord, knobs, moutning hardware, etc.
*Double quantity for two channels.

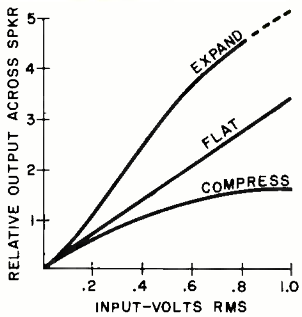



*Fig. 2. Graph shows how compander expands or compresses the relative output across speaker.*

hooked up between your preamp and power amp or through the tape monitoring circuit. (A compander is not to be confused with devices such as tone controls and equalizers, which alter the frequency response of a system.)

**Circuit Operation.** The heart of the compander circuit (Fig. 1) is an opto-isolator (*OI1*), which contains a light emitting diode and a low-distortion photocell in a light-tight plastic enclosure. This unit has much faster response time than devices using an incandescent lamp (often used in companders). It also introduces less distortion and has the advantage of providing a slight "slow release" action to enhance the expansion effect.

The audio signal at the speaker terminals of the amplifier is applied to connector *J1*. The level is controlled and reduced by *R1*, *R2*, and *R3*, with diodes *D1* to *D3* acting as voltage limiters to protect the LED's. The signal level is monitored by *LED1*. The brightness of the LED in *OI1* varies with the signal causing the resistance of the photocell to vary.

The power supply provides a small dc voltage (adjusted by *R10*) to keep the two LED's within their conduction range. This prevents a sudden snap in the volume when a signal is applied.

With *S1* in the OFF position and *S2* on OUT, the input signal at *J3* is applied to *R7* and *R8* and the output at *J5* is half of the input. This insertion loss is required to create the "headroom" needed for expansion.

When *S1* is in the EXPAND position, the photocell in *OI1* is connected across *R7* to vary the resistance of the upper half of the voltage divider. This changes the output on *J5*. Potentiometer *R6* acts as a "depth" control to determine how much the variations in the photocell resistance affect the voltage divider.

As the sampled signal increases, resistance of the photocell decreases, increasing the output at *J5*. This provides the desired expansion.

When *S1* is in the COMPRESS position, the photocell is connected across *R8* so that, as the sampled signal increases, the output at *J5* decreases.

The curves in Fig. 2 are typical of the expansion compression effects.

**Construction.** The complete circuit, with the exception of transformer *T1*, can be assembled on perforated board. The transformer should be located as far as possible from the signal leads to avoid pickup.

The circuit shown in Fig. 1 is for one channel, except that the power supply can handle two channels for stereo. Mount the various phono jacks and the two calibrate controls (*R10* and *R11*) on the rear apron (suitably identified) and the switches and depth potentiometers on the front panel. The two monitoring LED's can also be mounted in rubber grommets on the front panel. An on/off switch can be used in the primary of *T1* or the compander power supply can be plugged into a switched receptacle on the preamplifier.

**System Hookup.** The compander will work with any amplifier that delivers two watts or more of output. If you have a separate preamplifier/power-amplifier setup, use the hookup shown in Fig. 3A. Use shielded audio cables to interconnect the three devices. Be sure the "hot" side of the amplifier output is fed back to the compander.

If you have an integrated unit, use the hookup shown in Fig. 3B. Connect a shielded audio cable from the tape-output jack of the amplifier to *J5* of the compander and another shielded cable from *J2* on the compander to the tape-monitor jack on the amplifier. By switching the amplifier's tape monitor to "in," the compander will be put into the circuit.

**Checkout.** With the system properly connected (be sure not to confuse the channels) and operating, adjust each channel's calibrate control (*R10* and *R11*) until the front-panel monitor is just illuminated. Proper adjustment here provides the best linearity and channel balance.

Working with one channel at a time, place *S1* in the EXPAND position, the sensitivity control (*R1*) at minimum, and the depth control (*R6*) at maximum. Turn up the volume on your system to the most comfortable listening level. Then advance the sensitivity control until *LED1* starts to flicker. Avoid bright peaks on the LED. The music should sound more accented, with a greater dynamic range. Operate the depth control to obtain the desired amount of expansion. To be sure everything is working, turn off the compander and note how much flatter the music sounds.

To check compression, place *S1* on COMPRESS and the sensitivity and depth controls to maximum. Turn up the volume. You should note that the audio output does not rise above the preset level. Adjust both controls to obtain the best output.

At some low listening levels, there may not be quite enough signal to drive the compander properly. This produces a "breathing" effect which can be remedied by turning up the listening level or turning down the depth control. This effect may also occur if the calibration controls are not set high enough.

There is no such thing as the optimum amount of expansion. Some recordings require less than others. However, most will benefit from the extended dynamic range. ◈

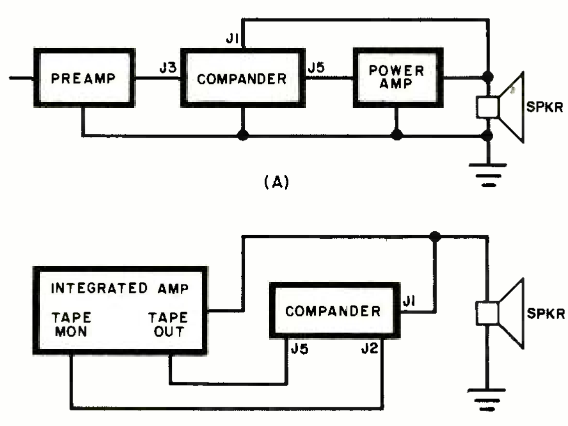



*Fig. 3. If you have separate preamp and power amplifier, use hookup at (A). For integrated amplifier, use (B). Both are for one channel only.*

# EXPERIMENTING WITH LIGHT-BEAM COMMUNICATIONS

*Only a few simple components are needed to get started in this fascinating type of communication.*

BY FORREST M. MIMS

Getting on the air with a light-beam communicator requires a bare minimum of parts and only a fraction of the money you would have to lay out for radio gear. You don't even need an FCC radio operator's license to get on the air. And with light-beam communication, you get the added bonus of interference-free, jam-proof, and private transmissions. It is no wonder, then, that thousands of experimenters are turning to this communicating medium that is currently enjoying new popularity after an almost century-long hiatus.

Light-beam communication is subject to the laws of optics, just as radio communication is subject to the laws of electronics. In most respects, the two types of communication behave basically the same in their respective media. So, you do not have to learn a whole new discipline to get into light-beam communication.

**Optical Considerations.** Little or no electronics knowledge is required for the simplest of light links but a few basic guidelines in optics can enhance even the most sophisticated light communication system. Let us start with the basic principles.

The first rule to remember is that a diverging beam of light follows the *inverse square law*, in which the intensity of the diverging beam decreases in direct proportion to the square of the distance. The implication is obvious: use a very narrow beam for long-distance transmission. This is easily said, but a narrow beam is more difficult to align with a receiver than is a broader beam.

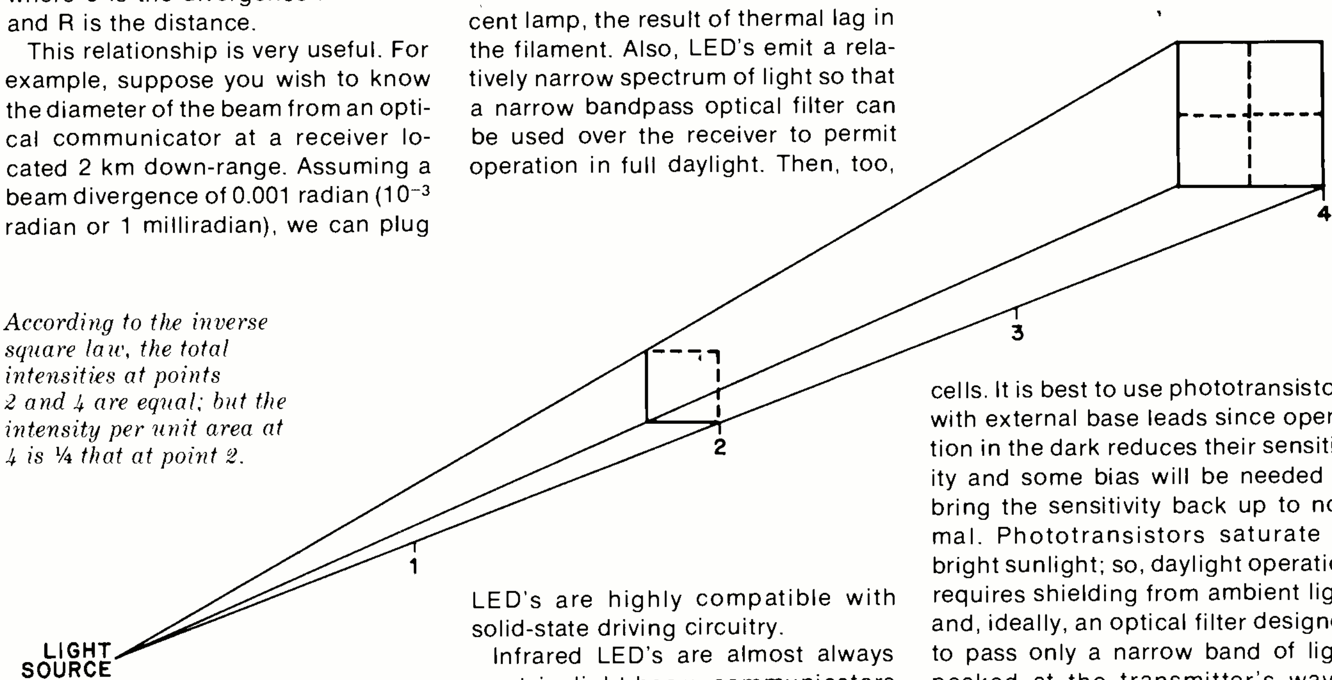
The second rule to remember is that the divergence (spread) of a light source paired with a simple lens is given by the formula $\theta = d/f$, where $\theta$ is the beam's divergence in radians, d is the diameter of the light source, and f is the focal length of the lens. (Don't be intimidated by radians. They are really a simple tool that can save you a lot of time when working with problems in optical communications.)

Remember that all numerical values must be stated in the same measurement system. In the case of optics, it is generally more convenient to use the metric system instead of the traditional "British" system of inches, feet, etc. So, let us assume that we have a 2-in. focal-length lens. Converting to the metric system (multiplying by 25.4 to obtain millimeters), the focal length can now be expressed as 50.8 mm. Now, assuming the light source to be a LED with a square chip measuring 0.5 mm on each side. Plugging these values into the above equation, we get a divergence figure of 0.5/50.8, or 0.0098 radian. Converting this answer to degrees (0.0098 × 57.3), we get 0.56° divergence.

Rule number three is: as the focal length of a lens is increased without a similar increase in lens diameter, the energy intercepted by the lense decreases. This is a particularly important rule because a long focal length gives a small beam spread. But since there is little advantage in reducing beam spread at the expense of the power contained within the beam, a compromise must be struck. The best approach is to use a "fast" lens (one with a diameter roughly equal to its focal length) to achieve small beam spread with high collection efficiency. The term "f/number" is used to define the ratio of lens diameter to focal length and is expressed as f/no = d/fl where d is the lens diameter and fl is the focal length. A lens whose focal length and diameter are equal has an f/no of 1, expressed as f/1.

The final rule to remember is that one radian corresponds to an angle which, when placed with its vertex at the center of a circle intercepts an arc whose length equals the radius of the circle. As we have already seen, one radian is equal to 57.3°. Therefore, it is approximately correct to say that the diameter of the field of view of an optical system is equal to the angle in radians times the distance or $d_{fov} = \theta R$ where $\theta$ is the divergence in radians and R is the distance.

This relationship is very useful. For example, suppose you wish to know the diameter of the beam from an optical communicator at a receiver located 2 km down-range. Assuming a beam divergence of 0.001 radian ($10^{-3}$ radian or 1 milliradian), we can plug the two numbers into the equation to obtain 2000 meters × 0.001 = 2 meters (roughly 6.56 ft). This is much faster and simpler than using trigonometry; it even eliminates the need for trig tables. In fact, simple radian calculations can be done in your head.




*According to the inverse square law, the total intensities at points 2 and 4 are equal; but the intensity per unit area at 4 is ¼ that at point 2.*

The basic rules cited above must be used properly for accurate results. For example, an internally lensed LED has a light source equal to the diameter of the lens—not the LED chip. Such a LED will give a broader beam-spread when used with an external lens than would a LED with a flat cap. Similarly, the LED with the flat cap permits less power to be captured by the external lens due to its wider emission angle. Nevertheless, it is usually best to use LED's with flat glass caps and sacrifice the power loss for the divergence improvement.

**Light Sources.** Very simple, low-cost light-beam communicators can be made using sunlight, an incandescent lamp, or a LED as the light source. Using the sun, of course, limits the useful operation period to times when the sun is at an appropriate angle in the sky. Consequently, incandescent lamps and LED's are better for general-purpose communication.

Given a choice between an incandescent lamp or a LED as the light source in a light communicator, the latter has several advantages to recommend it. LED's can be modulated at megahertz rates as opposed to the few thousand hertz rate of an incandescent lamp, the result of thermal lag in the filament. Also, LED's emit a relatively narrow spectrum of light so that a narrow bandpass optical filter can be used over the receiver to permit operation in full daylight. Then, too, LED's are highly compatible with solid-state driving circuitry.

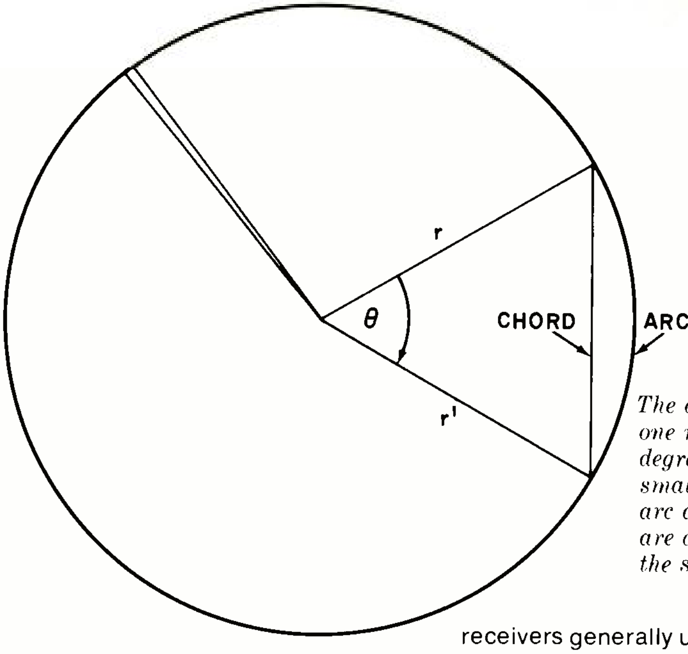
Infrared LED's are almost always used in light-beam communicators because of their greater efficiency when compared with other LED types. The two major types of IR LED's are plain gallium arsenide (GaAs) and silicon-doped gallium arsenide. Plain GaAs diodes are best where modulation rates exceed 500,000 Hz, while doped GaAs diodes are better for slower modulation rates, where they operate more efficiently than do straight GaAs LED's. (Manufacturers do not always reveal the composition of their diodes; so, check the wavelength. Straight GaAs diodes emit light at about 900 nanometers, or 9000 Angstroms, while silicon-doped GaAs diodes emit at about 940 nm.)

Amateur experimenters can communicate over long distances—more than a mile—with a well-designed LED system. Still greater distances can be obtained by going to one of the various types of lasers as the light source.

**Light Detectors.** An ordinary silicon solar cell is an excellent detector for many simple light-beam communicators. Their large active areas reduce the need for a collector lens over moderate communication ranges, a feature that greatly simplifies signal detection. Even when a collector lens or reflector is used, the cell's large detection area means that alignment is not critical as long as the focused light from the transmitter strikes some part of the active area.

Phototransistors and light-sensitive FET's have greater sensitivity and faster frequency responses than solar cells. It is best to use phototransistors with external base leads since operation in the dark reduces their sensitivity and some bias will be needed to bring the sensitivity back up to normal. Phototransistors saturate in bright sunlight; so, daylight operation requires shielding from ambient light and, ideally, an optical filter designed to pass only a narrow band of light peaked at the transmitter's wavelength.

Best operation of most light-beam communicators is obtained with a PIN photodiode. When operated in the reverse-biased mode, the PIN photodiode exhibits a linear response to light over at least seven decades of intensity. The diode can be used in




*The angle, theta, is one radian or 57.3 degrees. For very small angles, the arc and the chord are approximately the same length.*

daylight to detect a modulated light signal by using a capacitor to block the unwanted dc signal caused by ambient light. PIN photodiodes are also very good for detecting fast light pulses.

Don't buy just any PIN photodiode offered to you. The one you settle on should have a sensitivity of at least 0.35 mA/mW. Spend the $10 or $15 asked for a good diode and be sure of getting good results. (Less sensitive diodes are available for "bargain" prices, but they are not worth the investment.) You can always use the relatively expensive diode in more than one system. Simply use transistor sockets to permit quick insertion and removal.

Two very sophisticated light sensors are the avalanche photodiode and the photomultiplier tube. Both are very expensive for the average experimenter and each requires a fairly complex power supply and operating circuitry.

**Optical Devices.** Most light-beam communication systems can be built with a single optical element at the transmitter and receiver ends. Simple lenses are fine for LED systems, but color-corrected achromatic lenses should be used in multi-wavelength systems. Always use a convex lens to project light into a beam or to focus it into a point. And remember that plastic lenses can often be used but that they also absorb more light than do glass lenses.

Most transmitters will operate well with a single transmitting lens, while receivers generally use either a lens or a parabolic reflector. Another possibility for receivers is a large Fresnel lens.

For more on optical components, refer to any fairly detailed book devoted to light and optics.

**Where to Get Supplies.** The electronic portions of a light-beam communication system are generally straightforward and can be obtained from most local parts stores or mail-order houses. Good-quality LED's that are ideal for light-beam communicators are made by General Electric, RCA, Texas Instruments, Monsanto, Spectronics, and other semiconductor manufacturers. Check your local authorized dealers. Also, keep an eye out for special LED buys featured in the ads at the back of POPULAR ELECTRONICS. However, remember that surplus LED's may not have the output power capability of some of the newer LED's available from authorized manufacturer distributors.

PIN photodiodes are somewhat more difficult to come by than are LED's, but they are available. Most of this author's experiments are performed with PIN photodiodes made by EG&G, a major manufacturer of light-detection apparatus. The EG&G No. SGD-040B is a good economical diode that sells for $15 from Cramer Electronics, Inc., 85 Wells Ave., Newton, MA 02159. It has a typical sensitivity of 0.5 mA/mW at 900 nm.

Optics for light-beam communicators are available from a long list of sources. Fiber optics, for example, can be obtained from most electronic parts dealers, locally or by mail order. (Glass or low-loss plastic fibers must be used with infrared LED's, while ordinary plastic fibers can be used with most visible-light sources.)

The biggest supplier of optics for the experimenter is Edmund Scientific Co. (150 Edscorp Bldg., Barrington, NJ 08007). A free copy of the latest Edmund catalog is an essential part of the light-beam communicator's supplies. The catalog lists hundreds of lenses, parabolic reflectors, filters, and other optical components suitable for light-beam communication work.

Closer to home, you will find that an ordinary flashlight can make an excellent light-beam receiver. Simply remove the lamp and install in its place a pair of solar cells, back to back, and install an amplifier module in the place formerly occupied by the batteries. A lantern-type flashlight is best for this application because it has an internal volume large enough to accommodate the circuitry required for the receiver, including batteries, and its large reflector will easily pick up a voice-modulated beam at a half mile or more distance.

For really sensitive receivers and correspondingly greater reception ranges, try cutting off the cover lens of a sealed-beam automobile headlight with a glass saw. This is a job that requires a lot of patience and care. Wear heavy work gloves throughout the operation to the point where you remove the dangerously sharp edges of the glass with a carborundum stone, after which you can remove the gloves. Remove the filament and install the detector on the two posts, active area facing the mirrored surface of the reflector.

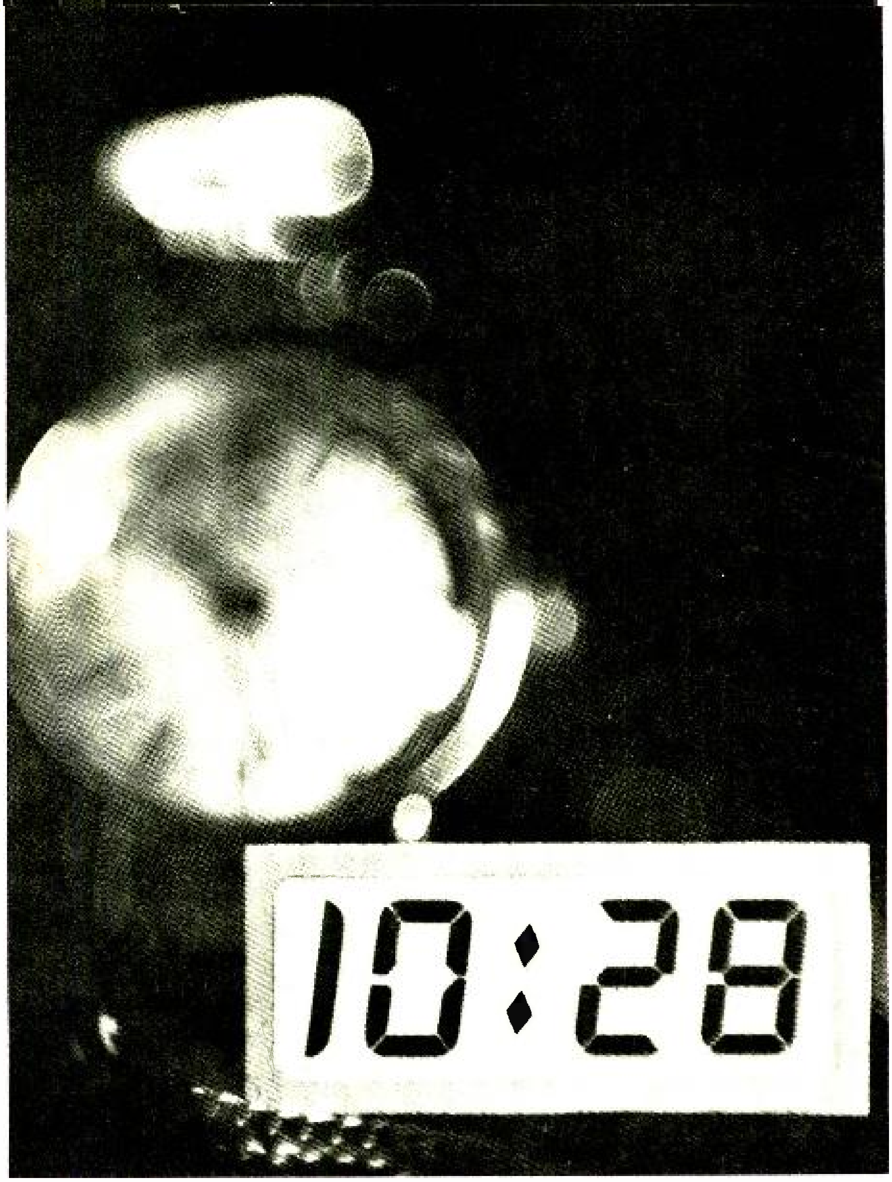
Even better systems can be made with the large Fresnel lenses sold by Edmund Scientific Co.

**More Information.** It is impossible to list and describe everything you need to know about light-beam communication equipment in a brief article. So, for more information on the topic, try any good library. Detailed information on laser diodes can be found in *Semiconductor Diode Lasers* by R. W. Campbell and F. M. Mims, while LED's and LED communicators are dealt with in detail in *Light Emitting Diodes* and *LED Circuits and Projects*, both by F. M. Mims. All three books are available from Howard W. Sams & Co., Inc., Indianapolis, IN 46268. ◈

A DISPLAY for modern digital electronic equipment would ideally have an extremely low current demand, almost infinite life, and a low price tag. While no present display design can be considered to be "ideal," the liquid crystal display, or LCD, comes a great deal closer to the mark than any of the other available types.

The latest LCD's draw only nanoamperes, as contrasted to the milliamperes and even amperes required for driving other types of displays. This current demand is a critical factor in battery-powered wristwatches, multimeters, etc. The new LCD's theoretically have infinite life, and they are relatively inexpensive when purchased in quantity.

The LCD is unique in at least one respect other than its minuscule current demand: It is *not* a light-generating device as are all the other types of displays. Instead, it uses (and requires) an independent source of light—usually ambient light—to make its activated segments visible. In the dark and under dim lighting conditions, the segments are not visible, which means that back-lighting or some other non-ambient light source must be provided. Conversely, the modern LCD becomes increasingly more legible as the ambient light level increases. (Light-generating displays operate in the opposite manner, washing out in bright ambient light but becoming more legible as the light level is decreased.)




*Siemans AG Field-Effect LCD*

# Getting To Know The Liquid Crystal Display

***When properly applied, the LCD offers many advantages over other displays.***

**BY GARY McCLELLAN**

**Types of LCD's.** There are two basic types of liquid crystal displays. The first to make its appearance was the dynamic-scatter LCD. It was later followed and has now been generally superseded by the field-effect LCD. Because of its growing popularity and the advantages it has to offer, our concentration here is on the field-effect LCD.

The field-effect LCD has risen in popularity because it requires only about 20% of the current demanded by the dynamic-scatter LCD. Furthermore, its display is a great deal more legible under a wider range of ambient lighting conditions. A display with either feature would have been instantly popular. That the field-effect LCD offers both in the same package is a welcome bonus.

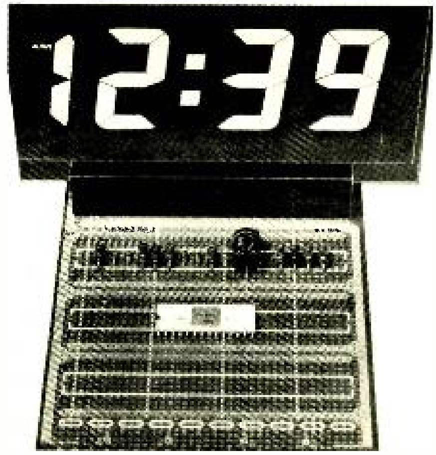
The physical makeup of a field-effect LCD is shown in Fig. 1. In the most basic terms, it consists of two pieces of glass separated by a nematic liquid (the name used for the liquid crystal material). The facing sides of the glass are coated with a microscopically thin layer of metal, so thin that it appears to be transparent. The metallization layer covers the entire active area on one piece of glass and is broken up into individually addressable, electrically isolated segment "islands" on the other piece of glass. The metallization continues from the single large area and segment islands, through the separator/seal, to the edges of the display package to provide electrical connection points for the driving circuitry.

The key to the electrical operation of the field-effect LCD is the *twisted nematic fluid* that fills the entire volume of space provided by the separator/seal between the pieces of glass. Just as important from an optical viewpoint are the polarizing filters bonded to the front and rear of the display package. The importance of the filters can be seen by powering a field-effect LCD with an ac voltage but leaving off the filters. Although the proper electrical activity would be taking place, a glance at the display would not reveal the fact. Add the filters, and the activated segments would show up sharply contrasted against the background of the display.

When the twisted nematic liquid is first placed in the cell between the two pieces of glass, its molecules arrange themselves parallel to the plane of the glass. When a voltage "field" is applied to the liquid, the molecules "twist" 90° to alter the light passing through it. (Hence the origin of the terms "field effect" and "twisted" nematic.)

The polarizing filters are equally important because they change ambient light that travels in all directions into polarized light in only one direction. This permits the nematic liquid to act like a shutter to control the light passing through the display by shifting the phase of the light. The light emerging from the nematic liquid is then converted back to its omnidirectional form to render it visible. (This sequence is shown in Fig. 2.)

It is possible to obtain either black or clear digits with a field-effect LCD. The only design change between the two types of numerals is a simple 90° rotation of one of the polarizing filters. Users of LCD's generally select the type of digits best suited for their equipment application. Wristwatch manufacturers use displays with black digits because of the sharp contrast they give against the background. Clear digits are often preferred in digital panel meters where back-lighting (usually through a milky-white or colored filter) is practical and desirable.




*LSI Computer Systems Cl200 MOS Clock Circuit drives an LCD.*

An interesting phenomenon about field-effect LCD's is that they are less prone to washing out under strong ambient light than any other type of display. The digits of a field-effect LCD actually become deeper black or clearer as the intensity of the ambient light increases.

The dynamic-scatter LCD is similar in many ways to the field-effect LCD. It differs mainly in that it does not have polarizing filters and that its segments are milky white when activated. Consequently, the construction of the dynamic-scatter LCD is the same as that of the field-effect LCD, minus the filters and with a different type of nematic liquid.

The dynamic-scatter LCD has a tendency to wash out under bright ambient lighting. So, some type of light shield is generally placed over the viewing side of the display.

All displays in the LCD lineup are available in either the reflective or the transmissive design, which means that a reflective surface, such as a mirror, may or may not be placed behind the display. Whether field-effect or dynamic-scatter LCD, the reflective display utilizes light striking its front to separate the activated segments from the background. Lacking a reflective surface, the transmissive display passes (transmits) light from the rear through the display itself.

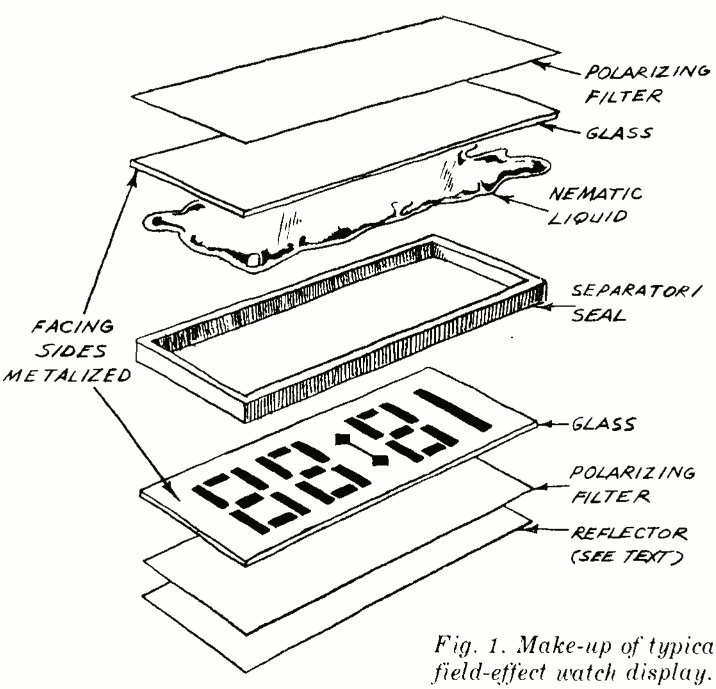



*Fig. 1. Make-up of typical field-effect watch display.*

**Driving the Display.** All LCD's require special drive voltages if they are to operate properly. Applying the improper voltages can drastically reduce the life of the display or cause the display not to operate at all. The proper driving voltage for any LCD is an ac voltage with no dc offset. Using a dc voltage or an ac voltage with a dc offset reduces the life of the display, often to only a few days, as opposed to several years with ac drive. The ac voltage applied to the display need not be sinusoidal. In fact, it is most often in the form of a square wave.

When an LCD is connected across an ac voltage source, it "looks" typically like a parallel RC circuit with resistance value ranging from 100 megohms to almost infinity and capacitance value ranging from 170 pF to 0.001 μF. Powered by a dc source, the display also looks like a 100- megohm resistance, but this time without the capacitance.

Since the display has a high resistance (and correspondingly high ac impedance), which might typically be 1000 megohms, as in a digital wristwatch, leakage in the switch and display connector become critical factors. Even if switches and connectors rated as high as 100 megohms are used in an LCD circuit, chances are that, when the humidity is high, some voltage may reach the display regardless of the position of the switch between it and the power source.

One solution to the problem is shown in Fig. 3. This is the basic circuit used to control liquid crystals. The backplane, common to all digit segments, receives a square wave signal. The segments are then either switched to the backplane or to the otuput of an inverter to turn them off and on, respectively. Switching the segment to the backplane shorts out the display. Switching to the output of the inverter applies to the display a 180° phase-shifted "on" signal. Admittedly, this is a brute-force approach, but it is very effective.

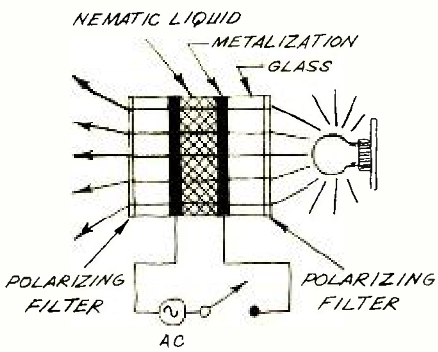



*Fig. 2. Basic theory of how liquid crystal display works.*

A driver for one segment of an LCD is shown in Fig. 4. Here, an exclusive-OR (XOR) gate takes the place of the switch in Fig. 3. It performs the same function, providing an in-phase signal to the segment when the gate input is low (off) and a 180° phase-shifted signal when the gate input is high (on). This circuit can be found almost anywhere liquid crystals are used.

The IC's used to drive LCD's are almost invariably CMOS devices. The reason for this is that, when a CMOS output stage goes low, the output looks like a resistor. (With TTL, DTL, and other IC families, the output looks like a diode that rectifies and puts dc on the display.) This is one of the reasons CMOS and LCD's are usually found together.

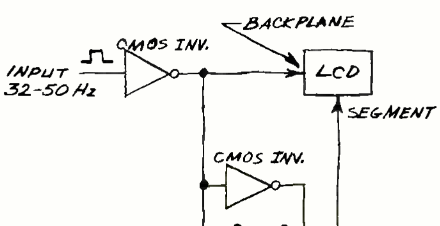



*Fig. 3. Practical circuit for driving an LC display.*

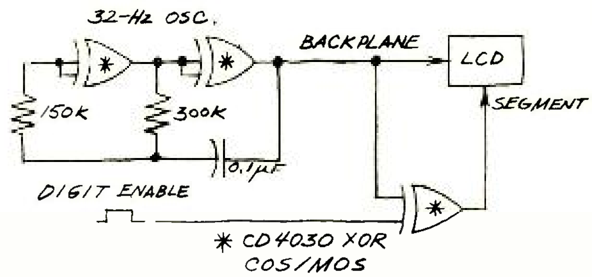



*Fig. 4. Standard driver configuration for an LC display.*

The drive voltage's amplitude in an LCD circuit is important. At least its rated voltage must be supplied to the display, which is the normal battery voltage in most CMOS systems. It is usually safe to exceed this voltage without harm, but the display segments might start to come on without being addressed as a result of internal display leakage if the voltage applied is too high.

The duty cycle and frequency of the drive voltage are equally important. The duty cycle must always be 50%, with equal on and off times. Anything other than a 50% duty cycle causes a dc offset that must be avoided. The frequency of the signal is usually about 32 Hz. Most displays have limited frequency responses, and 32 Hz is about optimum.

**Choosing a Display.** There are a number of things to consider and pitfalls to avoid when choosing an LCD. While it is true that you can use almost any LCD in almost any project, some preplanning can prevent your efforts from coming to grief at a later time.

First, consider the range of temperatures to which your project is likely to be subjected. Obviously, if it is to be operated reasonably near normal room temperature, you need not concern yourself with temperature problems. But if your project is going to be operating near 0° C (32° F), bear in mind that the display is going to respond very slowly, taking from several seconds to a few minutes for the digits to form and stabilize. On the other hand, where high operating temperatures are expected, consider putting the display in a cooler place, away from the instrument itself. Otherwise, the heat (up to 50° C in some environments) is likely to destroy the display.

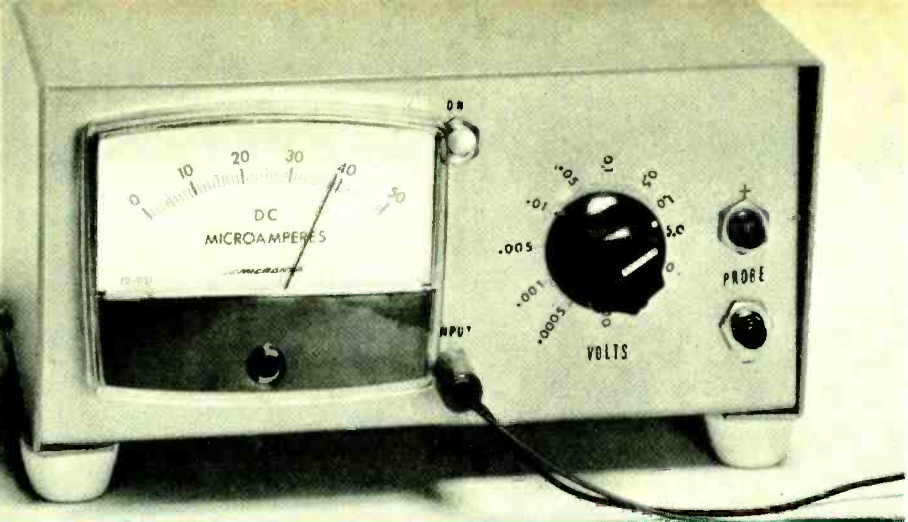
Bear in mind that you must be able to provide the proper voltages and phases to the display. Use a 32-to-50-Hz, 50% duty-cycle square-wave driving signal, and make sure its amplitude is at least the rated (but not exceeding twice the rated) driving voltage for the LCD. And do not forget to provide an XOR gate for each segment of the display as mentioned earlier.

Liquid-crystal displays are slower to respond than are other types of available displays. They are also more sensitive to the ambient temperatures at which they are operated. Consequently, an important factor to consider with your project is the speed at which the display must be able to respond. For digital clocks, watches, thermometers, multimeters, etc., the response of the typical LCD at normal room temperatures is sufficient. But where fast response is important, such as in frequency/events counters and computers, the response speed of the LCD, even under the best operating conditions, may prove too much for the display to handle. In such a case, you would be better off to consider an alternative display.

Now that they are becoming available through such outlets, you will in all likelihood be buying your LCD's from the surplus companies who advertise in the back of this and other magazines. But before you send in your order, carefully check the display descriptions in the ads to make sure that what you are ordering is what you want. If the description is incomplete, write to the dealer (or manufacturer if the company's name is given) for data on the display.

When you order, make certain that a connector is available for the display of your choice. In fact, take no chances; buy display and connector at the same time. Do not try to get along without a connector by soldering wires to the metallization layer along the display's edges. All you will accomplish is the destruction of the display.

The best way to become familiar with and find out the advantages of the liquid crystal display is to experiment. You can use an inexpensive display, even a "second" reject. Once you become familiar with them you are ready to incorporate LCD's in your digital projects. ◈




BUILD THE

# MINIVOLTER

PE TESTED

BY JOHN F. HOLLABAUGH

- *Twelve ranges from 500 μV to 100 volts full scale.*
- *Doubles as ohmmeter down to 0.02 ohm.*
- *Use to measure current down to 10 nA.*
- *Costs under $20.*

NOW you can have a voltmeter that measures from 500 microvolts to 100 volts full-scale, in 12 overlapping ranges, costing less than $20. Designed for use on circuits where a little voltage makes a big difference, the sensitive Minivolter is ideal for use on solid-state equipment. In these low-voltage circuits, many conventional meters can't be used because of their relatively low input resistance. The input resistance of the Minivolter is one megohm per volt, drawing a current of one μA.

The Minivolter can also measure ac voltages if a 1.2 multiplier is used. And it will serve to indicate r-f levels in orienting TV antennas and to peak the low-level stages of transmitters.

**How It Works.** As shown in Fig. 1, op amp *IC1* is used as a voltage follower and *IC2* as a linear rectifier. Any voltage applied to the (−) input of *IC2* is multiplied by the gain of the op amp and inverted. The difference between the input (pin 2) and the output (pin 6) is high enough that the fixed voltage drop across *D1* and *D2* can be hidden by the drop across the series portion of *R15*. So the difference can be considered not to exist. Also, the diode barrier potential (0.7 volt) does not place a lower limit on the value being measured since any practical value of voltage applied to the input causes some current to flow through the meter circuit.

If a positive voltage is applied to pin 2 of *IC2*, current flows through *D2*, controlled by *S3* (PROBE +), the meter, and part of *R15*. If a negative voltage is applied to pin 2 of *IC2*, the current flow is from the positive output and through *D1* back to the input. The current is actually from the input source since no current can be taken from the input terminal of the op amp. This current is between two and three times the meter rating for full-scale deflection. (In the prototype, the current was 2.8 times the 50-μA meter current or 140 μA.) The sensitivity of the meter has been reduced from 30,000 ohms/volt to 6800 ohms/volt, but we have gotten around the diode barrier drop. For a full-scale indication of 500 microvolts, the input resistance of *IC2* now looks like 3.6 ohms (500/140), which is not very good for a voltmeter. Thus it is necessary to use *IC1* as a voltage follower.

The voltage follower has a high input impedance and low output impedance due to the high open-loop gain of the 741 op amp. This makes it easy to match the high input impedance required of a voltmeter to the low impedance required by the linear rectifier.

Some compromises have been made in the design of the range selection circuit due to the high offset current of the 741 op amp. A voltage-divider type of selection (as in conventional VTVM's) would be preferred because of the better input resistance on low ranges. However the voltage divider would have a value of shunting resistance across the input of the voltage follower which would require a rezeroing of the meter each time the range is switched. With the conventional 10-megohm resistance, the bias voltage generated across the input would be 10 X $10^6$ times 500 nA or 5 volts for the 500-microvolt range. Thus the conventional resistor approach was used instead of a voltage divider.

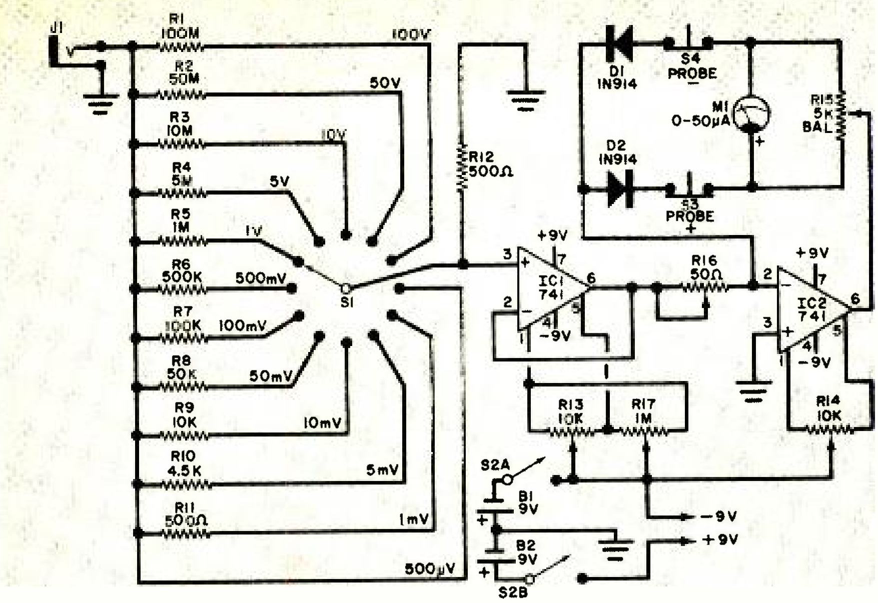
**Construction.** Most of the components can be wired point-to-point. A small board is required to mount the sockets for the IC's. Two 8-pin "mini-DIP's" can be accommodated in one 16-pin socket.

The potentiometers (except for *R17*) can be fastened with epoxy cement at convenient locations within the cabinet. Once they are adjusted, it is not necessary to have access to them. Install *R17* on the rear apron for easy access. Connect the range selector resistors to the appropriate terminals on *S1*. As noted in the Parts List, the high-value resistors can be made up of smaller units.

The 9-volt power supplies are made up of conventional AA cells in plastic holders.

**Calibration.** Before applying power to the Minivolter, connect a 10,000-ohm potentiometer across the meter and set the potentiometer to its minimum value. Adjust *R13* and *R14* to the far ends of their adjustments. Then back them off about 13 turns. Set *R17* to its midposition, and set *R16* to its maximum value.

Apply power to the Minivolter. Adjust the potentiometer across the meter until the meter gives an upscale reading. Then adjust *R13* and *R14* to make this reading a minimum. Progressively increase the value of the meter-shunting potentiometer and adjust the two trimmer potentiometers to obtain a zero until the shunting potentiometer can be removed from the circuit. Trim *R13* and *R14* a final time.




## PARTS LIST

B1, B2—6 AA cells each
D1, D2—1N914 diode
IC1, IC2—741 op amp
J1—Phono jack
M1—0-50-µA meter (Radio Shack No. 22-051 or similar)
Following resistors are ½-watt, 5%:
R1—100 megohms (five 20 megohms in series)
R2—50 megohms (five 10 megohms in series)
R3—10 megohms
R4—5 megohms
R5—1 megohm
R6—500,000 ohms
R7—100,000 ohms
R8—50,000 ohms
R9—10,000 ohms
R10—4500 ohms (two 9100 ohms in parallel)
R11, R12—500 ohms
R13, R14—10,000-ohm, miniature, multiturn trimming potentiometer
R15—5000-ohm, miniature multiturn trimming potentiometer
R16—50-ohm, miniature multiturn trimming potentiometer
R17—1-megohm potentiometer
S1—Single-pole, 12-position rotary switch (Radio Shack 275-1385 or similar)
S2—Dpst switch
S3, S4—Normally closed momentary-action pushbutton switch
Misc.—IC socket(s), battery holders (Radio Shack 270-384), battery clips, suitable enclosure (LMB No. N463), mounting hardware, rubber feet (4), wire, solder, etc.

*Fig. 1. IC2 forms a linear rectifier for the meter, while IC1 is a voltage follower to give high input impedance.*

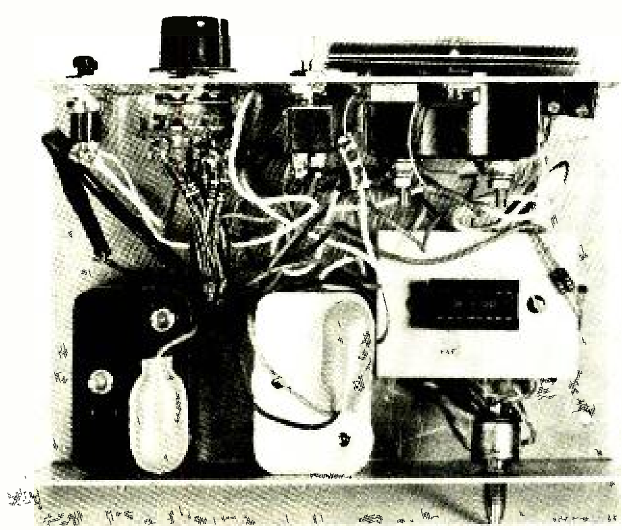


*Photo shows how components were laid out in prototype.*

Set *S1* to a range suitable to measure a voltage known to be accurate (voltage reference or battery) and adjust *R16* until the meter indicates the known voltage. Disconnect the reference and rezero the meter with *R13* and *R14*. Repeat these last two steps until calibration and meter zero are obtained.

The last part of calibration should be repeated if the meter tends to drift because of temperature effects on *IC1*. This drift will be about 1/50 of the meter range. After calibration, if the meter has been out of operation for some time, the drift will cause an upscale deflection when the Minivolter is first turned on. Do not re-adjust for this condition; it will disappear after a few minutes of warm-up.

To balance the polarity of indication, alternately apply the known dc voltage to the input and, operating the appropriate switch, adjust *R15* to remove half of the difference of each reading. Do this until both readings are the same to insure the independence of polarity at the meter input.

**Use and Applications.** After turning on the Minivolter, allow a couple of minutes for the IC's to warm up, noting that the meter goes to the zero mark. If it does not do so after a reasonable period, adjust *R17* to obtain a zero. Make this adjustment with *S1* in the 100-V position.

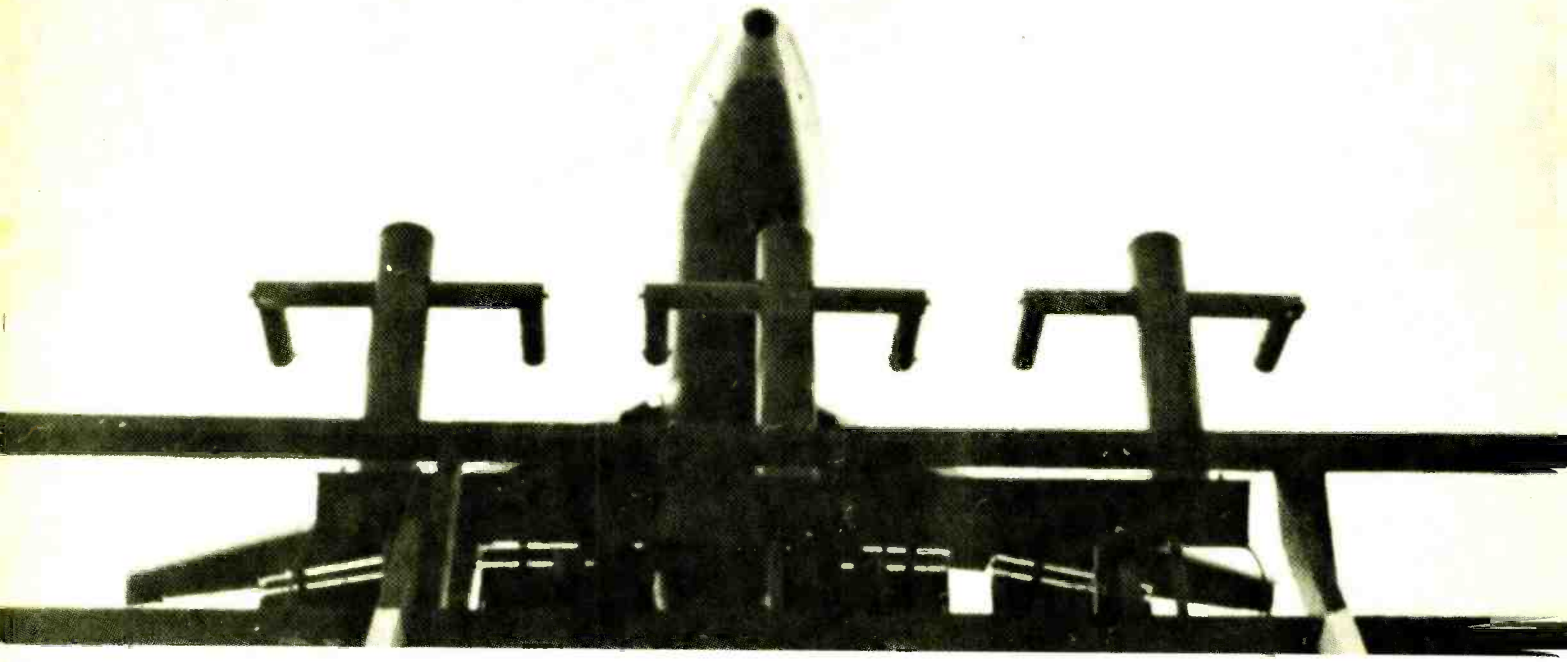
One can think of many unusual uses for the Minivolter. Here are some examples:

- It can measure the voltage across a junction of dissimilar metals when heated (thermoelectric effect) or the voltage generated across a conventional glass-enclosed semiconductor diode when exposed to light.
- Voltages across a solder joint or connector can be measured for either an ac or dc drop with normal current flowing through the circuit.
- With a loop of wire connected across the input, the Minivolter can be used to trace stray magnetic fields from power transformers, power lines hidden in walls, etc.
- By connecting the Minivoltor across an unknown resistor having a 1-mA current flowing through it, the instrument becomes an ohmmeter with readings down to 0.02 ohm.
- Switching to the 500-µV range, the Minivolter can be used as a 1-µA meter having an internal resistance of 500 ohms. (It can measure currents down to 10 nanoamperes.) ◈

CAREER GUIDE:

# HOW TO BECOME AN FAA ELECTRONICS TECHNICIAN

BY THOMAS R. SEAR



*Now is an opportune time to get started in one of the most rewarding careers in electronics.*

THERE are many routes to career development in electronics, but few are more exciting and rewarding than becoming an electronics technician for the Federal Aviation Administration. Currently, there are approximately 9000 electronics technicians in the FAA who help the Air Traffic Control Specialists (ATCS's) to maintain an outstanding record of service and safety.

The electronics extensions of the ATCS—communication equipment, radar, teletype, etc.—offer excellent career opportunities for those people who can qualify for the various FAA electronics technician positions. And this is a particularly opportune time to seek those positions. Right now, and for the foreseeable future, openings will be available as technicians who joined the FAA after World War II go into retirement.

Not everyone can get a job with the FAA. There are only 9000 positions in the entire country, and that number is not likely to change soon. So, what positions there are draw stiff competition. But an on-the-ball technician who lands one of the positions can look forward to a rewarding career where he can earn as much as $20,000 a year in an interesting job.

**Type of Work.** As a prospective technician for the FAA, an applicant has six basic options, or career fields, in which he can choose to specialize. They include: navigational aids, communication equipment, systems installation, relief work, radar, and computers. Each option has strong points, and which of them an individual works in depends on his goals, abilities, aptitudes, and the needs of the FAA. In general, and where possible, the interests of the individual are given primary consideration.

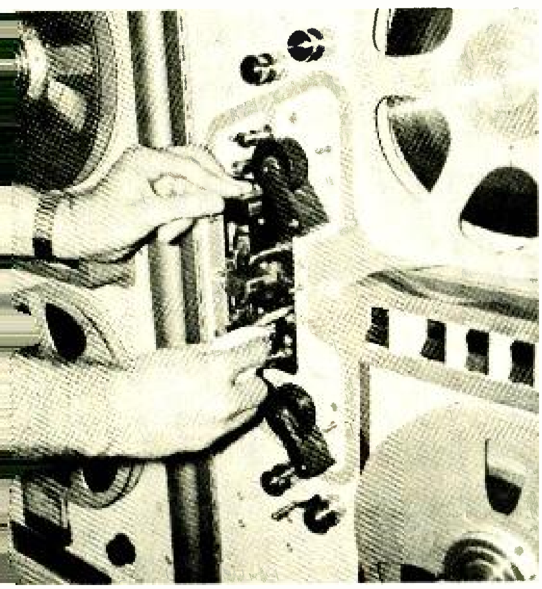
Whatever the option, the work of the technician is seldom boring or routine. Most technicians are certified to work on several types of equipment, which means that the day-to-day tasks they perform will usually be different on any two consecutive days.

There are also routine tests and measurements whose results must be evaluated and analyzed for trends that might lead to equipment failure. In addition, the technician is responsible for the repair and calibration of his test equipment, checking the operation and fuel level of his stand-by power plant, measuring and analyzing VSWR, frequency, and power as required. He must also perform checks on electronic navigation signals generated by his system for use by aircraft. Testing antennas, transmission lines, and control lines and checking airport weather equipment are other duties of an FAA technician.

Measurements are a routine part of the technician's job, whether they be of bandwidth and sensitivity of his equipment, the specific gravity of a bank of storage batteries, or the depth of snow as he walks into a site in the mountains on snowshoes. Weather is not allowed to prevent the technician from performing his duties, not when lives are at stake.

When the technician is not actually testing or repairing the equipment for which he is responsible, he might be in the shop modifying equipment, the stockroom checking supply levels, or office making out reports. If things are really slow, he can take time to work on one of the many college-level correspondence courses offered personnel by the FAA. These are free of charge for use in career development.

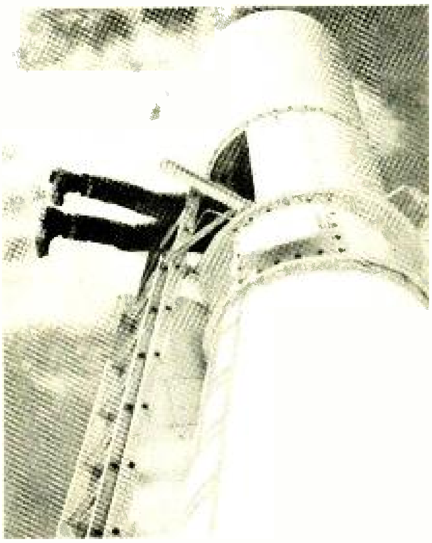
**Who Can Qualify.** Although any normally healthy citizen of the U.S. is eligible to apply for a job with the FAA, not just anyone can become an FAA electronics technician. The nature of the work demands an individual who has had extensive technical training and who is able to accept the fact that lives depend on how well he performs his duties. By themselves, these two factors narrow the field of applicants considerably.



*Technician checks ten-channel tape recorder used to make semi-permanent record of communications between controllers and aircraft.*

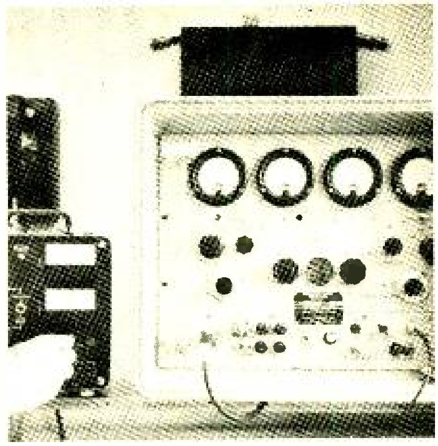
The FAA, very selective in its hiring, further narrows the field. First, an applicant must pass a series of Civil Service tests to achieve status on the applicable register. (The register is a listing of interested people according to the scores achieved on the tests taken.) When an opening occurs, the person whose name heads the applicable list is called in for intensive interviewing. Only the best qualified person will get through this screening process.

The qualification process is based on two factors. First, all federal hiring is based on merit—the best qualified are hired, promoted, etc. The second factor is that once an applicant is hired by the FAA, that is only the start of really extensive technical training. No matter how well-trained an applicant appears to be, he must prove to the FAA that he can perform his job according to specified standards. This means that he must pass a certification examination on every type of equipment upon which he might be required to work. (The certification procedure is roughly similar to the licensing program conducted by the Federal Communications Commission for commercial radio operators and repairmen.)



*Difficult position is required of technician shown here working on the bearings of a TACAN rotating antenna assembly.*

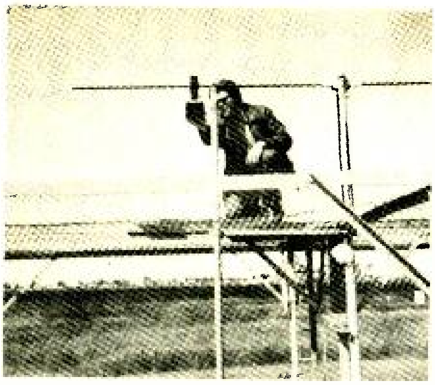
**Training Program.** The first step in training an FAA electronics technician may or may not be a period of on-the-job training to familiarize him with the equipment upon which he or she (yes, the FAA offers equal employment opportunities to men and women) will be working. Then the technician is sent to Oklahoma City to attend the FAA Academy at Will Rogers Airport. Here, the new technician will spend from several days to 52 weeks, depending on the option involved, in intensive training to assimilate in-depth knowledge related to his new duties.



*Calibrating one of the many specialized test instruments—a portable instrument landing system field detector, at left.*

The time a technician is required to spend at the FAA Academy is a function of the equipment involved. Getting through the training at the Academy is no easy task. In addition to spending eight hours a day, five days a week, in classroom and laboratory work, the average technician might have to give up a good portion of each evening and weekends to study. No one is permitted to fall behind. And to make certain they do not, a written examination and/or performance test, based on the week's work, must be passed every week. Failure to maintain a grade average of at least 70% results in the technician's being shipped back to his duty station without being given the opportunity to finish the course. (Such a result is less than desirable on a technician's record because progress in the FAA is a function of displayed ability.)

When the technician returns from the Academy, having successfully completed the program of training, he is permitted a period of readjustment. Then he is scheduled to take the applicable certification exam. During the exam, the technician is required to demonstrate his ability to perform specified tests, measurements, adjustments, and usually repairs on the system.



*Measuring critical antenna current on system which sends markers to an aircraft during final approach on instruments.*

The time needed to complete a certification varies from as short as 1 hour to as much as 40 hours, depending on the system involved. There are "lock-out" questions on the exam that can fail the technician if he cannot perform or answer them. Inability to satisfy a single lockout item, all of which are considered to be tests that are critical to the maintenance of the system, means that the technician must repeat part or all of the exam in not less than 30 days from the date of failure.

**Career Development.** The type of individual who makes it to the top in his particular area in the FAA is the creative person. Mindful of this, the FAA has developed a program that provides those people who wish to do so the opportunity to progress to positions of greater responsibility. For the technician, this means the opportunity to become an engineer if he wants to make the effort. Each year, all technicians are given the opportunity to apply for selection as an engineer development candidate.

From those people who apply for the positions, the best are selected and assigned to engineering-type positions at an FAA facility near a suitable college. Successful applicants generally have at least two years of college already; the FAA allows them up to two more years of study to achieve engineer status. This can be accomplished either by earning an engineering degree or by passing the Engineer-in-Training exam for the state in which the applicant is working.

During the two years allowed for completion of the program, the applicant works for the FAA, under the direction of a professional engineer, on engineering problems. Approximately half of his normal work week is spent attending classes. Only technical courses are authorized by the FAA under the program, and nothing less than a C average is acceptable in a given course.

**Salaries and Benefits.** The pay that the FAA electronics technician receives is based on his skill, training, demonstrated ability, and time on the job. For an individual just entering FAA service, annual base pay might be on the order of $5000 or so. For the "old timer" who has worked hard to get ahead and has 15 or more years with the FAA and has reached first level, base annual pay can reach $20,000.

*Technician checks that radiation pattern of his VOR system is within tolerances required by the FAA for radio-navigation.*

The benefits the FAA technician receives include vacation and sick leave. Vacation time is accrued by the technician at a rate of 20 days per year during the first 15 years of Federal Service. Thereafter, vacation is accrued at a rate of 26 days per year. Sick leave is authorized at a rate of 13 days per year, regardless of rank or time in service. Unused sick leave can be saved until it is needed.

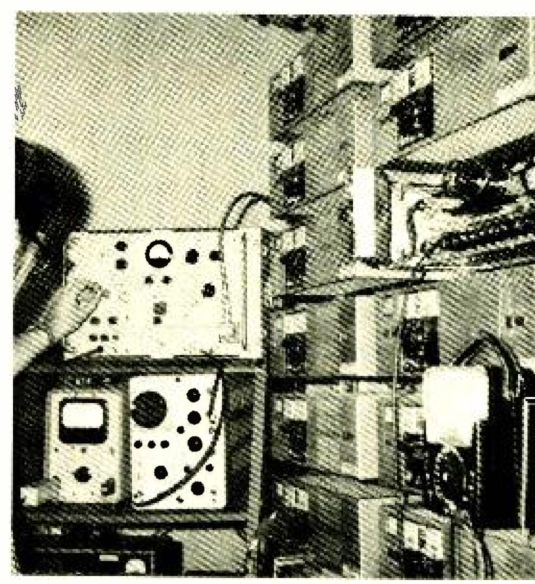
**How to Apply.** All in all, a career as an electronics technician with the FAA is hard to beat. If you are interested in pursuing a career as an FAA technician, the first step is to go to your local post office and ask for standard Federal Employment Application Form No. SF-171.

The form consists of at least four pages, each of which must be filled in with the information required. So, be careful when you fill it out, and don't rush the job. Remember, this form is the only means the Civil Service Commission has of initially evaluating you.

When you have completed the form, mail it to the FAA Regional Office nearest you. (A complete list of Regional Office addresses can be obtained by writing to FAA Headquarters, 800 Independence Ave., S.W., Washington, DC 20591.) However, if you are seeking a position in another area of the country, send your application to the Regional Office that has responsibility for that area. The Regional Office will then process your application, after which it is only a matter of time before you are contacted. But do not be impatient. Contacts are made only when a position has been vacated and must be filled.

Ordinarily, FAA technician positions are not vacated all that often. But, as mentioned earlier, this is a particularly opportune time. The 30-year veterans of FAA service are now retiring, and others will be going into retirement during the next few years at a rate much greater than during any previous period.

If your luck holds, that first contact from the FAA will arrive soon. Meanwhile, bone up on your electronics theory and algebra because once you are contacted, you will not have time for studying. So, be prepared for the battery of tests you will be required to take. Your scores on them will decide whether or not you are going to make the FAA technician team. ◈



*Some of the test equipment used to check a 70-MHz i-f strip in a 6-channel radar information microwave link repeater site.*

# Product Test Reports

## ABOUT THIS MONTH'S HI-FI REPORTS

*There seems to be a strong trend toward super-deluxe "high end" audio components coming from a number of manufacturers. The Kensonic Accuphase C-200 Preamplifier is an excellent example of what can be done when skilled design engineers are given free rein to develop the best possible product, free of the usual cost restrictions. In addition to a degree of flexibility and performance not likely to be approached by lower-priced components, the C-200 has an aura of precision and workmanship that go a long way toward justifying its considerable cost.*

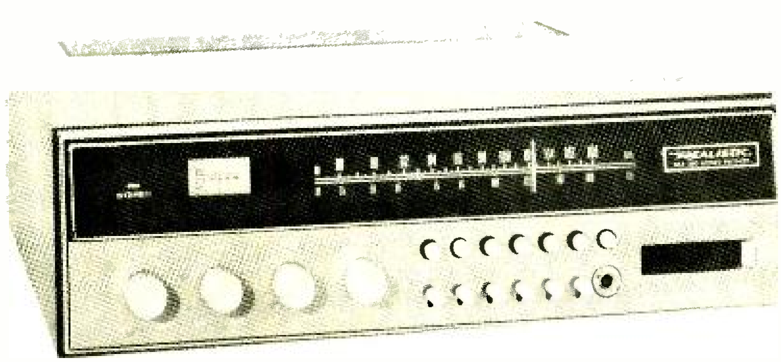
*Near the other end of the price scale is a medium-power stereo receiver, the STA-250 by Realistic, that manages to combine much of the operating versatility and electrical performance of some far more expensive receivers. With a price tag only slightly above the lowest priced stereo receivers, it shows quite effectively that very satisfactory high-fidelity performance is possible at a surprisingly low price.*

*Some audio components manage to achieve such lasting and widespread acceptance that their manufacturers continue to produce them for years instead of replacing them annually with "new" or slightly face-lifted models. In phono cartridges, the Stanton 681EE has long been recognized for its unusually flat, uncolored response, combined with physical ruggedness. Stanton has made some further improvements, principally in reducing the moving mass, that result in a fine cartridge's becoming even finer. The result is the new 681EEE—basically almost identical to the "double-E" but nevertheless significantly improved.*

*—Julian D. Hirsch*

## REALISTIC MODEL STA-250 AM/STEREO FM RECEIVER

*Excellent FM tuner section and 44 watts/channel.*



The Realistic Model STA-250 receiver, available from Radio Shack, offers an excellent AM/stereo FM tuner and a relatively powerful audio amplifier at a price of only $319.95. The 44-watt/channel rating (specified over a frequency range of 20 to 20,000 Hz into 8-ohm loads with both channels driven simultaneously) at less than 0.5% distortion is unique in the price range of this receiver. This power performance is rarely ever available in receivers that list for less than $400. And that is not all, because the STA-250's tuner specifications are also comparable to those of many receivers that are costlier.

**General Description.** The flywheel-type tuning "knob" in this receiver is horizontal, accessible through a slot in the front panel. The receiver's TREBLE, BASS, BALANCE, and VOLUME controls are of more conventional design, employing traditional control knobs. The program source, mode of operation, tape monitoring, and power are selected by a system of pushbutton switches. Six lever switches are provided for switching in and out the LOUDNESS compensation, FM MUTE, HI and LO filters, and MAIN and REMOTE speaker outputs. A jack is also provided for stereo headphones.

Behind the receiver's black-out dial window are the logging scales and a single tuning meter that light up in a soft green color when power is turned on. The meter, a zero-center type, is for FM tuning and indicating relative signal strength on AM. The legend FM STEREO appears in white when a stereo broadcast is being received.

On the rear apron are located all inputs, outputs (except headphone), and a resettable circuit breaker for line power. Two unswitched ac accessory outlets are provided for convenience. There are two sets of PHONO inputs, either of which can be selected by setting a slide switch to the appropriate position. Another switch has positions for setting up the PHONO inputs for CERAMIC or MAGNETIC cartridges.

The receiver has three pairs of speaker outputs, all of which are available at phono jacks instead of the more usual screw- or clip-type terminals. Two outputs are for the MAIN and REMOTE speaker systems selected by the switch on the front panel, while the third is for rear speaker systems that can be driven with a derived L−R signal to produce a pseudo-quadraphonic or enhanced stereo effect from the receiver's "Quatravox" circuit. A slide switch activates the special rear outputs.

The Realistic Model STA-250 receiver is supplied with a wooden, walnut-finished cabinet. It measures 16⅞ in. wide by 15½ in. deep by 5¼ in. high (43×40×13.3 cm) and weighs roughly 23 lb (10.5 kg).

**Laboratory Measurements.** The receiver's FM tuner measured 2.0 µV in mono and 6.5 µV in stereo in the IHF usable sensitivity test, the latter also being the stereo switching threshold. The 50-dB quieting sensitivites in mono and stereo were both excellent at 2.7 µV and 30 µV, respectively. The

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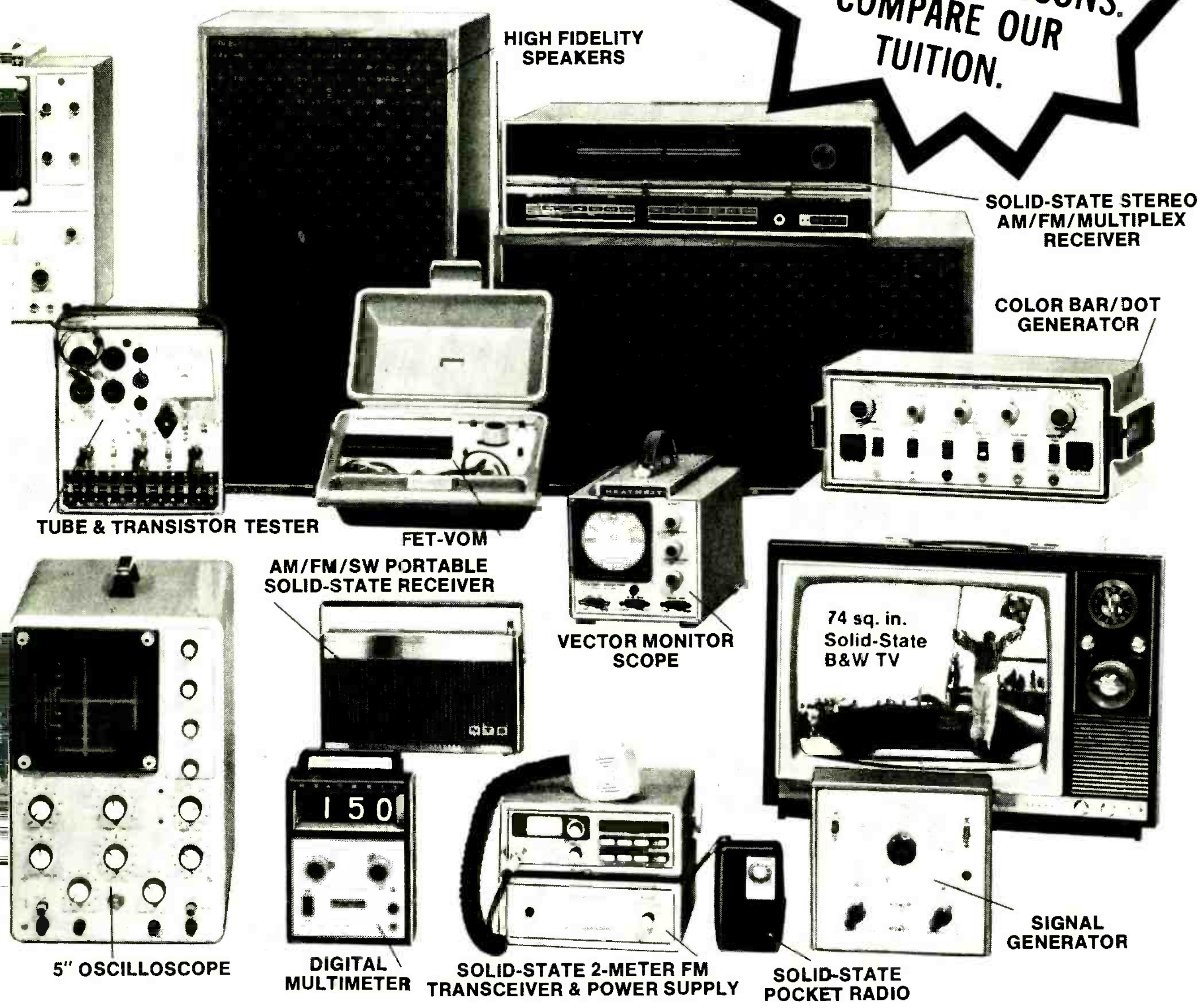


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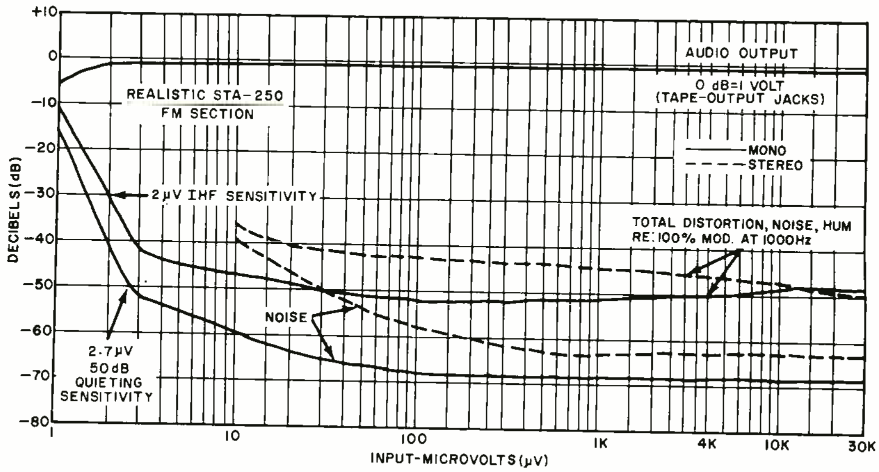
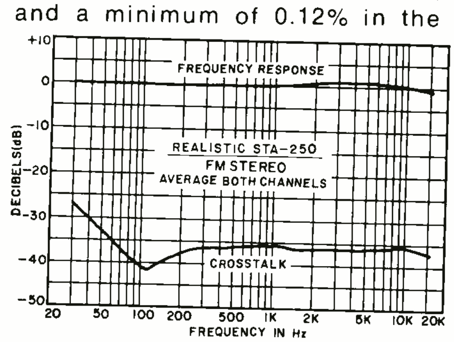
ultimate distortion, at a 1000-µV input, was 0.3% in mono and 0.63% in stereo, while the ultimate S/N was 68 dB and 63 dB in mono and stereo. The FM muting threshold measured 4 µV.

In stereo operation, the FM frequency response measured ±0.5 dB from 30 to 12,000 Hz and was down 1.1 dB at 15,000 Hz. The stereo channel separation was very good, exceeding 36 dB from 60 to 15,000 Hz and was still 26.5 dB at 30,000 Hz.

The capture ratio was exceptionally good, measuring 0.7 dB at a 1000-µV input and 1.6 dB at 10 µV. The AM rejection was 37 dB, except at very high signal inputs, where it reached 48 dB at a 10,000-µV input. Image rejection was 68.5 dB and alternate-channel selectivity was 65 dB, both good figures. The AM tuner's frequency-response characteristic caused the output to fall to −6 dB at 2500 Hz.

The conservatism of the audio power ratings of the receiver's amplifiers was demonstrated by the 1000-Hz clipping output power we measured at 56.5 watts/channel into 8 ohms, 75 watts into 4 ohms, and 36 watts into 16 ohms. At 1000 Hz, the THD was 0.16% at 0.1 watt and decreased smoothly to 0.07% at 1 watt and 0.025% between 20 and 50 watts, just before clipping. The IM distortion characteristic was somewhat similar, with the usual higher values of distortion: 0.4% at 0.1 watt, 0.26% at 1 watt, and a minimum of 0.12% in the 30-to-50-watt range. The distortion in the outputs was primarily due to "crossover" or notch distortion, which results in an increase in the measured value as the output power is reduced. The IM distortion rose to 1% at about 15 mW and to almost 4% at 1.5 mW, although at the usual listening levels of a few tenths of a watt or more, it was less than 0.25%.



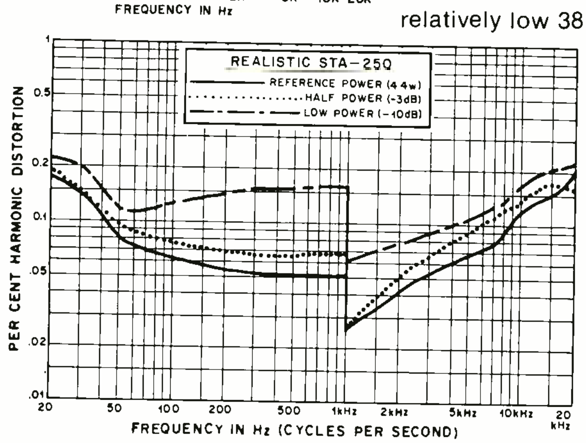

At full rated power and half power, the distortion in the audio amplifiers was less than 0.1% over most of the audio-frequency range. It reached a maximum of about 0.2% at 20 Hz and 20,000 Hz. The measurements at frequencies below 1000 Hz included the residual hum level, which was generally greater than the actual distortion. When we were able to use the high-pass filter in our distortion analyzer for measurements beyond 1000 Hz, it was obvious that the distortion was between 0.025% and 0.05% at most audible frequencies.

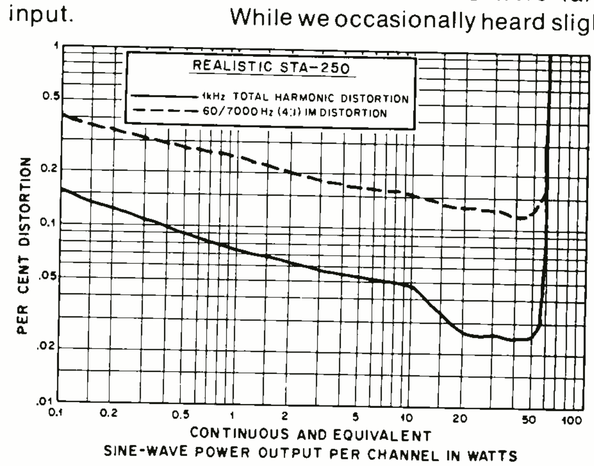
To attain a reference output power of 10 watts, a signal of 36 mV was required at the AUX inputs or 0.75 mV at the PHONO (MAGNETIC) inputs. The respective S/N ratios were 63 dB and 57 dB, with the "noise" consisting mostly of hum. Phono overload occurred at a relatively low 38 mV input.

The tone controls had conventional characteristics, and the loudness compensation boosted only the low frequencies to a moderate extent. The RIAA equalization was accurate within ±0.5 dB from 50 Hz to 20,000 Hz. However, the high-frequency phono response was influenced by cartridge inductance to a greater degree than is the case with many amplifiers, resulting in a drop of 2 to 5 dB in output at 15,000 Hz, depending on cartridge inductance. There was no effect on the response at frequencies of less than 10,000 Hz.

**User Comment.** The FM tuner section in the receiver was able to match—and occasionally surpass—the performance of some far more expensive tuners in receiving weak signals without excessive noise or distortion. With signals of normal strength, the tuner sounded exactly like "component" tuners costing a great deal more than the going cost of the entire Model STA-250 receiver.

We listened to the receiver at considerable length, using various types of speakers, and made A-B comparisons with other amplifiers whose measured distortions were far less. While we occasionally heard slight dif-



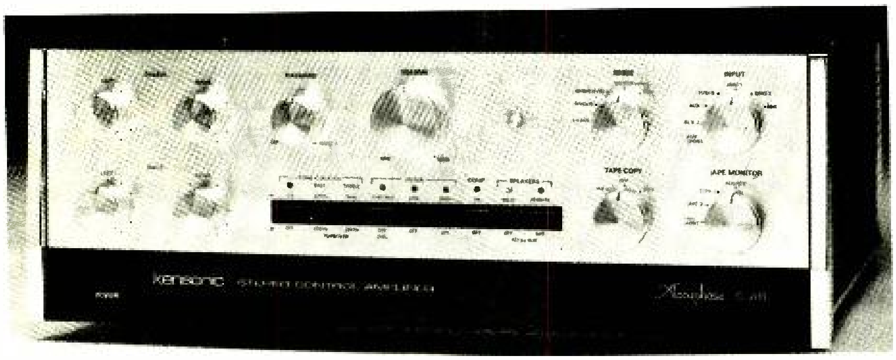
ferences between the Realistic and other receivers, they were merely differences, neither superior nor inferior sound characteristics. The Realistic receiver always sounded fine, and it was certainly better in quality than that inherent in the FM programs available to us.

It is manifestly unfair to compare the $320 Realistic receiver with other re- But we know of no other receiver at or even near its price that can match the combination of top-quality FM tuner performance and exceptional audio power capability of the Realistic Model STA-250 receiver. When used with good medium-priced speaker ceivers selling for hundreds of dollars more, even though many aspects of its performance invite this comparison. systems, record player and cartridge, and tape equipment, it could compete effectively in sound quality and overall user satisfaction with other receivers costing twice as much. To our way of thinking, this is a consideration that completely overshadows mere specifications or even laboratory bench performance figures.

CIRCLE NO. 65 ON READER SERVICE CARD

## KENSONIC MODEL C-200 PREAMPLIFIER

*Complementary-symmetry, push-pull design in every stage.*



HIRSCH-HOUCK LABS REPORT

The Kensonic "Accuphase" Model C-200 is a high-grade hi-fi system control preamplifier. Its performance specifications are exceptional, backed up by a high degree of operational flexibility and rugged quality construction. Manufactured in Japan by Kensonic Laboratories, Inc., and distributed in the U.S. by Teac Corp. of America, this preamp is rather unique in that it features a fully complementary-symmetry push-pull design in *every* stage from phono preamplifier to output stage.

**General Description.** The preamp has inputs for stereo microphones, two magnetic phono pickups, and four high-level sources. It can control two tape recorders from the front panel, with full monitoring capability. Additionally, the user has the option of copying from either recorder to the other while listening to a different program through the amplifier. There are also recording and playback connections for a third tape deck, but without the monitoring feature.

A MODE switch offers a choice of stereo programs with normal or reversed channel orientation, left-plus-right mono programs, or either left- or right-input mono through both channels.

The separate bass and treble controls for the two channels, each an 11-position switch, are teamed with conventional volume and balance controls. Pushbutton switches permit selection of different turnover frequencies for the tone-control setup (200 or 400 Hz for the bass and 2500 or 5000 Hz for the treble) or bypass the tone control circuits entirely.

A low-cut filter that operates below 30 Hz with an 18-dB/octave slope and a high-cut filter that operates above 5000 Hz with a 12-dB/octave slope can be switched in and out as desired. Also switchable is a subsonic filter that works with only the phono inputs, cutting off below 25 Hz at a 6-dB/octave rate when switched in.

Pushbutton switches are provided for loudness compensation and two pairs of speaker outputs from the power amplifier (in this case, the companion Kensonic Model P-300 amplifier). An optional remote switching relay accessory is available for the latter function.

The input and output jacks for the third tape deck, a headphone jack, the two auxiliary microphone jacks, a high-level source jack, and a second set of preamplifier outputs paralleling those on the rear apron are behind a section of the front panel where they are easily accessible. A switch provides a choice of 20,000-, 30,000-, or 47,000-ohm phono cartridge termination for the DISC 1 input, while the DISC 2 input is fixed at 47,000 ohms termination. Another switch adds either 0.5 or 1 dB to the low-frequency response through the phono inputs.

Another switch allows the power amplifier, when plugged into the appropriate outlet on the preamp's rear apron, to be switched on separately. The main power switch controls all preamplifier circuits and six switched outlets.

Located on the rear apron is a socket for plugging in the remote-control speaker switching accessory. Also on the rear panel are four gain controls for adjusting the gains of each channel for the phono inputs over a 10-dB range to match the signal levels of the high-level sources.

The preamp measures 17½ in. by 14 in. by 6 in. (44.5 × 35.6 × 15.2 cm) and weighs 30.8 pounds (14 kg). It retails for $600.

**Laboratory Measurements.** The preamplifier has a rated maximum output of 10 volts. Up to that level, its output distortion did not exceed 0.01 percent, except at 20 Hz, where it measured 0.025 percent at 10 volts. (The output clipped at about 13 volts.) The 200-ohm output impedance is low enough to drive any power amplifier without difficulty.

For a 1-volt reference output, a 94-mV signal was required through the AUX input, while through the PHONO inputs only 0.94 mV was required. The preamp's noise level was very low, measuring 78 dB down on AUX and 74 dB down on the DISC inputs at the 1-volt output level.

This preamplifier has the widest dynamic range on PHONO of any preamplifier we have ever measured. It overloaded at 440 mV with maximum phono gain. However, by reducing the phono level controls on the rear apron to minimum, the preamp overloaded at a remarkable 1.35 *volts*!

As might be expected from the choice of tone-control turnover frequencies and control settings, the range of available response curves was almost unlimited. The loudness compensation boosted to an 8-dB maximum only the low frequencies. The filters were among the most effective we have ever used from the standpoint of removing maximum noise with minimal effect on program material. For example, the low-frequency filter had no effect above 50 Hz; yet, it reduced the 20-Hz output by 10 dB. The high-frequency filter was down 3 dB at 5500 Hz and continued at a 12-dB/octave rate with increasing frequency.

The RIAA phono equalization was accurate to within ±0.5 dB from 20 to 20,000 Hz. Due to the differential amplifier circuitry, the phono cartridge is effectively isolated from the equalization components. Hence, cartridge inductance had no effect on the accuracy of the high-frequency equalization. The subsonic filter began to take effect at about 1000 Hz and was down 3 dB at 35 Hz. To a great extent, it seemed to overlap the much more effective low-cut filter in its operating range. The low-frequency enhancement circuit increased the response by either 0.5 or 1 dB below 1000 Hz.

**User Comment.** A study of the circuits and internal construction of the preamp leaves no doubt that the designers have avoided just about every compromise usually made in the interests of economy. In its ruggedness and mechanical construction, the preamp resembles a laboratory instrument rather than a hi-fi product.

The operating controls have a smooth feel, combined with positive action, that is consistent with and complements the outstanding electrical performance of the preamp. It would be difficult to imagine a preamp with greater operating flexibility than the Model C-200 in terms of frequency response adjustment and available inputs and outputs.

As to listening quality, we can only say that this preamp will provide almost any frequency-response characteristics an audiophile could wish for, a dynamic range far greater than that of any program likely to be supplied to it, and distortion that is barely measurable, let alone being audible. With tone controls and filters bypassed, this preamp comes as close to the proverbial "straight wire with gain" as anything known to us.

CIRCLE NO. 66 ON READER SERVICE CARD

## STANTON MODEL 681EEE STEREO PHONO CARTRIDGE

*Reduced stylus mass makes fine performance even better.*


HIRSCH-HOUCK LABS REPORT

The Model 681-EEE is the successor to and supersedes Stanton's Model 681EE stereo phono cartridge. In fact, the two models have identical external appearance, except for the difference in nomenclature marked on the removable stylus assemblies. The principal design difference between the two is that the EEE's stylus mass has been reduced by about one third.

The cartridge's stylus assembly has a removable "Longhair" brush that, when used, removes dust from the surface of the record. The use of this brush requires a slight modification in the usual method of setting up tracking force. The tonearm adjustment should be set 1 gram higher than the desired tracking force to compensate for the slight upward force exerted by the record's surface against the brush. This does not increase the force exerted by the stylus on the record groove. Generally speaking, the anti-skating compensation should be increased by a like amount.

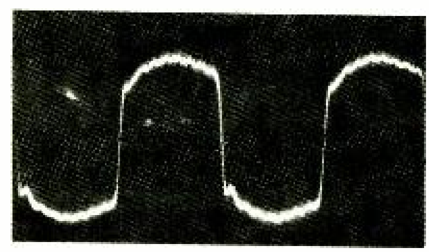
Called a "calibration standard" by Stanton, the Model 681EEE cartridge is notable for the flatness of its frequency response, which is tested and specified on a calibration card packed with each cartridge. The cartridge comes with mounting hardware and a small screwdriver.

Supplied standard with the cartridge is a 0.2-×0.7-mil elliptical diamond stylus that is rated to track at between 0.75 and 1.5 grams. Available separately as options are a 1.0-mil conical-tip stylus designed for tracking at 2 to 5 grams for mono LP's and a 2.7-mil stylus designed for tracking at 3 to 7 grams for 78-rpm discs.

The retail price of the Stanton Model 681EEE stereo phono cartridge is $82.

**Laboratory Measurements.** We installed the cartridge in the tonearm of a Dual Model 601 record player, set the tracking force to 1 gram, and used the recommended load of 47,000 ohms and 250 pF throughout our laboratory and listening tests. In preliminary tests, the cartridge tracked the highest levels of the Fairchild 101 and Cook Series 60 test records at the 1-gram tracking force.

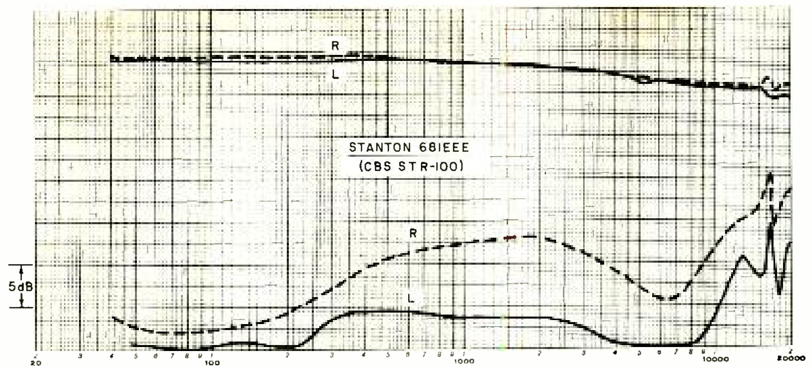
The frequency response we obtained by using the CBS STR100 test record was exceptionally free from irregularities. It had an almost perfectly linear, gentle slope downward from 500 Hz to 20,000 Hz, where the output was about 5 dB below the mid-frequency level. The only measurable departure from a smooth, straight line was a ±0.75-dB "blip" at about 17,000 Hz that was apparently due to a mechanical resonance. The response to a 1000-Hz square wave played from a CBS STR111 record revealed a moderately rounded convex top with no overshoot or other evidence of peaking or resonance.



*1000-Hz square wave.*

The separation measured typically about 30 dB on one channel and 20 to 25 dB on the other channel at frequencies up to about 10,000 Hz. It was 10 to 20 dB between 10,000 and 20,000 Hz, with a "blip" in the crosstalk curve at the 17,000-Hz resonance point noted above. The low-frequency resonance was 7 Hz, at which point it produced a 10-dB rise on the response curve.

To evaluate the effect of higher load capacitance on the frequency re-




sponse, we temporarily increased the load to 480 pF, which is as high as will ever be encountered in practice. This increased the drop rate in the output curve at frequencies beyond 10,000 Hz, amounting at 20,000 Hz to an additional 5 dB. The Model 681EEE obviously does not require excessive circuit capacitance to equalize its frequency response as do some other cartridges. It should deliver optimum performance with almost any load.

The cartridge's output was almost perfectly matched between the channels at a 3.2-mV level at a velocity of 3.54 cm/s. We measured the IM distortion with the Shure TTR-102 record and discovered that it was low (about 1%) at the usual velocities. It did not begin to increase appreciably until the recorded velocity reached 18 cm/s, at which point it measured only 3.2%. At the maximum test velocity of 27.1 cm/s, the IM was 10%.

We checked the high-frequency tracking ability of the stylus with the shaped tone bursts of the Shure TTR-103 test record. The resulting intermodulation, which cannot be numerically compared to ordinary IM figures, was also very low. It just exceeded 1% at the maximum 30-cm/s velocity. For midrange tracking, we tested the cartridge with a German record favored by some European manufacturers. It has a 300-Hz signal recorded at different amplitudes. Distortion became audible at the "70-µ" level, corresponding to about 15 cm/s.

**User Comment.** A cartridge's basic sound character can often be inferred from its distortion and frequency-response measurements, more successfully than is possible with many other audio components. Therefore, we were not surprised to find that the Stanton cartridge was able to track very-high-level musical recordings with ease, complementing the smoothest—if not the flattest—frequency response we have ever encountered in a phono cartridge.

These characteristics translate into a totally smooth, uncolored sound quality. When we used the cartridge to play the best records we had through the best speaker systems at our disposal, the results were spectacular. Even if the cartridge cannot receive the full credit for the total sound, it also cannot be charged with altering what was stored in the record.

The ability of the cartridge to track very-high-velocity music recordings without distortion was demonstrated by the manner in which it played the Shure "Audio Obstacle Course—Era III" disc. With the exception of the two highest levels of the sibilance test, which we have yet to hear played without a trace of "sandpaper" quality by any cartridge, the Model 681EEE revealed no signs of strain and was obviously not being pushed to its limits by this demanding record.

There are, quite literally, only a handful of cartridges that lead the field in every aspect of performance and that can fairly be said to surpass all lesser types, if not each other. The Stanton Model 681EEE cartridge is one of these.

CIRCLE NO. 67 ON READER SERVICE CARD

## HY-GAIN MODEL 623A AM/SSB BASE STATION CB TRANSCEIVER

*Digital frequency synthesizer eliminates multi-crystal need.*

HY-GAIN'S Model 623A base station Citizens Band transceiver is designed for both AM and SSB operation. In some respects, it differs from other AM/SSB rigs. For example, the circuitry is all solid-state in design, except for the transmitter's power amplifier stage, which is a vacuum tube. This design departure greatly reduces the chance of damage to the power amplifier due to mismatched loads.

Another significant departure is that all 23 channel frequencies are derived from a phase-locked digital frequency synthesizer, rather than by the usual synthesis from a multi-crystal scheme. Adding to this list are a microphone gain control located on the rig's front panel, and an SWR indicator that is the directional wattmeter type and can be switched to indicate actual output power at all levels into a 50-ohm load.

Among the usual transceiver features you will find on and in the Model 623A are: r-f gain control; adjustable squelch; AM/USB/LSB Operating modes, switchable noise blanker; full-time AM anl; fine tuning (AM/SSB); alc for SSB transmit; and a meter that indicates S units on receive and SWR and output power on transmit. A built-in power supply permits the rig to be operated on 117-volt ac line power or from 12- to 14-volt dc sources.

The retail price of the Hy-Gain Model 623A CB transceiver is $595.

**Receiver Details.** The receiver employs single conversion to a 7.825-MHz i-f. There are two r-f stages instead of the usual single stage. The r-f stages use dual-gate MOSFET's that are stagger tuned to provide a uniform bandpass for all channels and minimize unwanted signals while ensuring good sensitivity. We measured the sensitivity at 0.5 µV for 10 dB (S+N)/N on AM with 30% modulation at 1000 Hz and 0.16 µV with 10 dB (S+N)/N on SSB. A four-diode balanced mixer gives good signal-handling capabilities and minimized spurious responses. With respect to the latter, we measured a −60-dB figure. Image rejection was 80 dB, and i-f signal rejection was 78 dB.

Selectivity for both the AM and SSB modes of operation is obtained with a six-pole crystal-lattice filter. The filter has a 3.5-kHz bandpass at the 6-dB points. The overall a-f response at the 6-dB points on SSB was 300 to 3750 Hz, while on AM it was 100 to 1750 Hz. (On AM, the signal frequency is centered in the filter's passband.) Unwanted SSB sideband suppression was 45 dB at 1000 Hz, while adjacent-channel rejection on AM was 60 dB.

Three cascaded dual-gate MOSFET stages make up the i-f section, which feeds the AM and SSB detectors and an amplified agc setup. The latter held the a-f output to within 7.5 dB on AM and 6 dB on SSB with an 80-dB (1 to 10,000 μV) r-f input variation. The S meter registered S9 with a 30-μV signal. The squelch threshold was adjustable for signals in the range of 0.8 to 10,000 μV.

The a-f section has a complementary-pair transistor output stage that directly feeds a 3.2-ohm speaker built into the transceiver. We measured 5 watts of audio output power at 1000 Hz and 5.5% distortion.

The noise blanker operates through a balanced series gate. It attenuated noise peaks of 30 dB above a 0.3-μV signal level to a tolerable level in the presence of this signal. The AM anl is an a-f series-gate setup.

**Frequency Synthesis.** The heterodyning signal needed for deriving the receiver's i-f is obtained from a self-excited voltage-controlled oscillator (vco). The vco produces frequencies between 19.150 and 19.430 MHz as needed for a 7.825-MHz i-f on a particular channel.

An 18.810-MHz signal from a crystal oscillator and the vco signal are applied to a mixer to generate a difference signal that ranges from 330 to 620 kHz, depending on the channel in use. The difference signal goes to a programmable divider, where it undergoes division by a factor of 33 to 62 (depending on the setting of the channel selector) to produce a 10-kHz signal. The resultant signal, in turn, is compared by a phase detector against a 10-kHz reference signal derived from a separate crystal-oscillator-controlled circuit.

Any difference between the 10-kHz signals produces a voltage that is used to correct the frequency of the vco, locking both signals in phase with each other.

For SSB, the 18.810-MHz signal is shifted in either direction by 2050 Hz to shift the vco so that the i-f falls at the side of the filter required for accepting the desired sideband. Compensation is similarly made at a 7.825-MHz bfo for the overall frequency to remain on-channel.

**Transmitter Details.** On AM transmit, the 7.825-MHz bfo signal is routed to the receiver's mixer, which is used on both transmit and receive. Here, the on-channel carrier is produced in conjunction with the vco signal (19.140 to 19.430 MHz) using the sum frequency. This signal goes to two r-f stages that drive the power amplifier tube. The output of the latter employs a pi network that matches to a nominal 50-ohm load into which we measured a 3.5-watt carrier power level.

The output stage of the receiver's a-f system is transferred during transmit from the speaker to a transformer that provides the proper impedance match for plate-modulating the power amplifier stage. At 100% modulation, the distortion with a 1000-Hz test signal measured 5.5%. Adjacent-channel splatter, using a standard 2500-Hz test tone, was 50 dB down. With 6 dB of clipping, the distortion measured 17% and splatter was 40 dB down.

On SSB, the bfo and vco frequencies are shifted as noted above. SSB signal generation is accomplished with a balanced modulator and crystal filter. Once it is generated, the SSB signal goes to the mixer/transmitter system, which is set up for linear operation.

The PEP output was 8 watts with third-order distortion products 20 dB below a 2-tone test (26 dB below single-tone output). Unwanted sideband suppression was as on receive and carrier suppression was 45 dB on USB and 35 dB on LSB. The overall response was 300 to 3750 Hz at 6 dB.

**User Comment.** Large, well-spaced control knobs and a king-size meter movement make the Hy-Gain Model 623A CB transceiver a breeze to use and operate. A two-speed tuning system, including a vernier-type FINE TUNE control that provides a ±950-Hz deviation from center frequency on transmit and receive, makes tuning SSB signals a snap. Also, the agc attack and slow-release times make copying SSB transmissions smooth and free of pops.

The peak-indicating output indicator (meter) provides a guide for the proper setting of the MIC GAIN control. We discovered with our test unit that during modulation the cleanest SSB signal resulted when the meter's pointer registered 2 to 3 watts (actual peak power was 8 watts), while on AM, a rise of 1 to 1.5 watts above the carrier level was about right for clean 100% modulation.

A microphone is not supplied with the transceiver, nor are there any provisions for public-address (PA) operation. A high-impedance, push-to-talk microphone equipped with a standard three-way phone plug is required. This, plus the fact that the transceiver measures 11 7/8 in. by 11½ in. by 6¼ in. (30×29×16 cm), makes it basically a base station. But this does not preclude its use in mobile service, in which case, you might have to use an external speaker instead of the top-facing one built into the rig. Terminals are provided on the rear apron for hookup of the outboard speaker.

An excellent service manual for the transceiver is available as an extra-cost item from the manufacturer. It is well worth the extra money to get this manual when you buy the transceiver.

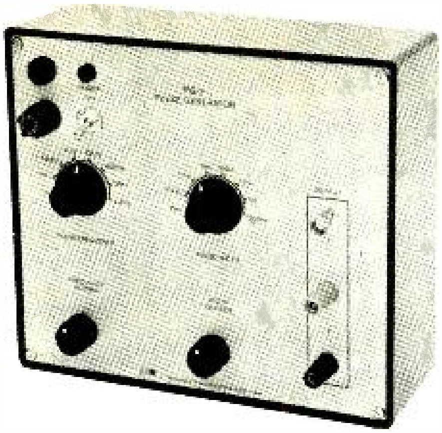
CIRCLE NO. 68 ON READER SERVICE CARD

## EL INSTRUMENTS MODEL PG-2 PULSE GENERATOR KIT

*Versatile test instrument at low cost.*

UNTIL fairly recently, the pulse generator was a little-used device, relegated to test equipment limbo. Most of the time, we were hard put to find a use for this strange instrument. Then, along came a tremendous swing to digital circuits and products. Now a source of variable-frequency/variable-width pulses—a good definition of the pulse generator—has become a must-have test instrument.

When we first found ourselves in a situation that required the use of a pulse generator, we looked for an instrument that would perform reliably without denting our budget too much. We found what we were looking for in the EL Instruments Model PG-2 basic pulse generator kit that retails for $49.95.



**Some Details.** Assembling the kit took us only an evening of unhurried work. No special tools were required, and we encountered no difficulties in putting the kit together. Everything mounts on the front panel, and even the line cord exits through a hole in the panel, held in place by a plastic strain relief. When we plugged the line cord into an ac outlet and turned on the power, the instrument worked properly the first time out.

The pulse generator contains two sets of controls, one for setting the output frequency and the other for setting the pulse width. The PULSE FREQUENCY switch is the coarse frequency control. It has seven positions in decade steps (except the last, or highest-frequency, position, which goes up a half decade from the previous position) for a 1-Hz to 5-MHz overall range. The FREQUENCY VERNIER provides a fine-tuning control for selecting discrete frequencies within the range selected.

The second set of controls works in a manner similar to those for the pulse frequency section. The PULSE WIDTH switch is a coarse control, with seven positions, six of which are labelled in decade steps from 1 s to 1 µs and the seventh is labelled 200 ns. The WIDTH VERNIER selects the desired discrete pulse width within the range selected.

Both the frequency and pulse-width switches, operating in conjunction with their respective vernier controls, have ranges that overlap each other for maximum flexibility. The output frequencies and pulse widths are more than adequate for almost any digital application you are likely to encounter.

The instrument has two output connectors. OUTPUT 1 is a BNC connector, while OUTPUT 2 is taken from across a pair of five-way binding posts. The two are in parallel with each other.

The rise time of the output signal is 15 ns, while the fall time is 10 ns, both with one TTL load connected to the instrument. A maximum of 10 TTL gates can be accommodated.

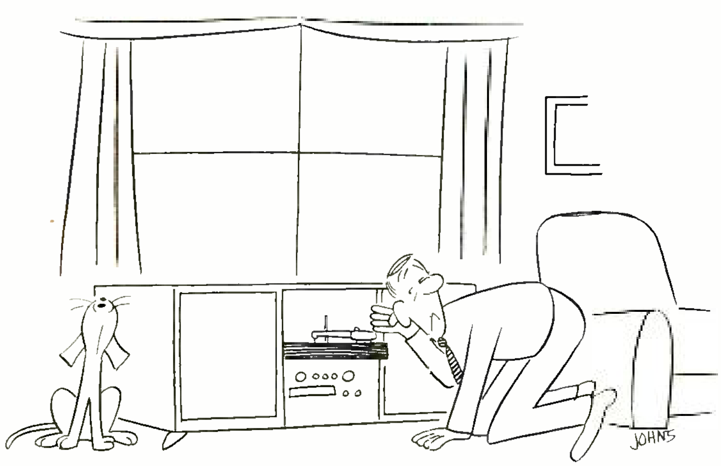
Aside from the frequency and pulse-width controls and the output connectors, the front panel has the power switch and lensed POWER ON lamp and the line fuse in bayonet-type holder.

**User Comment.** Since installing the pulse generator in our workbench, it has seen lots of service. Besides testing the many digital construction projects that come into the lab, the instrument has been used as a very-low-frequency clock generator for demonstrating calculator operation at a local school.

We have also used it as a horizontal sync simulator when troubleshooting a TV receiver and have used it as a trigger source for a dual-trace oscilloscope experiment. With the output frequency accurately set by a digital counter, we used the pulses as timing marks when injected into the Z (brightness) axis of a low-cost oscilloscope.

In all, the pulse generator has proven itself to be a very useful—and surprisingly versatile—instrument.

CIRCLE NO. 69 ON READER SERVICE CARD



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# Solid State

**By Lou Garner**

## THE PHOTO DETECTOR/POWER AMPLIFIER IC

ALTHOUGH hundreds of new IC's are introduced each year by semiconductor manufacturers, only a score or two ever "make it" as far as hobbyists and experimenters are concerned. A few—the ubiquitous 555 timer and the familiar 741 op amp are prime examples—become tremendously popular. Others achieve modest popularity and are used by most, if not all, hobbyists. A smaller number are used by a few experimenters here and there in special projects. But the overwhelming majority of new IC's seldom reach the home experimenter's workbench.

Often, the reasons for the lack of hobbyist interest in a new IC are obvious from its very nature. The device may be too expensive. It may be difficult to use, requiring extensive design calculations. It may have limited distribution, being offered only to the military and industrial markets. Its characteristics may be too specialized, limiting its area of application. Or it may require expensive external components.

On the other hand, there are a number of extremely versatile, modestly priced, and readily available devices which have remained in limbo from the average experimenter's viewpoint. After chatting with a number of hobbyist friends and corresponding with others, I've concluded that there are two major reasons why hobbyists ignore what, otherwise, seem to be extremely promising devices: (1) A general lack of knowledge about the device, despite the fact that it may have been described briefly in most popular publications; and (2) a lack of sufficient application data—i.e., practical circuits—to spark the potential user's imagination and start his/her creative juices flowing.

Consider, for instance, RCA's extremely versatile CA3062 Photo Detector and Power Amplifier. Introduced several years ago, the CA3062 is suitable for a wide variety of applications. It can be used in position sensors, intrusion alarms, level controls, counters, isolators, safety controls, light switches, edge monitors, and inspection equipment. The device is a monolithic IC comprising two independent sections on a single silicon chip—a photosensitive array and a differential power amplifier. Offered in a modified 12-lead TO-5 style package, the CA3062 is an extremely interesting device to study, even if never wired into a working circuit. The case top consists of a transparent lens, permitting ready observation of the entire chip and its connecting leads. By using a stylus microscope or powerful hand magnifier, one can examine the chip geometry in detail and gain a clear view of the working heart of an integrated circuit. Currently, the CA3062 nets for $4.86 each in small quantities and is (or should be) available from all RCA franchised semiconductor distributors.

As illustrated schematically in Fig. 1, the CA3062's light-sensitive section consists of a photo-Darlington pair, *Q1-Q9* and *Q10-Q11*, while the second section includes a differential amplifier, *Q2-Q3-Q8*, coupled through *Q4* and *Q5* to a pair of uncommitted-collector-and-emitter output transistors, *Q6* and *Q7*. Each output transistor can handle currents of up to 100 mA, enough to provide direct drive to a relay or thyristor.

In practice, the photo-Darlington pair may be, at the user's option, either emitter or collector coupled to the differential amplifier, *Q2-Q3* and its constant current sink, *Q8*. With emitter coupling, pin 11 is connected to pin 1 and pin 10 to a suitable voltage source. With collector coupling, pin 11 connects to circuit ground and pin 1 to pin 10 and thence to a voltage source through an appropriate load resistor. In most applications, the photo-Darlington's base terminals, pins 9 and 12, are tied together.

If the device is to be used primarily in switching applications, it can be wired for Schmitt trigger operation by

*Fig. 1. The CA3062 photo detector and power amplifier consists of a photo-Darlington pair and a differential amplifier coupled to uncommitted output transistors.*

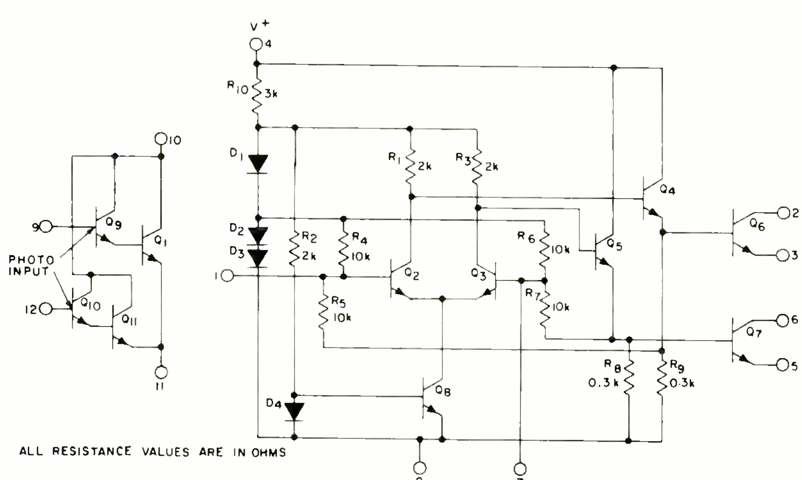
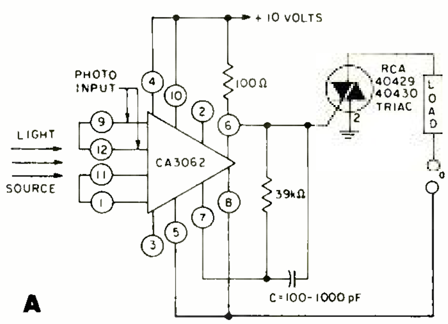
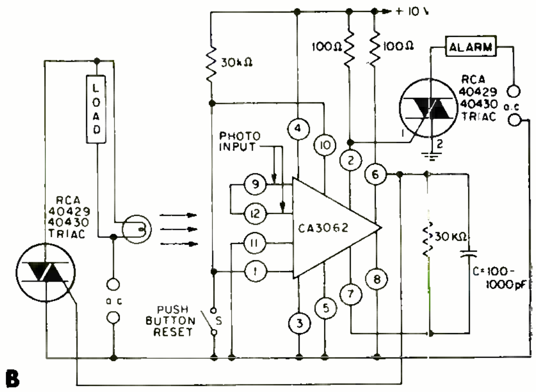


*Fig. 2. Typical applications for the CA3062. (A) is a light-activated triac control; while (B) is triac control with automatic shutoff.*




providing feedback from one of the output transistors to the differential amplifier section, thus insuring a positive and rapid transition from on to off conditions. When used as a switch, output transistor *Q7* conducts as long as light falls on the photoarray, while *Q6* remains in an off (non-conducting) state. When the light source fails or is interrupted, *Q7* switches off and *Q6* starts conducting. If desired, either, or both, of the output transistors may be used to achieve the required mode of operation.

RCA suggests that certain precautions be observed when using the CA3062 in practical circuits. First, because of the amplifier's high gain, all component and wiring lead lengths should be kept as short and direct as practicable. Second, applied light levels should be limited to below 60 lumens/ft$^2$ to avoid switching both output transistors on at the same time. Third, if an inductive output load is used, such as a relay or solenoid, a reverse-connected damping diode should be shunted across the coil to absorb transient voltage peaks during switching. Finally, all operating voltages and currents must be kept within maximum specified limits. The basic device is designed for operation on dc supplies of from 5 to 15 volts (between terminals 4 and 8) while the output transistors, *Q6* and *Q7*, can handle up to 30 volts; however, the output current must be kept to within 100 mA. The signal voltages applied to the differential amplifier section (pins 1 and 7) must not exceed 3 volts.

Typical application circuits for the CA3062 are illustrated in Figs. 2 and 3. These were abstracted from both the specifications bulletin on the device and RCA's Application Note ICAN-6538, *Applications of the RCA-CA3062 IC Photo-Detector and Power Amplifier in Switching Circuits*, by J. D. Mazgy. All of the circuits feature standard, readily available components. All may be operated on batteries (except for the external load devices) or low-voltage, line-operated power supplies. The resistors are ¼- or ½-watt types. The capacitors are either ceramic or electrolytics, as appropriate to their value, with working voltages suitable to the source voltages used for circuit operation.

The simple light-activated triac control circuit shown in Fig. 2A may be used in a number of remote control applications. It could be used, for example, to actuate an advertising display, to operate a garage door opener, or to provide remote switching of an electrical appliance. Here, feedback is provided between output transistor *Q7* (pin 6) and one of the differential amplifier's inputs (pin 7) to achieve Schmitt trigger operation. The device's output transistor supplies a gate drive signal to a standard triac, controlling current through an external load powered by an ac line. The load's size is limited only by the triac's power-handling capability.

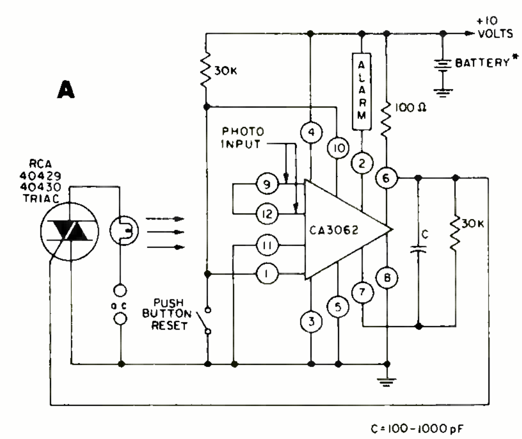
In operation, power is supplied to the load as long as light falls on the CA3062's photosensitive surface (through its transparent case top). If the light is removed, load current is switched off.

A modified circuit suitable for use as a safety control on industrial equipment is given in Fig. 2B. Here, an interruption in the light beam automatically shuts off power to an external load (such as a drill press), darkens the control light, and simultaneously sounds an external alarm. Operation can be restored and the alarm silenced only by removing the obstruction to the light beam *and* closing the momentary contact pushbutton reset switch.

As in the previous circuit, the IC is wired as a Schmitt trigger and the external ac load controlled by a triac which, in turn, receives its gate signal from the IC's output transistor, *Q7*. A conventional 117-volt ac incandescent lamp connected in parallel with the external load serves as a light source. The alarm feature is achieved by using the IC's normally off output transistor, *Q6*, to supply a gate drive signal to a second triac which, in turn, controls an external alarm signal. When *Q7* switches off, cutting off load and lamp power, *Q6* switches on, sounding the alarm.

Since the CA3062's output transistors can handle up to 100 mA, *Q6*'s 100-ohm load resistor could be replaced by a Mallory SC628 *Sonalert*, with the second alarm triac and its external alarm device eliminated.

If the external Triac is used *just* to control a lamp, then a circuit modified as described above can serve as a reliable



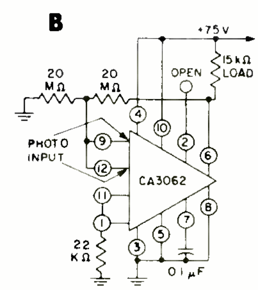




*Fig. 3. Circuit shown at (A) is a modification of Fig. 2B to provide an intrusion alarm. A linear photoelectric amplifier can be built as shown at (B).*

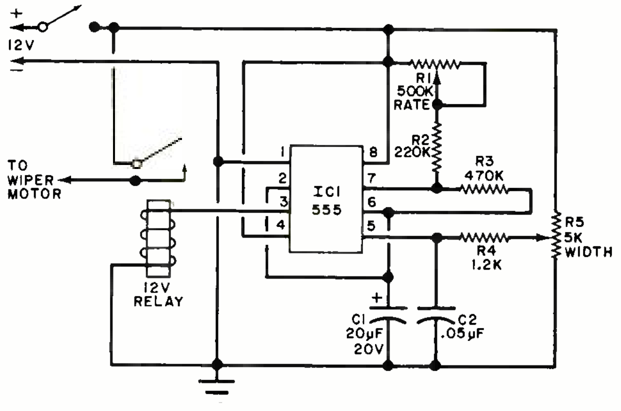



*Fig. 4. Slow-sweep wiper control.*

intrusion alarm. Such a modification is illustrated in Fig. 3A. Here, it is recommended that the circuit's power supply consist of a rechargeable battery *and* a line-operated trickle charger to insure continuous operation. As before, once the circuit has been "tripped" by an interruption of the light beam, it is necessary to actuate the reset switch to restore operation. In most installations, a key-operated lock switch would be used in place of the pushbutton switch so that an intruder could not reset the system, silencing the alarm.

Although the CA3062 is intended primarily for use as a control switch and is not ordinarily for linear operation, it can be used in such applications, as shown in Fig. 3B. When using the device as a linear photoelectric amplifier, the output load resistor should have a value greater than 1000 ohms to limit the unit's power dissipation and minimize thermal effects. Some experimentation with component values and initial light levels may be needed to achieve optimum performance.

**Readers Circuits.** Considering the time of year, it may not be surprising if raindrops keep falling on your head. While, according to tradition, April showers bring May flowers, there are days when there's just enough moisture in the air to smear a car's windshield, but not enough to lubricate the windshield wiper blades for continuous operation. When light rain and the foggy, foggy dew become a problem, an intermittently operating windshield wiper can offer real advantages. Of course, the basic concept is not new. Several intermittent windshield wiper control circuits have been published in the past and commercial units are available from most auto accessory stores as well as new car dealers. But you can build your own unit at considerably less cost than commercial models using the simple circuit illustrated in Fig. 4. Featuring a standard 555 timer, the design was submitted by reader Craig S. Kellem (48 Briarwood Road, Wayne, NJ 07470).

Requiring relatively few components, Craig's circuit can be assembled in a single evening, even allowing time for a coffee break.

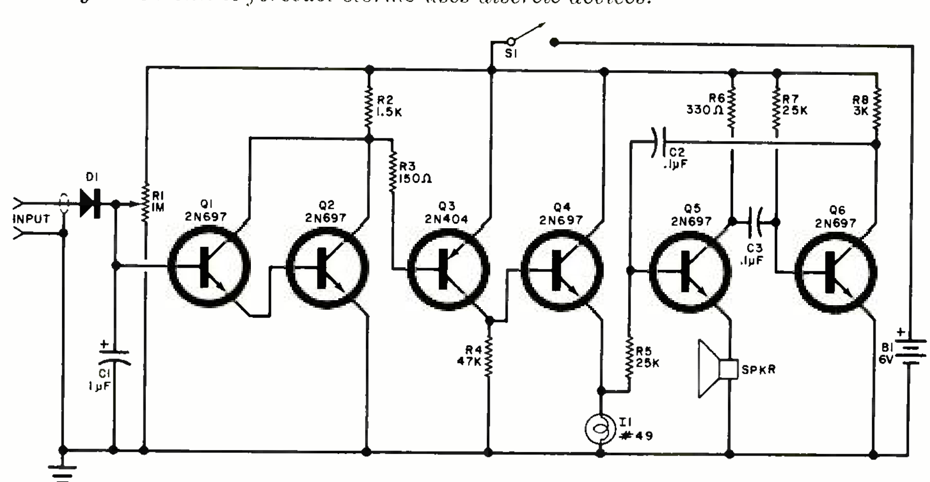
In operation, the relay is actuated at periodic intervals by the timer circuit, closing the wiper motor contacts. Potentiometer *R1* serves as the *pulse rate* control and potentiometer *R5* as the *pulse width* control. These two controls should be adjusted for optimum performance after the unit is installed in a car.

If impending storms are of more concern than gentle rain, you might want to try the storm forecaster circuit illustrated in Fig. 5. Unlike other "stormcaster" circuits we've featured in the past, all of which used type 555 IC's, this circuit employs discrete devices and, according to the contributor, Robert L. Phillips, FTM1 (FM Division, U.S.S. Oklahoma City, CLG-5, FPO San Francisco, CA 96601), offers distinct advantages over earlier versions. Bob's design does not require an unusually large input capacitor and does not lock-in on incoming signals, requiring manual reset. It does, however, feature both a visual and audible alarm.

In operation, noise signals obtained from a standard AM radio receiver are coupled through rectifier diode *D1* and used to charge input capacitor *C1* which, in turn, supplies a control bias to Darlington amplifier *Q1-Q2*. The Darlington stage is direct-coupled through current-limiting resistor *R3* to a two-stage complementary amplifier, *Q3-Q4*, with *Q4* serving to operate the visual alarm signal, incandescent lamp I1. At the same time, *Q4* supplies a control bias to a collector coupled multivibrator, *Q5-Q6*, which develops an audible alarm signal, reproduced by the PM loudspeaker serving as *Q5*'s emitter load. Circuit power is supplied by a six-volt battery, *B1*, controlled by spst power switch *S1*.

Bob indicates that the circuit will work well with almost any general-purpose, small-signal transistors, including those offered in bargain "surplus" assortments, provided the devices are not leaky. Input capacitor *C1* is a 1-µF high-quality electrolytic or metallized paper type, while *C2* and *C3* may be either paper or ceramic units. Indicator alarm lamp *I1* can be replaced by a LED with a suitable series resistor.

*Fig. 5. Circuit to forecast storms uses discrete devices.*



Neither layout nor lead dress should be overly critical although, because of the multiple stages involved, good wiring practices should be followed when duplicating the design. Signal-carrying leads should be kept short and direct and care should be taken not to overheat the semiconductor devices when soldering them in place. A pc board might be advisable.

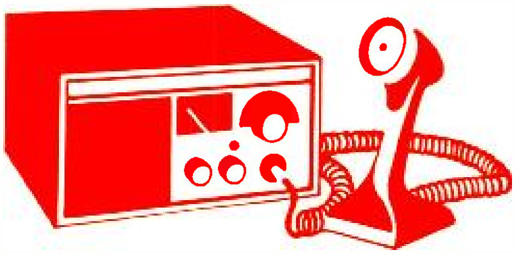
Bob suggests the following adjustment procedure for his version of the "stormcaster": (1) Connect the input to the output (earphone) jack of a standard AM radio receiver tuned to a station-free area near the low end of the broadcast band. (2) With the receiver *off* and *S1* closed, adjust *R1* until *I1* lights and a sound is heard from the loudspeaker. Back off *R1*'s adjustment until the lamp goes dark and the sound stops. (3) With the receiver on, adjust the set's volume control for the desired level of sensitivity, readjusting *R1* if necessary for optimum performance.

**Device/Product News.** Motorola Semiconductor Products, Inc. (P.O. Box 20924, Phoenix, AZ 85036) has introduced a number of new devices over the past few weeks, two of which should be of particular interest to experimenters and hobbyists: a new low-cost programmable operational amplifier and an inexpensive gas-discharge display driver.

Available in both round metal cases and plastic 8-lead DIP's, Motorola's operational amplifier is designed to permit the user to optimize (program) such dc characteristics as input current, power consumption and bias current, as well as ac characteristics such as open-loop voltage gain, slew rate and gain-bandwidth product, simply by choosing a suitable external resistor value or external current source. Designated type MC3476, the op amp can be used on supply voltages of ±6 to ±15 volts, and requires only 4.8-mW in typical applications. It features low input offset and bias currents and a high input resistance of 5 megohms, typical. Requiring no frequency compensation, the device has internal short-circuit protection. Programming is accomplished by varying the current supplied to a special terminal.

Intended for use with high-voltage gas-discharge displays of the types offered by Beckman and Burroughs, Motorola's new IC driver features eight separate channels, one for each of the seven display segments and another for the decimal point, and is directly compatible with the MOS outputs of electronic calculators due to its low 300-μA input current requirement. Identified as type MC3491, it offers a minimum breakdown voltage of 80 V and is priced at only $3.50 each in unit quantities.

RCA's Electronic Components group (415 South Fifth Street, Harrison, NJ 07029) has introduced a new series of eight GaAs laser arrays and a new IR emitting diode. Both the arrays and the diode are suitable for a variety of applications in industrial, military and commercial equipment, including intrusion alarms. The eight laser arrays, offered in RCA's OP-4A case, have minimum power outputs ranging from 25 to 300 watts at a drive current of 25 amperes at room temperature, but the devices, designated types C30002 through C30009, also may be operated at cryogenic temperatures (−196°C) if desired. The new IR LED, identified as type SG1009A, has a typical power output at 940 nanometers of 7.5 mW with a dc drive current of 100 mA. Priced at only $3.50 each in small quantities, the SG1009A is supplied in a hermetically sealed two-lead type TO-18 case, with a glass lens top cover. ◈



# CB Scene

By Len Buckwalter, K1ODH

## HOW TO MOUNT MOBILE ANTENNAS

AN OFFICIAL of a CB antenna company told me recently that someone ought to write about the mobile antenna mount. That sounded about as exciting as watching your fingernails grow, but the man constructed his case. When a CB'er goes to a dealer, he argued, the man is rarely forewarned about all the antenna supports now on the market. Only after the CB'er has cut into his car, maybe drilled through the gas tank, does he wonder if there's a better way to do it. There probably is, considering there are now a dozen ways to loft a mobile antenna.

Before designers came out with today's array of clever fittings, choosing an antenna mount was mostly a matter of whether you wanted to drill a hole or not. Most people worry about decreasing their auto's resale value. One homebrew genius cooked up a scheme that would fool even a used-car dealer. He removed a tailight, then installed an antenna mount in the opening. When time came to sell the car—heh-heh—he screwed the tail light back on.

The fear of cutting a hole in the car is exaggerated; any careful worker can do the job. Just avoid the following pitfalls. The first happened to me when I climbed to the top of a shiny new Ford some years ago to mount a center-roof antenna. By concentrating too much weight on one foot, the roof sank into an ominous hollow the size of a soup bowl. Luckily, it rebounded like the bottom of an oil can. I quickly learned that an installer must spread-eagle himself across the roof to avoid making a depression.

*New-Tronics TLM trunk lip mount.*

Another mishap occurred to a friend of mine when he was attempting to drill into the car's curving contour. He didn't hammer a starting dimple in the metal and the drill bit skittered off the mark and etched its way across the rooftop. The pattern in the paint resembled something I'd once seen on the side of a tepee.

But drilling the hole is often the easiest part of the job if you watch out for those hazards. One other precaution: place a block of wood next to the drill mark to act as a stop when the bit bursts through the metal. Otherwise, the bit continues to spin into an upholstered ceiling or, if you're making a trunk-deck installation, into your spare tire.

Now to deal with that question of a car's resale value. Time was when a body-and fender shop would seal it up for five bucks. Today it probably costs as much as brain surgery! That antenna manufacturer mentioned earlier, though, said most dealers must do some work on a trade-in anyway, so you can argue against a deduction for a piddling hole. Another cure is to insert a rubber plug, especially sold for the purpose, into the hole to make a neat restoration. You might also leave the antenna mount in place and hope that it *increases* the car's value. If CB is Everyman's medium, the next owner may be grateful for your consideration. Just be sure he doesn't suspect the car was once a taxi or police car.

Before buying any mount or drilling holes, consider these questions. Will the antenna be located on a slanting surface? Must it be detachable or have a fold-down feature because of a low garage entrance? Will the antenna occasionally be transferred between vehicles? To see how these and other details affect the choice, let's consider each major mounting approach for what it has to offer:

**Bumper.** The attraction of a bumper mount is that you can go all the way. It carries the 102-inch whip, biggest CB mobile antenna. A long whip produces a hearty signal for miles around, despite a bit of directionality because part of the whip is low. Installing a bumper mount is simple: clamp-on brackets fit almost any vehicle and permit the whip to be adjusted in a vertical position.

**Ball.** If your antenna will rest on a slanting surface (a curved fender, for example), you'll need a mount that can offset it. A ball is split and tilted to permit you to align the whip in the vertical plane. Although a ball can mount on a front cowl, it is usually placed on the rear deck. Excellent strength and durability make the ball mount the favorite type for commercial and public-safety radio services.

*New-Tronics standard ball mount (left). Antenna Specialists bumper mount (right).*

They almost always add an impact spring to absorb shock when the antenna strikes an obstruction. The various components—ball, spring and whip—generally terminate in a standard 3/8"-24 thread. You can buy these items separately if you choose, or as a complete antenna system.

A ball mount requires a hole cut in the car body. But it's not difficult to make one at the rear deck because there's access to the underside of the hole through an open trunk.

**Cowl.** This mounting is much the same as the one supplied by auto makers for the standard car radio. Because it has a swivel arrangement similar to the ball mentioned before, but is not as rugged, the cowl mount may be considered a light-duty equivalent. It mounts at the front or rear deck, requiring a hole diameter that runs between 15/16-inch to 1 1/8-inch.

An advantage is that you can install a cowl mount in a "blind" hole; you don't have to get your fingers or a wrench inside the hole to tighten the nut. This is often a requirement when installing a cowl-mount on a front fender. You must also snake the coaxial cable inside the fender channel toward the CB set.

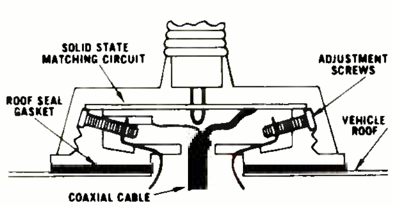
**Roof.** Placed near the center of the car roof, a roof mount also needs no wrench inside the hole for tightening. It has set screws which are accessible from the outside. The advantage of a roof mount is a lofty position on the car, which yields excellent range and uniform signal pattern. The most difficult part of a roof-mounting job is snaking the coaxial cable through the headliner to the window post. It calls for patience and a reasonably clear path between the headliner and metal roof.

The mounts mentioned so far are for permanent mounting. They offer the most flexibility in locating the antenna and add the advantage of placing the cable completely inside the car body. Now let's look at the newer series of mounts which solve special problems or ease the job of installation:

**Trunk Groove**. This mount requires two tiny drill holes, usually 7/32-inch diameter, in the trunk crack. But there's virtually no evidence left when the antenna is removed. The antenna can be placed at the sides or rear of the trunk, good locations for signal propagation.

**Body Mount.** Some manufacturers use "body" for what others call a "trunk" mount. It has the same mechanical arrangement—a versatile bracket held by two small screws and applied in difficult mounting situations: on farm tractors, construction machinery or a luggage rack. It can also adhere to a door edge or hood groove.

**Trunk Lip.** Another mount designed for the trunk, this one requires no holes. It has a clamp that curves around, and clamps to the trunk lip. It also prevents the cable from pinching when the trunk is closed. The bracket installation needs little more than a screwdriver to tighten setscrews.




*Hy-Gain rooftop mounting system.*

**Mirror.** This design came into vogue when truckers joined CB. No drilling is required to install a clamp-like arrangement which grips the side-view mirror bracket.

**Magnetic.** A powerful Alnico magnet in the base of this mount hugs the car's sheet metal in winds up to 100 mph. No clamping or drilling is needed. Just plunk the magnet anywhere there's flat steel and the installation is done. Remember, however, that the cable emerges from the side of the mount. Thus, it must be led into the vehicle through a partly open window, or a groove made in the molding. This mount is easily transferred between vehicles, a factor that may be important to your type of operation.

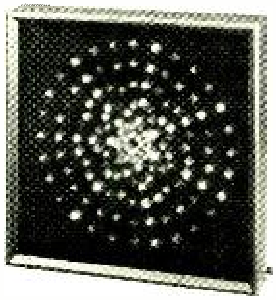
**Camper.** Conventional antenna mounts don't easily mount on a camper. Happily, engineers have developed a single, flexible bracket that attaches in a variety of ways to almost any surface. Sometimes it's not even necessary to drill holes because the bracket may match existing screws in the camber body.

An added problem in recreational vehicles is that there may not be sufficient metal surrounding the base of the antenna to create good ground-plane action. Accordingly, signal radiation suffers. One solution is the camber bracket, installed with a short, marine-type antenna. Because small boats are generally constructed of fiberglass, CB marine antennas are electrically constructed to operate with no ground plane.

**Motor-home.** The camber bracket described above also works on a motor home. If height limitations compel you to buy a short whip, you can mount it on the roof of a *metal* motor home with no electrical problem. Where the roof is fiberglas you'll have to provide an electrical ground plane. (Some manufacturers of motor homes embed a copper screen in the roof for this reason, so find out if one is provided.) At least one manufacturer overcomes the ground-plane problem in plastic roofs with a kit of aluminized tape. Self-sticking, it is placed in a cross-hatch pattern over the roof to simulate ground and should last several years.

There's more to mobile mounting than meets the eye, but there's enough hardware to prevent you from installing the right antenna the wrong way, or vice-versa. ◈

# exciting new projects for '75



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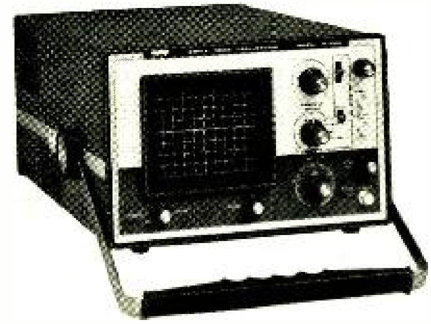

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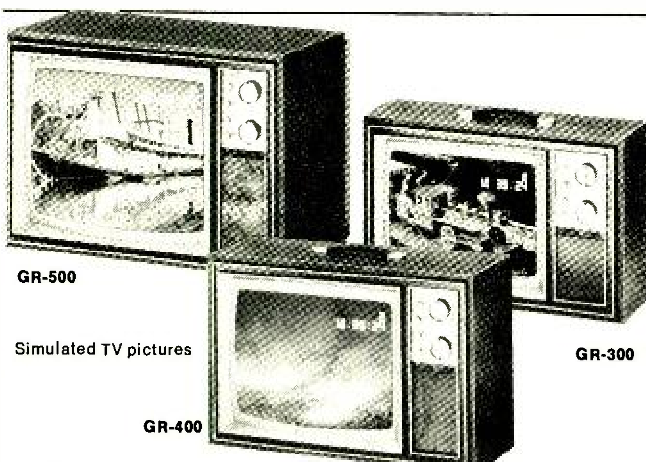


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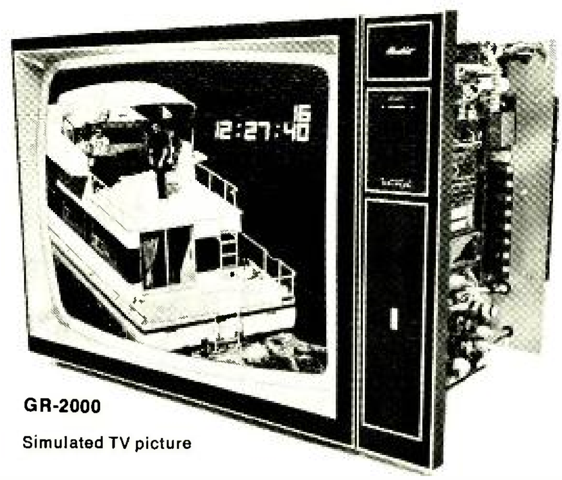


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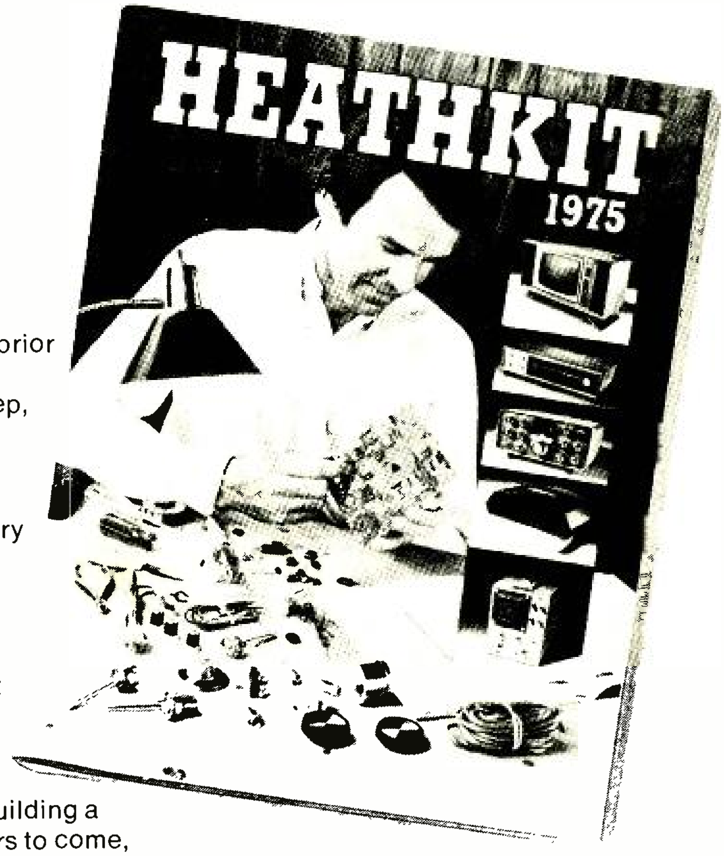


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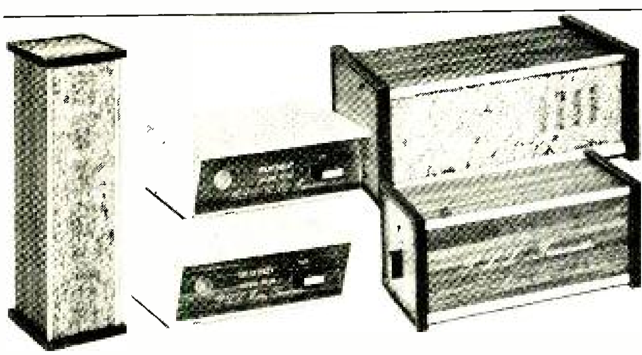

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# Amateur Radio

By Herbert S. Brier, W9EGQ

## RESTRUCTURING THE AMATEUR SERVICE

On December 4, 1974, the Federal Communications Commission broke with tradition by proposing to issue a new code-free, amateur Communicator's license. The new license would authorize FM phone operation on the amateur frequencies above 144 MHz with a maximum transmitter power of 250 watts input. The new Communicator license would be one of two new licenses and many changes that will affect every amateur in the United States contained in FCC rule-making Docket 20282. Its major proposals, which are a distillation of 35 sometimes-contradictory petitions presented to the FCC over a period of several years, are summarized below. As you read the summary, remember that all the proposals are subject to revision. Any interested person has until June 16, 1975, to file original comments on them and until July 16, 1975, to file counter comments. The FCC specifically invites informed comments, which must be in the form of an original and 14 copies addressed to the Federal Communications Commission, Washington, D.C.

**The Proposals.** The proposals in FCC Docket 20282 divide the amateur spectrum into two parts at 29 MHz. Part A covers the high-frequency or shortwave spectrum below 29 MHz; part B covers the spectrum above 29 MHz. In general, seven separate licenses with their examinations tailored to the frequencies and the privileges they cover are available. All of them, including the new *Communicator* and the *Novice* class licenses, will be issued for a basic period of five years and will be renewable.

In addition to the Communicator license with its simple written examination, the big news in the series is a new *Experimenter* license, counterpart of the *Advanced* class license in the hf series. It authorizes all amateur privileges above 29 MHz using a maximum transmitter power of 2000 watts, peak envelope power (PEP) output, which can translate to a dc power input up to 4,000 watts or so, depending on the mode and the efficiency of the transmitter used. Its examination consists of a 5-wpm code test and a written test covering amateur regulations and advanced amateur vhf/uhf theory and techniques. The *Technician* class license completes the vhf/uhf series. It will authorize code and phone operation on all frequencies above 50 MHz using a transmitter power of 500 watts PEP output. Its examination is a 5-wpm code test and a general written test on amateur regulations and vhf/uhf techniques and operation.

Below 29 MHz, the big changes in the *Novice* license are its expansion into a 5-year, renewable license with a maximum power input of 250 watts. Operating privileges, frequencies and examination remain unchanged. The *General* class license remains essentially unchanged below 29 MHz, except the privilege of using RTTY and other exotic modes of transmission are withdrawn. Also its new maximum transmitter power rating of 500 watts PEP output is somewhat below the old 1000-watt input limit. The General class examination will still include a 13-wpm code test, but the written test will have questions about vhf/uhf operations and specialized emissions eliminated. The new *Advanced* class license will authorize all amateur privileges below 29 MHz, except to operate CW in the restricted CW segments in the 3, 5, 7, 14, and 21-MHz bands. Maximum transmitter power of both the *Advanced* and *Extra* class licenses is 2000 watts PEP output. Under the new scheme of things, the present written part of the *Extra* examination is deleted and made a part of the *Advanced* and *Experimenter* examinations, eliminating uhf/vhf questions from the *Advanced* class version and hf questions from the *Experimenter* class version. Present *Extra* class licenses are to become life-time licenses authorizing all amateur privileges. The 20-wpm *Extra* class code test will be retained, and future holders of both *Advanced* and *Experimenter* class licenses who pass it will graduate to the life-time *Extra* license. They will still have to renew their station licenses every five years, however.

**Additional Details.** Present licensees will retain their present call letters, if they wish. New licensees will be issued call letters indicating their class of license. Details will be a subject of a future docket. Also, present *Advanced* class licensees will get *Experimenter* licenses and *General Technician* licenses by simple application. *Technicians* may obtain *Novice* class licenses via the same route. Future licensees will have to pass separate examinations to obtain privileges in both regions.

*Communicator* and *Novice* licenses will normally be issued and renewed by mail. Applicants for other classes of licenses who live over 175 miles from the nearest regular FCC examination point can also obtain them by mail but only for a maximum of five years. If they do not appear at an FCC office and pass the appropriate examination within that time, the license will not be renewed. In addition, if they move within 175 miles of an examination point or a new examination point is established within 175 miles of their locations, they will have a year to appear for the exam before their by-mail license will be cancelled. Physically disabled applicants may take the exams by mail, wherever they live, and the licenses may be renewed as long as the disability lasts.

Two volunteer examiners, over 21 and not related to the applicant, at least one of them having a license of a higher grade than the one being sought, are required to witness by-mail examinations. Extra-class licensees may be the principal examiners for any class of license examination, Advanced class licensees for General and Novice exams, Experimenter licensees for Technician and Communicator exams, and Technicians for Communicator exams, all assisted by another licensed amateur.

It has been predicted that the United States amateur population will be doubled within a few years after these proposals are enacted, possibly by the end of the year. The possibility that a flood of new Communicator licensees will take over the frequencies above 144 MHz and disrupt forms of communication already established on these frequencies is a matter of deep concern to many uhf/vhf operators. The possibility might be minimized by allotting certain segments of these bands for weak-signal experiments especially susceptable to interference and amateur radio's long tradition of keeping its own house in order will also help.

**50-MHz "Short Skip".** Each year, as spring approaches, experienced 50-MHz operators anticipate the start of the annual spring-summer "short-skip" season. Its start is signalled by the band suddenly jumping with strong signals originating from distances up to 1200 miles and farther away. The signals may come from any direction and be heard for periods ranging from a few seconds to hours at a time before they disappear as suddenly as they appear, not to reappear for days at a time. Or the signals may pop in and out around the compass and around the clock for days at a time.

This form of "short-skip" or sporadic-E propagation is thought to be the result of high-velocity cross winds in the E layer of the ionosphere approximately 70 miles above the earth concentrating its ambient ions into super-ionized patches that bounce vhf signals striking the patches back to the earth. Any shift in the winds affects the strength, number and positions of the patches, which explains the variable nature of the propagation. The most likely times for vhf short skip in the United States are before noon and late in the afternoon during the warmer months of the year, but it can occur at any time. Its fascination is that it is practically the only avenue open to the low-power 50-MHz phone station, with a simple antenna, to work distances beyond a few hundred miles during most of a normal sunspot cycle. It is not unusual for a good operator to work well over 30 states, Canada, and possibly a couple of countries like Bermuda, Cuba, and Mexico between April and September. And it is downright habit forming to try to outguess the skip.

Short skip reaches as high as the 144-MHz band on rare occasions and with increasing frequency on the 28-, 21-, and 14-MHz bands.

**News Notes.** In the December, 1973, 10-meter contest, Jurgen, DJ6RD/W9, Valparaiso, Ind., was frustrated because none of the Novices he called could copy his call letters. In 1974, however, only one Novice he called had that difficulty. After several attempts to make a successful contact, Jurgen found the Novice in the Call Book, called him on the telephone, and said, "My call letters are D-J-6-R-D-Slant-band-W-9. Now, get on the air and have a contact. They made it! . . . The Chicago FM Club worked with Project LEAP (Legal Elections in All Precincts) to provide communications for the representatives of the Attorney General, State's Attorney, and LEAP poll watchers during the last election in Chicago. Thirty-four amateurs were active from 6:00 a.m. to 6:00 p.m., relaying complaints ranging from illegal electioneering to a death threat to an election judge. The communications were relayed through the CFMC 2-meter repeater, WR9ABY, which covers Chicago like a blanket. Senator Charles Percy complimented the club and LEAP. The club will be back for the next elections. ◈

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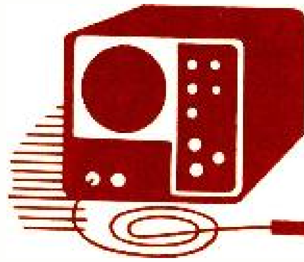


# Test Equipment Scene

By Leslie Solomon

## SOME RULES FOR USING EQUIPMENT

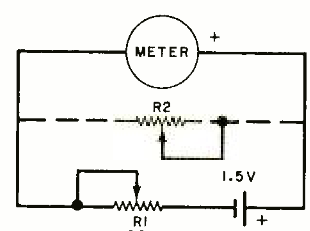
MOST test equipment, when properly used, will perform its natural function—make tests. Unfortunately, too many people treat their test equipment as if it were just another appliance, like a can opener. They jam the probes into the dark recesses of a chassis (which probably has power applied to it), twist some knobs, and hope that the results they get will tell them what they want to know. These are the same people who usually complain about the inaccuracy and short life of their test equipment and blame the manufacturer for their self-inflicted problems.

There are rules to be observed in using test equipment. They are simple to learn and they should be obeyed —starting now. The first rule is to read the manual that comes with the test gear. Too many times, a guy will unwrap a piece of new equipment, throw away the carton, glance briefly at the instruction manual, and then stow it away in the dark recesses of his work bench, never to consult it again unless something goes wrong with the equipment.This guy, if you pin him down, will usually say, "These things are all the same. Once you've used one VOM (or sweep generator or logic probe), you can use any other." Not once does he consider that, when a new model is designed, it may function differently from the old one. It may be capable of performing some sort of test that the old one couldn't. This is all spelled out in the manual, and it behooves the user to sit down and read it from cover to cover before he does anything else.

The next rule is to be fully aware of the capabilities, specifications, etc., of any piece of test equipment that you are using. For example, how much current does your ohmmeter deliver when the probe tips are shorted? You probably don't know; but you will apply it across a transistor or a low-power signal diode and then wonder why you keep having burned-out components. By the same token, you should know what the voltage is at the tips of the ohmmeter. Also, are you sure which lead is the positive input and which is the negative. I happen to have two ohmmeters (nationally known brands) and the color coding on the inputs is different between the two.

In addition, you might try checking a conventional rectifier diode on the various ohmic ranges of your multimeter. Then ask yourself why the resistance values are different on the various ranges. You forget that your multimeter is not delivering a constant current so that you get different indications when the meter is switched between ranges. On the other hand, a digital multimeter uses a constant-current source for resistance readings so that it will show the same value on different ranges.

Still on the subject of meters, a number of readers have asked how they can determine the resistance of a meter that they want to use in building some test equipment. The circuit shown here is one way of doing it.




Using a 1.5-volt cell, the resistance of potentiometer *R1* should be high enough to limit the current to a safe value. (In this case, a value of 100 kilohms will limit the current to 15 μA.) Do not connect *R2* at this time. With *R1* at full resistance, connect up the circuit. The meter may or may not move upscale. Carefully adjust *R1* until the meter goes to full scale. Using a potentiometer of several thousand ohms for *R2*, set it at full resistance and connect it across a full-scale-reading meter. Then adjust *R2* until the meter indication drops to exactly half scale. Without disturbing the *R2* setting, remove it from the circuit and, using an accurate ohmmeter, carefully measure the resistance of *R2* between the open end and the wiper. This is the resistance of the meter. Depending on the meter, you may have to experiment with the value of *R2*—decreasing its end-to-end value as required.

There is one other area that should be considered. If you look at the manual for your meter, you will find the maximum voltage value that can be safely applied to the probe tips. This is usually called out as maximum dc and dc plus ac. When using the meter, particularly on vacuum-tube TV circuits, be sure not to exceed this value or you might ruin the meter.

Do you know what the input resistance of your old VOM is on the various voltage ranges? This is important when considering the loading effect of the VOM on a high-impedance circuit. The parallel combination of meter and circuit resistance can produce wrong indications. So, before making voltage measurements with a VOM, check the impedances so that you get a satisfactory voltage reading.

**How About Oscilloscopes?** The instruction manual for an oscilloscope tells you how to correct the various vertical amplifier attenuators for frequency to remove ringing and tilting. If you have a probe, it too must be compensated by trimming its built-in capacitor to prevent distorted waveforms. Since pulse shapes are important in many signal paths in TV receivers, this frequency compensation must be made if you are to get the right waveform. Also, if you use a square- triangle- or sawtooth-waveform generator in audio testing, the wrong waveform on your CRT will throw off your tests. Once again, consult the manual.

R-f signal generators present other problems. Many of them require a terminating resistor at the end of the output lead. Check the manual and be sure that, if needed, you have the necessary resistance.

If you do any work on digital circuits and have a digital multifrequency generator, keep in mind that many of these must also be driven into a certain load or the waveforms will not be correct. Check the manual to see if you need a 51-ohm terminator. ◈

# Art's TV Shop

By Art Margolis

## THE MISSING BURST

As I walked into Peters' Electronic Parts a few days ago, old man Peters greeted me and said, "Art, I'm desperate—I need some help. Can you spare a few minutes?" I told him I could, and he led me to the back of the store. On a table I saw some factory-fresh test equipment, shiny hand tools and a chassis. "Going into the TV service business?" I asked. "Not by choice, my boy, not by choice," he muttered.

Then I noticed a tag on the receiver's line cord. It was from my crosstown competition, "Bob's TV." I smiled and asked, "Are you doing Bob's bench work now?"

"Not by choice," he said again, with more than a trace of disgust in his voice. I could see that the chassis was a GE CX model. There were a lot of them in the large motel on the highway near Bob's Shop. Bob had installed them quite a few years ago.

Peters moaned, "Bob's contracted to overhaul a lot of these old babies with new CRT's and flybacks. I ordered a hundred flybacks for him, but they don't work. He won't accept them. He's cancelling the order and is going directly to GE for good ones."

"What do you mean by that?" I asked. "How don't they work?"

"See for yourself," he said. I reached over and turned the receiver on. All the filaments lit up, and I heard a slight high-voltage crackling. The CRT lit up, and I examined the raster. It was full, straight, and bright. I attached an antenna and an excellent black and white picture appeared. I looked at Peters questioningly.

**No Color.** "It's supposed to be a color picture," he said sheepishly.

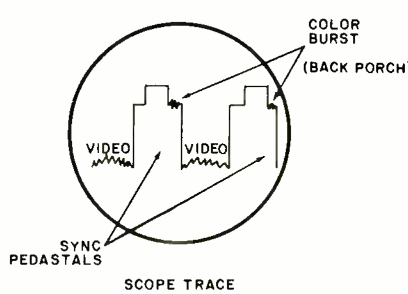
I reached for the color control and turned it. The black and white picture remained. Peters said, "There was good color before we changed the flyback."

I looked down. A new flyback transformer was soldered neatly in place. It wasn't a GE model, but one of the "exact replacement" types. I checked the installation against the wiring schematic. It was soldered according to the instructions.

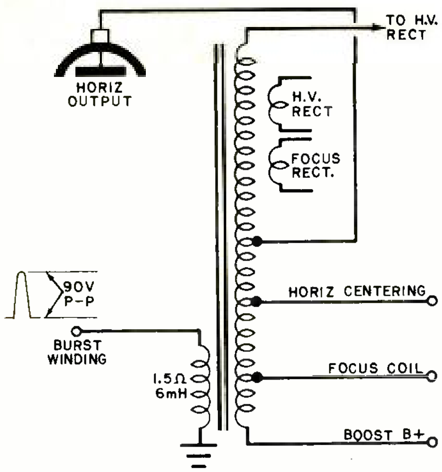
Peters said, "I had only one GE unit, and it caused no problems. The color was perfect. But these . . ."

I creased my brow and wondered—what could the flyback do to kill the color? I sat down and examined the receiver. The picture showed no trace of color. I took a small screwdriver and rocked the COLOR KILLER control back and forth. Aha! Some color snapped in and out of the picture as I varied the control's setting. A closer look showed faint color running through the picture in narrow stripes, but it was way out of color sync. This helped me narrow down the problem to the circuitry associated with color sync.

The best way to diagnose this type of difficulty is to attempt an AFPC alignment and see how far you can get. I shorted out the control grid of the reactance tube. This removes the variable capacitance effect of the reactance circuit and allows the color oscillator to free-run. The colors stopped racing through the picture and began to just float by. That meant that the oscillator was performing well, and near the correct frequency,




*Color bursts are located on back porch of sync pedestal.*




*Flyback transformer has special winding to generate spikes.*

since the colors were almost stationary. Removing the short caused the colors to start whirling by again. Trouble in the phase detector or burst circuit seemed likely.

I then shorted the input to the burst amplifier, preventing the burst signal from reaching the phase detector. The only signal reaching the phase detector is the sine-wave output of the 3.58-MHz oscillator. Voltages of equal magnitude but opposite polarity should appear at the twin diodes. If the voltages are not mirror images, the detector stage is the culprit. They did measure about ± 12 volts. The detector stage was OK, and trouble in the burst circuit was indicated.

The burst amplifier requires two inputs to function properly, the video signal and a horizontal pulse. The burst information is contained in the composite video signal, appearing as eight cycles on the back porch of the sync-and-blanking pedestal. The burst amplifier is biased into cutoff. If a video signal is applied to the input, no signal gets through. If a horizontal pulse and the video signal are applied simultaneously, the amplifier turns on, and the amplified burst appears at the burst output. The bursts then sync the color oscillator with the correct phase. The net result is a good picture with all the colors in place, not running through the picture like a moving rainbow.

"What effect would a new flyback have on the color sync?" I asked myself. Well, the flyback is the source of the horizontal pulse which turns on the burst amplifier. I picked up the probe of a transistorized multi-meter (TMM) and started to take dc voltage readings around the burst amplifier tube. All read near normal. I switched the TMM to read peak-to-peak volts. Both the video signal and the flyback pulse appeared. I scratched my head and decided to check the flyback pulse again, since this was generated by the new flyback. The schematic called for 90 volts p-p, but the meter read 60 volts. This might not be indicative of a problem, since the meter's response drops off at high frequencies such as this (15,750 Hz). However, it did warrant further examination.

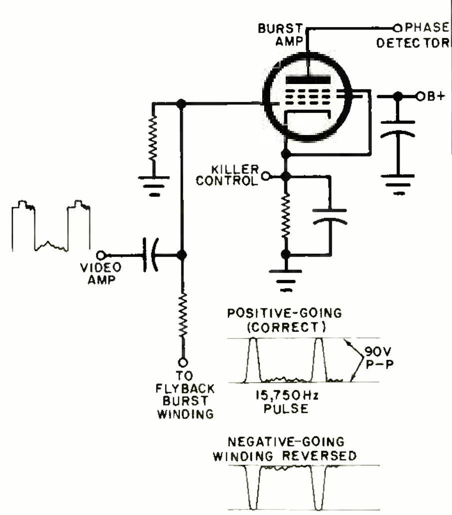
"I need a scope to see the pulse waveform," I told Peters. He went to a shelf and took down a new model.

Shortly, we had the scope displaying a bright green trace. I connected the scope's probe to the burst amplifier input to look at the horizontal pulse. A good spike was displayed on the CRT. I rechecked the schematic, and suddenly it struck me—the spike was a NEGATIVE (down-going) one! Instead of turning the amplifier on, as a positive spike would, it was driving the amplifier deeper into cutoff. The burst could not get through to sync the color.

It appeared that the leads on the flyback were reversed. I turned off the receiver and switched the leads. This wiring change should produce color sync. I turned on the set.

Peters was saying, "I hope it's just mislabelling and not . . . .," as the picture came on with the colors correctly in place.

Peters laughed and slapped me on the back. "Good work, my boy! You've saved the day!Take what you need from my stock—it's on the house!" ◈




*Burst amplifier has video input plus spike from the flyback.*

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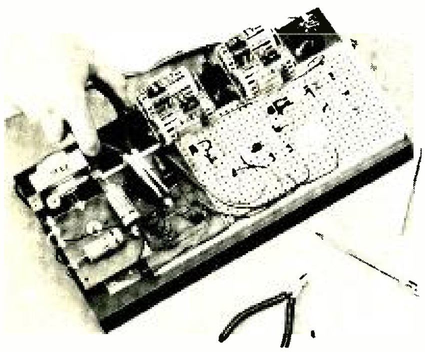

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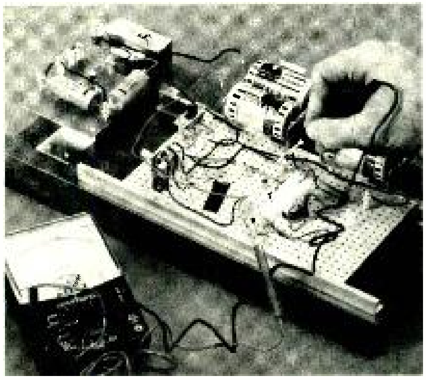

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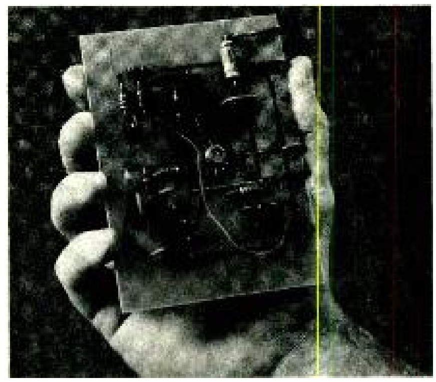

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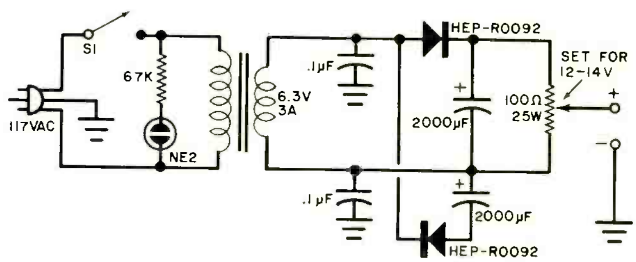
# Hobby Scene

## MOBILE CB POWER SUPPLY

**Q.** ***I'm a CB bug and I've been trying to build a power supply for my mobile rig (12-14.5 V, 1 A), but all the 6.3-volt transformers tried give me 8, 10, or 12 volts on my meter. Can you give me a circuit for such a supply, or give me the name and model of a transformer which will give an honest 6.3 volts?***—*R. Rodriguez, Bronx, N.Y.*

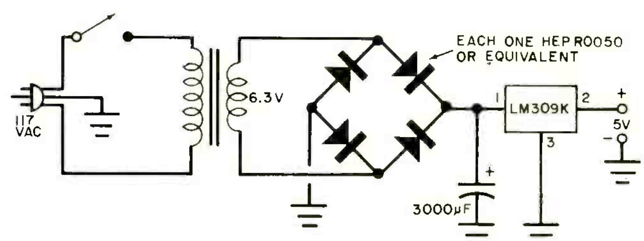
**A.** We have always found transformer labelling to be accurate. Why not have your dealer check out the questionable component? In your case however, you may be reading peak-to-peak voltage, which is 1.414 times greater than the 6.3 V-rms output the transformer is rated for. Here's a power supply that will work with most transceivers and auto tape players. It uses a 6.3-volt transformer and a voltage doubler.




## A SUPPLY FOR TTL EXPERIMENTS

**Q.** ***I would like to experiment with TTL, but I don't know what 5-volt supply would be suitable. Can you help?***—*Chris Sommers, Oakland, Ca.*

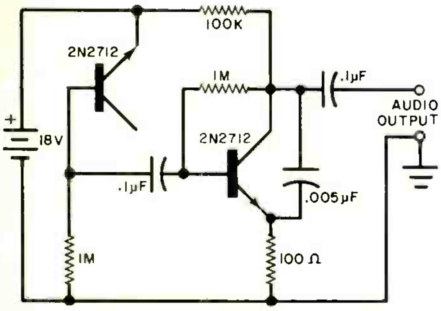
**A.** Sure! The circuit here uses a 6.3-volt filament transformer, a four-diode full-wave bridge (a one-package bridge module can be used), a large electrolytic, and a 5-volt regulator. Parts can be found in almost any electronics store, or by mail-order—check the back of this magazine!




## WHAT ARE WHITE AND PINK NOISE?

**Q.** ***What are "white noise" and "pink noise?" Is there a simple circuit which will generate pink noise?***—*C. Spaulding, Fredonia, NY.*

**A.** A concise and technically correct definition of white noise is: noise whose amplitude (strength) is a random (Gaussian) variable but which has equal energy distribution over all frequencies of interest, regardless of the center frequency of the frequency range being considered. Pink noise is noise whose amplitude is inversely proportional to frequency over a specified range. Equal energy distribution occurs in any octave bandwidth within that range. Pink noise is very pleasing to the human ear, which is why many people feel relaxed listening to the patter of rain (a close approximation of pink noise). Other examples include the sound of surf and a shower stream. In the circuit below, a

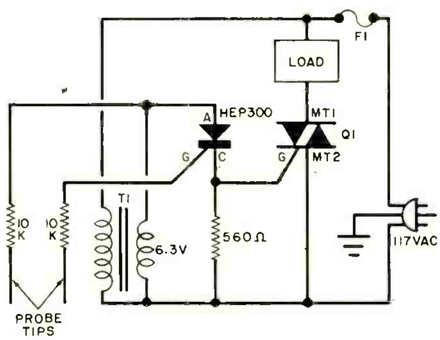



reverse-biased pn junction of a 2N2712 transistor is used as a noise generator. The second 2N2712 is an audio amplifier. The 0.005-μF capacitor across the amplifier output removes some high-frequency components to simulate pink noise more closely. The audio output may be connected to high-impedance earphones or to a driver amplifier for speaker listening.

## MOISTURE SENSOR

**Q.** ***Can you furnish me with a circuit for a moisture-sensing system which will turn on a pump when my basement gets flooded?***—*M.R. Cash, W. Palm Beach, Fla.*

**A.** We have had several requests for similar applications, so the circuit shows a "black-box" load. The triac,




*Q1*, is not given a specific part number since various loads demand different currents. Check how much current your load demands and obtain a triac that can handle this amount. The triac should be well heat-sinked. Use the same current rating for *F1* as *Q1*, and make it a quick-acting type fuse. The resistors may be mounted on a board, with leads in the clear used as probe tips.

# Electronics Library

### COLOR TV TROUBLE FACTBOOK (2nd Edition)

This revised edition of the Factbook, by Editors of Electronic Technician/Dealer, includes an indexed reference guide to color TV problems and recommended solutions, manufacturers' service notes, and production change data. Service tips, troubleshooting data, and special problem-solving advice are given for many of the popular U.S. and Canadian color TV models. Each set is arranged alphabetically by manufacturer and model number. Partial schematics, location diagrams, chassis layouts, and sketches are included to make parts identification and replacement easier.

*Published by Tab Books, Blue Ridge Summit, PA 17214. 348 pages. $8.95, hard cover; $4.95, paperback.*

### SECOND-CLASS RADIOTELEPHONE LICENSE HANDBOOK (FIFTH EDITION)

*by Edward Noll*

The objective of this book is to prepare the reader for the required FCC examination, including the Elements I, II, and III tests. The first chapter provides a summation of operator and station licensing requirements. Operating frequencies, propagation characteristics, and emission types are described in Chapter Two. Later chapters concentrate on the responsibilities of the Second-Class licensee. Sample tests, rules and regulations, and progressive quizzes are included.

*Published by Howard W. Sams & Co., Indianapolis, IN 46268. 448 pages. $7.50 soft cover.*

### THE VIDEO PRIMER

*by Richard Robinson*

This "how-to" book about the video media explains basic theory, hardware hookup and operating techniques for video cassette systems. Each chapter covers a specific topic, such as lighting, editing, and vidicons, to provide the user with as complete an exposure to video production as possible. The book is geared towards those who are disenchanted with network programming and who would like to produce their own material, whether for personal or community benefit.

*Published by Links Books, 33 West 60th Street, New York, NY 10023. 380 pages. $7.95 soft cover.*

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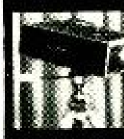

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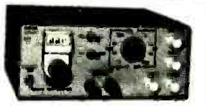

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|---|---|---|---|---|---|---|---|
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| 7401N | .23 | 7445N | 1.04 | 74100N | 1.45 | 74162N | 1.50 |
| 7402N | .22 | 7446N | 1.10 | 74104N | 1.25 | 74163N | 1.48 |
| 7403N | .22 | 7447N | 1.10 | 74105N | .45 | 74164N | 1.78 |
| 7404N | .21 | 7448N | 1.10 | 74107N | .45 | 74165N | 1.78 |
| 7405N | .21 | 7450N | .17 | 74109N | .92 | 74166N | 1.54 |
| 7406N | .36 | 7451N | .53 | 74110N | .72 | 74170N | 2.60 |
| 7407N | .45 | 7453N | .23 | 74111N | .92 | 74173N | 1.55 |
| 7408N | .23 | 7454N | .26 | 74114N | .92 | 74174N | 1.48 |
| 7409N | .23 | 7455N | .37 | 74115N | .92 | 74175N | 1.80 |
| 7410N | .18 | 7460N | .25 | 74118N | 1.51 | 74176N | 1.54 |
| 7411N | .27 | 7462N | .37 | 74119N | 1.80 | 74177N | 1.54 |
| 7412N | .52 | 7464N | .37 | 74121N | .54 | 74180N | 1.05 |
| 7413N | .72 | 7465N | .37 | 74122N | .51 | 74181N | 3.49 |
| 7414N | 2.25 | 7470N | .30 | 74123N | .90 | 74182N | .78 |
| 7415N | .37 | 7471N | .49 | 74125N | .64 | 74184N | 2.86 |
| 7416N | .37 | 7472N | .33 | 74126N | .64 | 74185N | 2.29 |
| 7417N | .37 | 7473N | .41 | 74128N | 1.32 | 74188N | 4.90 |
| 7420N | .18 | 7474N | .40 | 74132N | 2.06 | 74190N | 1.49 |
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| 7422N | .27 | 7476N | .45 | 74140N | 2.50 | 74192N | 1.45 |
| 7423N | .48 | 7478N | .55 | 74141N | 1.19 | 74193N | 1.29 |
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| 7426N | .27 | 7481N | 1.19 | 74147N | 2.95 | 74195N | .89 |
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| 7430N | .20 | 7484N | 3.02 | 74151N | .84 | 74198N | 2.09 |
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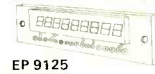

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| 226 | Green | .30 |
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| 74LS03 | .58 | 74LS109 | .92 |
| 74LS04 | .63 | 74LS112 | .92 |
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| 74LS08 | .58 | 74LS114 | .92 |
| 74LS09 | .58 | 74LS138 | 2.38 |
| 74LS10 | .58 | 74LS139 | 2.38 |
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| 74LS54 | .58 | 74LS181 | 3.72 |
| 74LS55 | .58 | 74LS251 | 2.55 |
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|---|---|---|---|---|---|
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| 74S02N | .80 | 74S85N | 6.10 | 74S160N | 4.70 |
| 74S03N | .75 | 74S86N | 2.70 | 74S161N | 4.70 |
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| 74S08N | .80 | 74S113N | 1.50 | 74S175N | 3.30 |
| 74S10N | .75 | 74S132N | 3.60 | 74S181N | 10.20 |
| 74S11N | .65 | 74S133N | .90 | 74S189N | 5.10 |
| 74S20N | .80 | 74S138N | 2.40 | 74S194N | 3.30 |
| 74S30N | .80 | 74S139N | 2.40 | 74S195N | 3.30 |
| 74S32N | .80 | 74S140N | .90 | 74S251N | 2.40 |
| 74S40N | .80 | 74S151N | 2.40 | 74S253N | 2.40 |
| 74S51N | .80 | 74S153N | 2.40 | 74S257N | 2.40 |
| 74S64N | .80 | 74S157N | 2.40 | 74S258N | 2.40 |
| | | | | 74S260N | .90 |
| | | | | 74S280N | 5.70 |

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| TBA641B11 | 6-18 | 2.20 | 4 | 3.00 |
| TBA800 | 5-30 | 4.70 | 8 | 2.20 |
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| 14 pin DIL | .26 |
| 16 pin DIL | .29 |
| 24 pin DIL | .75 |
| 28 pin DIL | 1.10 |
| 36 pin DIL | 1.70 |
| 40 pin DIL | 1.90 |
| **WIRE WRAP-GOLD** | |
| 14 pin DIL | .40 |
| 16 pin DIL | .45 |
| **SOLDER - GOLD** | |
| 14 pin DIL | .35 |
| 16 pin DIL | .40 |
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| 3 pin TO-5 | .55 |
| 4 pin TO-5 | .65 |
| 6 pin TO-5 | .90 |
| 8 pin TO-5 | 1.10 |
| 10 pin TO-5 | 1.40 |

## 75107

| | |
|---|---|
| 75107BN | 2.60 |
| 75108BN | 2.30 |
| 75109N | 2.20 |
| 75110N | 2.20 |
| 75115N | 2.25 |
| 75138N | 2.95 |
| 75150N | 3.10 |
| 75154N | 4.10 |
| 75208N | 2.70 |
| 75234N | 2.50 |
| 75450N | 1.25 |
| 75451N | 1.00 |
| 75452N | 1.00 |
| 75453N | 1.00 |

## 7520 SERIES SENSE AMPS

| | |
|---|---|
| 7520N | 4.00 |
| 7521N | 2.00 |
| 7522N | 4.25 |
| 7523N | 1.75 |
| 7524N | 2.00 |
| 7525N | 4.50 |

## LINEAR ICs

H=TO5 N=DIP M=MINI-DIP D=CER-DIP K=TO3

| | | | | | |
|---|---|---|---|---|---|
| LM114H | 3.00 | LM311H | 1.70 | LM711CN | .90 |
| LM300H | 1.20 | LM311D | 1.90 | LM715CH | 4.30 |
| LM300N | 1.20 | LM311M | 1.75 | LM715CD | 4.60 |
| LM301AH | .90 | LM311N | 2.00 | LM723CH | .90 |
| LM301AM | .80 | LM312H | 2.70 | LM723CN | .75 |
| LM301AN | 1.10 | LM318H | 2.60 | LM725CH | 5.00 |
| LM301M | .90 | LM324N | 1.90 | LM725CD | 5.20 |
| LM301H | .90 | LM331N | 2.20 | LM733CH | 1.40 |
| LM302D | 3.50 | LM339N | 3.20 | LM733CD | 3.50 |
| LM302N | 1.30 | LM320-5K | 2.90 | LM733CN | 1.30 |
| LM302H | 1.50 | LM320-5T | 2.50 | LM741CH | .45 |
| LM304H | 1.50 | LM320-12K | 2.90 | LM741CD | 1.25 |
| LM305H | 1.05 | LM320-12T | 2.50 | LM741CM | .44 |
| LM305AH | 1.05 | LM340-05K | 2.60 | LM741CN | .70 |
| LM305N | 1.00 | LM340-06K | 2.60 | LM747CH | 1.70 |
| LM306H | .95 | LM340-08K | 2.60 | LM747CN | .90 |
| LM307H | .75 | LM340-12K | 2.60 | LM747CD | 2.50 |
| LM307M | .95 | LM340-15K | 2.60 | LM748CM | .55 |
| LM307N | 1.50 | LM340-18K | 2.60 | LM748CN | .55 |
| LM308H | 1.20 | LM340-24K | 2.60 | LM777CH | 2.15 |
| LM308AH | 5.00 | LM555CM | .90 | LM777CM | 2.10 |
| LM308D | 2.00 | LM556CN | 1.30 | LM3046CN | .95 |
| LM308M | 1.20 | LM709CH | .45 | LM3054CN | 1.50 |
| LM309H | 1.75 | LM709CN | .45 | SG4501T | 2.20 |
| LM309K | 1.95 | LM710CH | .90 | SG4501N | 2.20 |
| LM310H | 1.60 | LM710CN | .90 | LM5000K | 7.50 |
| LM310M | 1.80 | LM711CH | .90 | | |

## LOW POWER TTL

| | |
|---|---|
| 74L00N | .34 |
| 74L02N | .34 |
| 74L03N | .39 |
| 74L04N | .39 |
| 74L10N | .34 |
| 74L20N | .39 |
| 74L42N | 1.62 |
| 74L51N | .34 |
| 74L73N | .74 |
| 74L74N | .89 |
| 74L90N | 1.62 |
| 74L93N | 1.74 |
| 74L95N | 1.62 |

## HIGH SPEED TTL

| | | | |
|---|---|---|---|
| 74H00N | .34 | 74H53N | .36 |
| 74H01N | .34 | 74H54N | .36 |
| 74H04N | .38 | 74H55N | .36 |
| 74H05N | .37 | 74H60N | .36 |
| 74H08N | .40 | 74H61N | .36 |
| 74H10N | .36 | 74H62N | .36 |
| 74H11N | .36 | 74H71N | .80 |
| 74H20N | .36 | 74H72N | .74 |
| 74H21N | .36 | 74H73N | .90 |
| 74H22N | .36 | 74H74N | .87 |
| 74H30N | .36 | 74H76N | .90 |
| 74H40N | .36 | 74H101N | .80 |
| 74H50N | .36 | 74H102N | .80 |
| 74H51N | .36 | 74H103N | 1.10 |
| 74H52N | .36 | 74H106N | .95 |

| | |
|---|---|
| 93L00 | 1.50 |
| 93L01 | 1.60 |
| 93L08 | 3.20 |
| 93L09 | 1.80 |
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| 93L11 | 4.20 |
| 93L12 | 1.80 |
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| 93L34 | 4.00 |
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| 93L60 | 3.00 |
| 93L66 | 2.70 |

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|---|---|
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| MM507H | 3.20 |
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| MM551H | 5.60 |
| MM555H | 5.60 |

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| | |
|---|---|
| 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 |

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| | | | |
|---|---|---|---|
| P1101A | 6.90 | C2102-2 | 8.00 |
| P1101A1 | 8.50 | P2102-2 | 6.00 |
| 1402AN | 5.40 | 2505K | 3.30 |
| 1403AH | 8.00 | 2512K | 5.50 |
| 1403AN | 5.40 | 2521V | 4.00 |
| 1404AH | 8.00 | 2524V | 3.90 |
| 1404AN | 5.40 | 2525V | 5.30 |
| 1405A | 4.10 | 2533V | 8.50 |
| 1506 | 4.00 | 3341PC | 8.20 |
| 1507 | 4.00 | MM5025N | 20.00 |
| 1602 | 33.00 | MM5026N | 20.00 |
| 1702 | 33.00 | MM5027N | 20.00 |
| C2102 | 8.00 | MM5055N | 5.50 |
| P2102 | 6.00 | MM5056N | 5.50 |
| C2102-1 | 8.00 | MM5057N | 5.50 |
| P2102-1 | 6.00 | MM5058N | 5.50 |

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|---|---|---|---|
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| BU205 | 3A | 1500V | 4.95 |
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| BU207 | 6A | 1300V | 5.85 |
| BU208 | 6A | 1500V | 6.93 |
| BU209 | 6A | 1700V | 8.64 |

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| 2N512B | 2.90 | 2N3563 | .15 | 2N3971 | 1.00 |
| 2N677C | 5.50 | 2N3565 | .19 | 2N4045 | 1.95 |
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| 2N711 | .50 | 2N3569 | .17 | 2N4249 | .18 |
| 2N918 | .40 | 2N3642 | .19 | 2N4303 | .30 |
| 2N1136 | 1.50 | 2N3643 | .14 | 2N4341 | 1.35 |
| 2N1377 | 1.50 | 2N3645 | .15 | 2N4347 | 1.60 |
| 2N1483 | 1.20 | 2N3657 | 9.00 | 2N4348 | 2.00 |
| 2N1534 | 1.00 | 2N3684 | 1.25 | 2N4395 | 1.30 |
| 2N1540 | 1.10 | 2N3702 | .18 | 2N4416 | .90 |
| 2N1544 | .90 | 2N3707 | .17 | 2N4858 | 1.10 |
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| 2N1934 | 9.40 | 2N3725 | .36 | 2N4922 | 1.00 |
| 2N2102 | .60 | 2N3731 | 2.00 | 2N5036 | 1.18 |
| 2N2219 | .30 | 2N3771 | 2.20 | 2N5127 | .16 |
| 2N2221 | .25 | 2N3772 | 2.30 | 2N5198 | 4.30 |
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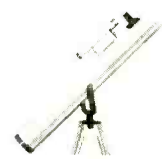

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