HOW TO EVALUATE TAPE RECORDER SPECS

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE OCTOBER 1974/60¢

Features:

Clandestine Shortwave Broadcasts

How to Light Up with Modern "LEDs"

Digital Electronics Course, Part I

Construction Projects:

Low-Cost Background Music Adapter

Versatile Nickel-Cadmium Battery Charger

Test Reports:

Heathkit AR-2020 4-Channel Receiver

Design Acoustics D6 Speaker System

Dynascan Cobra CAM-89 CB Transceiver

Data Precision Digital Multimeters

EXCLUSIVE!

An Electronic Salt Meter For Family Health

ZIFF-DAVIS PUBLISHING COMPANY
18101

t of each is up to us

professional 10½-inch tape reels. Its unique combination of bias and equalization switching controls give 12 different settings to optimize the performance of any tape on the market.

The RT-1050's 3-motor transport system is activated electronically by full logic, solid state circuitry, triggered by feather touch pushbutton controls. Its transport is completely jam- and spill-proof, permitting you to switch from Fast Forward to Fast Rewind, bypassing the Stop button.

The RT-1050 was specifically designed for easy operation with a wide combination of professional features like extended linearity VU meters with adjustable sensitivity, mic/line mixing, pushbutton speed selection and reel tension adjustment buttons. There's also an exclusively designed pause control and independent control of left and right recording tracks.

The same 2-track recording system studios use for better signal-to-noise ratios and higher dynamic range is incorporated into the RT-1050. Yet it can be easily converted to 4-track use with an optional plug-in head assembly. Everythin considered it's the most versatile open-reel deck you can buy. Professionals prefer it for its studio-quality performance Everyone appreciates its completely simple operation.

Pioneer open-reel and cassette deck are built with the same outstanding quality, precision and performance of al Pioneer stereo components. That's why, whichever you choose, you know it's completely professional and indisputably the finest value ever in a studio-quality tape deck.

PIONEER®

when you want something better

U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074
West: 13300 S. Estrella, Los Angeles 90248 / Midwest: 1500 Greenleaf, Elk Grove Village, Ill. 60007 / Canada: S.H. Parker Co.

Giving you the bes

High fidelity is important to us at Pioneer. It's all we do and it's all we care about. We are excited that cassette tape decks have reached a level of performance that meet the highest standards. We are excited because we know that it means more enjoyment for you from your high fidelity system. We also know that you can now get more versatility and more value out of your high fidelity system than ever before.

The great advances in cassette technology have had impact on the reel-to-reel tape deck concept as well. We believe that the era of the small, inexpensive 7-inch reel tape deck is past. Neither its convenience nor its performance make it a good value compared to the new cassette technology. And it is now possible for Pioneer to offer you a professional studio-quality 10½-inch reel deck at prices that compare favorably with what you might expect from old fashioned 7-inch reel units. In our judgment the old ideas must move aside for the new ideas. And Pioneer has some very intelligent new ideas in tape for you.

The convenience of cassette. The performance of open-reel.

The stereo cassette deck has become a "must" in complete high fidelity systems. Because of its convenience, price and performance, it has virtually replaced the once popular 7-inch open-reel deck. As Julian D. Hirsch, prominent audio reviewer put it, "The best cassette machines compare favorably with a good open-reel recorder in listening quality." Pioneer proves it with four top-performing models.

Stacks compatibly with other components.

Our new CT-7171, with built-in Dolby, is a deck with a difference. It's designed with all controls up front so you can stack other components on or under it. Even the illuminated cassette compartment is front loading, for easy access and visibility.

Performance features stack up, too. Bias and equalization switches provide optimum recording and playback for every type of cassette tape made. You'll produce distortion-free recordings consistently with two oversized, illuminated VU meters plus an instant-acting peak level indicator light. And for those unpredictable program source peaks, there's a selectable Level Limiter circuit. It's similar to the type used in professional recording studios to prevent "clipping" distortion.

Finding a desired program point in a recorded cassette is simple with our new CT-7171. A memory rewind switch, working together with the 3-digit tape counter, plus an exclusive Skip button, lets you monitor audibly at accelerated speed to make precision cueing a breeze.

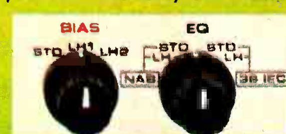
Automatic tape-end stop, dual concentric level controls, separate mic/line inputs, pause control, in addition to many other features, make the CT-7171 the recording studio that fits on a shelf.

Whether you choose the sophistication of the CT-7171 or Pioneer's CT-5151, CT-4141A or CT-3131A, which share many of its features, you're assured optimum performance and maximum value. One tradition that never changes at Pioneer.

Open-reel. A professional recording studio in your home.

Professionalism comes with all three studio-quality open-reel models. The RT-1020L (7½, 3¾ ips) is unequalled in 4-track units. With three motors and three heads, it has virtually every professional feature you'd want. Yet it's extremely simple to use. In addition to stereo record/playback, it also highlights 4-channel playback. The complete extent of its capabilities becomes apparent only after you've worked with it. Then you'll recognize the magnitude of Pioneer's accomplishment.

Our RT-1050 is a 2-track, 2-speed (15, 7½ ips) 3-head deck which, like all our open-reel models, can handle



12 Bias & Equalization settings optimize performance.

Whether you use a cassette or open reel deck is up to you.

Pick The Open-Reel Deck Features You Need

Model	RT-1050	RT-1020H	RT-1020L
Maximum Reel Size	10½"	10½"	10½"
Speeds	15 & 7½ ips	15 & 7½ ips	7½ & 3¾ ips
Number of Tracks	2 (4 optional)	4	4
Wow & Flutter (at high speed)	0.06%	0.06%	0.10%
Frequency Response (±3dB)	30Hz-22kHz	30Hz-22kHz	40Hz-20kHz
Tape Bias Selection	3 position	3 position	3 position
S/N Ratio	57dB	55dB	55dB
Equalizer Selection	4-Position	2-Position	2-Position
Mic/Line Mixing	yes	yes	yes
LED Peak Indicator	yes	no	no
Memory Recording	yes	yes	yes
VU Meter Scale Selection	yes	no	no
4-Channel Playback	no	yes	yes
Motors	3	3	3
Price	$699.95	$649.95	$549.95

Pick the Cassette Features You Need

Model	CT-7171	CT-5151	CT-4141A	CT-3131A*
Dolby Noise Reduction	yes	yes	yes	no
Tape Selection	Bias & Equal.	Bias & Equal.	Bias & Equal.	Equalization
Auto. Tape Stop	yes	yes	yes	yes
Memory Rewind	yes	yes	no	no
Pause Control	yes	yes	yes	yes
Freq. Response*	30-16,000 Hz	30-16,000 Hz	30-15,000 Hz	30-15,000 Hz (*Chrome Tape)
Peak Indicator	yes	yes	no	no
Level limiter	yes	yes	no	no
Skip cueing	yes	yes	yes	no
Signal/Noise (Dolby)	58 dB	58 dB	58 dB	—
S/N (Less Dolby)	48 dB	48 dB	48 dB	47 dB
Tape Heads	Ferrite	Ferrite	Permalloy	Permalloy
Motor Type	DC Servo	DC Servo	DC Servo	DC Servo
Wow & Flutter (WRMS)	0.10%	0.12%	0.13%	0.13%
Price	$369.95	$269.95	$239.95	$179.95

*not shown

OCTOBER 1974 VOLUME 6, NUMBER 4

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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CONSTRUCTION STORIES

COLUMNS

PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

TWENTY YEARS AGO—

Color TV emerged from the laboratories. . . Citizens Radio Service included only one frequency (465 MHz) for low-power, party-line use. . . The first stereo tape recorders appeared. . . The acoustic suspension speaker was developed. . . A magazine called POPULAR ELECTRONICS was started.

The year was 1954. And the first issue of POPULAR ELECTRONICS (October 1954) was sold out at newstands to an electronics-hungry public. Devoted to how-to-do-it, how-to-use-it, how-it-works and why-it-works, the magazine quickly captured a large, loyal readership.

The lead article in that first issue was "Build Your Own Bike Radio"—a four-tube, point-to-point wired AM radio that barely fit across the straight part of a bike's handle bars. It was written by Lou Garner, our *Solid State* columnist. Other 1954 features covered subjects such as how to build a coil-winding jig, a 4-watt power amplifier (mono, of course), and the beginning of a series called "So You Want to be a Ham."

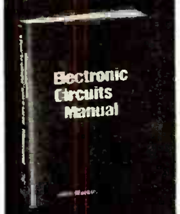
As the years passed, POPULAR ELECTRONICS served as an information center for active electronics enthusiasts, introducing them to the latest technologies: homemade pc boards in 1956, video tape recording in 1957, FM multiplexing in 1959, the laser in 1961, hi-fi laboratory checks in 1962, and a transistorized auto ignition system project in 1963. In 1966, a major article on integrated circuits predicted that these devices would make possible a new generation of products for home and industry.

Then, in 1968, POPULAR ELECTRONICS embarked on a series of "firsts"—exciting, advanced-technology projects to occupy the hands and minds of readers. For example, in 1968, the first digital readout construction project was introduced by POPULAR ELECTRONICS. This was followed by the first laser communications system in 1969. (That one was shown at the Smithsonian Institution, by the way.) In these pages, readers saw the first digital multimeter project in 1970, the first build-it-yourself calculator in 1971, the first alpha brain-wave project in 1973, and the first digital wristwatch kit in 1974. Continuing this stimulating tradition, next month we will introduce a moderately priced laser video communication link—that's video transmission and reception without strung wires and with no license requirement!

It has certainly been a revolutionary two decades for POPULAR ELECTRONICS. There's much more to come as new generations of electronic devices and thrilling applications are developed in the unfolding years. You'll be sure to read about them here.

Art Salsberg

Another introductory offer to new members of the ELECTRONICS AND CONTROL ENGINEERS' BOOK CLUB



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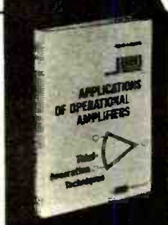

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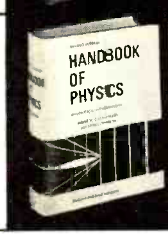

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Please enroll me as a member of the Electronics and Control Engineers' Book Club and send me the two books indicated below. I am to receive the higher priced of the two for just $1, and my first selection at the special Club price. Actual postage, plus 25¢ handling charge will be added (sales tax, also, if applicable). These books are to be shipped on approval, and I may return them both without cost or further obligation. If I decide to keep the books, I agree to purchase as few as four additional books (including this first selection) during the next two years at special Club prices (guaranteed 15% discount, often more).

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CIRCLE NO. 16 ON READERS SERVICE CARD

Letters

THE LONG AND THE SHORT OF TONEARMS

Ralph Hodges's clear, thorough article on "Matching Tonearms And Cartridges" (Stereo Scene, July 1974) goes a long way toward providing an understanding of the factors involved in improving the reproduction of ripply and warped records. On the subject of tonearm length, however, it should be pointed out that, as stated, a shorter arm will contribute more warp wow than will a longer one (all else being equal)—particularly if the pivot allowing vertical motion is the same distance above the record in both arms. If the pivot is in the plane of the record, the warp wow contributed by the arm's geometry is minimized.

JACK REED
Chicago, Ill.

FOR A GOOD CAUSE

I am attempting to build up a library of POPULAR ELECTRONICS for our newly formed Lynbrook Amateur Radio & Electrical Hobbyist Club. If any readers feel generous and would like to donate past issues of PE (and other magazines) to our club, please drop me a note at the address below, and we will gladly pay postage. We can use all types of magazines devoted to hobby electronics, communications, etc.

ROBERT HUMMEL
Director/Radio Club
30 Durland Rd.
Lynbrook, N.Y. 11563

Any interested readers are asked to write directly to Mr. Hummel.

SEES NO NEED FOR TWO COUNTERS

I agree with Paul Michael ("Portable Time Base for Digital Clocks," July, 1974) that the 555 makes an excellent source of 60-Hz pulses for driving a digital clock when an ac line signal is not available. However, I see no need for the two 7490 decade counters shown. There is no reason why the 555 itself cannot be operated at 60-Hz, thus eliminating the extra circuitry. A high-quality 1-μF capacitor can be used for *C1*, and the output can be taken from pin 3 of the 555. A high-quality tantalum, Mylar, or metallized paper capacitor is more stable than the average 0.01-μF ceramic disc capacitor.

HAROLD J. TURNER, JR.
Senior Technical Editor
National Radio Institute
Washington, D.C.

IN REBUTTAL

In response to Kenneth B. Rothman, KBY-0535 ("Letters," July 1974), there *are* groups across the country working with the FCC on a continuing basis in an effort to clean up the air. We of the "Quit Skip QSL Club" have chapters in 12 states cooperating with the local FCC Offices. In fact, in three states, our members who are qualified to do so are given the TVI complaints to investigate. This relieves the FCC of much work and does a great deal toward improving public acceptance of us CB'ers. We do not pretend to be a "police force," but each State Chapter has assigned monitors gathering information on infractions of Part 95.

GEORGE CAPPS, QS1MO
National Director
Quit Skip QSL Club
Rte. 2, Box 174
Rolla, MO 65401

CAN'T PEAK WITH Q MULTIPLIER

After assembling the Q Multiplier (April 1974), I checked it out with an oscilloscope to assure myself that it was operating properly. I installed it in my Hallicrafters SX62A receiver. It operates fine on NULL, but on PEAK, I lose everything. When I pull the plug on the Q Multiplier, the receiver works properly again. In an attempt to get the multiplier working properly with my receiver, I have attempted to adjust the receiver's i-f transformers—to no avail. How can I get my Q Multiplier to work in the PEAK mode?

OWEN P. BURKLOW
Scottsdale, Ariz.

The Author replies: "It appears that your SX-62A already has a pretty good i-f. From the description of your problem, it is pretty definite that the Q of the i-f transformer is such that it is pulling the Q Multiplier out of oscillation as you tune to the center of the i-f passband.

"There are several solutions I can recommend: (1) Reduce the value of C1 to 50 to 180 pF, using the largest value that will keep the multiplier in smooth oscillation. (2) Decrease the value of C6 to 500 to 800 pF. This will increase oscillator feedback, but it will change the frequency (readjust L1 as necessary) and will result in some reduction in the height and depth of the peak and null. (3) Increase the value of R2 to 15,000 ohms, which has basically the same effect as solution 2."

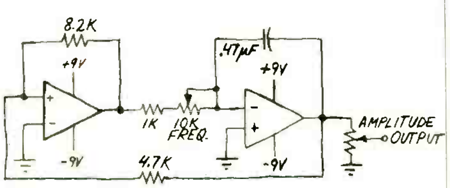
A CLEARER UNDERSTANDING OF DECIBELS

"Understanding Decibels" in the April 1974 issue was very good. However, some clarification is desirable. The second sentence would be more accurate if the word "bel" were used in place of "decibel." The "deci" prefix is used to denote a quantity that is one tenth that of a bel, thus simplifying how we write power levels. Mr. Ward's formulas take this into consideration. (Note: The word "bel" was designated by an international committee for countries using common logarithms. For those countries using the natural, or naperian, logarithms, the words "neper" and "decineper" were formulated. The latter differ somewhat from "bels" and "decibels.")

A. L. AYERS
Appleton, Wisc.

AN EASIER WAY TO DO IT

The triangle-wave generator shown in the Test Equipment Scene (May 1974) was doing things the hard way. My circuit is much simpler. It uses less than half the



parts, but it doesn't sacrifice performance. It also features better linearity, which is important for test purposes. And the circuit is drift-free, eliminating the need for relatively expensive output capacitors. I have designed the circuit to be frequency-variable without the need to readjust the output level to maintain a constant amplitude.

WOLFGANG RUPPRECHT
Munich, Germany

COMMENTS ON THE "NEW LOOK"

. . . The new big size is great.

CHARLES L. KELSY
Mayville, N.Y.

. . . I think it's in great taste. Especially, enjoyed your article "How to Set Up a Home TV Service Shop."

BOB J. LATHIM
Dwight, Ill.

. . . These latest changes have helped to further increase its effectiveness.

GEORGE E. PARKER
Englewood Cliffs, N.J.

. . . Keep the new size and the metrics and you have a permanent subscriber.

ARTHUR YASUI
Palo Alto, Calif.

DON'T SUPPLY KEYBOARDS INDIVIDUALLY

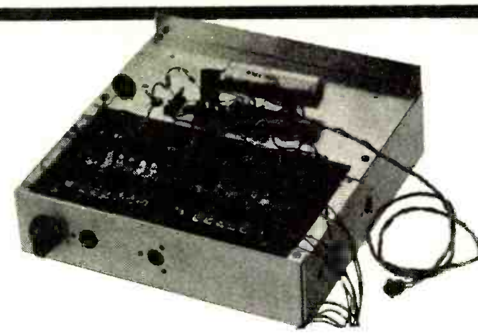
Our company was accidentally listed in Don Lancaster's article in your July 1974 issue ("How to Select EM Keyboards & Controllers") as a supplier of AGO keyboards. While we do manufacture keyboard controllers for our modular synthesizer systems, we cannot economically handle individual keyboard manuals. We'd like to extend our apologies to those people to whom we have not replied in this regard.

DAVE ROSSUM
Eµ Systems
Santa Clara, Calif.

good with 7 kits . . . $312

Or low monthly terms

A basic TV/Audio Servicing Course including 7 training kits for your experiments. You build your own solid-state radio, solid-state volt-ohmmeter, and experimental electronics lab. Includes 65 bite-size lessons (16 on color TV), 15 special reference texts with hundreds of servicing short cuts, tips on setting up your own business, etc. This completely up-to-date course covers black & white and color TV, FM multiplex receivers, public address systems, antennas, radios, tube, transistor and solid-state circuits.



better . . . with 11 kits and B/W TV . . . $425

Or low monthly terms

A complete course in B&W and Color TV Servicing, including 65 lessons (16 on color TV), 15 special reference texts and 11 training kits. Kits you build include your own solid-state radio, solid-state volt-ohmmeter, experimental electronics lab, plus a 12" diagonal solid-state black & white portable TV . . . to build and use. At each assembly stage, you learn the theory and the application of that theory in the trouble-shooting of typical solid-state TV sets.

better yet with 12 kits and 19" diag. Color TV . . . $695

Or low monthly terms

The same basic 65 lessons and reference texts as before, plus kits and experiments to build a superb solid-state 19" diagonal color TV receiver . . . complete with rich woodgrain cabinet, and engineered specifically for training by NRI's own engineers and instructors. This handsome set was designed from the chassis up to give you a thorough understanding of circuitry and professional trouble-shooting techniques. You build your own solid-state radio, solid-state volt-ohmmeter, and experimental electronics lab.

best . . . with 14 kits and 25" diagonal Color TV . . . $995

Or low monthly terms

The ultimate home training in Color TV/Audio servicing with 65 bite-sized lessons, 15 reference texts, and 14 training kits . . . including kits to build a 25" diagonal Color TV, complete with handsome woodgrain console cabinet; a wide band, solid-state, triggered sweep, service type 5" oscilloscope; TV pattern generator; digital multimeter, solid-state radio, and experimental electronics lab.

This Master course combines theory with practice in fascinating laboratory units. Unlike "hobby kits", the NRI color TV was designed with exclusive "discovery" stages for experimentation and learning. Building the set will give you the confidence and ability to service any color TV set on the market. And you'll have a magnificent set for years of trouble free performance.

Plus Advanced Pro Color . . . $535 Or low monthly terms

An advanced Color TV Servicing Course for experienced technicians. 18 color lessons, 5 new "Shop Manuals", and the NRI 19" diagonal solid-state Color TV set are included.

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.

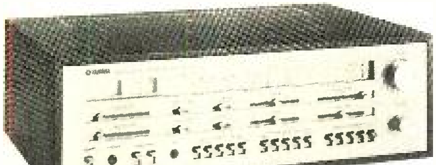
CONTINENTAL SPECIALTIES BREADBOARD

Continental Specialties Corp. is now marketing the new Proto Board-203, a breadboarding system that consists of special connector-matrix sockets capable of accommodating up to 24 14-pin DIP IC's and a built-in 5-volt, 1-ampere power supply. The power supply is regulated and has protection against short circuits. The Proto Board contains three QT-59S DIP-type sockets, four QT-59B bus-strip sockets, and one QT-47B bus-strip socket. Circuits are breadboardec by plugging component leads and prepared hookup wire into the connector matrix, eliminating the need for soldering. The unit measures 9¾ in. by 6½ in. by 2¾ in. (23.5 x 16.5 x 7 cm) and weighs 5 lb (2.3 kg). It retails for $75.

CIRCLE NO. 69 ON READER SERVICE CARD

YAMAHA STEREO FM RECEIVER

The Model CR1000 stereo FM receiver is the top of Yamaha's line. The FM tuner section features a MOSFET front end, an IC i-f amplifier with a seven-stage differential amplifier and six ceramic filters, and a mul-



tiplex demodulator with negative feedback. The preamplifier section includes a microphone amplifier for mixing, two tape record/monitor circuits with dubbing capability, tone controls, and a loudness control. The amplifier section is rated at 75 watts continuous rms power per channel into 8 ohms, rated at less than 0.1 percent IM and THD and 10-100,000 Hz (+0, −1 dB) frequency response. Yamaha's Auto-Touch Tuning system automatically defeats the afc during tuning. The retail price of the receiver is $850.

CIRCLE NO, 70 ON READER SERVICE CARD

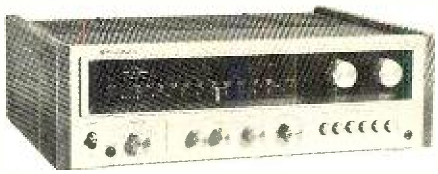
UNGAR DOUBLE-INSULATED SOLDERING IRON

The new double-insulated DI line, from Ungar, features a heater and handle with two-conductor cord set and safety plug. The entire system is double-insulated to meet the latest safety standards. Four rugged stainless-steel heaters and three heat ranges provide flexibility for different soldering jobs. The handle is molded of durable plastic and incorporates a cool finger grip for operator comfort. The No. 555 double-insulated two-conductor handle accepts thread-in No. 300 series heaters. A 45-watt integral heater with built-in iron-plated chisel tip for heavy duty applications is also available.

CIRCLE NO. 71 ON READER SERVICE CARD

KENWOOD STEREO RECEIVER

Direct-coupled, complementary-symmetry output circuits, a power transformer with heat sinks, and a dual protection circuit are three of the features of Kenwood's new Model KR-5400 stereo receiver. The amplifier section is rated at 35 watts rms per channel into 8 ohms, with both THD and ID



values of 0.5%. A front-panel selector switch controls up to three pairs of speaker systems (any two of which can be switched in at a given time) and silences the speakers for headphone listening. The FM tuner sensitivity is 1.9 μV (IHF); capture ratio is 1.5 dB (IHF). The stereo decoder employs an IC phase-locked loop to reduce beat interference and intermodulation distortion. Special input and output terminals are provided for any 4-channel decoder or adapter, as is a special FM DET OUT for future discrete broadcasts. Retail price is $279.95.

CIRCLE NO. 72 ON READER SERVICE CARD

ANTENNA SPECIALISTS MOBILE ANTENNA

A new three-way antenna has been announced by the Antenna Specialists Company. They say that the Model M-267 antenna is designed to offer significantly improved mobile performance over previcus combination CB/AM/FM designs. Featured is a new coupler to reduce insertion losses and deterioration of AM and FM broadcast reception. The coupler allows use of the single antenna system for both broadcast receiver and CB transceiver without switching or adjustments. On transmit, the antenna system has low VSWR and is designed for cool operation with a power rating safety factor of 20. The single-length, non-telescoping whip unscrews from its waterproof mount for low overhangs, garages, and car washes. Retail price is $35.60.

CIRCLE NO. 73 ON READER SERVICE CARD

BOSE 4-CHANNEL PREAMPLIFIER

The Bose Model 4401 is described as an ultra-quiet preamplifier that offers complete 4-channel discrete and matrix capabilities. Signals from all current program sources, both stereo and quadraphonic, can be processed by the preamp. Circuitry for the SQ decoder and the CD-4 demodulator is contained on easily-installed plug-in modules. The preamp features full tape recorder flexibility, with the tone controls and high- and low-cut filters in the circuit to process the signal prior to recording. There are also provisions for using an external equalizer system with the preamp. Specifications include: output impedance 600 ohms; rated output, 2 V rms min; frequency response, 20 Hz to 20 kHz ±0.2 dB; harmonic or IM distortion, less than 0.2%; hum and noise, −80 dB min. Dimensions are 6" high by 13⅛" deep. The basic preamp is $499.00; SQ decoder module, $74.95; enclosure, $34.95.

CIRCLE NO. 74 ON READER SERVICE CARD

ACOUSTIC RESEARCH SPEAKER SYSTEM

The new π/one from Acoustic Research is a three-way acoustic-suspension speaker system that features a control panel located on the front panel. The control panel has a "woofer environmental control" that can be set to insure proper spectral balance regardless of the location of the speaker, room acoustics, or personal preference. The 0π position provides acoustical balance in a corner setting; 2π is for speakers against a wall; and 4π is for a free-standing position. The control panel also contains a three-level (0, −3, and −6 dB) set equalizer for both the midrange and tweeter drivers. With the midrange and tweeter switches set to 0 dB, brilliance and presence are said to be achieved with a uniformly flat response. The π/one employs a 12" woofer, 1 ½" dome midrange, and a ¾" dome tweeter.Impedance of the system is 8 ohms, and recommended amplifier power is 25 watts rms. Each system weighs 55 lb and measures 14" by 25" by 12".

CIRCLE NO. 75 ON READER SERVICE CARD

SIMPSON DIGITAL MULTIMETER

A new digital multimeter, the Model 360 from Simpson Electric, is designed and engineered for a broad spectrum of testing and measuring applications. Handy and

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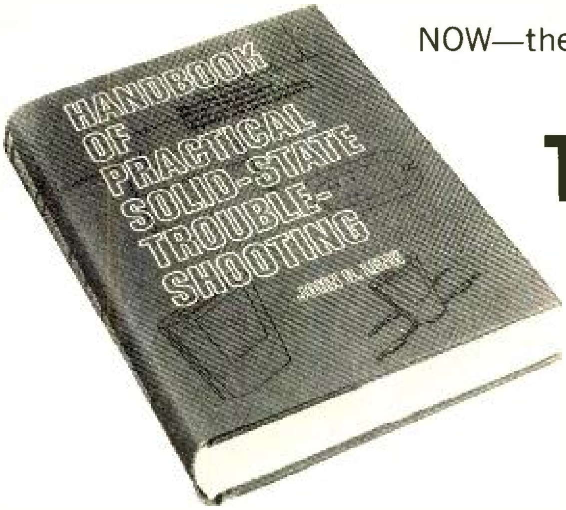

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- Diodes
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rugged enough for field use, it is claimed to have the accuracy and flexibility required of a good general-purpose laboratory instrument. The 3½-digit non-blinking LED display is 0.33-in. high. Polarity selection (both + and − on the display) is automatic, as is overrange indication. A special analog indicator just below the display is useful for scanning nulls and peaks. The DMM features 29 ac, dc (voltage and current), and resistance ranges, including a low-power ohms function. The Model 360 operates on rechargeable batteries or ac line power. A wide range of accessories is available, including carrying case and a variety of r-f, high-voltage, and other special probes.

CIRCLE NO. 76 ON READER SERVICE CARD

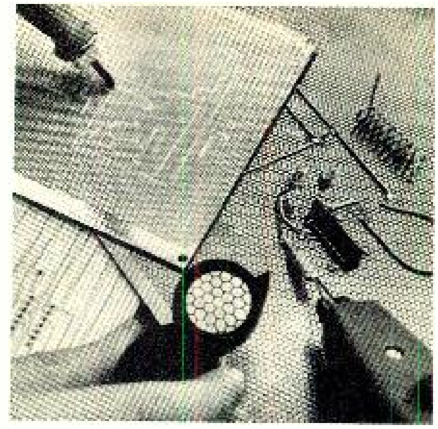
BIC AUTOMATIC PROGRAMMED TURNTABLE

The Model 980 is one of two belt-driven "programmed" 33- and 45-rpm turntables marketed by British Industries Co. It uses a low-speed synchronous motor with 5-Hz fundamental vibration frequency. It is also the only automatic turntable with a record-changing capability using a solid-state electronic frequency module to adjust speed and featuring a ±3-percent pitch range. A built-in Programmer can be set to repeat a single record up to six times before automatic shut-off and is also used for automatically playing up to six different records. Shut-off is manually programmed, rather than sensed by the automatic spindle, eliminating one of the major causes of changer malfunction. Critical styles pressure and anti-skating adjustments are performed by tandem controls which can be operated separately or simultaneously. Other features include: a "feather-touch" cycling button, rubber shock mounts that minimize feedback problems, adjustable-rate ascent and descent cueing, etc. Retail price is $199.95. A walnut wood or black molded base and a hinged dust cover are available.

CIRCLE NO. 77 ON READER SERVICE CARD

METAL CIRCUIT SYSTEMS PC MATERIALS

A new nonconducting metal sheet for printed circuitry has been developed by Metal Circuit Systems. To make pc boards, a design is drawn or scribed directly on the surface of the pc material, rendering a working board. Because pressure is all that is required, there is a substantial saving in time, labor, and materials. Without using a new board, circuits can be erased for making new designs. A more economical version for direct wiring purposes, rather than printed circuitry, is also available. Since the metal sheet is nonconducting, components and wiring can be spot soldered at random, independent from adjacent areas of the board.



CIRCLE NO. 78 ON READER SERVICE CARD

DUAL CASSETTE DECK

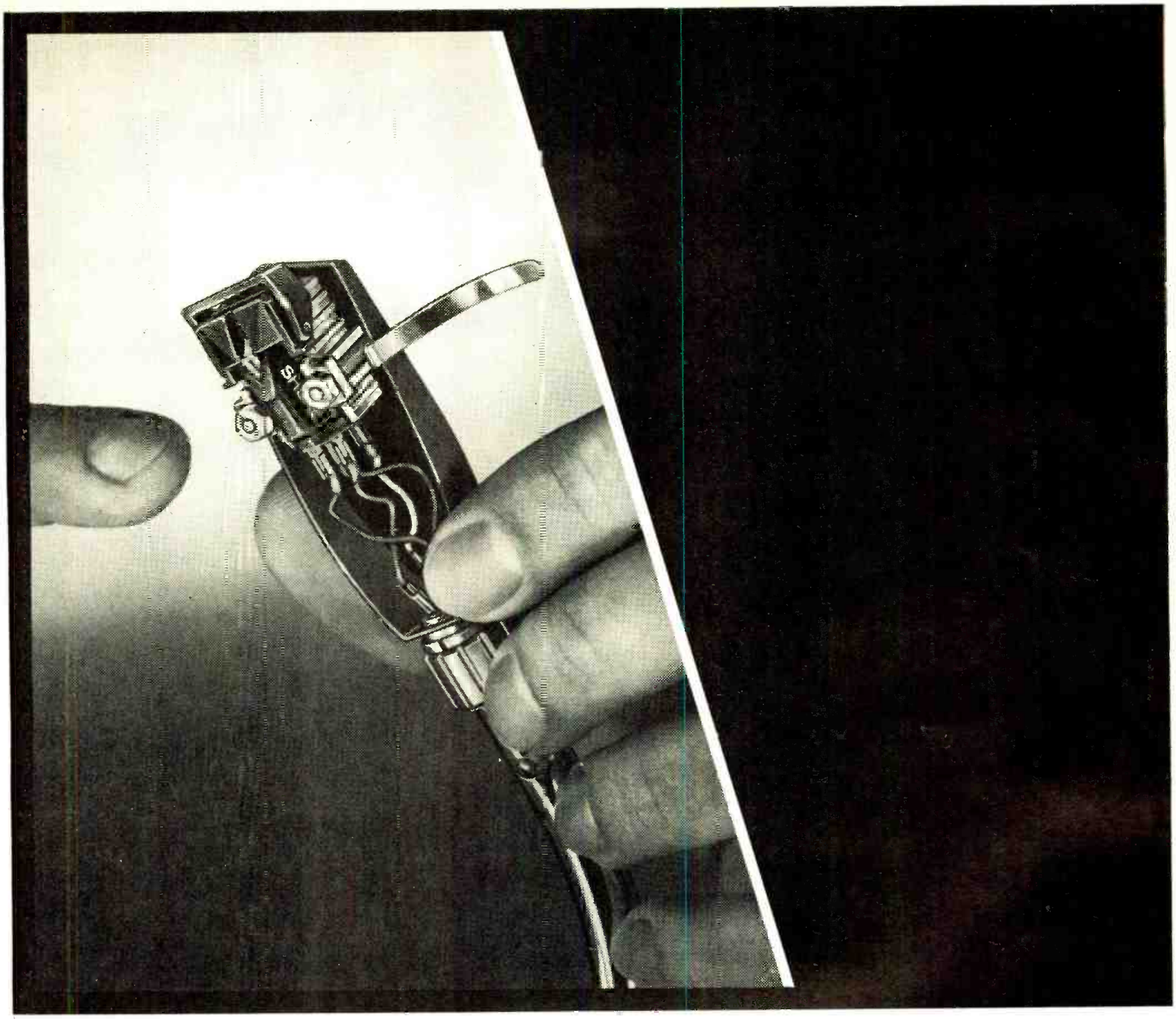
Long known as a manufacturer of quality automatic record players, Dual is now in the cassette deck business with the introduction of the Model 901. Automatic reverse, continuous playback, bi-directional recording, and automatic bias switching for pre-coded standard and chromium-dioxide tape formulations are provided. A built-in oscillator permits the Dolby noise reduction system to be calibrated for any tape formulation. The deck's recording level meters are said to be designed with the ballistics of broadcast-quality VU meters so that the pointers give precise indications of the recording level. Others features include a continuous-pole/synchronous motor, precision belt-driven system, intermode switching without the use of the STOP switch, and alc. Response is 20 Hz to 14 kHz ±1.5 dB. Wow and flutter are 0.09% Wrms. Retail price is $4.50.

CIRCLE NO. 79 ON READER SERVICE CARD

DYNACO HIGH-POWER STEREO AMPLIFIER

You can get 200 watts rms/channel or 600 watts rms in mono, both into 8-ohm loads, from Dynaco's new Stereo 400 power amplifier. To protect both the amplifier and driven speaker systems, Dynaco has incorporated into the amplifier several safety features. The Dynaguard ™, an exclusive dynamic power limiting circuit, provides speaker protection in direct proportion to the damage potential of the signal. A delay circuit eliminates turn-on thumps, and relay protection is provided against as little as 0.5 volt dc at the output. Volt-amp limiting protects the output stages against reactive and low-impedance loads, and separate thermal sensors are used for each channel. Basic amplifier can be equipped with a forced-air cooling fan and an optional dB-output metering system. The Stereo 400 is available in both kit and factory-wired forms.

CIRCLE NO. 80 ON READER SERVICE CARD



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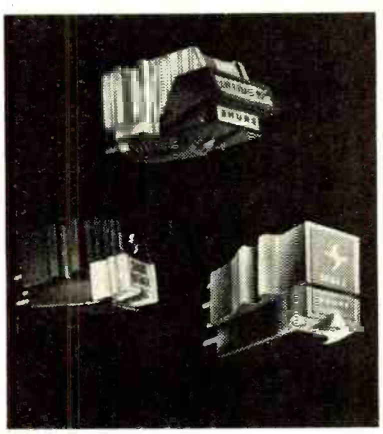

Beauty is truth, truth beauty. The fact is that all too few music lovers realize that while certain high fidelity components can be less than best, there is one component that cannot endure a sacrifice in quality: the cartridge. Because the hi-fi cartridge functions as the *source of sound* (the point at which the recording is linked with the balance of the hi-fi system), its role is absolutely critical. Just as the camera can be no better than its lens, the finest hi-fi system in the world cannot compensate for an inferior cartridge. Suggestion: For a startling insight into the role of the cartridge in the overall hi-fi system, and a breathtaking re-creation of your favorite recording, see your nearby Shure cartridge dealer. He'll introduce you to the Shure cartridge that is correct for your system and your checkbook. Or, next best, send for our brochure:

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New Literature

BROOKSTONE "HARD-TO-FIND" TOOLS CATALOG

The Brookstone Co. has just published its second 1974 catalog of hard-to-find tools (and other things). This 60-page catalog features 76 new products in addition to the thousands of other very useful items listed in previous editions. The listings include unusual craftsmen's hand tools and small power tools, as well as a wide array of devices, especially applicable to the electronics field. Address: Brookstone Co., Brookstone Bldg., Peterborough, NH 03458.

DYNASCAN "COBRA" CB BROCHURE

Highlighted in the four-color "COBRA" brochure from Dynascan are eight CB transceivers. Four AM models (three mobiles and one base) and four SSB/AM models (two mobiles and two bases) are described, and individual features are detailed. Address: Dynascan Corp., 1801 W. Belle Plaine Ave., Chicago, IL 60613.

BSR SOUND PRODUCTS BROCHURE

Brochure No. MD 11179 from BSR describes nine record players, a "Quasi-Quad" 4-channel synthesizer, two cartridge tape players, and two graphic equalizers. This colorful brochure contains a table of turntable features, brief descriptions of all products listed, and a glossary of BSR turntable features. Address: BSR (USA) Ltd., Blauvelt, NY 10913.

CEI TIME PRODUCTS CATALOG

Listed and described in Caringella Electronics' new time products catalog are four all-electronic digital clocks and a standard time receiver. The clocks range from a 1-digit desk model to a 1-digit wall model to a 6-digit crystal-oscillator-driven model, ending with a giant 6-digit crystal-controlled model featuring 3½" (8.9-cm) numerals. The receiver tunes WWV on 5, 10, and 15 MHz. Prices are given for both assembled and kit-form units. Address: Caringella Electronics, Inc., P.O. Box 327, Upland, CA 91786.

RCA ELECTRONICS INSTRUMENTS CATALOG

RCA's Electronic Instruments Catalog No. 1 lists and describes a wide range of test gear for servicing, industrial maintenance, laboratories, schools, and safety tests. The catalog is broken down into instrument types and includes multimeters, safety measurement devices, dc power supplies, R/C substitution box, oscilloscopes, color and signal generators, etc. Along with the instrument descriptions, the 24-page catalog also provides brief descriptions of accessories. Prices are given for all items listed. Address: RCA Electronic Instruments, 415 South Fifth St., Harrison, NJ 07029.

SOLITRON SEMICONDUCTORS

A new condensed catalog covers Solitron's Florida division's complete line of power transistors, hybrids and diodes. The 56-page book, printed in two colors, provides a quick reference guide to the company's discrete power devices, hybrid power regulators and Schottky diodes. Package illustrations and dimension drawings are also given for reference. Address: Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404.

AMPHENOL CONNECTOR CATALOG

A 52-page general catalog (No. GL-4) that describes the company's broad lines of r-f, coaxial, and microphone connectors and tube/relay sockets and plugs is available from Amphenol. The catalog fully describes and illustrates all listings. It features a comprehensive page-referencing index to all components described. Altogether, three separate indexes are provided to help users quickly locate required components. Also included is a glossary of often-used connector terms. Address: Amphenol Sales Div., Bunker Ramo Corp., 2875 S. 25 Ave., Broadview, IL 60153.

GC ELECTRONICS PROJECTS BOOK

Thirteen easily assembled electronic projects are featured in the new *Fascinating Electronic Projects* book (No. FR-174) available from GC Electronics. The book contains schematics, instructions on how to build such devices as an emergency lamp flasher, metal locator, rechargeable lantern, lie detector, etc. Most of the projects are battery operated, have solid-state design, and can be built for less than $10. The book also contains an introduction that offers valuable construction tips for electronic project construction. For a copy of book No. FR-174, send $1.25 to:GC Electronics, Div. of Hydrometals, Inc., 400 S. Wyman, Rockford, IL 61101.

INTERSIL TRANSISTOR REFERENCE GUIDE

Intersil has just published a comprehensive 24-page guide to bipolar transistors and FET's. Called the "Intersil Bipolar and Field Effect Transistor Cross Reference Guide," the publication lists 1162 industry part numbers in alphanumeric order, with 2N and 3N numbers, followed by the house numbers of all major suppliers. For each part listed, there is a description of the transistor and a brief indication of its typical application. Address:Intersil, Inc., 10900 N. Tantau Ave., Cupertino, CA 95014.

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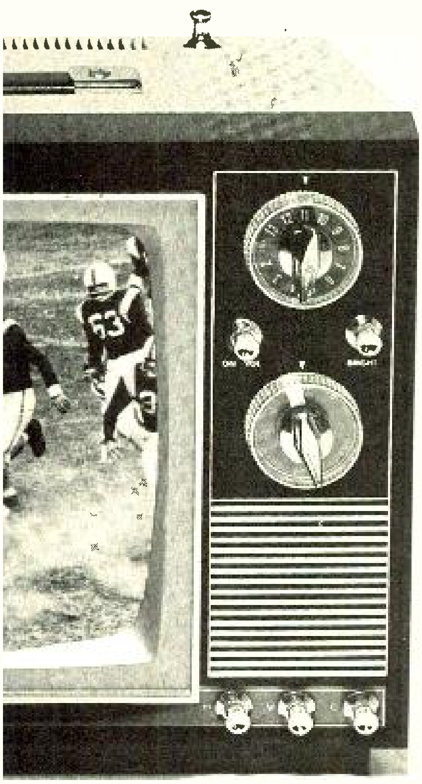

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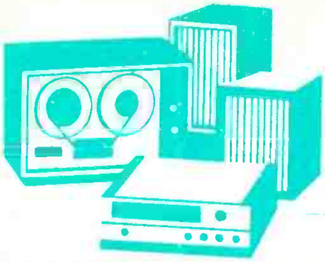

Stereo Scene

By Ralph Hodges

PROMISES FOR 1975

THE June Consumer Electronics Show is now well established as the principal showcase for the high-fidelity industry and its annual introductions of new products. It is a trade-only show, functioning primarily to allow dealers to select their lines of merchandise for the fall season. But the press is also invited to attend, which it does in droves, since most of the big audio stories for the coming six months are there in one form or another—often as advance prototypes on display in the exhibition booths, or sometimes just as twinkles in the eyes of product managers who are usually not too reluctant to talk about future plans.

The greatest drawback of the show is its sheer size, which puts mental and physical endurance to a severe test. I'm never confident, after leaving, that I was able to see all I should have, and the subsequent weeks usually prove me right. But in any case, the following is a selective compendium of what I did see this year that might, in my estimation, be of mild or passionate interest to readers of this column. Apologies in advance to those readers (and manufacturers) who feel *their* interests have been slighted, should that be the case.

Logic. Last year, when a host of manufacturers introduced four-channel receivers with built-in CD-4, SQ, and QS (or RM, as it is frequently labeled) facilities, there were grumbles about the lack of sophistication in the SQ and QS matrix circuits, which tended to be quite rudimentary. So it remained to be seen what steps, if any, would be taken this year to elevate the status of the matrix decoders.

Good news. In the interim, SQ IC's with logic became available from several sources, and hence Fisher and Kenwood both appeared at the show with CD-4/SQ full-logic receivers. Lafayette, Pilot, and Sherwood also offer models with full-logic SQ, but without CD-4. Marantz, meanwhile, have retained the pocket on their receivers' undersides into which an optional decoder module—full-logic SQ or QS with Vario-Matrix are offered at the present time—can be plugged.

SQ full logic currently exists in two forms: wave-matching with front-back and wave-matching with variable blend. Wave-matching and front-back are both gain-riding systems; channels into which leakage information has crept (and which are not carrying important information of their own at the moment) are attenuated by the logic action. Variable-blend works by logic-controlled mixing of channels in which leakage signals are mutually out of phase, thereby achieving electrical cancellation. (The channels' proper information is *not* out of phase, and thus is not reduced.) Also of interest: the SQ IC packages incorporate voltage-controlled amplifiers. This means that a single potentiometer can serve as a master volume control for all four channels. Since the potentiometer does not handle any audio, the arrangement is ideal for remote-control applications—a feature on which Fisher has already capitalized.

Frequency Synthesizing. For some years the Heath Model 1510 has been the only frequency-synthesizing FM tuner on the market. Those who favor the principle (providing virtually flawless tuning accuracy) will be glad

to learn of two new products in the running: the Kenwood 700-T and the Scott T33S. The Scott unit is a redesign of a model offered some years back. It retains the digital readout and the coded card system the Heath tuner also employs. Kenwood, on the other hand, feels the consumer will be more comfortable with a conventional tuning dial. It is precisely calibrated, however, and it is actually twice as long as it appears, since throwing a switch displays the frequencies of either the lower or upper half of the FM band on the dial face.

Yamaha, incidentally, has introduced what is called the lowest distortion FM tuner in the world. For stereo reception, typical rated distortion is well below 0.1 per cent. It's next to impossible to find an FM signal generator that can match such a figure.

Signal Processors. The term "preamplifier" is becoming inadequate to describe the latest generation of control equipment, whose functions often go considerably beyond providing adjustable gain with low noise and distortion. Infinity's new preamp, still a prototype, has a correlator-type single-pass noise reduction system at present. It may be offered with unique suppressor for record noise (scratches, etc.), employing an audio delay line. A new equalizer shown by Technics, also a prototype, operates in twelve bands, with each band continuously variable in "Q" (essentially, effective bandwidth) and center frequency. SAE's Mark 1XB preamplifier incorporates a seven-band equalizer. And a number of companies have come up with some interesting preamplifier controls, such as front-panels switches that alter the input characteristics of the magnetic-phono sections.

A new Dynaco product is always an event. The PAT-5 preamplifier, besides featuring redesigned phono and tone-control sections, has been especially designed for use with superpower amplifiers, and employs heavy-duty power and speaker switches. Four-channel preamplifiers are still relatively rare, but Bose now offers one (Model 4401) with built-in full-logic SQ, and BGW will shortly have a four-channel unit with comprehensive switching and equalization facilities. Marantz's Model 3800 stereo preamp has built-in Dolby B noise reduction circuits.

Power Amplifiers. Amplifiers delivering more than 100 watts per channel are becoming pretty commonplace now. The focus of attention has therefore turned to new *types* of amplifiers, with the FET designs developed by Sony and Yamaha looming large in this category. FET's are inherently lower in certain types of distortion than bipolar transistors, and the new power FET's seem to offer some advantages in terms of reliability as well. Great claims are being made for the *audible* superiority of FET output devices by the companies involved, and it will be interesting to see how these pan out. Rated power outputs are 80 watts per channel for the Sony unit (Model TA-8650 integrated stereo amplifier) and 150 watts per channel for the Yamaha CM-5000X power amp.

Infinity is on the point of bringing out a Class D "switching" power amplifier. The most obviously advantageous features of Class D operation (employing digital techniques with a duty cycle of, in this case, 500 kHz) is less heat buildup, and the possibility of using a high-frequency power supply stepped up considerably from the rate of the 60-Hz power line. This results in a very compact amplifier—17 x 11 x 3 inches—capable of 250 watts per channel.

Speaker Systems. The numbers of speaker systems on the market at any given moment always exceed the space available to describe them, so I have to be very selective here. First I'd like to mention the Dahlquist DQ-10, which made its initial appearance at the show this year. The DQ-10 closely resembles the Quad electrostatic speaker, and in this instance imitation is a very sincere form of flattery. Although the DQ-10 employs all dynamic drivers, the electrostatic is its acoustic model. Paramount in the design considerations is the reduction of wavelength-associated diffraction effects from enclosure surfaces and edges, and the elimination of time-delay effects between its five drivers. I mention this because these are "hot" issues among speaker designers today. For anyone looking for a speaker in the close-to-$400 price bracket this one is worth a listen.

Rectilinear has two new models, the 5 and 7, which are said to be highly efficient. The new Technics speakers, comprising four models, also made their first and very gratifying appearance at the show. Other systems that I was not able to hear but heard about are: the JBL L65 "Jubal," with a new wide-dispersion compression tweeter; the latest in Altec's Stonehenge series, the Model III, employing a single coaxial driver; the Leslie Model DVX-580, a design with dipole radiation characteristics that can be aimed at any part of the listening room; and the Philips Motional-Feedback speakers. The Philips feedback loop, involving only the woofer, uses a motion-sensing transducer near the woofer voice coil. The output of the transducer is routed back to the input of the power amplifier (built into the speaker cabinet) where it is employed as a conventional negative-feedback signal to "condition" the audio signal to the woofer's characteristics.

The unique Heil woofer, discussed in some detail in the June installment of this column, will reportedly be ready in the early autumn. It is, if anything, even smaller than I reported then, and it will certainly have some impact on future speaker-system design if it proves successful.

The Acoustic Research people have developed new versions of their venerable dome midrange and tweeter drivers. Reportedly these are capable of significantly more acoustic output. The first product in which they'll be available—the AR π/one—has calibrated level controls meant to suit various room placements.

Record Players. BIC, which nominally stands for British Industries Corp., has introduced a line of impressive American-made automatic multiple-play turntables—the only changers in the hi-fi component field using belt drive.

Otherwise, most of the action in record players is in the area of single-play units, which are becoming increasingly popular. Dual now offers the Model 601, a belt-drive version of the direct-drive 701. Technics has several new models, all of them direct-drive, and Pioneer has added three single-play units, with the direct-drive Model PL-71 leading the list.

Turntables employing magnetic suspensions have been few, far between, and not particularly well-received. This year, Stanton and Teac are offering such units, the Teac being direct driven and the Stanton featuring belt drive. I think it can be safely assumed that the troubles afflicting earlier magnetic-suspension designs have been corrected in these newer products.

There appears to be a trend in Europe towards automation—as exemplified by the Philips GA-209 and B&O 4002. Both of these single-play turntables attempt to come as close as possible to single-pushbutton operation. The Philips machine has three motors to perform the chores of cueing, tone-arm cycling, and platter drive. The B&O 4002, with a remarkably sophisticated straight-line-tracking tonearm, has more features and automatic safeguards than can be listed here, and is probably, for the present, the most elaborate record player now available.

Tape Decks. If you have become jaded with ordinary four-channel tape decks featuring track synchronization, 15-ips operation, 10½-inch reels, and flawless solenoid-actuated controls, the Teac A-7340 is the next frontier. In this model the transport and electronics are entirely separate, the latter having been turned into an elaborate eight-channels-in, four-channnels-out mixer with balanced microphone inputs, external processor loops, and peak-indicating LED's for low, middle and high frequencies augmenting the four VU meters. Dokorder's Model 1140 is not quite so flexible, but it does feature an easy-to-use system for bias adjustment. Tandberg's Model 10X, with three tape speeds, is, I believe, the first machine with the 15-ips tape speed and 10½-inch reels to offer Dolby B-Type noise reduction.

Developments in the cassette format surge forward, as always. The most far-reaching innovation of the year is likely to be the double-layer tapes from 3M (Scotch) and Sony. Generically termed "Ferri-Chrome" tapes (two oxide layers, the bottom being ferric oxide, the top chromium dioxide), they appear to provide significant advantages in terms of sensitivity and overload headroom. Machines optimized for their use are just beginning to appear, but since compatibility with FeCr tape is merely a matter of bias and equalization adjustment, no alteration of cassette-equipment design will have to be involved.

As for cassette equipment, it looks as though the difficult technology of three-head cassette-deck design (with separate heads for erase, record, and playback, to permit off-the-tape monitoring) is finally being coped with, if the Sony TC-177SD and Dokorder MK-60 are any indication. Reports have it that the Sony is a very viable three-head design. On the other hand, Nakamichi Research, which pioneered three-head cassette decks, has introduced a pair of two-head units, the Model 500, and its portable equivalent, the Model 550. The Nakamichi machines share two important features: unusually high headroom before high-frequency tape saturation (rated approximately 4 dB above other machines at 10,000 Hz); and recording-level meters (peak-reading) with a range of 45 dB. This latter would enable the user to actually observe the basic noise level of the program source while recording, in most cases.

Whether you consider them merely a styling exercise or a genuine boon for convenience of installation, front-loading cassette decks are beginning to appear thick and fast. In addition to the handsome Pioneer Model CT-F7171, introduced shortly before the show, there are similar decks from Concord, Sony, and Technics. Several of these units incorporate solenoid transport controls; while the ones that don't have that feature, do have switch mechanisms with ample mechanical advantage to provide light-touch operation. In general, these products have panel dimensions matching those of other electronic components in their respective manufacturer's line. Complete control access from the front facilitates stacking the decks with amplifiers and tuner, or even flush-mounting them in equipment cabinets.

In passing, I should make some mention of the rapid developments taking place in the eight-track tape field. Why any serious recordist should want to work with eight-track is beyond me, but if he does, he now has Dolbyized machines from AKAI and 3M (Wollensak), as well as an ANRS-equipped model from JVC. The latest offering for the quadraphonic enthusiast is the Model ARS-858 four-channel recorder from Technics. But most important of all, new tapes are becoming available for eight-track recording, the first of which is the Scotch "Classic" cartridge. If eight-track is ever to rise to the stature of cassettes, it's likely that new tape types, along with other tape refinements, are going to have to lead the way. ◈

news HIGHLIGHTS

New ASCII Standards Proposed

The National Bureau of Standards has proposed new standards for graphic representation of the control characters of ASCII, and for code extension techniques in 7 or 8 bits. The control character proposal adopts the voluntary industry standard developed by the American National Standard Institute and specific graphical representation for the 34 control characters of ASCII.

The second proposal provides for extensions through the use of the coding structure. Additional control codes and graphic character codes may be defined, and thence used in a 7- or 8-bit environment. It is expected that, as a result of this standard, additional sets of character codes will be defined for extended Roman characters, mathematical symbols, Greek and Cyrillic characters, and control characters needed for visual displays and automatic typesetting.

The NBS, as proposed, would then serve as the registry for additional code assignments and will publish these as a basic reference. Copies of the proposed standards are available from the Office of ADP Standards Management, NBS, Washington, DC 20234

Noise-Reduction Discs and Tapes

The release by Klavier of a solo recital of selections from French romanticists by harpist Susan McDonald marks the arrival of dbx-encoded discs. According to Klavier, surface noise is virtually eliminated on discs using the dbx process, with approximately 35-dB reduction in tape and background noise, as well as improved transient and dynamic response. The encoded discs are priced at $7.00. For more information, contact Klavier Records, 5652 Willowcrest Ave., North Hollywood, CA 91601.

The Advent Corporation announced the release of the first Dolby-encoded recordings on chromium-dioxide tape in the U. S. Called Process CR/70™, the recorded cassettes feature music from the Nonesuch and Connoisseur Society catalogs and original recordings produced by Advent. It is claimed that the design of the tape housing prevents jamming, permitting use of thinner-base C-90 and C-120 tape. Advent reports that each Process CR/70 cassette is individually sampled to insure that all recorded cassettes are of uniform quality. Prices range from $4.95 to $7.95 per cassette.

First Solar-Powered Digital Watch

The use of solar power cells and LSI CMOS technology has resulted in a new digital watch called Synchronar, made by Ragen Precision Industries. Silicon solar cells constantly charge the watch's storage cells, drawing power from sunlight, ambient light, or an ordinary light bulb. An average daily exposure of 10 to 15 minutes of sunlight is all that the watch is said to require.

LED's are used to display time, date, and month. The display is mounted on the edge of the watch case facing the wearer, and the two solar cells are set into the face. The display adjusts its brightness to the prevailing light. The Ragen Synchronar is priced at $500.

Four-Channel FM Tests Underway

Station K-101, San Francisco, is conducting a test program of various schemes for discrete 4-channel FM broadcasting. The National Quadraphonic Radio Commission, in making the test, is using five proposed methods for discrete transmission. The program, from midnight to 6 a.m., will run through October.

Audio manufacturers such as JVC, RCA, Fisher, Marantz, and Panasonic are participating; and the FCC has a group of engineers observing the tests. Results will provide information for formulating a national standard for discrete four-channel transmissions.

In another test, a group of CATV companies and a cable FM equipment manufacturer, in cooperation with Santa Clara University and Panasonic, are transmitting discrete four-channel FM programs over CATV/FM lines in the San Jose and Santa Clara areas. On the university's FM radio channels of 91.1 and 89.1 MHz, over the lines of CATEL and TelePrompter, will use the CD-4 system and the prototype Dorren discrete four-channel FM generator. It is hoped that the tests will lead to discrete CD-4 transmissions on cable FM lines.

Price Reductions on CMOS IC's

Price reductions averaging 15 percent on plastic, commercial ceramic and chip versions of standard CMOS integrated circuits have been announced by RCA Solid State Division. These price reductions apply across the standard CD4000A product line. Price reductions of 20 percent are being applied to popular medium-scale integration types, with a 10 percent reduction on gates and some other MSI types. The world-wide market for CMOS is expected to more than double this year, probably exceeding $130 million.

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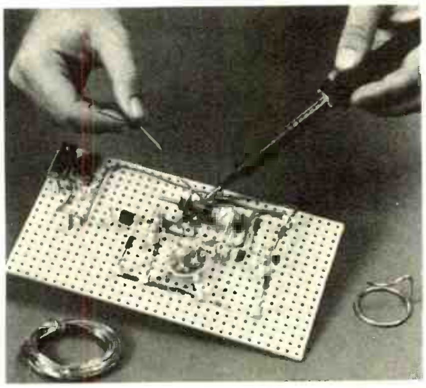

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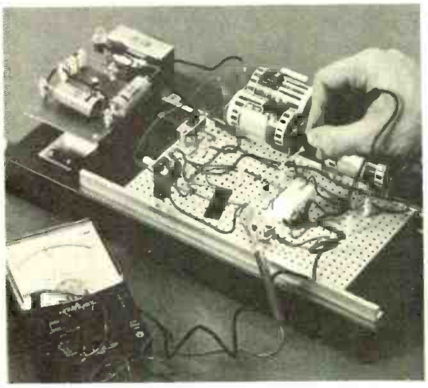

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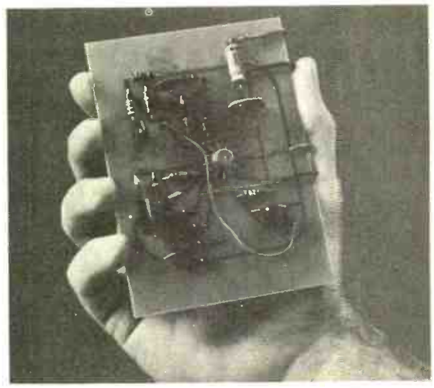

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Popular Electronics
OCTOBER 1974

CONSTRUCTION

BY L. GEORGE LAWRENCE

An Electronic Salt Meter For Family Health

With this low-cost device, you can check food for salt content, an important consideration for weight and hypertension control

COMMON table salt, like water, is an essential ingredient to all animal life on earth — including man. Recently, however, research has revealed that diets high in sodium, one of the elements in salt, may be a leading cause of hypertension. Also, the reduction of dietary sodium intakes has become an important treatment in the management of congestive heart disease. (For more information on the clinical and physiological roles of salt in human nutrition, see the box on the third page of this article.)

With salt being linked to medical problems, it is no wonder that many of us have become concerned with the benefits of low-salt diets. Unfortunately, progress in salt metering has long been held back by the high cost of ac-type conductance meters required for testing foods. (Dc-type ohmmeters are useless for this application.) While commercial ac salt meters cost $1000 or more, less than $30 will buy the components for you to build your own. The salt meter described in these pages will permit you to rapidly sample the salt content in baby foods, canned and raw foodstuffs, and drinking water. Simply immerse the probe tip into the food sample, and observe the meter pointer's deflection.

The salt meter's design takes advantage of the fact that salt-enriched foods conduct electrical current. The higher the salt content, the greater the current flow. Pure salt-free water has a specific conductance (the reciprocal of resistance, or 1/R) of 0.05 µmhos, or a resistance of 20 megohms. Its low conductivity results from a deficiency of ions. Our saltmeter, on the other hand, expresses conductivity in terms of currents ranging from 0 to 1.0 mA, affording the greatest possible convenience for the average user.

About The Circuit. The salt meter (see Fig. 1) is a true ac-type conductance meter. It is based on an ac-energized bridge circuit, which consists of *R2, R3,* and *R5*. External test probe *PL1* is switched (via *S2B*) across *R3*. Dipping the probe into a food sample places a given parallel resistance across *R3* which, in effect, unbalances the bridge and causes current to flow through the 20,000-ohm primary winding of *T2*. This current is inductively coupled into the secondary circuit of *T2* where it is rectified and fed to meter *M1*. Note that no dc appears in the circuit.

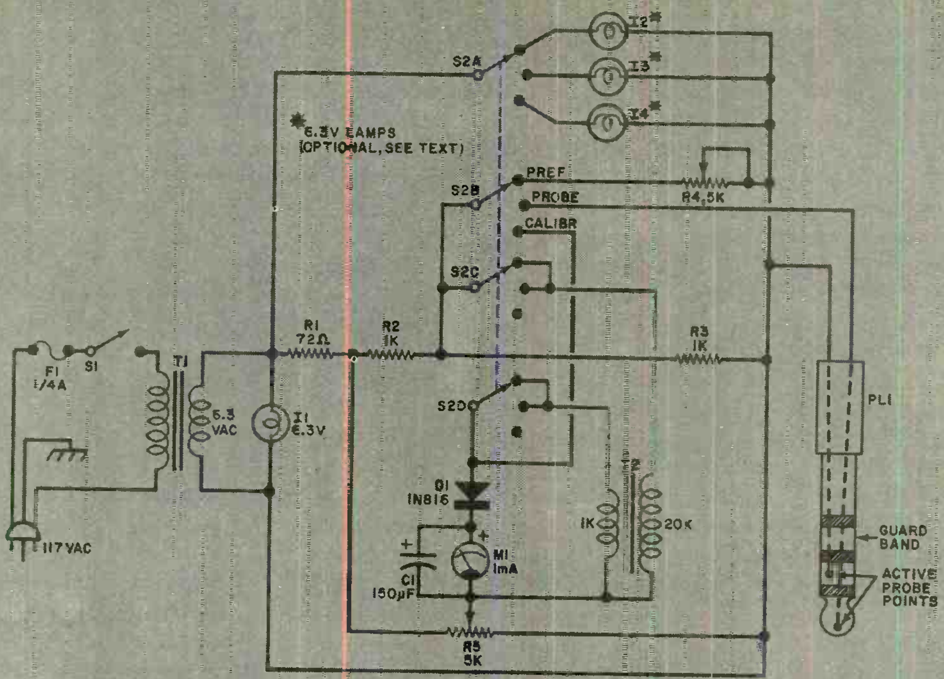


Fig. 1. The circuit of the salt meter is a true ac-type conductance arrangement. The bridge circuit is unbalanced by resistance across probe.

PARTS LIST

C1—150-μF, 50-volt electrolytic capacitor
D1—1N816 diode
F1—¼-ampere fuse
I1-I4—6.3-volt lamp (I2-I4) optional—see text)
M1—0-1-mA meter movement (Calectro No. D1-912 or similar)
PL1—Four-conductor, ¼-in. phone plug (Calectro No. F2-833 or similar)
R1—72-ohm, 1-watt resistor
R2,R3—1000-ohm, 1-watt, 5% resistor
R4—5000-ohm, linear-taper potentiometer with screwdriver-adjust shaft
R5—5000-ohm, linear-taper potentiometer
S1—Spst switch
S2—Four-circuit, 3-position rotary switch (RCA No. 56584 or similar)
T1—6.3-volt, 1-ampere filament transformer (Lafayette Radio No. 33P80946 or similar)
T2—20,000-ohm primary, 1000-ohm secondary miniature driver transformer (Calectro No. D1-719)
Misc.—Suitable chassis; control knobs (2; 3 if building reference standard); 5-percent resistors (see Fig. 2 for values) and ¼-in phone jack (for reference standard); probe cable; three-conductor power cord; fuse holder; machine hardware; hookup wire, solder; etc.

Switch *S2* has three positions: PREF, PROBE, and CALIBR (meter null). Each position is equipped with an indicator lamp (*I2* to *I4*) that identifies the position to which the switch is set. These lamps are optional. Omitting them will not affect the instrument's performance and will allow you to use a simpler switch for *S2*.

In the PREF position of *S2*, taste-preference potentiometer *R4* is adjusted to a low-salt value of, say, 0.73 as indicated on the meter. However, before *R4* is adjusted, *S2* must first be put into the CALIBR position and *R5* set for a meter reading of 0.1 mA.

In the PROBE position, external test probe *PL1* is in the circuit. (Note that this probe is a standard ¼-in., four-conductor phone plug. Only the tip and second conductor are active.) Inserting the probe into a food sample causes a current to flow, its magnitude dependent upon the salinity of the food, and resistance drop across *R3*. This resistance drop, resulting from the flow of current, causes the meter's pointer to swing up-scale to give a measure of saltiness. (For typical readout values, see the table on the opposite page.)

In the CALIBR (meter null) position, the ac bridge can be balanced by adjusting calibration control *R5*. Balancing is achieved by adjusting *R5* until the meter's pointer rests at the zero index of the scale. To ready the instrument for taste preference calibration and probe readings, adjust *R5* for a 0.1-mA meter reading. Now, if the test probe's active contacts are shorted to each other, the meter will read precisely 1.0 mA.

The saltmeter is also capable of indicating probe contamination. If *PL1* is not wiped perfectly clean after each sample test, an error will be indicated by the meter pointer's up-scale swing. To investigate probe contamination or internal leakage due to extensive use,

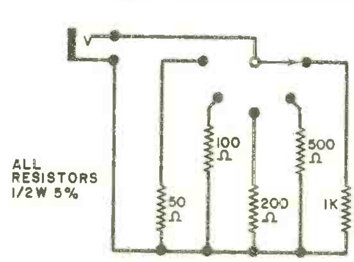


Fig. 2. The salt meter's calibration should be checked periodically by using known resistances.

set *S2* to CALIBR and *R5* for a meter pointer null indication. Then switch to the PROBE position. If the meter's pointer remains at the zero index, no contamination or leakage exists.

The salt meter should be periodically checked against a calibration reference of known resistance. Such a reference can be made from a rotary switch, 5-percent tolerance resistors, and a phone jack that properly mates with the four-conductor phone plug used for *PL1* as shown in Fig. 2. The jack and potentiometer can be housed in an external box, or room can be made for mounting them on the front panel of the instrument case where the reference will be always handy.

Now, by plugging the salt meter's test probe into the reference circuit's jack, you can obtain an error-free analog meter reading. Consult the table for reference values.

Construction. The salt meter's simple circuit lends itself nicely to

FOOD SAMPLE READINGS

Food Sample	Meter Reading (mA)	DC Resistance (ohms)	Test Resistance (ohms)
Fresh tap water*	0.17	5000-13,000	1000
Fruit dessert with tapioca	0.64	3400	220
Plums	0.64	3400	220
Coffee with cream*	0.68	4000-8500	185
Bananas	0.73	3200	155
Custard Pudding	0.77	7500	132
Vegetables with ham	0.80	6500	110
Vegetables with lamb	0.81	4000	105
Beef stew	0.88	6100	67

*All food samples, except those indicated by an asterisk, are baby foods in glass jars. Readings obtained with 0.1-mA calibration setting and test probe inserted in food above guard band; dc resistance taken with standard dc-type ohmmeter connected only to probe.

CLINICAL AND PHYSIOLOGICAL ROLES OF SALT IN HUMAN NUTRITION

It is important for all of us to understand both the clinical and physiological roles salt plays in human nutrition. Major importance resides in the quantities of sodium that can be consumed without harm.

Therapeutically, low-salt diets were employed as early as 1901 for patients with edematous heart disease. Later, this form of treatment was extended to people suffering from congestive heart failure, renal diseases, hypertension, cirrhosis of the liver, toxemias of pregnancy, and Meniere's disease. In tests, when eating salt-restricted foods, one-fourth to one-third of hypertensive patients responded with a reduction in blood pressure.

There is good evidence that an adult's daily ingestion of 250 to 375 mg of sodium-chloride salt causes no harm. This is all the human body requires to maintain good health. Even so, the daily intake ranges from 10 g for Americans to 27 g for many people in certain areas of Japan. Diabetic children have been observed to have an intense craving for salt — as much as 60 to 90 g/day — which triggers a powerful hypertensive effect.

High salt intake can become a critical issue where infants are concerned. Unable to speak, the infant is totally subordinated to the food preferences of the mother, who salts things "just right" for her own tastes — not baby's true health needs. A special problem begins when the infant is between one and three months old, the age most American infants are fed supplementary commercial foods (baby food) comprised of strained vegetables, meats, and fruits. Even to many fruits, salt is added prior to canning.

The sodium concentration in strained fruits is fairly low, typically 0.6 to 2 mg/100 g of food substance. However, in the case of strained meats, sodium contents may range from 293 mg to 510 mg/100 g of food weight. Vegetable samples have an average sodium content of about 358 mg/100 g of food weight.

The seriousness of the above numbers becomes clear when we examine a 5-month-old infant weighing 6 to 8 kg and who consumes at least 100 g of commercial baby food per day. In addition to an average of 305 mg of sodium ingested, the infant will drink about 1.1 liter of cow's milk, which can have as much as 2.14 g of sodium per liter. The only statement likely to be printed on a carton is that the contents are pasteurized and that vitamin D has been added.

Adding all his food sources together, baby is bound to consume about 2.3 g of sodium chloride daily. This is equivalent to 23 g/day for a 68-kg (150-lb.) adult. It is certainly dangerously high for a small child. Here, researchers are concerned about the possibility that such abnormally high intake of sodium chloride in infancy might play an important part in hypertension in adulthood.

In research work conducted under the auspices of the Atomic Energy Commission, the lifetimes of laboratory rats were drastically shortened when the rats were fed nothing but baby foods. Three out of seven of the rats developed hypertension and died.

Clerarly, some form of salt metering is of vital importance to any family interested in good dietary control.

straightforward point-to-point wiring in a suitably large chassis case. Most of the work is involved in machining the front panel to accept the meter movement, controls, and lamps. (Do not forget to allow room for the calibration standard's switch and jack if you intend to mount them on the front panel.) In the prototype, *PL1*'s cable exited the salt meter through a grommet-lined hole in the rear panel; if you wish, the cable can exit a grommet-lined hole in the front panel.

Mounted on the rear panel should be the holder for *F1*, and the three-conductor line cord should exit through a grommet-lined hole or be held in place with a plastic strain relief. The two transformers mount to the floor of the chassis. Then all resistors, the diode, and the capacitor install directly between the appropriate lugs of the controls, meter, etc., as shown in Fig. 1.

In Use. One of the ac salt meter's outstanding features is its ability to speedily sample baby foods. Conduct all tests at room temperature.

In practice, a taste preference reading is set prior to actual food tests. Assume this reading to correspond to a very mildly salted food item, such as bananas, or 0.73 on the meter scale. Now, with the salt meter switched to PROBE, a similarly mildly salted food item should yield an equally low reading. The taste-preference calibration allows an electronically unskilled person to recognize safety levels without having to figure out complex electrical relationships.

Some food items will surprise you. One sample jar of beef-stew baby food yielded a reading of 0.92 — much too salty for an infant. Fresh water, supposedly pure, turned out to be highly conductive, indicating high ion activity due to pollution.

The approximate percentage of sodium chloride (salt) in foods can be determined by weight. For a test, prepare mashed potatoes from fresh potatoes. Add 500 mg of salt to 99.5 g of mashed potatoes and measure the conductivity of the mixture. Then add another 500 mg of salt and again measure the conductivity; note how far up-scale the meter's pointer deflects beyond your first test reading.

Most prepared foods contain such conductive substances as acids and food coloring in addition to salt. However, salt tends to be the dominant conductive agent. ◈

BUILD AN

AC Power Line Monitor

Don't risk losses due to power outages

BY GARY McCLELLAN

IN THESE times of fuel shortages and increasing electric power demands, power outages have become common occurrences. At the very least, an outage can be a nuisance. The outage becomes serious when it lasts several hours and you have a freezer full of food. To play it safe, you should equip your home with an ac line monitor that will alert you in the event of an outage so that you can take corrective measures.

An ac power line monitor need not be expensive. The one shown schematically below will cost about $8 for all new parts. Once assembled, it will monitor your power line on a continuous 24-hour basis, remaining passive until an outage occurs. Then when power is interrupted, a loud buzzer sounds and a panel light comes on. The panel lamp serves as an alert system for those times when power is interrupted and you are away from home. Even if power is restored before you return home, the lamp remains on until the system is manually reset.

The circuit consists of three basic parts. Its power supply is comprised of *T1*, *D1*, *C1*, and *R1*. This is followed by controlling relay *K1*. Finally, there is a dual alarm system, with the buzzer independently powered by *B1* providing an audible alarm and *I1* providing a visual alarm in the event power was interrupted and restored.

In operation, the incoming ac is rectified by *D1* and dropped to about 75 volts by *R1*. Capacitor *C1* filters the rectified ac to prevent relay chatter and provides about 5 seconds of delay after power goes off, thus preventing false alarms.

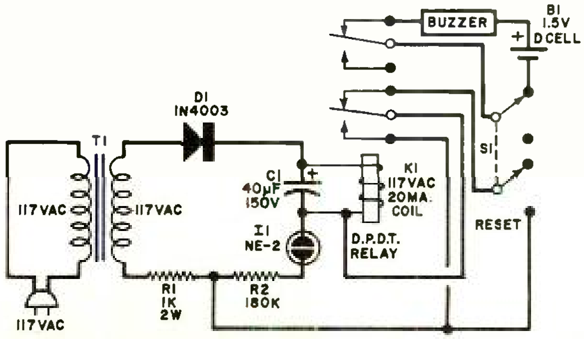
When the line cord is first plugged into an ac receptacle, *K1* does not immediately energize. Instead, *I1* lights up. For *K1* to energize, *S1* must be momentarily depressed to bypass the *I1* circuit. Once *S1* is depressed and returned to its operating position, *K1* will remain energized for as long as ac power is supplied to the circuit.

Now, if power is interrupted for longer than 5 seconds, *K1* deenergizes, making its upper contacts. This completes the B1/buzzer circuit and sounds the audible alarm. The buzzer will continue to sound until *S1* is set to RESET or the battery runs down.

In the event that power is restored, *I1* comes on and remains on until *S1* is set to its RESET position, at which time the relay pulls in and *I1* extinguishes.

There is nothing critical about assembling the alarm system. If you build it into a metal utility box, make certain that no ac portion of the circuit contacts the box itself.

Periodically check out the condition of *B1* to make sure it is capable of sounding the buzzer. To do this, simply unplug and reinsert the line cord in an ac outlet. If the buzzer does not sound or puts out a weak buzz, replace the battery. If you wish, you can substitute a nickel-cadmium battery for *B1* and periodically recharge it. This way you will not have to worry about running out of batteries on a weekend. ◈



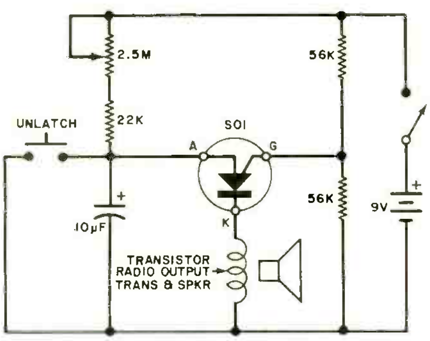
A PAIR OF USEFUL TEST IDEAS

Check & Select PUT's

BY RALPH TENNY

IF you have some programmable unijunction transistors (PUT's) whose condition you are not quite sure of, you will want to build this simple test circuit. It will quickly sort good PUT's from bad ones. With a PUT plugged into the socket and the power turned on, the potentiometer is slowly adjusted from maximum to minimum. If the PUT is good, the speaker will emit a series of clicks or pops over some portion of the potentiometer's range.

You can also sort PUT's into grades and determine the correct anode resistor for reliable operation. To do this, use a dial plate and indicator knob to record the resistance of the potentiometer. With the PUT oscillating, a high resistance setting indicates the lowest allowable value of input current, while the lowest resistance setting indicates the maximum input current. To use that particular PUT in a circuit, the anode resistor must be within the indicated resistance range. If the resistance is too high, the PUT will not turn on; with too low a resistance the input will cause the PUT to latch in. To unlatch the circuit, the power must be removed or the capacitor must be discharged (using the switch shown).



The PUT will oscillate at certain input currents.

PUT's that operate with a wide range of permissible input current can be used in variable oscillators, while those with a narrow range can be used in less demanding circuits where the anode resistor can be tailored for the application. ◈

Use VOM as Dwell-Angle Indicator

BY JAMES CAMERON

WITH ONLY two or three extra components, you can use the dc-voltage function of your multimeter to set the dwell angle in the distributor system of your car. The theory behind this is that, if a square wave is measured with a dc voltmeter, the potential indicated depends on the amount of time the voltage is at its peak versus its 0-level time. A square wave with a 10-volt peak and 50-percent duty cycle (on time) would measure 5 volts. Increase the duty cycle to 75 percent, and a 7.5-volt reading would be obtained.

The dwell angle in an ignition system corresponds to the closed versus the open time of the points. The voltage "seen" by the dc voltmeter is then proportional to the dwell angle. In an ignition system, the peak potential is that delivered by the battery. This voltage varies when the engine is being cranked and is therefore not suitable as a reference. To obtain a stable reference (or peak) voltage, a simple zener-diode arrangement can be used as shown in the schematic.

In practice, best accuracy is obtained when the zener diode's voltage is near the full-scale index of the meter's scale. Since most cars now employ a 12-volt system, and most multimeters have a 10-volt scale, a zener diode with an 11-volt rating is most convenient to use.

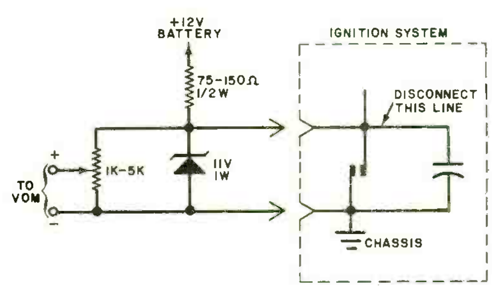
With an 11-volt zener diode and power limited to 100 mW, the zener current should be less than 10 mA (100 mW/11 V). If a 12-volt battery and an 11-volt zener diode are used, the drop across the current-limiting resistor is 1 volt. Hence, if 10 mA flows through the resistor, the resistor's value should be 100 ohms. This is not a critical value; you can use any ¼-watt resistor of a value within the 75- to 150-ohm range.

The potentiometer in the circuit eliminates the need for making calculations on paper. (Select a pot with a 1000- to 5000-ohm resistance.)

To use the zener-diode circuit with a voltmeter, disconnect the distributor points from the coil and disconnect the capacitor from across the points to eliminate any charge/discharge time-constant effects. The zener-diode circuit then connects to the ignition system as shown in the schematic. Now, open the points and measure the voltage. If the meter's pointer does not swing to exactly the 10-volt mark on the scale, adjust the potentiometer for a 10-volt reading.

To take a dwell-angle measurement, crank the engine and observe the voltmeter's pointer swing. Your reading indicates the percentage of the time the points are *open*. What you want to know is the dwell angle, or the amount of time the points are *closed*. Hence, you must subtract the meter reading from 10 and multiply the result by 10 to obtain the dwell angle in percentage. For example, if you obtain a reading of 4.8, subtract this figure from 10 to obtain 5.2. Then when you multiply the result by 10, the dwell is 52 percent.

It is a good idea to check the battery voltage while cranking the engine. The zener voltage must be lower than the battery voltage or an error will be introduced into the measurement. ◈



Zener diode provides a reference to measure voltage across points and determine dwell angle

A New Wave of Test Instruments

Experimenters, hobbyists, and service technicians can now obtain brands of test gear that were previously sold only on a commercial basis

BY W. J. EVANZIA

A LARGE number of test-equipment manufacturers specialize in supplying electronics technicians and hobbyists with test and measuring instruments. In contrast, OEM (original equipment manufacturing) instrument companies concentrated their production efforts to meet commercial needs—"defense" industries, device manufacturers, laboratories, etc.

But times have changed. Now, some of these OEM companies recognize that electronics enthusiasts are accustomed to spending substantial amounts of money for good-quality instruments and that the numbers of such potential customers run into the thousands. The result is that a few OEM companies have diverted some of their energies to reaching this "consumer" market with reasonably priced test instruments.

Currently, the most common test instrument offered is the digital multimeter, or DMM. But other instruments—such as oscilloscopes, frequency counters, and signal and function generators—are making their appearances. The manufacturers involved include some of the "biggest" names in the industry. Here is a roundup of what they are offering to the "consumer" market.

A Choice of DMM's. *Data Precision* is offering a pair of DMM's. Serious experimenters looking for a good bench and field DMM will find the Model 245 battery-powered multimeter to be a very convenient and versatile multi-tester. Priced at $295, it offers a very high degree of testing accuracy in a truly miniature package. If you want a bench-only DMM, the 3½-digit Model 134 is available for only $189

Because low-power complementary n and p MOSFET's are used with a liquid crystal display in the Model 2000 Danameter, *Dana Laboratories'* DMM requires less power than any other multimeter on the market. A single 9-volt battery will operate the DMM for about a year.

Although the 3½-digit Danameter is less precise than the Data Precision Model 245, it is also considerably less expensive at its retail price of $195. And the Danameter is built to take the rough-and-tumble environment of a TV service shop and tool caddy.

The Danameter can measure ac and dc voltages to 1000 V full-scale with a l-mV resolution, direct current over a range of 20μA to 2 A, and resistance to 200 megohms.

The *Ballantine* Model 3/24 DMM sells for $195. It has a full, three-function measuring capability with 24 ranges and features a 3½-digit display and battery operation. Ac and dc voltages are each provides with four measurement ranges, while alternating and direct currents are each allotted five measurement ranges. Six ranges are set aside for resistance measurements. Accuracy on the dc voltage ranges is typically 0.2 per cent, ±1 digit, and on the direct-current ranges 0.5 percent, ±1 digit.

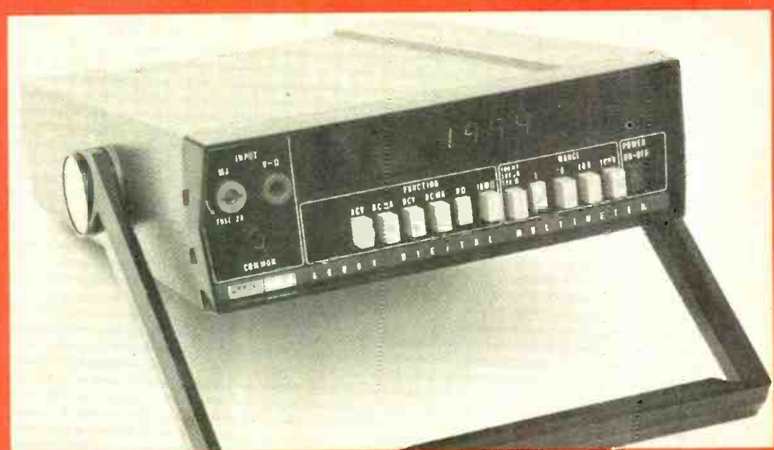
Three options are available as power sources for the Model 3/24: an adapter for storage battery or external dc supply; an ac power supply adapter; and a rechargeable battery supply.

The *John Fluke* entry into the low-cost DMM market is the Model 8000A, priced at $299. It offers numerous options to increase the instrument's

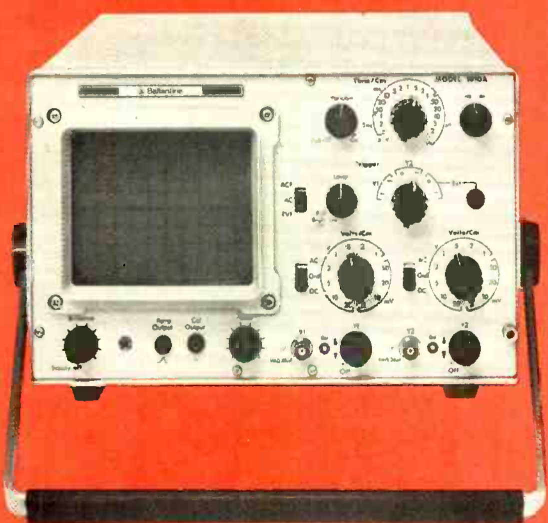
Hewlett-Packard 1221A Oscilloscope

Data Precision 134 DMM

Data Technology 21 DMM



Fluke 8000A DMM



Ballantine 1010A Oscilloscope

Dana Laboratories
2000 Danameter DMM

Ballantine
3/24 DMM

Hewlett-Packard
790A DMM

basic flexibility. Among them are a rechargeable battery pack, 100-kHz to 500-MHz r-f probe, high-voltage probe, BCD output, 2-A to 200-A clamp-on ac adapter, etc.

The Model 8000A has 26 ranges, including one that measures down to 1 μV on ac and dc, down to 100 nA on ac and dc, and down to 100 milliohms. The display consists of a 3½-decade cluster.

Data Technology offers no less than three low-cost DMM's. The miniature Model 21 (it is about the size of a hand-held calculator) sells for $269, including a battery charger and carrying case. It features a 3½-digit display and ac and dc voltage and resistance measuring capabilities. It also measures capacitance (not electrolytic values). No current-measuring capability is featured.

The Model 20, selling for $269, is basically the same as the Model 21 in features and functions, including the capacitance-measuring capability. However, it is a bench-type instrument, designed to be operated from line power. Featuring four decades of display and current-measuring capability on both ac and dc, but no capacitance-measuring capability, the $329 Data Technology Model 30 rounds out the company's low-cost DMM line. This model offers a choice of either line or battery powering and features automatic polarity sensing and display on the dc voltage and current functions. (The Models 20 and 21 also feature automatic-polarity capability on their dc voltage ranges.)

United Systems Corp., a subsidiary of Monsanto, offers two DMM's retailing at less than $300, plus a rather unique third that sells for $395 (it features a direct-readout decibel-measuring function). The *Digitec* Model 2110 sells for $219. It employs a 3½-digit display and measures up to 1000 V dc, 500 V ac, and 20 megohms. It does not measure current. A choice of power options —standard ac or rechargeable battery—is available.

Providing current-measuring capability on ac and dc, the Digitec Model 2120 sells for $295. Also a 3½-decade instrument, it features auto-polarity on the dc voltage and current ranges. It measures to 1000 V dc, 750 V ac, and 20 megohms.

The $395 Digitec Model 2180 is the only DMM in this report to offer decibel-measuring capability. Except for this, the Model 2180 is identical in features and functions to the Model 2120.

Hewlett-Packard's Model 970A miniature DMM has a highly unconventional package design. The instrument weighs only 7 ounces and resembles a small flashlight with a probe sticking out the top (with interchangeable tips available). The 3½-decade miniature LED readout can be flipped over so that it appears right-side-up no matter in what orientation the user has the instrument.

The Model 970A is basically a field-service troubleshooter's instrument. It features automatic ranging, autopolarity, and automatic zeroing. It can measure dc and ac (optionally up to 500 MHz) voltages and resistance. (An optional ammeter adapter is available.) Voltages to 500 V on both ac and dc and resistance to 10 megohms can be measured with the DMM. Decimal point location is automatic. The instrument comes with a sun shield, carrying case, battery charger, and instruction booklet.

Keithley Instruments' Model 168 DMM, selling for $299, is a full-function instrument, capable of measuring dc and ac voltages and currents and resistance. It has a 3½-digit LED display, autoranging, choice of line or battery operation, and LED function indicators. A choice of high or low ohms test voltages is available. In the high ohms function, the test potential is 1 V, while on low ohms, it is 100 mV (which eliminates pn junction conduction when running resistance tests in circuits containing transistors and diodes).

Low-Cost Oscilloscopes. Until the advent of digital electronics, most general-purpose oscilloscopes were adequate for the great majority of tasks they had to perform. Digital circuitry changed all that, as many of us have discovered when tracing pulses through a system with a scope limited to a 5-MHz bandwidth and risetime measured in the slow microseconds. In the early days of digital electronics, an adequate scope for digital work cost upwards of $1000. Now, reasonably priced scopes for this use are available.

Tektronix, one of the most famous names in laboratory-type scopes, selling has a lower-cost line of scopes that includes the Telequipment Model D61 for $475. It has a bandwidth of dc to 10 MHz at the −3-dB points and a risetime of a mere 35 ns (that's *nano*seconds!). Vertical deflection is variable from 10 mV to 5 V/cm in nine calibrated steps, while horizontal deflection is variable between 500 ns to 500 ms/cm in 19 calibrated steps. Input impedance is 1 megohm, shunted by 35 pF.

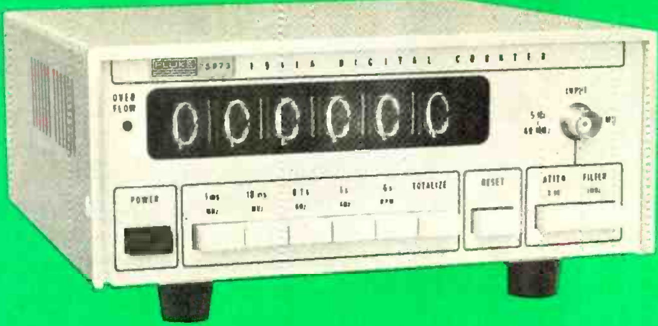
The dual-trace, single-beam scope has alternate and chopped modes, triggered sweep with automatic and normal trigger modes, X−Y capability, and a vector mode. Also featured is a X5 magnifier.

You get more bandwidth (dc to 15 MHz) and greater sensitivity (2 mV) with *Hewlett-Packard's* Model 1220A and Model 1221A oscilloscopes. The $595 Model 1221A features a single trace, while the $695 Model 1220A is a single-beam, dual-trace instrument.

In the dc mode, bandwidth is dc to 15 MHz, while in ac it is limited to 2 Hz on the lower end. The specified risetime is about 23 ns. Input impedance is approximately 1 megohm, shunted by 30 pF. Maximum input signal level is ±400 V dc plus peak ac. The time-base sweep ranges from 0.1 μs to 0.5 s/cm. A X10 magnifier permits detailed examination of the displayed waveform. The scopes are triggered internally from approximately 10 Hz to 15 MHz on signals causing 1 cm or more vertical deflection. The external trigger operates over the same range on signals with amplitudes of 0.1 V peak-to-peak or greater. As with the Telequipment Model D61, both H-P scopes can be triggered by the TV field line, a feature particularly useful in TV servicing. And the three scopes operate in the X−Y mode to provide a means of making phase- and sweep-frequency measurements in tests of TV tuners and i-f strips.

Rounding out our report on scopes is the *Ballantine Labs*. Model 1010A, a dual-trace, single-beam instrument retailing for $595. This scope has a bandwidth of dc to 10 MHz at the −3-dB points from a 50-ohm source. The input impedance is 1 megohm, shunted by 28 pF. Featured are both alternate and chopped modes and a X10 trace magnifier.

Frequency Counters. Among the first test instruments to "go digital" was the frequency counter. These instruments proved to be invaluable to anyone who had to know the precise frequencies of such diverse signals as a digital-proportion R/C pulse train, transmitter's r-f carrier wave, and the



Fluke 1941A Digital Counter

Tektronix Telequipment D61 Oscilloscope

Hewlett-Packard 5381A and 5382A Frequency Counters

Ballantine 5725A Frequency Counter

Wavetek 30 Sweep Generator

clock rate of a time base. Now several OEM companies are supplying the consumer market with a variety of counters at relatively low prices.

Hewlett-Packard has two counters. The Model 5381A, retailing for $249, has a frequency range of 10 Hz to 80 MHz. A 1-MHz internal crystal time base in this counter provides less than 0.3 ppm/month aging and ±10 ppm temperature compensation from 0° C to 40° C. Input sensitivity is 25 mV at 30 Hz to 20 MHz, and 50 mV from 30Hz up to the upper frequency limit of the counter. Input impedance is 1 megohm, shunted by a capacitance of 50 pF.

A three-position (X1, X10, X100) switch determines the input signal levels. On the X1 range, up to 5 V rms can be accommodated over the entire frequency range. From dc to 40 Hz, up to 200 V (dc plus peak ac) is permitted, and from 40 Hz to 100 kHz, 250 V rms can be applied without damage to the instrument. Gate times are manually selectable, providing resolutions of 10 Hz at 0.1-s, 1 Hz at 1-s, and 0.1 Hz at 10-s gate timing.

For even more precise counting, Hewlett-Packard sells the Model 5382A frequency counter for $450. It offers an optional temperature-compensated oscillator that meets FCC requirements for professional communication equipment. In addition, it has a specified top end range of 225 MHz and features temperature compensation of ±2 ppm from 0° to 40° C as well as greater sensitivity. Both H-P frequency counters can operate on an external precision time base through a built-in rear-panel connector. Input levels at these connectors from 250 mV to 25 V can be accommodated. The 80-MHz Model 5381A has a seven-decade display, while the 220-MHz Model 5382A has an eight-decade display.

Ballantine Labs.' Model 5725A 90-MHz frequency counter sells for $325. It features frequency-counting, totalizing, and ratio capabilities. In the count mode, it is a straight frequency counter. Switching to the totalize mode, the instrument continuously counts the events (pulses) applied at the input. Separate pushbutton switches are provided for stopping and starting (or continuing) the events count and for resetting the display and logic to zero.

In the ratio mode, any signal from 5 Hz to 90 MHz applied to the front-panel input is compared to another signal of from 10 kHz to 2 MHz applied to a rear-panel input. The display indicates the ratio between the two signals.

Fluke's general-purpose Model 1941A laboratory frequency counter that sells for $299 has a 5-Hz to 40-MHz range, 40-mV sensitivity, and gate times of 1 ms to 1 s in decade steps (plus a 600-ms time). Resolution is 1 Hz at 1 s, decreasing to 1000 Hz at 1 ms gate times. An LED overflow indicator comes on when the six-digit display is exceeded.

The counter utilizes a highly stable 10-MHz crystal-controlled oscillator as a time-base reference. An external 10-MHz signal can be substituted for the internal time-base signal. The time base provides an aging rate of 6×10^{-7} parts/day. Temperature dependence is 10^{-6} parts over a range of 20° C to 30° C, or 5×10^{-6} parts from 0° C to 40° C.

The Model 1941A provides a totalize mode. By using external switching, the number of events occurring per minute, hour, day, week, month, or any other desired period can be counted and displayed. A BCD output and an offset input are available as options.

Unique Generators. *Wavetek's* Model 30 could be called "every man's sweep generator" because it has a price tag that belies its performance capabilities. Retailing for only $149, it has a unique combination of features. It is, first and foremost, a basic sine/square-wave signal generator with a frequency range of 2 Hz to 200 kHz in three 1000:1 ranges.

Adding to the instrument's versatility are linear and logarithmic functions with fixed sweep times of 2.5 s for driving the horizontal amplifier of a scope, 250 ms for general-purpose use, and 25 ms for driving an X-Y recorder. External capacitors can be added to increase the sweep time.

The log sweep function is particularly useful in audio work for aligning tape recorder heads, making equalization tests, etc.

A high-level sine-wave output that is variable up to 1 V rms open circuit from a 600-ohm source has a specified distortion of less than 2 percent from 2 Hz to 20 kHz. Available also is a 50-percent duty cycle square-wave pulse output with nominal 0-V to 0.5-V and 3-V to 5-V TTL levels.

The rear panel of the Model 30 contains a 0.8-V peak-to-peak triangle-wave output, a low-level sine-wave output, a sync pulse output, a sweep ramp output, and a generator-controlled voltage output.

The Model 30 generator employs conventional 9-volt batteries as a power supply, making it completely independent of line power. For an additional $25, you can get an optional rechargeable battery pack and recharger unit.

For $445, you can buy a combination frequency counter/function generator in the Model 304A from Monsanto's *United Systems Corp*. This rather unique instrument provides sine, square, and offset square waves over a frequency range of 10 Hz to 1 MHz in its generator function. Distortion on the sine function is specified at 0.1 percent typical. Settability and resolution over the generator's range is 0.1 Hz. Three 20-dB steps of attenuation are provided. Operated as a frequency counter, the Model 304A has a frequency range out to 15 MHz.

Systron-Donner's Datapulse Division offers a wide-range function generator in their Model 400. This $450 generator provides sine, square, and triangle waveforms. It has a frequency range of 0.02 Hz to 2 MHz in six decade range steps.

The Outlook. It is obvious from the foregoing that today's technician and serious experimenter have available to them a wide variety of test instruments from a host of brand-name manufacturers. The OEM entry into the technician/consumer market widens the scope even farther, bringing to the average shop a prestige heretofore reserved for space-agency research and development, and military and government test facilities.

Hobbyists and experimenters must shop carefully, of course—assessing needs and analyzing available equipment. With options and accessories, some low-cost instruments may wind up more than the budget allows.

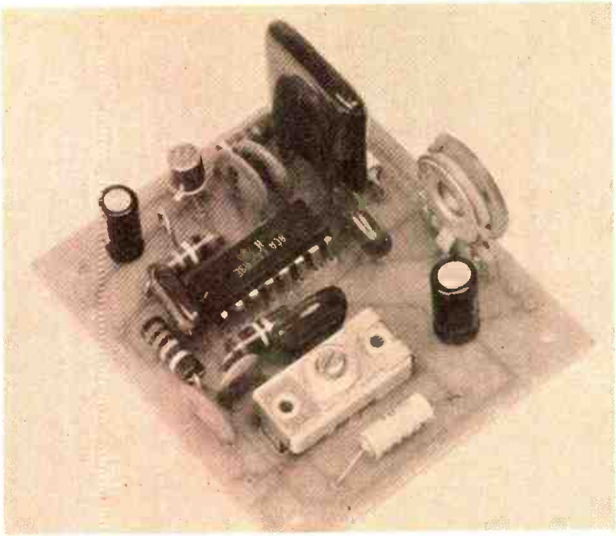
The OEM incursion into the market is still very new and, as a result, only superficial at present. We predict that over the next few years, other companies will join the ranks of those OEM companies already doing business on the consumer market. We further predict that the move will bring a greater diversity in test and measurement capabilities. ◈

FOR MORE INFORMATION:

Some of the OEM companies mentioned in this article plan to sell directly to the consumer, others only through authorized representatives.

For purchasing information and detailed specifications on the instruments discussed in these pages, write to the companies at the following addresses:

Ballantine Labs., P.O. Box 97, Boonton, NJ 07005
Dana Labs., Inc., 2401 Campus Dr., Irvine, CA 92664
Data Precision Corp., Audubon Rd., Wakefield, MA 01880
Data Technology Corp., 2700 S. Fairview St., Santa Ana, CA 92704
John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, WA 98113
Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304
Keithley Instruments, 2877 Aurora Rd., Cleveland, OH 44139
Systron-Donner, Datapulse Div., 10150 W. Jefferson Blvd., Culver City, CA 90230
Tektronix, Inc., Telequipment Div., P.O. Box 500, Beaverton, OR 97005
United Systems Corp., Div. of Monsanto, 918 Woodley Rd., Dayton, OH 45403
Wavetek, 9045 Balboa Ave., San Diego, CA 92123.



BY FRANK P. KARKOTA, JR.

SCA ADAPTER REVEALS HIDDEN MUSIC AND NEWS ON YOUR FM RECEIVERS

IN AN EFFORT to utilize more fully the radio spectrum, the Federal Communications Commission some time ago authorized FM radio stations to use special subcarriers to broadcast additional program material. This was covered in the FCC's Subsidiary Communications Authorization — hence the letters SCA, applied to the process in general. The most common use of SCA is in the transmission of background music; but other broadcasts include detailed weather forecasting, special time signals, and other material designed and intended for special-interest groups, doctor's offices, stores, factories, and other public places.

Broadcasters who use SCA generally make their profits by leasing the special receivers required to detect the subcarriers. However, the SCA adapter described here will enable the owner of almost any conventional FM

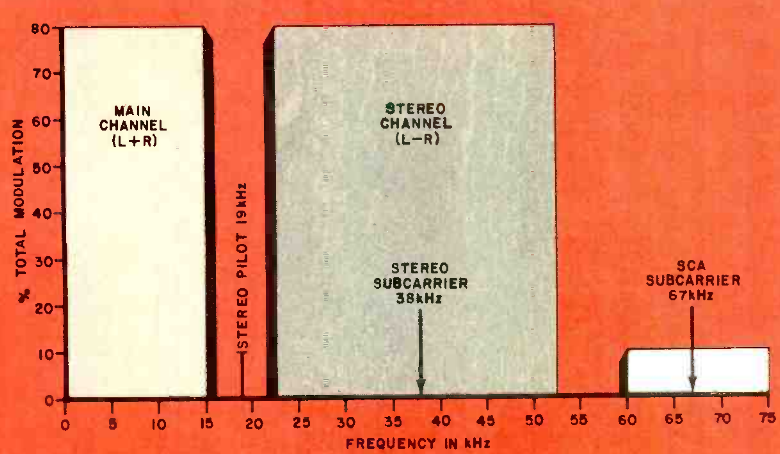


Fig. 1. Makeup of the frequency spectrum of an FM transmitter carrying both stereo and SCA signals. Main channel is at left, stereo at center, and SCA subcarrier at right.

receiver to listen to these broadcasts. (*A word of caution*: it is illegal to use SCA broadcasts for commercial purposes without written permission from the broadcaster.) Using a single IC, this low-cost SCA adapter can derive its operating power from the receiver with which it is used. In many cases, the adapter can be built directly into the cabinet with the receiver. A small pc board and simple alignment procedures make the project easy to construct and use.

How SCA Is Handled. In mono FM broadcasting, the main channel transmits only audio frequencies up to 15 kHz, and the transmitter/modulator is designed for this range only. For all stereo FM broadcasting, the transmitter/modulator is designed to pass not only the 15-kHz main (L + R) channel, but also a 19-kHz stereo pilot carrier and an amplitude-modulated 38-kHz subcarrier that contains the stereo (L − R) information. For an FM station to transmit also the SCA information, it must be able to accommodate the SCA channel as a narrow-band (7-kHz deviation) subcarrier centered at 67 kHz. The audio-modulation frequency spectrum for an FM transmitter carrying both stereo and SCA is shown in Fig. 1.

To extract the SCA material from this composite signal requires the equivalent of two receivers — one to demodulate the composite from the FM transmission and the other to recover only the SCA from the detected composite signal. A conventional FM receiver performs the first operation, and the output of its detector forms the input signal for the second "receiver." Essentially, the latter is in the form of a narrow-band FM receiver tuned to 67 kHz. The audio output of this SCA adapter is used to drive an external amplifier and speaker.

How It Works. The schematic of the adapter is shown in Fig. 2. The IC is a new unit which contains a complete FM strip on a single chip. Although designed to work at the conventional 10.7-MHz i-f, this IC works well at 67 kHz for SCA.

The demodulated composite signal is applied to control potentiometer *R1*, which acts as a squelch (to be explained later). The relatively low value of *C1* provides a high-pass filter to reject the main channel and most of the stereo subcarrier. Capacitor *C2* and inductor *L1* form a tuned circuit that helps to reject noise above and below 67 kHz. Capacitors *C3* and *C4* are used as bypasses to allow one side of the tuned circuit (*C2*–*L1*) to remain at signal ground while current from pin 3 biases the i-f amplifiers connected to pin 1.

The internal i-f amplifiers also provide the limiting that eliminates any amplitude variations that might be present on the input signal. This also improves the rejection of the stereo subcarrier since the stereo information appears as amplitude noise.

The limited and amplified signal then enters the internal quadrature detector where capacitor *C7* and the tuned circuit formed by *L2*, *C8*, and *C9* form the required phase-shift network for tuning the detector. Resistor *R5* connected across the tuned circuit determines the bandwidth of the detector. The detected signal then drives a squelch-controlled audio preamplifier (also on the chip) and a set of level detectors in each i-f amplifier that provides a dc output proportional to the log of the input signal. This dc voltage is applied through *R2* to the base of *Q1*, while *C5* removes any 67-kHz component that might be included. When a predetermined signal level appears at the input to the i-f amplifiers, the base current of *Q1* causes it to saturate. Resistor *R3* forms the load for *Q1*. When *Q1* saturates, the low emitter-to-collector voltage cannot squelch the internal audio system. When the signal level drops below the predetermined level, *Q1* is cut off; and its output signal (at pin 5) is sufficient to operate the internal audio squelch.

The recovered audio output (pin 6) is de-emphasized by *R4* and *C10* while *C11* blocks the dc component from the audio output.

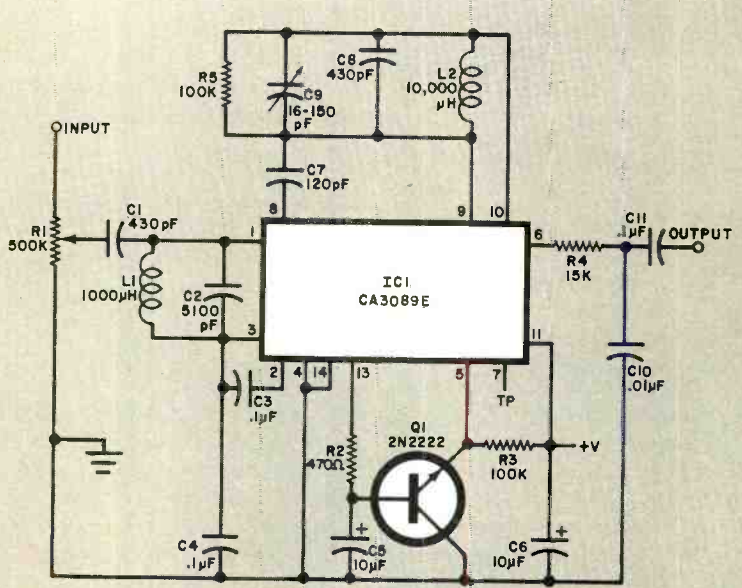
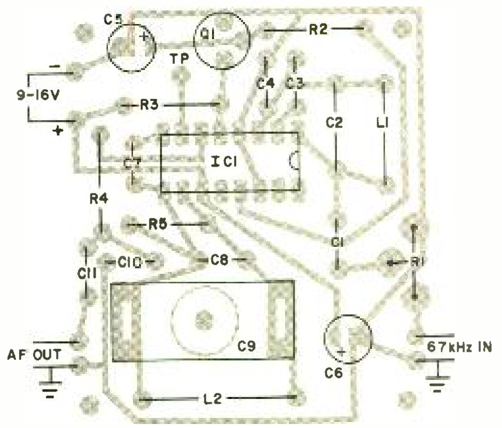


Fig. 2. Single IC contains a complete i-f system, a quadrature FM detector and an audio amplifier.

PARTS LIST

C1, C8—430-pF, 5%, silver-mica capacitor
C2—5100-pF, 5% silver-mica capacitor
C3, C4, C11—0.1-μF, 10-volt disc capacitor
C4, C6—10μF electrolytic capacitor
C7—120-pF, 5% silver-mica capacitor
C9—16-150-pF trimmer capacitor (Arco 424 or similar)
C10—0.01μF disc capacitor
IC1—CA3089E
L1—1000-μH, 5% inductor (Nytronic WEE-1000 or similar)
L2—10,000-μH, 10% inductor (Nytronic WEE-10,000 or similar)
Q1—2N2222
R1—500,000-ohm trimmer potentiometer (CTS X-201 or similar)
R2—470-ohm, ½-watt resistor
R3, R5—100,000-ohm, ½-watt resistor
R4—15,000-ohm, ½-watt resistor
Misc.—Power supply, interconnecting shielded cables, pc board, optional mounting hardware, etc.

Note—The following are available from Communications Poly Services, 46 Groton Rd., Westford, MA 01886: etched and drilled pc board at $2.10; complete kit of parts at $11.95, both postpaid. Massachusetts residents, please add 3% state sales tax.



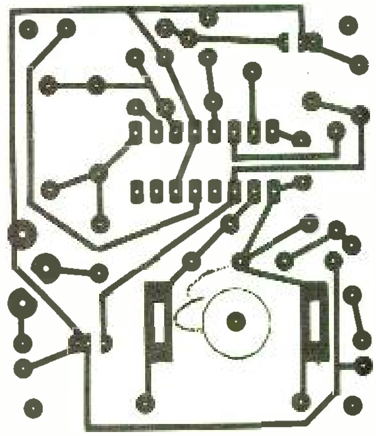


Fig. 3. Actual-size foil pattern and (far left) component installation. Observe polarities on electrolytics.

Construction. Although there are no r-f signals present, the high gain of the IC makes parts placement in the circuit somewhat critical. A pc board is therefore recommended (Fig. 3). When the tuning capacitor, *C9*, is installed, the side of the capacitor having the top plate should be closest to capacitor *C6*. Observe the notch code on *IC1* and the polarities of the two electrolytic capacitors.

The test point is simply a small loop of bare wire, soldered into the board at the point (TP) shown in Fig. 3.

The demultiplexer requires between 9 and 16 volts dc at 20 to 30 mA. If it is not available from the conventional receiver, a small supply can be built using the circuit shown in Fig. 4.

Alignment. Use shielded cable to connect the adapter input to the FM receiver. If you are lucky, the FM stereo receiver will have a phono jack marked "detector out," "composite out," "output to MPX adapter," "output to stereo adapter," or some variation of these. If the receiver does not have this jack, or if it is a mono receiver, a connection must be made to the FM detector *before* the deemphasis network. Make the connection as shown in Fig. 5. Connect the output of the SCA adapter to the external audio amplifier and speaker.

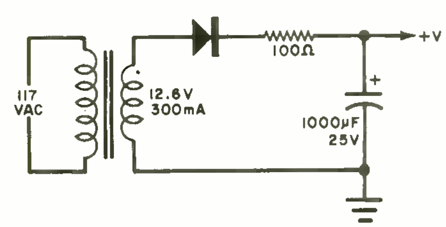


Fig. 4. This power supply can be built if not available elsewhere.

Before applying power, temporarily connect a short circuit between the emitter and collector of *Q1*. Adjust variable capacitor *C9* for half mesh, and set potentiometer *R1* fully clockwise (rotor at input end).

Connect a dc voltmeter from the test point to the side of *C9* closest to *C6*. Turn on the FM receiver and apply power to the SCA adapter. When the FM receiver is tuned across the band, noise and distorted main-channel programming will be heard on those stations not carrying SCA. When a station carrying SCA is tuned, this material will be heard. Adjust *C9* for zero volts on the dc voltmeter. If a dc voltmeter is not available, adjust *C9* for best results.

Remove the temporary short across *Q1*. If the audio output drops away when this is done, the SCA adapter is receiving too little signal. Check the connection to the FM receiver to make sure it is properly made.

The internal squelch circuit is used to quiet the SCA adapter between music selections in the event that the station making the SCA broadcasts turns off the subcarrier between selections. In this case, adjust potentiometer *R1* to silence the noise between selections.

The ultimate quality of the demultiplexed SCA signal is largely a function of the FM receiver. It is important to have a strong signal, as free of multipath as possible. It should be noted that the signal level required for noise quieting increases as the bandwidth of the received signal increases. It is for this reason that a stronger signal (compared to a mono transmission) is required for adequate reception of stereo broadcasts; and an even stronger signal is required when an SCA subcarrier is added. Note, also, that any distortion (such as phase) present in the FM receiver will appear in the demultiplexed signal as crosstalk.

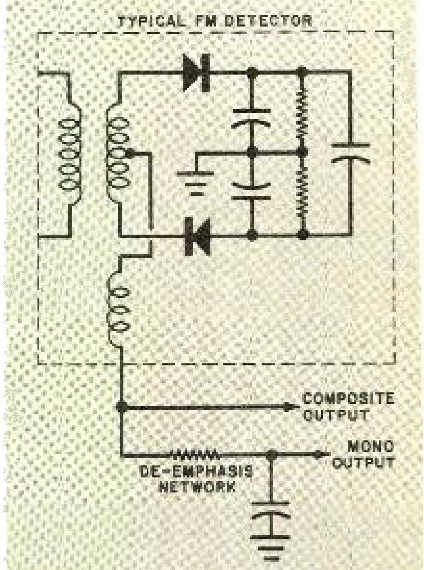
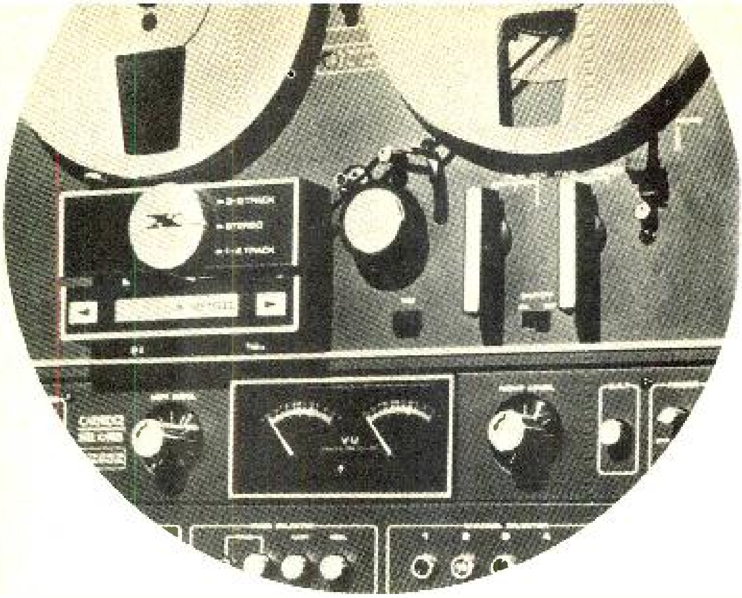


Fig. 5. Typical FM detector showing where the composite output can be taken out.

Modifications. There have been rumors of a proposal to reallocate the FM subcarriers to accommodate four-channel sound. If this comes about, or if you hear of any frequency other than 67 kHz being used for the SCA subcarrier, the SCA adapter described here can easily be modified for the new frequency by changing the value of two capacitors. For *C2*, the value is $10^9/(4\pi^2 f^2)$; and for *C8*, use $10^8/(4\pi^2 f^2) - 70$; where C is in picofarads and f is in kilohertz. ◈



HOW TO EVALUATE TAPE RECORDER SPECS

BY JULIAN D. HIRSCH
Hirsch-Houck Laboratories

TECHNICAL terms and figures cited in test reports and manufacturers' literature on tape recorders may confuse some prospective buyers. Presented here are the major ones used to judge a tape recorder's performance, with explanations and observations to clarify their true meanings. Though test conditions are rarely specified by manufacturers, we will detail those used in our Hirsch-Houck Laboratories evaluations given in the Product Test Reports in POPULAR ELECTRONICS.

Frequency Response. One of the first specifications one looks for in evaluating a tape recorder is its frequency response. As a minimum, a frequency-response specification should include the range limits, variation over the specified range, and tape speed (for example, 40-20,000Hz ±3 dB at 7½ ips). The frequency response also depends on the tape used, but with most open-reel recorders, this is not very critical.

Most tape recorders cannot achieve their rated frequency response at maximum recording level, especially at the lower tape speeds. This is due to saturation of the magnetic coating on the tape at the higher frequencies that are boosted by the recording equalization and appear as a roll-off of high-frequency response. As a result, it is customary to measure frequency response at a lower level (not more than −10 to −15 dB).

Recorders differ considerably in their susceptibility to high-frequency tape saturation. The recording equalization, a key factor, is rarely (if ever) specified and cannot be measured from outside the machine. The easiest way to judge a recorder's high-frequency "head-room" is to measure its frequency response at 0 dB and at a lower level (such as −20 dB.) The smaller the difference in high-frequency response between the two measurements, the better the recorder in this respect.

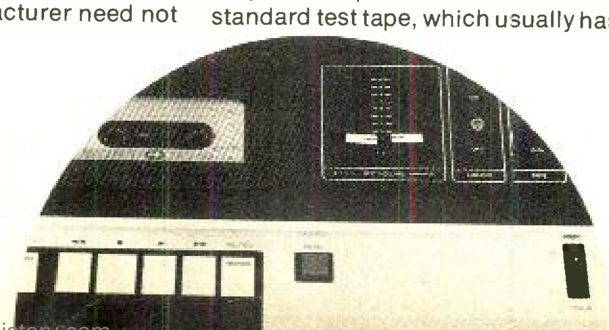
In the Hirsch-Houck Labs tests that appear in this magazine, we record at −20 dB, using a sweeping oscillator and play back into a chart recorder that is synchronized to the frequency sweep. Similar results, with less resolution, can be obtained by recording spot frequencies and reading the playback levels on a meter.

Cassette recorders present special problems. The high-frequency recording equalization is greater than that used in open-reel machines, and the test level should not exceed −20 dB. One manufacturer even recommends a −30 dB level for testing his recorder. For best results in any tape recorder, the recording bias should be matched to the tape characteristics. This is absolutely vital with cassette recorders. Not only must the bias be set for the type of tape, it must also be set for the specific brand. (With reference to the latter, bias set for chromium-dioxide tape from one manufacturer need not be reset for another manufacturer's tape since there is so little difference among brands of CrO_2 tapes.)

A frequency-response rating of "40-20,000 Hz ±3 dB" means that the output can vary a total of 6 dB from maximum to minimum within the specified frequency range, in this case, 40-20,000 Hz. Without an actual response curve (rarely supplied by the manufacturer but included in most equipment test reports), one cannot assume that two recorders with identical ratings will sound alike. One recorder may have a rising response at the high end and sound "bright." Another, still within the ±3-dB rating, could have a falling high-frequency response and sound subdued or even dull. Between the extremes, there are an infinite number of response variations that can be defined only graphically. If the variations were small, such as ±1 dB, the ratings could be compared with greater validity. But most recorder manufacturers use a broader tolerance to encompass the wider range of variations found within an extended range of frequencies.

Another aspect of recorder frequency response that is not always specified separately is *playback* response. This parameter indicates the accuracy of a recorder's playback equalization and its suitability for playing commercially recorded tapes or tapes made on another recorder. Playback response is measured with a standard test tape, which usually has a

What the specs mean and how they're determined provide guidelines to product performance



relatively limited range compared to the coverage of most of today's recorders. Typically, these are 50-15,000 Hz at 7½ ips, 50-7500 Hz at 3¾ ips, and 31.5-10,000 Hz for cassettes.

Distortion. Tape recorder distortions are difficult to summarize in a single specification because they vary widely with level, frequency, and the nature of the test signals. At middle frequencies (such as 1000 Hz), the total harmonic distortion (THD) is easy to measure. At frequencies exceeding one-half to one-third of the recorder's maximum response frequency, the harmonic levels in the playback will be reduced or eliminated by the deck's inherently limited response so that THD cannot be used to measure nonlinearity at the higher audio frequencies where it is most serious. Two-tone intermodulation (IM) distortion measurements are needed for this, but there is no universal standard for such tests at present.

The THD ratings published for tape recorders (such as "less than 1 percent") can be assumed, in the absence of other information, to be measured with a 1000-Hz signal recorded at an indicated level of 0 dB on the recorder's meters. This is the procedure followed at Hirsch-Houck Labs, and we believe it to be typical of industry practice. Since distortion is also affected by tape speed, it should be specified at each operating speed.

As with many other tape recorder specifications, distortion can also be affected by the type of tape used. Fortunately, in the case of open-reel recorders, the differences are minor within any one classification of tape. Most manufacturers do not specify the tapes used in their own tests, but our test reports do. In the case of the cassette recorder, the tape is a critical factor and *must* be known for any interpretation of the ratings.

Signal-To-Noise Ratio. The dynamic range of a tape recorder is limited by the maximum level that can be recorded and played back with an acceptable distortion and by the residual noise level in the playback output. The ratio of these two levels is known as the "signal-to-noise" (or S/N) ratio and is expressed in decibels (dB). Strictly speaking, it is the signal plus noise-to-noise, or (S + N)/N, ratio, but in this case, the difference is minor.

Usually, a single figure like "55 dB" is given as the S/N rating. Implicit in such a rating is a specific—but often unstated—distortion level at maximum signal input. A THD of 3 percent is generally used as a reference for S/N rating of home tape recorders.

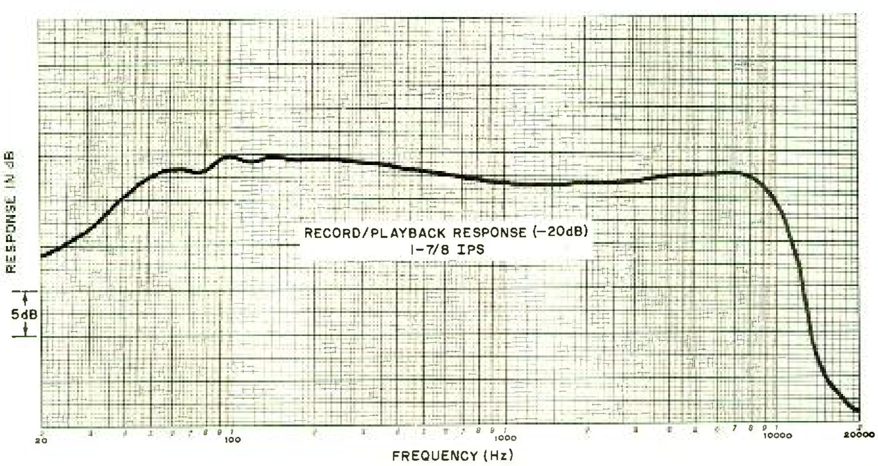
As with all hi-fi components, the distortion of a tape recorder increases as the program level increases, especially near the recorder's maximum capability. However, one cannot assume that 3-percent THD will coincide with a "0-dB"—or any other maximum—recording level on the deck's meters. As a rule, the reference distortion will be reached with an input of +3 to +6 dB, allowing some recording "headroom" for brief peaks that might not register on the meters. In the case of cassette recorders, the headroom is usually not more than 2 or 3 dB at middle frequencies (and sometimes considerably less) and reduces greatly at higher frequencies due to the greater recording equalization necessary to achieve a wide frequency response.

The audible noise level in the playback output consists mostly of hiss or wideband random noise. There will usually be some low-frequency noise (such as power-line hum) as well. But this is much less audible due to the characteristics of human hearing. An unweighted noise measurement responds equally to hum and hiss and may give an unduly pessimistic result in terms of the subjective character of the noise. Hence, it is customary to "weight" the noise measurement to discriminate against the less-audible low and high frequencies. Sometimes the weighting curve is specified—such as "ANSI A"—but often it is not. As with flutter, S/N ratings can only be compared when they are based on the same reference distortion and noise-weighting characteristics.

Crosstalk And Separation. These are two different manifestations of the same effect—leakage of a signal from one track of the tape to another. This leakage is largely a function of head design, but it can also occur in the wiring to the heads and in the recorder's electronics.

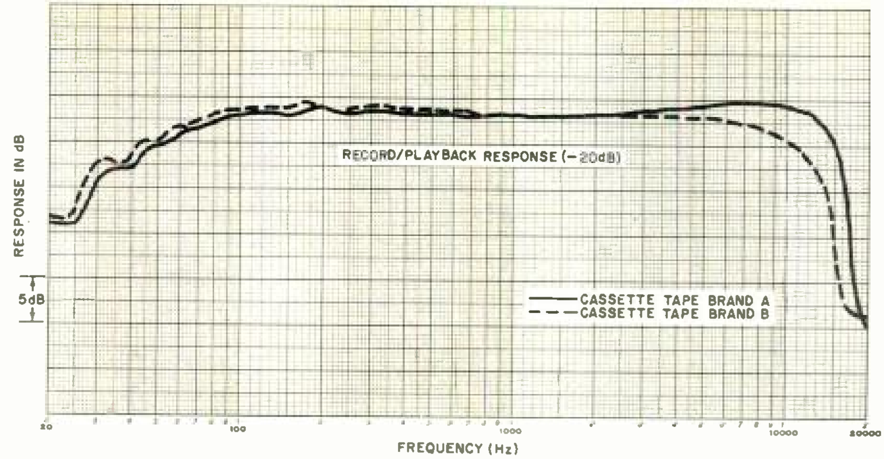
Crosstalk and channel separation are usually specified at a middle frequency, such as 1000 Hz, although they vary with frequency. Crosstalk is the more serious from a listening standpoint. It is a transfer of signal from one pair of tracks to the other. When playing the tape in the forward direction, the second pair of tracks is being played backwards, and the crosstalk will be in the form of noise or garbled sounds with no relationship to the desired program.

When the leakage occurs between the two stereo channels in the same direction of tape travel, its only effect is to slightly dilute the audible separation of the program. Since any tape recorder is likely to have much better channel separation than the program being recorded actually requires, this "problem" is trivial. Typical specifica-



Response of a high-quality open-reel recorder at 1 7/8 ips. This is good for an open-reel recorder at this speed. Cassette recorder at same speed would be as good, if not better.

Curves show difference in over-all frequency response for two types of cassette tape (with same bias setting).



tions for a high-quality recorder might be: crosstalk more than 60 dB at 1 kHz; separation more than 50 dB at 1000 Hz.

Wow And Flutter. These are the audible effects of frequency modulation of the program material caused by uneven tape motion across the heads. When the speed fluctuation occurs at a low rate (less than 10 Hz), the characteristic "wow" sound can be heard. This is especially apparent on tones of extended duration, such as the organ and the decay of piano notes. Faster rates, up to 200 Hz or more, are heard as "flutter"—a slight muddying of the sound and, in extreme cases, a "gargling" quality.

Wow and flutter measurements are frequently combined in a single flutter rating, expressed as a percentage of frequency modulation. For example, a 0.2-percent flutter will cause a 1000-Hz tone to vary between 998 and 1002 Hz. Higher and lower frequencies will be affected proportionately. The audibility of flutter depends on several factors, including: magnitude, rate, and program material (duration and frequency range of tones).

The human ear is most sensitive to flutter affecting frequencies in the vicinity of 3000 Hz, which is why a 3150-Hz frequency is now generally used for flutter measurements. Standard test tapes are recorded with a 3150-Hz tone that has very low intrinsic flutter, typically less than 0.02 percent. The tape is played on the recorder and its output is measured with a flutter meter, a device that is essentially a calibrated FM receiver that is fixed-tuned to 3150 Hz and contains a meter that indicates the percentage of frequency modulation.

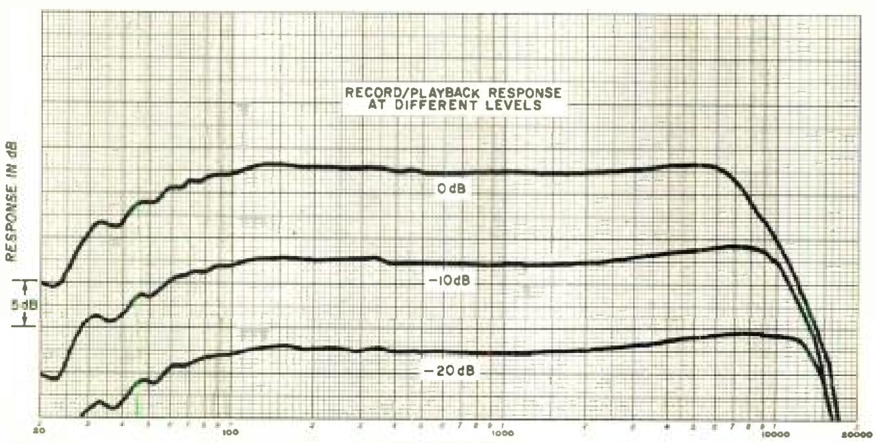
Unweighted rms flutter measurements respond equally to flutter rates over a wide range (such as 0.5 to 10 Hz for wow, 10 to 200 Hz for flutter, or 0.5 to 200 Hz for a combined measurement). Since the most audibly objectionable flutter rates occur between 1 and 10 Hz, current IEEE standards call for a *weighted peak* flutter measurement, emphasizing the frequency range and reducing the contribution of higher and lower frequencies to the final measurement. Some recorder manufacturers use a similar weighting curve applied to rms rather than peak measurements. These are usually identified as "Wrms" flutter measurements.

Weighted readings are always less than unweighted readings, usually by 20 to 30 percent. A peak measurement will always be greater than an rms measurement. A comparison among published flutter ratings for different recorders is valid only if the same technique is used in all cases.

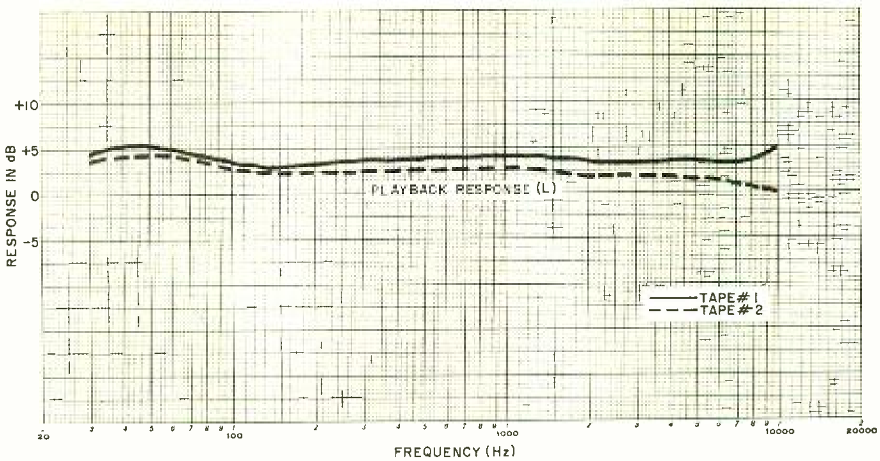
Cassette recorders are tested in the same manner, except that presently available test cassettes have a residual flutter level between 0.1 and 0.2 percent, which is more than that claimed for the latest recorder designs. To test cassette decks, a standard test tone is recorded and played back into the flutter meter. Some flutter is introduced when recording and some during playback, adding to or cancelling each other at different times. By taking several readings and averaging the results, it is possible to establish an approximate flutter rating.

In multispeed recorders, flutter is usually less at the higher speeds. Bidirectional recorders may exhibit slight differences in flutter when running in forward and reverse directions due to variations in the tape-tensioning and guidance system. As a rule, these effects are minor.

In most cases, a flutter level of 0.1



Effects of recording level on frequency response of a cassette recorder. Testing level is usually −20 dB.



The playback response of a cassette recorder using two different samples of the same test tape.

percent or less will not be audible. Most of the better open-reel recorders and a few cassette decks can meet this requirement. Typical good cassette recorders have 0.15 to 0.25 percent flutter, while low-priced open-reel decks fall into the same range. With some types of music, this can be audible; but, in general, it would be apparent only to a critical listener. Flutter levels exceeding 0.3 percent are not consistent with high-fidelity reproduction.

Miscellaneous. There are a number of tape recorder characteristics that are never mentioned in published specifications. Most of them are probably of little interest to the average user, who can generally obtain the information from the manufacturer. But a few items that might be meaningful to the home recordist deserve mention.

Meter Characteristics. The level meters of many recorders are labelled as being "VU," usually incorrectly. The VU stands for volume unit, and the characteristics of a VU meter are detailed in an IEEE/ANSI specification. These include a frequency response within ±0.5 dB from 25 Hz to 16,000 Hz and a 0-VU reading corresponding to 1mW at a specified impedance (usually 600 ohms). When a signal that will result in a 0-VU reading is applied, the meter pointer should swing to 99 percent of that reading in 0.3 second, with an overshoot of 1 to 15 percent, and should return to rest in approximately the same time when the signal is removed.

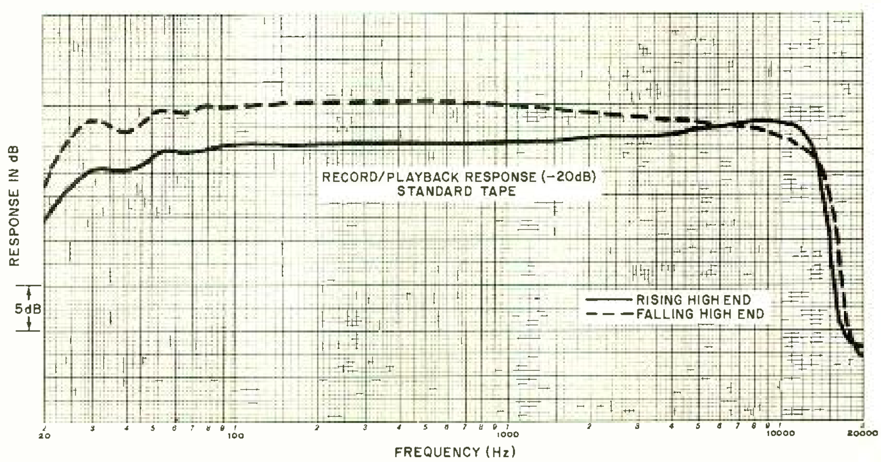
Typical home-recorder meters rarely have the ballistic characteristics of a VU meter and are more correctly labelled as "dB meters" (assuming that their dB calibrations are correct, which is not always the case). In our recorder tests, we apply toneburst signals to check the response of the meters. Some meters overshoot considerably, but most are too slow and indicate considerably less than a true VU meter on transient signals.

It is important to know the general response characteristics of a recorder's meters to be able to allow sufficient reserve range for brief program peaks. Most meters, including true VU meters, are average-responding devices and will not indicate the peak level of the signal. Some recorders have peak-reading meters that are able to respond in a few milliseconds. In some units, the meters indicate the outputs of the recording amplifiers, thereby including the effect of the equalization and reducing the likelihood of over-recording a signal containing strong high-frequency content.

Microphone Input Dynamic Range. The noise level of a good open-reel recorder, or a cassette recorder equipped with Dolby noise reduction circuitry, is negligible for most practical purposes. When taping from records or FM tuners, the noise in the input signal will usually exceed that introduced by the recorder.

A notable exception is the case in which microphones are used for "live" recording. Assuming that ambient background noise is low and that precautions have been taken to eliminate hum pickup, the noise (hiss) in the recorder's microphone preamplifiers will often be unpleasantly audible, especially when operating near maximum gain. Although no recorder manufacturer known to us specifies the noise contribution of his microphone amplifiers, our lab tests include a check of the increase in noise at maximum and at lower microphone gain settings. ◈

Response curves for two recorders with almost identical specs. However, recorder with solid-curve response has a rising high end and would sound brighter than recorder with dashed curve, which has droop at the high end.



Ionic Industries "Performer" Modules

BY DON LANCASTER

SELECTING AN ELECTRONIC MUSIC SYNTHESIZER

THERE ARE SYNTHESIZERS FOR EVERY TASTE AND POCKETBOOK— FROM ELABORATE STUDIO MODELS TO DO-IT-YOURSELF MODULES

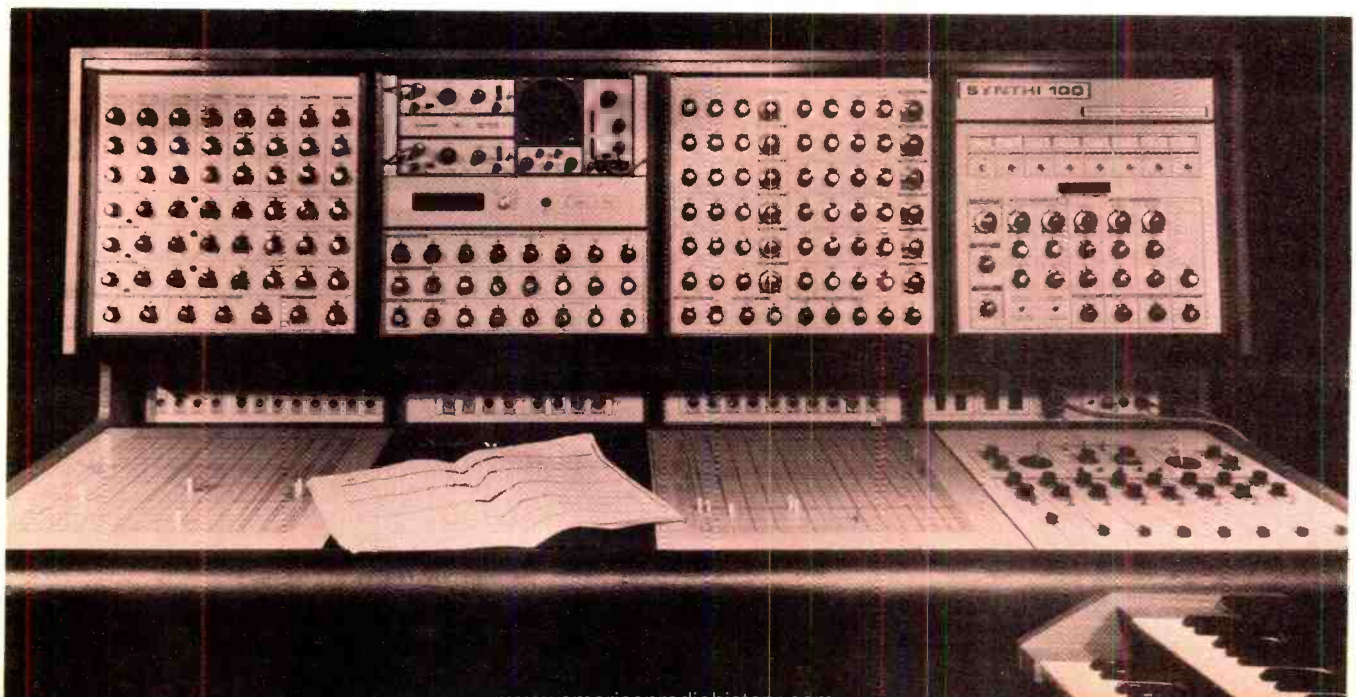
THE design of most commercial synthesizers is based on the original RCA and Moog systems — a series of keyboard-controlled vco's and vcf's interconnected through patch cords, matrix switches, relays, or stop-like fixed presets. The majority have only one- or two-note-at-a-time capability, although the latest designs are beginning to go truly polyphonic.

At present, synthesizers fall into several broadly defined categories: studio models, live-performance models, economy build-it-yourself kits, and individual modules.

Studio Models. Synthesizers for recording studios are the most expensive, featuring as much in performance and variations as can possibly be offered. However, they are not really suitable for live performances. Typical of the synthesizers in the studio category are several custom Moog units (see box on page 51 for manufacturer and supplier addresses), the Synthi 100 from Electronic Music Studios, and the ARP 2500 from ARP Instruments.

Live-performance synthesizers are usually offered through music stores for retail prices ranging from a low of about $900 to a high of $3000 or more. Currently popular versions are the ARP *Odyssey* and *Soloist*, the *Minimoog*, and EMSA's *Electrocomp 101* (made by Electronic Music Labs., Inc.), and the Ionic *Performer*.

Prices for these synthesizers are somewhat high, but they are comparable to what you would have to pay for other quality musical instruments, and much less than for most electronic organs. At present, the prices are high because the synthesizers are sold and serviced by retail music stores, because much engineering cost must be



MORE EM BOOKS

Organ Building, R.L. Eby. This is a complete handbook on electronic organ and synthesizer parts and pipe-organ materials. It costs $3 from Newport Organs, 486 Production Place, Newport Beach, CA 92660.

Musical Acoustics, C.A. Culver. Discussed in this book are the basics of all musical instruments, timbre, tone production, harmonic structures, etc. The book was published by McGraw-Hill Book Co. in 1956.

Music, Physics, And Engineering, H.F. Olsen. An updated version of the out-of-print *Musical Engineering*; it includes material on much of the original RCA synthesizer experiments. The book was published by Dover Publications in 1967.

Psychology of Music, C.E. Seashore. Published by McGraw-Hill Book Co. in 1938; you may have to hunt through the shelves of a large library to find a copy of this book. In it you will find discussions on instruments, their tonal structures, and how music is interpreted.

SYNTHESIZER MANUFACTURERS

The following is a list of addresses of the manufacturers and suppliers of commercial synthesizer products mentioned in the text:

ARP Instruments, 320 Needham St., Newton, MA 02164
Electronic Music Laboratories, Inc., Box H, Vernon, CT 06066
Electronic Music Studios, 460 West St., Amherst, MA 02164
Eμ Systems, 3455 Homestead Rd. #59, Santa Clara, CA 95051
Ionic Industries, 128 James St., Morristown, NJ 07960
Moog Music, Inc., Box 131, Williamsville, NY 14221
PAIA Electronics, Box 14359, Oklahoma City, OK 73114
Southwest Technical Products Corp., 219 West Rhapsody, San Antonio, TX 78216
Total Technology, Box 828, Belmont, CA 94002

ARP Instruments Model 2600 (above) costs about $2800

The EMSA Synthi 100 (opposite) is complete professional studio model ($20,000 up).

amortized over a relatively few units, and because, when these instruments were designed, components and techniques were far more expensive and complex than they are with today's IC's.

If you question that last statement, consider that you can get four analog switches that double as sample/hold devices in the RCA CD4016 for only $1.50. Just $2.50 will buy a three-waveform vco with extreme stability in the Intersil 8038. Motorola's MC14049 gives you a hex analog switch that doubles as a hex vca for only $2, and their MC1408 8-bit D/A converter sells for $5. RCA's CD4046, another $5 IC, can be used to make a phase-locked loop tracker. In addition, the price of the 741 operational amplifier IC, the mainstay of all EM, now sells for less than 50c.

Another frequently overlooked cost factor is that the switches, patches, controls, etc. used in synthesizers are expensive items in the quantities required for EM systems. And don't forget that the cabinet is another high-expense item.

Once the newer IC's are put to use in synthesizers and all-digital tone generation schemes are prevalent, we can reasonably expect prices to drop drastically. But even if the prices remain the same, there should be considerably more in the way of performance from the instruments.

Basic Models. The third synthesizer category is the bare-bones kit type. PAIA Electronics, with their Model 2720 that sells for $200, is a good example of such a system. The least expensive synthesizer (actually a composer) you can buy is the *Psychtone* from Southwest Technical Products Corp. It sells for $53.

The fourth route to synthesizers is the use of modules to build up a custom system that does exactly what you want. Two leaders in this field are Eμ Systems (their catalog is $5, which is refundable with your first order) and Total Technology.

Buying Hints. This seems to be the overall picture as we see it. If you are interested in the commercial gear, try to arrange a live demonstration so you can compare several different makes and models. Better yet, try to rent a synthesizer or use it on a lease/purchase basis to make certain that it meets your specific needs. In short, if possible, try before you buy. ◈

CONSTRUCTION

INDOOR 20-METER HAM ANTENNA

BY ROLAND J. MCMAHAN

Author pulls in overseas contacts easily with 6-ft. home-brew antenna

AMATEUR RADIO contacts from the west of North America to Europe are not unusual on 15 and 20 meters. But when they are made using a 6-ft (1.83-m) long coil of wire sitting on a desk as an antenna, that's something new and different. With just such an antenna, this author was able to contact Northern Ireland, France, and Costa Rica in a few short minutes —which is a little out of the ordinary.

Such an indoor ham antenna will be of great value to apartment dwellers and travellers who do not have the space in which to erect a more elaborate antenna. Add to this the fact that the antenna has a minimum of TVI and a high signal-to-noise ratio. It can be fabricated at a minimum of cost.

How to Make the Antenna. To fabricate the indoor antenna, wind 22 turns of #14 stranded wire around the outside of a 2-in. (5.08-cm) inner-diameter plastic pipe. (You can get the pipe at most hardware stores.) The pipe should be 6 ft (1.83 m) long. The preferred type of pipe to buy has holes through it and is used in septic-tank drain-line applications. You can use the holes to tie or hold the ends of the coil.

Other than winding the 22 turns of wire, there are two rules that must be observed when making the antenna: (1) The top turn must form a closed loop and be soldered to assure good electrical conductivity and mechanical strength. (2) When connected to the ground or counterpoise system, the antenna must resonate on the 20-meter band.

The second rule is the only difficult part of the fabrication process because not all ground systems are the same. In this step, you will have to use a dip oscillator to find the resonant frequency.

If you try to use this 20-meter antenna on 15 meters as well, you will find that the response is too sharp for this. However, you can tap the coil five turns up from the bottom to obtain 15-meter operation. Slide the first five turns together so that they are closely wound before completing the 20-meter antenna. The remaining turns can be randomly wound, some as much as 8 or 10 in. (20.3 or 25.4 cm) apart.

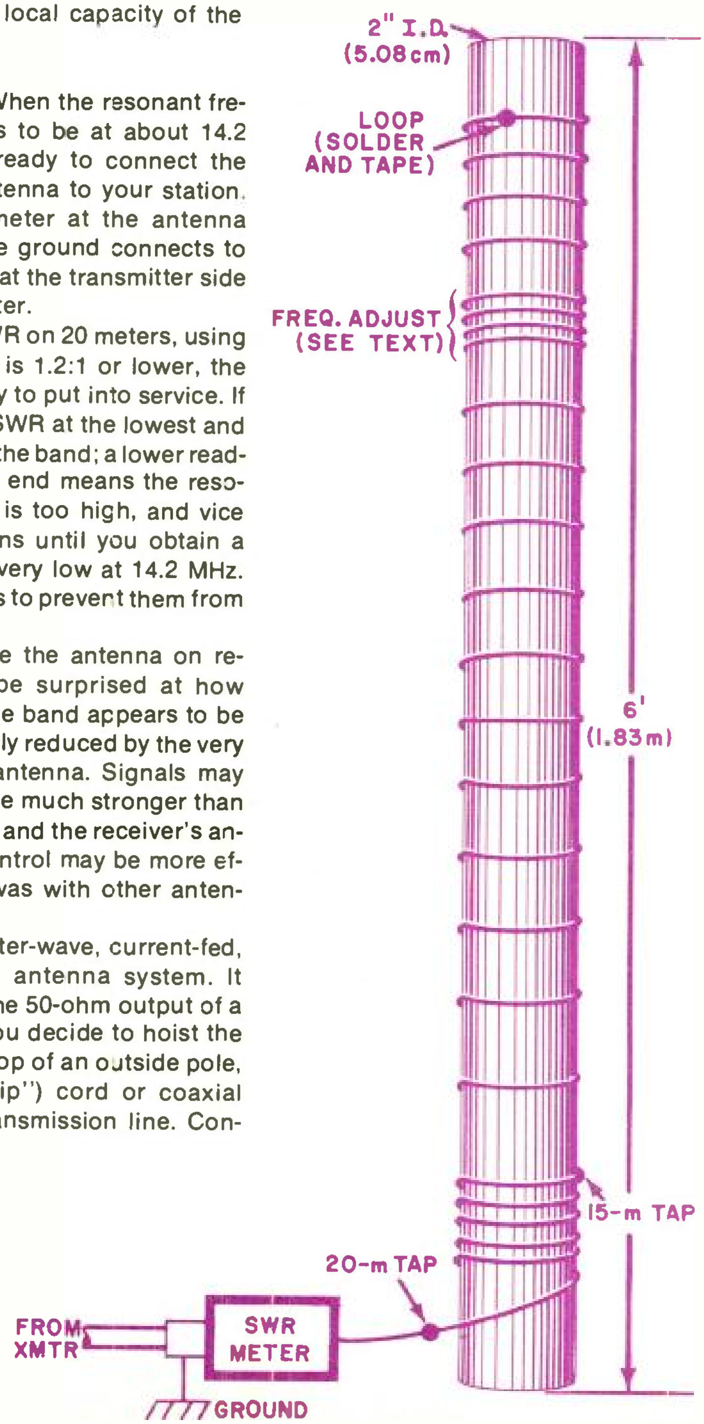
To adjust the antenna to 20 meters, you might try sliding the top four turns close together, about 10 in. (25.4 cm) from the top. Sliding the turns down lowers the resonant frequency, as does close winding. Your own adjustments will depend on your ground system and the local capacity of the ground.

Final Steps. When the resonant frequency appears to be at about 14.2 MHz, you are ready to connect the ground and antenna to your station. Use an SWR meter at the antenna connection. The ground connects to the coax fitting at the transmitter side of the SWR meter.

Check the SWR on 20 meters, using low power. If it is 1.2:1 or lower, the antenna is ready to put into service. If not, check the SWR at the lowest and highest ends of the band; a lower reading on the high end means the resonant frequency is too high, and vice versa. Slide turns until you obtain a reading that is very low at 14.2 MHz. Tape some turns to prevent them from slipping.

When you use the antenna on receive, do not be surprised at how much quieter the band appears to be as static is greatly reduced by the very high Q of the antenna. Signals may also appear to be much stronger than you are used to, and the receiver's antenna tuning control may be more effective than it was with other antennas.

This is a quarter-wave, current-fed, low-impedance antenna system. It works best on the 50-ohm output of a transmitter. If you decide to hoist the antenna to the top of an outside pole, use ac line ("zip") cord or coaxial cable as the transmission line. Connect the ground side of the transmission line to the metal pole, and use some ground radials, making each radial long enough to total 17 ft. (5.17m) when added to the length of the pole. Resonance is all-important; so, work with the antenna until it is properly resonant.



DX'ING THE CLANDESTINE SHORTWAVE STATIONS

Tune in on international intrigue

BY C. M. STANBURY II

THE SECRET ambition of a great many shortwave listeners is to single-handedly uncover a piece of international intrigue. The radio waves themselves offer enormous opportunities to do just that. For example, beginning with a single piece of unusual transmission during the Cuban missile crisis, when *Radio Americas* switched ID's with VOA sites (including the historic one at Brentwood, now of ITT SW facsimile fame), we determined that it was primarily a military, rather than a CIA, operation. We further learned that it was capable of transmitting from secret locations other than its publicized Swan Island site. Now these conclusions have been confirmed by none other than E. Howard Hunt of Watergate fame.

Of course, *Radio Swan* has faded into the past (the same can't be said for Hunt and his Bay of Pigs book, *Give Us This Day*), but many other clandestine broadcast operations are still in business. Any one of these clandestine operations can prove to be the *Radio Swan* of this decade. All you have to know is where and when to listen for sudden changes in signal strength, schedules, and format.

Radio Free Russia. Although it has never received the publicity enjoyed by the CIA's *Radio Free Europe* and *Radio Liberty, Radio Free Russia* could become one of the most important operations of the 1970's, now that the CIA's clandestine broadcast role has been substantially reduced. Operated by the right-wing National Alliance of Russian Solidarists (or NTS in Russian), *Radio Free Russia* began with a low-powered portable transmitter in West Germany. A decade later, it was claimed that the same transmitter was still being used, but shortly after the Cuban missile crisis, a major expansion got under way.

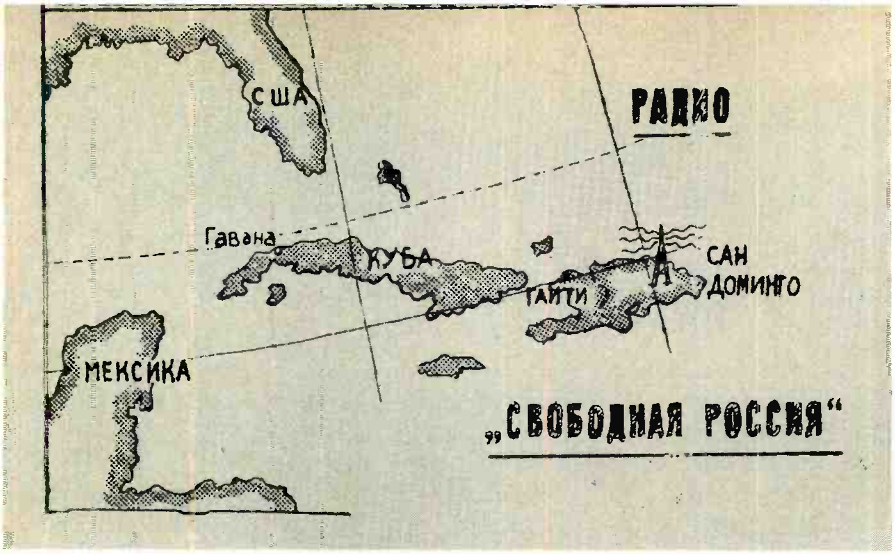
Starting about the latter part of 1962, *Radio Free Russia*'s programs were aired over transmitters belonging to the Taiwan government —Broadcasting Corporation of China—and those belonging to *Radio Caribe* in the Dominican Republic (now merged with *Radio-TV Dominicana*). But it was an off-spring of *Radio Swan—Radio Libertad*—that became the most effective outlet for NTS.

According to Hunt's book, the original Bay of Pigs blueprint consisted of three parts. First, a Cuban expeditionary force would establish a beach head and "government-in-arms." Second, *Radio Swan*, transmitting from Swan Island "and elsewhere," would broadcast appeals for help on behalf of the government-in-arms. Finally, with these widely heard *Radio Swan* broadcasts as justification, there would be massive Pentagon intervention. Someone, apparently the newly elected President John F. Kennedy, cancelled all but the first part of the plan. When that failed, Hunt tells us that he and the Chief of Propaganda Operations "issued one communique. . . It denied there had been an invasion, downplaying the assault as a resupply effort to guerillas in the Escambray." What Hunt doesn't tell us is that at 2300 EST the next night (April 20, 1961), "*Radio Escambray Libre*" appeared on 7000 kHz with anti-Castro slogans and fictitious orders to those same fictitious guerillas. Then, in October 1961, *Radio Libertad* commenced transmissions on that very same frequency (while at almost the same time *Radio Swan* became *Radio Americas* and the Defense Intelligence Agency was created as an entity completely separate from the CIA).

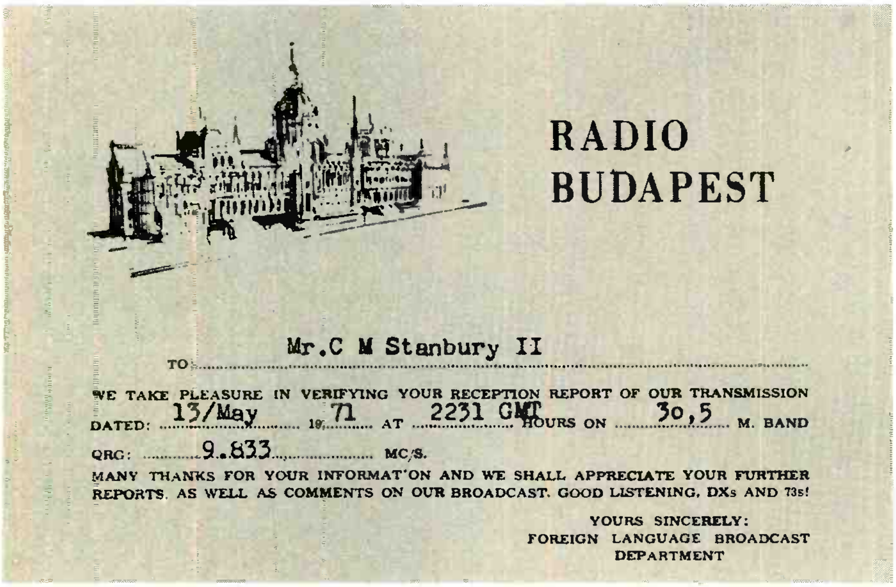
The French Connection. The easiest way to QSL *Radio Libertad* was always to log them while carrying *Radio Free Russia*'s programs and send your report to NTS at their French address, 125 bis rue Blomet, Paris 15. Before *Radio Libertad* faded from the scene in 1968, the same year *Radio Americas* went silent, NTS was verifying all *Radio Libertad* transmissions from a Venezuelan address.

Meanwhile, until early in 1974, *Radio Free Russia*'s Bavarian transmitter site was heard from time to time in North America prior to 1500 EST sign-off on heavily jammed frequencies varying between 11,400 kHz and 6350 kHz. Now, these two transmitters have also gone silent. Apparently, the government of West Germany has cancelled their transmitting privileges in the interest of detente with Moscow. This raises a question for the SWL that could turn out to be as historically important as the truth about *Radio Swan/Americas*: Where and in what form will NTS reappear?

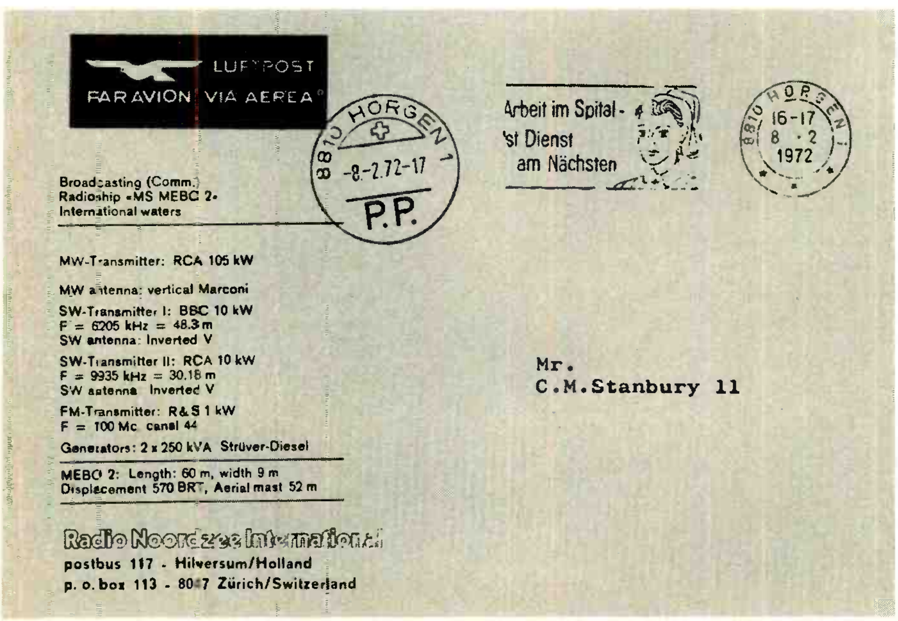
The North American SW Association provides a possible clue. They report one "*Radio Omega*," a religious organization that formerly shared the NTS West German transmitters, broadcasting over *Radio Monte Carlo*. Although nominally a commercial station RMC is controlled through a complex corporate structure by the French government. RMC has two SWBC frequencies of its own—6035 kHz and 7135 kHz—and feeds programs to an MW relay on the island of Cyprus in the Mediterranean via various SW point-to-point channels. It leases a pair of 100-kW SWBC transmitters to the evangelical *Trans World Radio*, whose schedule also includes programs in Russian.



Map from a pamphlet advertising Radio Free Russia transmissions over R. Caribe in the Dominican Republic.



A QSL card confirming reception of Radio Budapest while it was carrying R. Espana Independiente transmissions.



Radio Northsea International QSL card.

In And Around Venezuela. *Radio Caribe* in the Dominican Republic began its career as *Radio Liberacion de Venezuela,* an operation that culminated in the attempted assasination of the then Venezuelan President, Romulo Betancourt. It is also certain that one of the sites used for NTS's *Radio Libertad* was in or near Venezuela, although for a time they probably also used a non-Venezuelan location. Today, the most widely heard clandestine station in the Americas operates from a location in or near Venezuela. *Radio Euzkadi,* beaming Spanish- and Basque-language broadcasts to Spain in the late afternoons (EST), transmits on frequencies varying from 13,250 kHz to 12,070 kHz.

As in the case with NTS, *Radio Euzkadi*'s key address is in France: B.P. 59, Poste Centrale, 75790-Paris, Cadex-16. But this is where the similarity between the two broadcasters appears to end. Unlike the rightist NTS, *Radio Euzkadi* can best be described as "liberal left" but is, nevertheless, in direct competition with the Marxist *Radio Espana Independiente.*

Interchangeable ID's. With so much competition on the SW frequencies nowadays, including deliberate jamming, high power has become increasingly more essential for successful clandestine operations. Except when used as a cover like Swan Island, the days of the exotically isolated, low-power site used exclusively for a single clandestine purpose (for example, the NTS base in the Bavarian forest) are passing away. Thus, *Radio Espana Independiente* used transmitters owned by *Radio Bucharest* on, for example, 12,140 kHz until sign-off at 1810 EST. The same transmitters are also used for *Radio Portugal Livre* (12,005 kHz between 1820 and 1850 EST), although *Radio Bucharest* denies involvement in clandestine activities. Similarly, *Radio Peyk-e-Iran (Radio Courier of Iran)* uses at least one transmitter belonging to *Radio Sofia* between the hours of 0930 and 1310 EST on 11,695 kHz.

Just as *Radio Swan, Radio Americas,* and *Radio Libertad* were either intended to or did in fact operate from more than one transmitter site, so do the Communist clandestine stations. In the mid-1960's *Radio Espana Independiente* was noted sharing a transmitter with one of the Soviet home services and in 1971 used one of

Radio Budapest's transmitters for a short time. *Peyk-e-Iran* has an outlet on 11,415 kHz that, unlike the more readily heard 11,695-kHz channel, may emanate from a Soviet location in central Asia.

Because big-league clandestine operations have access to a multitude of high-power transmitters at a variety of locations, they can greatly expand their coverage whenever the action heats up. Such an expansion, especially when it occurs suddenly, is precisely what the SWL should be listening for. It indicates covert major-power involvement in the crisis and, therefore, history in the making.

White, Black, and Grey. There are three classifications into which the intelligence community officially divides clandestine broadcast stations. A black operation is one in which there is a major element of deception. It now appears that as soon as *Radio Swan* came on the air in May 1960, a CIA agent leaked word to the DX community that it was officially classified as "black," and this is what originally started the debate among radio clubs as to the real nature of the station.

The only thing clandestine about a white station is that its broadcasts are illegal in the country to which they are beamed. Of course, if a station transmits from the country to which it is beamed, then the transmitter site is also kept secret—for reasons of security rather than deception. Nearly all the clandestine stations in the Near East and Africa are white operations.

In other parts of the world, the majority of clandestine operations are various shades of grey. *Radio Bucharest* denies airing *Radio Portugal Livre* transmissions, but RPL does not hide its eastern Europe support. As long as *Radio Free Europe* and *Radio Liberty* hid their CIA funding, they were grey. The Bonn government's own *Voice of Germany* officially leases time from *Radio Trans Europe* in Portugal, along with *Radio Canada International* and various religious organizations, but according to informed sources, V of G actually owns RTE.

Medium-Wave Operations. The standard AM broadcast band has often played parts in clandestine operations. Hence, it shouldn't be overlooked by the serious SWL. For example, this author's observations of VOA's missile crisis station on Dry Tortugas eventually established that, for security reasons, the ID's of those SWBC stations feeding it programs had been arranged to provide confusion.

During the 1960's, Cuba's *Radio Progreso* network, including its 50-kW transmitter operated on 690 kHz, aired the English-language *Radio Free Dixie* with the then-fugitive Robert Williams as principal commentator. In recent years, however, most of the clandestine MW activity has been from international waters and *apparently* nothing but white operations. This includes a number of transmitters off the European coast and Carl McIntyre's *Radio Free America*, which operated briefly off Cape May, New Jersey, last fall.

Any of the white operations could be hiding a black operation like *Radio Swan*. Some of these white stations already have complex international connections. The owners of *Radio Northsea International*, for example, originally financed the station (6205 kHz) by selling electronic equipment to Biafra. As RNI explained it in an exclusive statement to this author: "Our mission took place on the request of the Swiss Red Cross and the Caritas, both welfare institutions, as their major problem existed in the communications media. . . There was no direct telephone, telegraphic, telex, or any other communication link to Biafra, only over Nigeria. Therefore, Mr. Bollier and Mr. Meister installed a wireless communication link with a transmitting and receiving station in Biafra."

With most of the stations like RNI operating in European international waters about to be forced off the air by Dutch anti-pirate legislation, one must wonder where some of these broadcasting ships are likely to wind up. ◈

CLANDESTINE & CLANDESTINE-RELATED STATIONS FOR THE BEGINNER

Frequency (kHz)	Station Identification	Remarks
6035	R. Monte Carlo	Listen for new or expanded Russian programs
6205	R. Northsea International	May have left air or changed ID
6240	R. Libertacao	Until 1800 EST sign-off
7135	R. Monte Carlo	Same as RMC above
9505	Radio-TV Dominicana	Includes facilities of former R. Caribe/ Free Russia/Liberacion de Venezuela
9615	R. Canada International, relayed by R. Trans Europe (Sines, Portugal)	2245-2300 EST in Russian; site reported to be secretly owned by W. German government
11,415	R. Peyk-e-Iran	1310 EST sign-off; site unknown
11,695	R. Peyk-e-Iran	1310 EST sign-off; uses R. Sofia transmitter
12,005	R. Portugal Livre	1820-1850 EST; uses R. Bucharest transmitter
12,070*	R. Euzkadi	1430-1500, 1530-1600, 1630-1700 (all EST)
12,140	R. Espana Independiente	Until 1810 EST sign-off; uses R. Bucharest transmitter
13,250*	R. Euzkadi	Same as R. Euzkadi above

* Frequency varies.
Note: For EDT add one hour to times given under "Remarks."

BASIC DIGITAL LOGIC COURSE

PART I: NUMBER SYSTEMS

THE emergence of experimental digital IC projects has been so rapid that many people tend to get lost amid strange-sounding names like "quad 2-input positive NAND gate" and "BCD to 7-segment decoder/driver." Such terms describe the building blocks of digital electronics. To provide an introduction to logic for beginners and refresher information for more advanced experimenters, here is the beginning of a Digital Logic Course series.

This first instalment describes number systems and provides important background information for the next two instalments.

Number Systems. Early man was forced to count with small pebbles or knots on a string when he wanted to inventory his possessions. As time went on, and perhaps because he found it convenient to count with his fingers, man eventually devised a number system with ten digits. This provided a far more convenient and versatile counting system since, for example, the number 16 could be represented with merely two digits rather than 16 pebbles or knots.

The comparatively recent development of electronic digital computers has revived interest in number systems based on something besides the decimal. A system based on two digits is of particular importance in electronic digital computers. The reason for this is that an electronic circuit can be made to occupy only one of two states: on or off (saturated or cut off). Of equal significance is that any form of logic statement can be reduced to contain only true and false assertions.

Since electronic circuits required to implement true and false logic statements are very simple, a computer can be designed based on a two-digit number system, in which one digit corresponds to "true" and the other to "false". The two-digit, or base-two, number system is called the binary system and its digits, called bits (for *bi*nary digi*ts*), are 1 and 0.

BY FORREST M. MIMS

The Binary System. The easiest way to understand the binary system is to learn to count in binary fashion. One basic rule governs counting in any number system: record successive digits for each count until the count exceeds the total number of available digits; then start a second column to the left of the first and resume counting.

Since the binary system has only two digits, counting is very easy. You can prove this to yourself by counting to the equivalent of the decimal number 10 in binary. The binary of decimal 0 is 0. The binary of 1 is 1. Here the similarity ends. To express 2 in binary, you must start a new column since both binary bits have been used in the first column. Hence, the binary of 2 is 10 (read one-zero—*not* ten). Three is expressed as 11 (one-one) in binary, which uses up both binary bits for the first two columns. So, a new column must be started for binary 4, which becomes 100, while 5, 6, and 7 become 101, 110, and 111. With 8, represented by the binary 1000, we must once again start a new column.

Binary Arithmetic. By learning how to count in binary, we have also derived three basic rules for addition: (1) 0 + 0 = 0; (2) 0 + 1 = 1; and (3) 1 + 1 = 10 (1 + 1 = 0, carry 1). These rules can be used to add any two binary numbers. For example, let us add 12 and 9 in binary:

$$\begin{array}{r} 1100 \\ +1001 \end{array}$$

Start with the right-hand column and add the *least* significant digit. Then continue adding each successive column, working from right to left, finishing up with the *most* significant bit:

$$\begin{array}{r} 1100 \\ +1001 \\ \hline 10101 \end{array}$$

Note in the above example that the addition of the two most significant bits yielded a 0 with a 1 carry. A carry can also occur within the addition as in: 1011 + 1101 = 11000.

Converting Binary to Decimal. Binary numbers are fundamentally easy to work with. But how do you convert a string of 1's and 0's to easily recognized decimal numbers? The process is simple, using a technique known as "expansion." Each digit column of a decimal number corresponds to a power of the base-10 to which it must be raised. Let us use the number 846 as an example:

$$\begin{array}{ccc} 10^2 & 10^1 & 10^0 \\ \hline 8 & 4 & 6 \end{array}$$

$$\begin{array}{rcl} 6 \times 10^0 & = & 6 \\ 4 \times 10^1 & = & 40 \text{ (add)} \\ 8 \times 10^2 & = & 800 \\ \hline & & 846 \end{array}$$

A binary number can be expanded in the same way and converted into a decimal number. For example, let us expand $(10111)_2$. The subscript denotes the base of the number system—in this case, 2 or "binary"—and helps in preventing confusion. The expansion is as follows:

$$\begin{array}{ccccc} 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \\ \hline 1 & 0 & 1 & 1 & 1 \end{array}$$

$$\begin{array}{rcl} 1 \times 2^0 & = & 1 \\ 1 \times 2^1 & = & 2 \\ 1 \times 2^2 & = & 4 \text{ (add)} \\ 0 \times 2^3 & = & 0 \\ 1 \times 2^4 & = & 16 \\ & & (23)_{10} \end{array}$$

Since the position of each digit in a binary number determines the power of 2 invoked, it is easy to convert binary to decimal simply by assigning the decimal equivalent to each column. A 0 in a column means that the column's power-of-2 decimal equivalent is *not* invoked. Therefore, the decimal equivalents of all columns containing a 1 are added to find the total decimal equivalent. Let us convert 10011 to decimal:

$$\begin{array}{ccccccccc} 16 & & 8 & & 4 & & 2 & & 1 \\ \hline 1 & & 0 & & 0 & & 1 & & 1 \\ 16 & + & 0 & + & 0 & + & 2 & + & 1 = (19)_{10} \end{array}$$

Manual binary arithmetic involving numbers containing more than three or four bits is both tedious and cumbersome when you are accustomed to counting in a decimal system. But an electronic computer can perform thousands of lengthy binary additions in fractions of a second. This ability is vital to the success of digital computers and calculators, since all arithmetic operations can be performed by addition or its variations. Subtraction is the inverse of addition, while multiplication is simply repeated additions and division is the inverse of multiplication.

These facts about addition are important because they mean that even the most complicated arithmetic operations can be solved by addition. In practice, manual arithmetic rarely invokes this process. After all, you would find it inconvenient to multiply 641 by 197 if you had to write 197 times the number 641 and add the columns. But an electronic computer does the equivalent of this in only a few milliseconds.

The Octal System. Sometimes binary numbers are condensed into other number systems to further simplify computer processing. Since the binary system has only two digits, it does not take long to accumulate a string of seemingly endless 1's and 0's. A decimal number with only two digits, for example, requires five binary bits. A six-digit decimal number requires 19 bits.

Complicated binary numbers can be simplified by dividing them into groups of three or four bits and encoding the results in other number systems. Since the binary numbers for the decimal digits 0 through 7 form groups of no more than three binary digits each, a long binary number can be reduced to a third of its length by converting it to a base-8, or *octal*, number system.

You can use a table of octal numbers and their binary equivalents to convert a long binary number such as 11101100001101 into octal. First, divide the number into groups of three bits each, beginning with the least significant bit:

11 101 100 001 101.

Then assign the octal equivalent to each three-bit group, using the octal-to-binary equivalents given in the table:

Decimal	Binary	Octal
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	6
7	111	7
8	1000	10
9	1001	11
10	1010	12
11	1011	13
12	1100	14
13	1101	15
14	1110	16
15	1111	17
16	10000	20
17	10001	21
18	10010	22
19	10011	23
20	10100	24

$$\begin{array}{ccccc} 11 & 101 & 100 & 001 & 101 \\ 3 & 5 & 4 & 1 & 5 \end{array}$$

Hence, $(11101100001101)_2$ equals $(35{,}415)_8$. It is obvious that the latter number is easier to process than the former.

Sometimes the base-16 (*hexadecimal*) number system is used to further simplify long binary numbers. The hexadecimal technique requires that the binary number be subdivided into groups of four bits each, again starting with the least significant digit. The result is a hexadecimal number that is only a fourth the length of the original binary number.

Next month, we will discuss logic concepts and circuits and demonstrate how logic circuits can be combined to make a binary adder. ◈

LIGHT UP YOUR CIRCUITS WITH LED'S

How light-emitting diodes work and some tips on where to use them

BY WALTER G. JUNG
Contributing Editor

IN JUST a few short years, the light-emitting diode (LED) has found its way into innumerable circuits and devices as a "state" indicator. Not too long ago, there was only one type of LED (red); but today there is such a wide variety from which to choose that selection can become confusing.

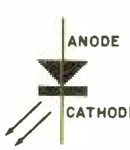


Fig. 1. Schematic symbol for LED is standard diode with arrows for light output.

To correct this, let's take a look at what a LED is, how it works, what electrical and optical characteristics are available, and how to make the best use of them.

What Is a LED? A LED is a pn-junction semiconductor device specifically designed to emit light when forward biased. This light can be one of several colors—red, amber yellow, or green—or it may be infrared and thus invisible. The schematic symbol for a LED is shown in Fig. 1. It is similar to the symbol for a conventional diode except that the arrows are added to indicate light emission.

Electrically, a LED is similar to a conventional diode in that it has a relatively low forward voltage threshold. Once this threshold is exceeded, the junction has a low impedance and conducts current readily. This current must be limited by an external circuit, usually a resistor.

The amount of light emitted by the LED is proportional to the forward current over a broad range, thus it is easily controlled, either linearly or by pulsing. The LED is extremely fast in its light output response after the application of forward current. Typically, the rise and fall times are measured in nanoseconds. Because of this fast response, LED's make excellent high-speed switched sources of light for

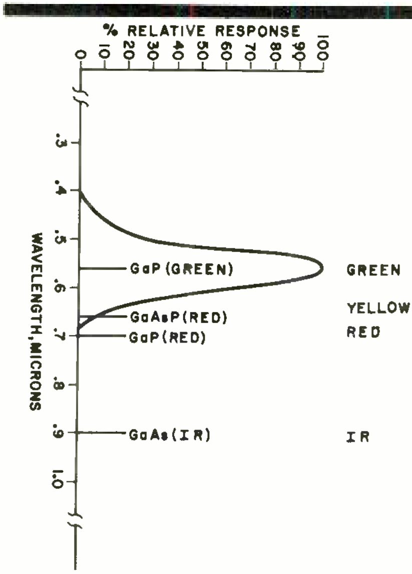


Fig. 2. Response of the human eye to various types of LED light emissions.

use in multiplexing, strobing, and optical communications systems.

LED's are small in size compared to conventional incandescent lamps; and, in fact, a LED actually consists of a tiny "chip" a few thousandths of an inch across mounted in a relatively large plastic package. As you might expect, a LED is also very light in weight.

Because of their low operating voltage and low current drive requirements, LED's consume very little power—about 30 mW (20 mA at 1.6 V being typical). Consequently, LED's generate little heat. A side benefit of the low power requirement permits interfacing LED's with most digital and linear IC's or low-power transistor stages.

A LED does not "use itself up," and has little wearout mechanism, so very long life can be expected. Some manufacturers predict 100,000 hours or more, which amounts to over 11 years of continuous use. On a practical basis, once wired in and operated within specified ratings, a LED should last forever.

Characteristics. It was once said that LED's came in three colors—red, redder, and reddest; but recent advances in semiconductor technology have changed the picture greatly. The early red LED's were made of gallium-arsenide phosphide (GaAsP) compounds. These are still the most inexpensive types available. Gallium phosphide (GaP) is now used to produce green, yellow, and red LED's.

The relative sensitivity of the human eye to the standard LED emission wavelengths is shown in Fig. 2. Note that the eye is most sensitive in the green area with the peak at 0.56 microns. The GaP red emission is at 0.69 microns, while GaAsP red is at 0.66 microns.

The light output of a LED tends to be monochromatic—of a single color (wavelength). The light output of LED's is usually specified in candelas, a measure of intensity; though sometimes it is specified in foot-lamberts, a measure of intensity per unit area.

Interpreting Data Sheets. To use a LED properly, you must have some understanding of the data sheets. A few illustrations from typical data sheets are shown in Fig. 3.

The simple curve in Fig. 3A shows that LED light output increases linearly with forward current up to 50 mA, which, incidentally, is a typical continuous maximum current for plastic-packaged devices. Figure 3B is a current/voltage characteristic, showing the "knee" where conduction starts (in this case, at about 1.65 V, which is typical for a GaAsP diode). A GaP diode has a higher knee voltage (2 to 3V), but the curve's general shape is similar. Note that the diode current increases rapidly above the knee, which is why current limiting must be used to prevent damage to the diode.

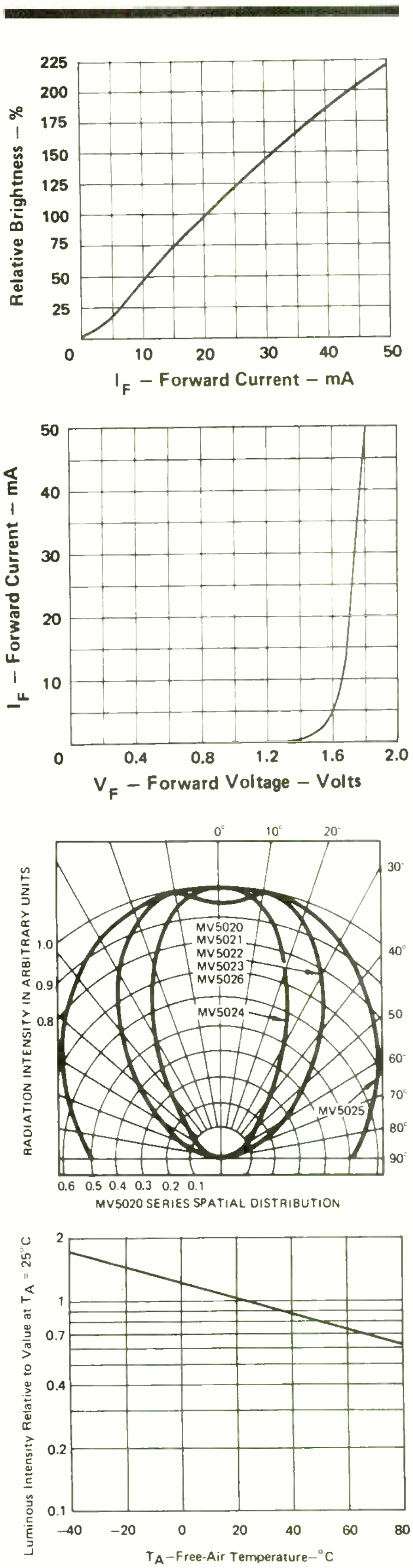


Fig. 3. Brightness (A) and voltage (B) vs current for Fairchild 100 units. (C) Intensity for various lenses (Monsanto MV5020). (D) Intensity vs temperature for TI type TIL209A.

The lensing arrangement of the diode package makes a big difference in how bright the LED appears off axis. As shown in Fig. 3C, the light can be formed into a narrow beam (as for the MV5024) or it can be wider (as for the MV5025). The beam-width used depends on the application. For example, a narrow-beam LED is correct for an optical communicator, but it is not good for a panel lamp since it will not catch the eye off to one side.

Even with a constant-current drive, temperature plays a role in the light output of a LED, as shown in Fig. 3D. However, for most hobby applications, this is not an important consideration unless a high-temperature environment is contemplated.

As a general rule, the LED should always be operated within recommended values. Maximum current can be exceeded on a *peak* basis as long as the *average* current is within specifications. The reverse voltage applied should be watched—3 volts is the usual maximum. A clamping diode can be used to prevent voltages that are too high.

Package Styles. Although LED's are manufactured in a wide variety of packages, only a few of the configurations have become favorites.

One of the most popular packages is the T-1 ¾, a ¼"-diameter, high-dome, epoxy-encapsulated style. The Monsanto MV5020 series is typical of this type. It is intended for front panel or pc board mounting, and is available with a clear lens (MV5020), a diffused lens (MV5021), a plain red lens (MV5022), or a diffused red lens (MV5023). An uncolored, clear lens produces a point source of light, while a clear diffused lens softens the effect. A red lens aids contrast if the ambient light is high. A diffused red lens spreads the beam and widens the angle of visibility, often desirable features.

These LED's are shipped in a plastic clip for insertion in a panel. The leads

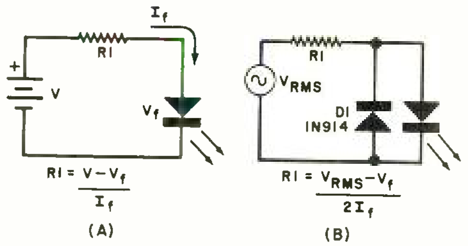


Fig. 4. Calculation of series current-limiting resistor for dc shown at (A); for ac, shown at (B).

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"Optoelectronics at Work," Motorola
"The Optoelectronics Data Book," Texas Instruments
"Application Notes," Hewlett-Packard

Manufacturers' Addresses

Chicago Miniature Lamps, 4433 N. Ravenswood, Chicago, IL 60607
Dialight, 60 Stewart Ave., Brooklyn, NY 11201
Fairchild Microwave & Optoelectronic Div., 464 Ellis St., Mountain View, CA 94040
General Electric Co., E. Nela Park, Cleveland, OH 44101
Hewlett-Packard Co., 620 Page Mill Rd., Palo Alto, CA 94304
Litronix, 19000 Homestead Rd., Cupertino, CA 95014
Monsanto, 10131 Bubb Rd., Cupertino, CA 95014
Motorola Semiconductor Products, 5005 E. McDowell Rd., Phoenix, AZ 85036
National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051
Opcoa, 330 Talmadge Rd., Edison, NJ 08817
Texas Instruments, Dallas, TX 75222
Xciton Corp., 5 Hemlock St., Latham, NY 12110

are square and can either be soldered or wire-wrapped. The cathode lead is identified by the flat side on the plastic base, though in some cases the cathode is identified by a shorter lead. Green and yellow LED's that complement the MV5020 red series and have the same packaging are the MV5222 and MV5322, respectively.

The Fairchild FLV 100/101/102/108 series of "button" LED's are in small plastic packages similar to the TO-106 outline, but with only two leads. The respective part numbers correspond to a point source (FLV 100), diffused wide angle (FLV 101), red diffused area source (FLV 102), and an uncolored version (FLV 108) of the FLV 102. All of these packages benefit from the contrast enhancement provided by a black case. Although these units are best suited to pc board mounting, a plastic panel-mounting clip is available.

Another useful type of LED is the Texas Instruments TIL209/TIL209A, a red LED is a miniature ⅛"-diameter T-1 lamp size. It has a diffused red lens and is visible over a wide angle. The TIL209 has round leads, while the 209A has square leads. A companion green LED (TIL211) is also a diffused source. TI is currently working on yellow LED's, which should be available soon.

Hewlett-Packard has a series of red LED's which have a built-in current-limiting resistor. This eliminates the need for an external limiting circuit. Two models that operate from a 5-volt supply (can be driven by TTL) are the 5082-4860, a red diffused unit in T-1 ¾ size, and the 5982-4468, a clear diffused unit in T-1 size. The 5087-4860 can be panel-mounted and has wrap leads.

Litronix has also incorporated a current limiter in a LED package to operate over a wide variety of supply voltages. These devices come in T-1 ¾ and T-1 sizes. They have red diffused lenses. The RLC-200 is usable at voltages up to 12.5 V maximum, while the RLC-210 works up to 16 volts.

Driving LED's. A LED can be driven by either an ac or dc source, requiring a current-limiting resistor in either case. The two basic driving circuits are shown in Fig. 4 The equations show how to determine the value of the limiting resistor.

In Fig. 4A, the positive of the voltage source is connected to the LED's anode, so a forward current, I_f, flows. The current depends on V, the LED forward voltage drop (V_f), and the value of *RI*. The forward voltage drop varies between 1.6 and 3 volts, depending on the type of LED and can be determined from the published data sheets. As an example, assume that the LED requires 20 mA, has a V_f of 1.6, and the voltage source is 5 V. Then $RI = (5 - 1.6)/0.02 = 170$ ohms. (180 ohms would the nearest standard value.) Check the required wattage of

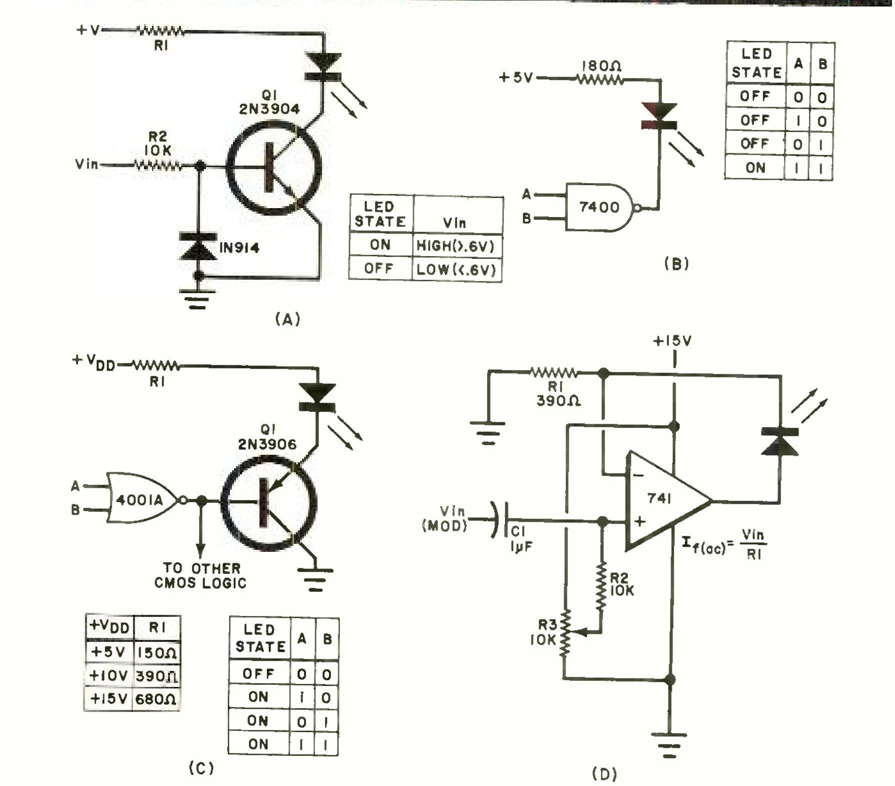


Fig. 5. (A) Saturated transistor drive and truth table. (B) and (C) are TTL and CMOS drives. (D) uses linear modulator.

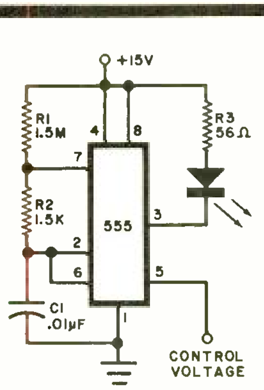


Fig. 6. Using a 555 IC to pulse-modulate LED.

the resistor since it will dissipate most of the source voltage.

In the ac circuit in Fig. 4B, the voltage source is V_{rms}, a sine wave. If the peak reverse voltage applied to the LED is over 3 V, the protective clamping diode, *D1*, is used. Any small-signal or rectifier diode can be used for *D1*. Since the LED rectifies the ac, only half of the total current contributes to useful light output. To maintain a brightness equal to that obtainable with dc, the value of the limiting resistor is cut in half—thus the 2 in the denominator of the equation.

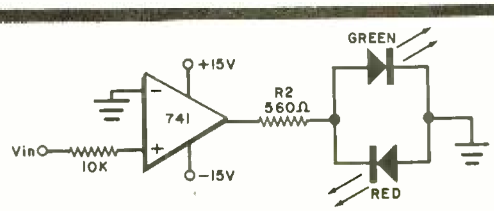
Some practical drive circuits are shown in Fig. 5. An npn switching transistor is used in Fig. 5A. A high level on the input line switches *Q1* into saturation, supplying current to the LED. Current-limiting resistor *R1* is chosen as shown in Fig. 4A. The value of the supply voltage (+V) can be anything up to the V_{ceo} rating of *Q1*.

One of the most important uses for the LED is as a logic status indicator in digital circuits. Since TTL logic can sink up to at least 16 mA, it mates easily with a LED as shown the example in Fig. 5B. This is an AND gate so that the LED is on only when both A and B are high. Keep in mind that the current flows through the LED when the gate output is low. This, in effect, subtracts from the fanout of the stage if it is coupled to another logic stage. If the fanout is required, use a TTL buffer to drive the LED alone.

Low-power logic such as CMOS cannot drive LED's directly so a buffer such as a CD4049 or CD4050 must be used, but current is limited. A solution is to use an emitter-follower buffer as shown in Fig. 5C. A beta of 100 for *Q1* will reduce the drive current required to 200 μA, which is compatible with the 4000A series of CMOS. The circuit in Fig. 5C is an example of OR logic since the LED is lit for a logic one on either A or B. Limiting resistor *R1* should be selected to match the supply voltage. An npn transistor could also be used for *Q1* by connecting the collector to the supply with the LED and *R1* in the emitter circuit. A basic asset of CMOS is its very high noise immunity, so a slightly reduced output swing from the gate in Fig. 5C is not a real detriment as far as driving other CMOS inputs is concerned. There are no fanout restrictions.

So far, we have discussed only on-off types of LED drives. A linear driver is shown in Fig. 5D. An op amp is used to make the LED current precisely proportional to the input modulation signal. Potentiometer *R3* determines the dc bias current in the LED since the voltage at the rotor of *R3* also appears across *R1*. If *R3* is centered, *R1* "sees" 7.5 volts and the current through the LED is 20 mA. The audio signal, through *C1*, modulates the dc bias signal to control the LED current proportionally. This circuit could be used as the transmitter end of light-beam communicator. It is simple, inexpensive and easy to set up; and none of the components is critical.

Fig. 7. Sensitive polarity indicator using op amp and two LED's of different colors.



Some Applications. A pulser that is useful for on-off modulation of visible or IR LED's is shown in Fig. 6. A 555 timer IC is used as an astable oscillator which provides a 10-μs pulsed output every 10 ms (a 100-Hz rate). The circuit can be frequency modulated by applying an audio signal to pin 5. Resistor *R3* sets the peak LED current to about 200 mA; and, since the duty cycle is only 0.001, the LED is not overloaded.

Using a narrow-beam IR LED (such as the Motorola MLE60) in this circuit and a silicon detector at the receiver, an invisible light-beam communication link can be constructed.

A sensitive polarity (or null) indicator is shown in Fig. 7. The circuit uses an op amp to achieve a very low input-voltage threshold. Since the input signal is applied to the op amp noninverting input (+), the op amp output is positive when the input is positive and negative when the input is negative. A positive input lights the green LED, and a negative signal lights the red LED. The LED's can be separate devices, or a dual unit such as the Monsanto MV5491 (red/green) LED can be used.

The input threshold is the offset of the op amp used. For a 741, it is ±6 mV or less. There are no loading effects since the input draws very little current. If the added sensitivity is not needed, the op amp can be omitted and the LED's driven directly through *R2*. This is a useful option if the source impedance is low.

The circuit shown in Fig. 8 uses two high-gain comparators to determine whether a critical voltage is between two limits. In the circuit shown, the limits are +4 and +6 volts. The two comparators are wired as OR gates, so that the LED is energized if either comparator output is low. This would occur if V_{in} were less than +4 V or more than +6 V. Using this general idea, different reference voltages can be used to monitor almost any voltage level.

Conclusion. Of course, we have not covered all of the possible uses for the various types of LED's. Hopefully, some ideas have been generated. Others can be obtained from the references given in the accompanying box. ◈

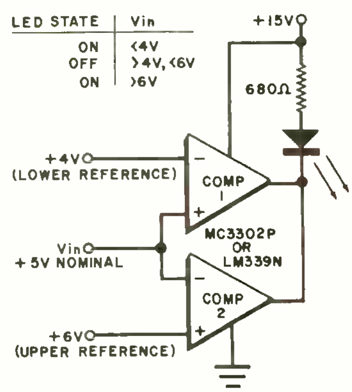
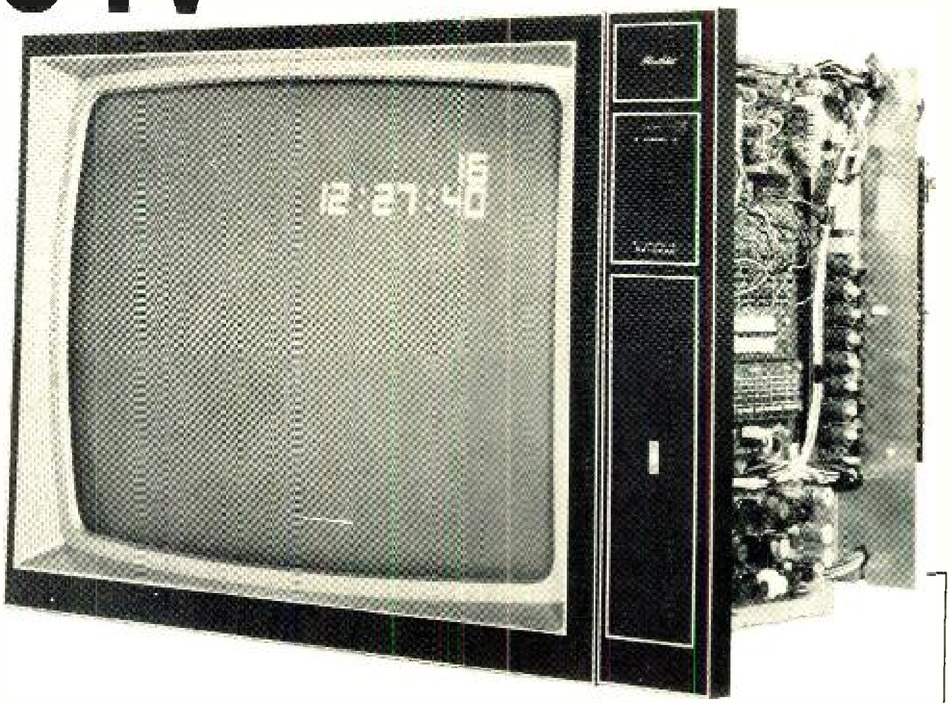


Fig. 8. Window comparator turns LED on when input exceeds predetermined limits.

EXPERTS AGREE
The TV of the future is here... in the Heathkit Digital-Design GR-2000 TV



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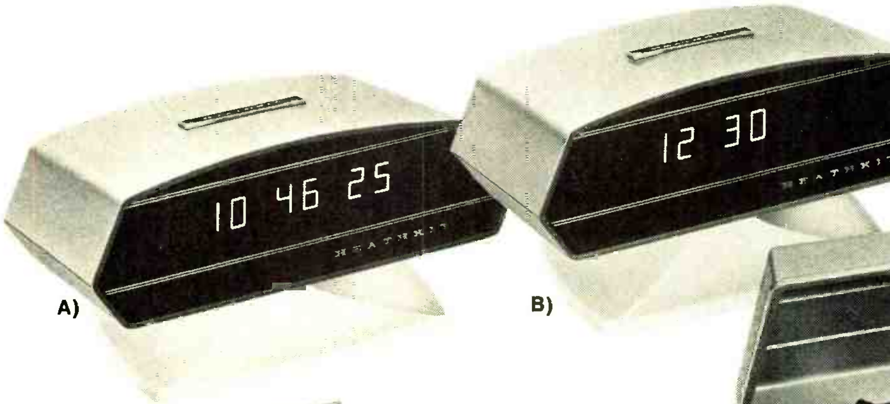
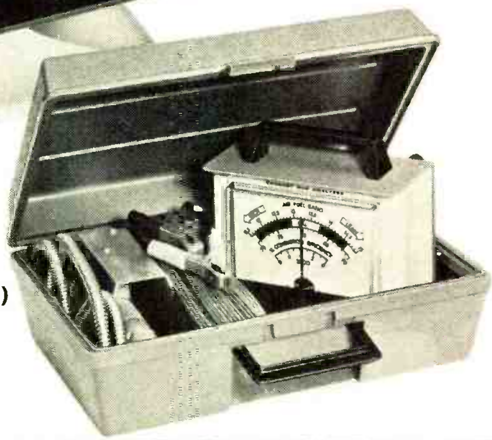


A) B)



C)

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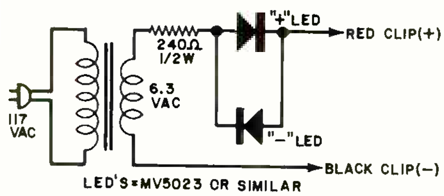
BUILD A

POLARITY-SENSING CONTINUITY TESTER

BY CALVIN R. GRAF

A COMPACT polarity-sensing continuity tester can prove a very useful tool on any workbench. With it, you can check for short circuits, open circuits, continuity, and the polarity and condition of rectifier and light-emitting diode and transistor junctions. It can even be used to check most capacitors and any purely resistive component rated at up to 20,000 ohms.

The tester's circuit (see schematic) is very simple, consisting of a 6.3-volt transformer, two LED's, and a current-limiting resistor that is common to both LED's. Owing to the fact that test current comes from the stepped-down 60-Hz ac line, only one LED will come on for each alternation. The forward conduction of one LED protects the other LED from reverse-current conduction during alternating cycles of the ac voltage.

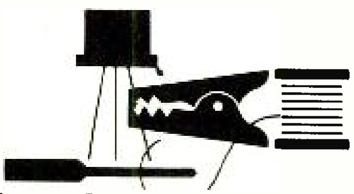


When a unidirectional device (diode or transistor) is tested, current flows in only one direction. Hence, only one LED lights. (Note: If one LED comes on at full brilliance and the other glows very faintly, the device under test can be considered good.) If both LED's come on, the device is shorted. And if neither LED comes on, the device under test is open.

Transistors can be safely tested with this device because of the low current drawn. Less than 5 mA of current produces a bright LED glow, while as little as 200 µA of current can be observed as a faint glow.

The circuit is designed so that, when the red alligator clip is connected to the anode of a diode (or p side of a transistor junction) and the black clip is connected to the cathode of the diode (or n side of the junction), the "+" LED will light. Reversed connections do not require that the leads be transposed; simply observe which of the LED's lights and check the alligator clip hookup.

Continuity for resistance can be observed by the brilliance at which the LED's glow. The brighter the glow, the lower the resistance, and vice versa. Also, capacitances greater than about 0.05 µF will cause a faint glow of both LED's (demonstrating that the capacitor is good at 60 Hz). ◈



Tips & Techniques

SWITCH OFF SOLDERING IRON TO PREVENT INDUCED-VOLTAGE DAMAGE TO MOSFET'S

Damage resulting from induced voltages during soldering is the biggest problem the experimenter and technician must face when dealing with MOS devices. One way to contend with the problem is to install in the line cord of your soldering iron a switch that will break the ac power circuit on demand. Now, just before you solder a MOS connection, switch off the iron's power and solder away. The tip will remain hot long enough to complete quite a number of solder connections. As the tip cools off, power will have to be restored to the heating element. But do not switch on the power until the iron is a couple of feet away from the MOS device.

—Michael W. Zachary

STRANDED WIRE AND BRAIDED SHIELD FACILITATE EASY SOLDER REMOVAL

The next time you prepare a length of coaxial cable and have some braided shield left over (or if you have a short length of cable that does not seem worth saving), do not throw it away. The porous braided shield makes an excellent solder removal aid during desoldering operations. Just place the braid over the soldered connection and press the tip of your soldering iron or gun against the braid over the connection. As the braid heats up, it will draw off most of the solder. In a pinch, when you have no braid handy, you can also use stranded wire. Simply strip away about 2 in. of insulation and lay the exposed conductors over the connection and heat. Capillary action will again draw off most of the solder.

—Ron Samchuk, VE4SR

MOLEX SOCKET TERMINALS MAKE MINIATURE JUMPER CABLES

It is often desirable to make fast connections to single terminals of IC's or closely-spaced wire-wrap posts. Jumper cables made from conventional alligator clips are too bulky for such applications. But you can assemble miniature cables that will fill the bill from lengths of stranded wire and Molex Soldercon® socket terminals (available from a number of surplus parts outlets). Simply solder the wires to the terminals and tightly shrink a short length of heat-shrinkable tubing over the connector. Care must be exercised to prevent solder from flowing into the connector proper. This can be obviated by pushing a flat toothpick into the clip end of the connector before soldering.

—B.F. Rordorf

DOWEL AND LONG NOSE PLIERS MAKE QUICK SUBSTITUTE FOR SPANNER WRENCH

On occasion, you might have to install or remove a spanner nut. Lacking the proper wrench, you first instinct is to grab your long-nose pliers and set to work. While using the wrong tool for the job is not recommended, on rare occasions you can make do with a substitute if you are careful. If you must work on a spanner nut with long nose pliers, clamp between their jaws a hardwood dowel and grip tightly. Set the jaws into the spanner nut's slots and carefully apply tightening or loosening torque. If you are careful, no damage should result. Forgetting to use the dowel will likely produce marred and gouged results as the jaws slip out of the slots while you are attempting to apply grip and torque pressure.

—John T. Bailey

MASKING TAPE SIMPLIFIES KIT AND PROJECT BUILDING

When assembling an electronic kit or project, keeping track of the components that go into assembly can be difficult even if you use muffin tins and other such devices for holding the components after separation. Double-sided masking tape can be an enormous help in alleviating the situation. Just run parallel strips of the tape on a sheet of cardboard, spacing the strips so that components can be easily accommodated without interfering with each other, and press the components into the tape. You can arrange the components by category: resistors, disc and other small capacitors, diodes, transistors, etc. Now, as you need the component, you can locate it at a glance. When you are all through, if the tape's mastic is still usable, cover the cardboard with waxed paper and it can be used again.

—Mark Austin

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LM205H	3.00
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LM209K	3.70
LM300H	.90
LM300N	1.40
LM304H	1.40
LM305H	1.10
LM305AH	1.40
LM305N	1.20
LM309H	1.75
LM309K	1.95
LM335	2.30
LM336	2.40
LM337	2.40
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LM340-06K	2.60
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209	Yellow	.35
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.160"dia.

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LM308AH	TO-5	5.00
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7410N	.25
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7413N	.80
7414N	2.80
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7417N	.65
7420N	.26
7421N	.50
7423N	.50
7425N	.50
7426N	.50
7427N	.55
7428N	.50
7430N	.24
7432N	.30
7433N	.60
7437N	.50
7438N	.50
7439N	1.00
7440N	.24
7441AN	1.15
7442N	1.00
7445N	1.15
7447N	1.40
7448N	1.30
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7454N	.25
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7472N	.40
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7474N	.48
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7476N	.60
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7482N	1.00
7483N	1.00
7484N	3.00
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7486N	.50
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7493AN	.85
7494N	1.30
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BY MARSHALL LINCOLN

Build a Versatile Nickel-Cadmium Battery Charger

Provides variety of charging rates and operates from ac line or 12-V dc source

IN THESE DAYS of portable devices powered by nickel-cadmium batteries, recharging devices are becoming increasingly important. Unfortunately, most chargers are designed for a specific application. For example, a charger for a calculator may not satisfactorily charge the batteries in a portable tape recorder. Similarly, you can't expect to charge the batteries in a walkie-talkie with a charger designed for a photographic speedlight. Here's a general-purpose battery charger you can build for under $15 that will accommodate popular AA-, C-, and D-size nickel-cadmium cells. With this unit, you won't need a separate charger for each piece of equipment containing batteries.

The battery charger, shown schematically in Fig. 1, overcomes the single-application design by providing a variety of charging rates. To make it as versatile as possible, the power source for the charger can be the ac line through *PL1* or any 12-volt dc source (including a car battery) through *PL2*. It can charge from 1 to 4 C cells at once with the cells either installed in battery clips on the charger or connected to the charger through an external cord.

Values of current-limiting resistors *R1* through *R4* were selected to keep the charging current through the cells low enough so that damaging overcharging would not occur. Switch selection, via *S2*, automatically switches in the proper series resistance to match the number of cells connected to the charger circuit. Meter *M1* provides a means of monitoring the charging current so that you always know the charge current is within cell ratings.

A 12-volt filament transformer, *T1*, and diode, *D1*, permit the charger to operate from a 117-volt ac line source. To operate the charger from a 12-volt dc source, *S1* must be in its alternate position, placing the *R6/PL2* circuit in the system and removing the *PL1/T1/D1* circuit. Resistor *R6* is in the circuit to insure that the same charging current is delivered in the dc mode as in the ac mode.

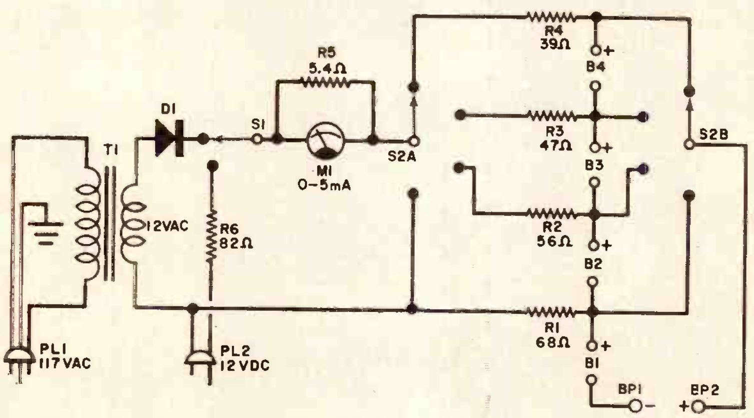


Fig. 1. Charger can be used for one to four C cells with cells in clips or connected to binding posts.

PARTS LIST

B1-B4—D-cell battery holders
BP1, BP2—Five-way binding post (one black, one red)
D1—200-PIV, 200 mA silicon diode
M1—0-5-mA meter movement
PL1—Ac plug with line cord, or use chassis-mounting plug
PL2—Polarized dc plug (automotive or other), or use chassis-mounting plug
R1—68-ohm, 1-watt resistor
R2—56-ohm, 1-watt resistor
R3—47-ohm, ½-watt resistor
R4—39-ohm, ½-watt resistor
R5—5.4-ohm, ½-watt resistor
R6—82-ohm, 1-watt resistor
S1—Dpst switch
S2—2-pole, 4-position rotary switch
T1—12-volt, ½-ampere filament transformer
Misc.—Chassis box; hookup wire; hardware; rubber grommet or plastic strain reliefs (2) for line and dc power cords; solder; etc.

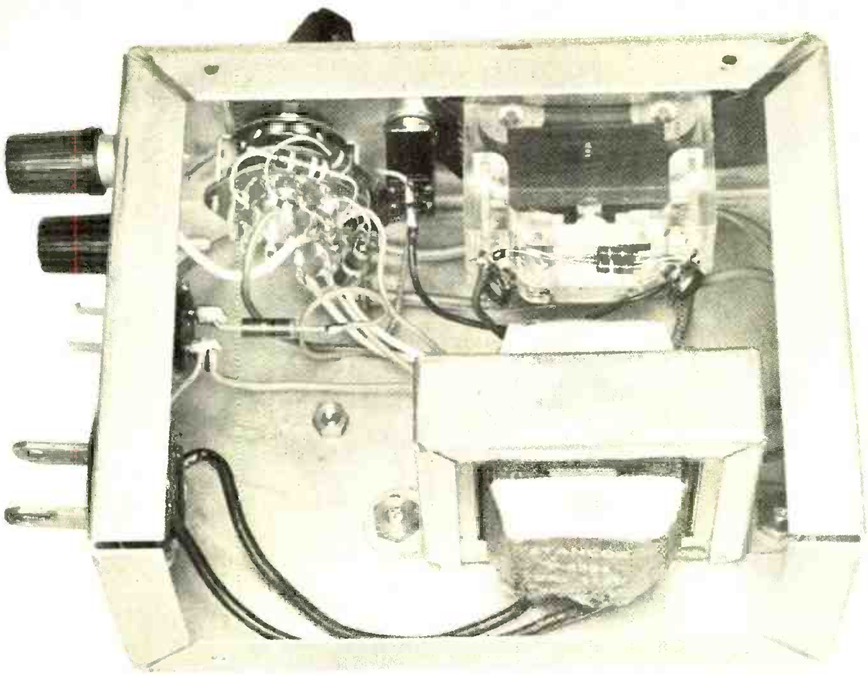


Fig. 2. Photo shows inner assembly of the prototype. All parts are installed by point-to-point wiring so it is not necessary to use circuit board.

The values of *R1* through *R4* were selected to yield slightly less than 100 mA of charging current. When *S2* puts *R1* in the circuit, charging current is delivered to only the *B1* battery contacts. Switching through *R2*, *R3*, and *R4* successively adds the remaining battery contacts so that up to four batteries can be recharged simultaneously. Note, however, that the circuit is "live" only if the proper number of batteries are installed for any given switch position. For example, if *S2* were in the *R4* position, four batteries must be in the charger; any lesser number would leave an open circuit.

If you examine the schematic, you will note binding posts *BP1* and *BP2*. These connectors are a convenience feature that allows batteries of different physical configurations to be recharged with the aid of test leads. Select black and red binding posts for *BP1* and *BP2*, respectively.

The only other component in the circuit is *R5*. This resistor serves as a current shunt for *M1*. It permits the meter, a 0-5-mA movement, to accommodate a 0-120-mA current range.

Building the battery charger is a simple and straightforward project. As shown in Fig. 2 and the lead photo, no printed circuit or perforated phenolic board is required during assembly. All parts are installed by point-to-point wiring.

In use, the battery charger, operating at a 1/10 C charging rate, will fully charge a depleted nickel-cadmium battery in about 14 to 16 hours. For only partially discharged cells, the recharging time will be shorter. ◈

Product Test Reports

HEATHKIT MODEL AR-2020 4-CHANNEL RECEIVER
(A Hirsch-Houck Labs Report)

Low-cost quadraphonic kit

THE Model AR-2020 is the Heath Company's new low-priced 4-channel hi-fi receiver. It contains AM and stereo FM tuners, an SQ matrix decoder, and four amplifier channels rated at 15 watts each continuous output power into 8-ohm loads. The receiver is designed to accept external 4-channel programs from up to three different discrete high-level sources and has inputs for 2-channel stereo AUX and magnetic PHONO cartridge. Tape recording outputs are provided for use with a 2- or a 4-channel tape deck.

The receiver measures 20 in. (50.8 cm) wide by 14 in. (35.7 cm) deep by 5 in. (12.7 cm) high. Its weight is 24 pounds (10.9 kg). The retail price of the Model AR-2020 receiver kit is $249.95, which includes decorative wood end panels.

General Description. The front panel of the receiver features a "blackout" dial window, behind which the logging scales illuminate in soft green when power is turned on. The legend STEREO appears in red when a stereo FM broadcast is received. (There is no tuning meter.)

Pushbutton switches are provided for selecting the input source (AUX 4, AUX 2, TAPE 4, PHONO, FM, or AM) and selecting the operating mode (4 CH discrete, STEREO, MATRIX, or MONO) and for turning on and off the power and energizing the speaker outputs. In the STEREO mode, the same program appears at the front and rear outputs on each side of the 4-channel listening setup, while in MONO, an input to any of the channels appears in all four channels simultaneously. Front- and rear-channel stereo headphone jacks are provided for private listening.

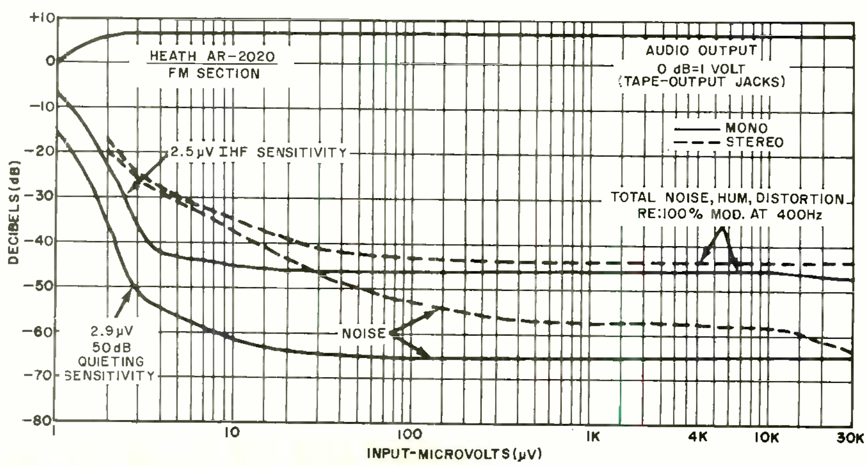
Four controls permit individual channel level adjustments to be made, while a single master VOLUME control operates on all channels simultaneously. Separate bass and treble controls are provided for the front and rear channels, each operating simultaneously on the left and right channels over which it exercises control.

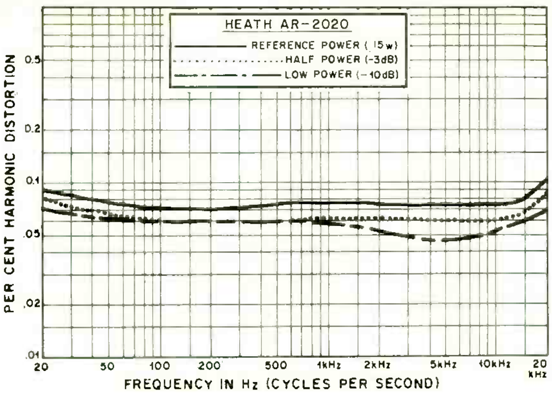
The receiver has facilities for 300-ohm and 75-ohm external FM antennas. A pivoted AM ferrite-rod antenna is featured, but no connectors are provided for using an external AM antenna.

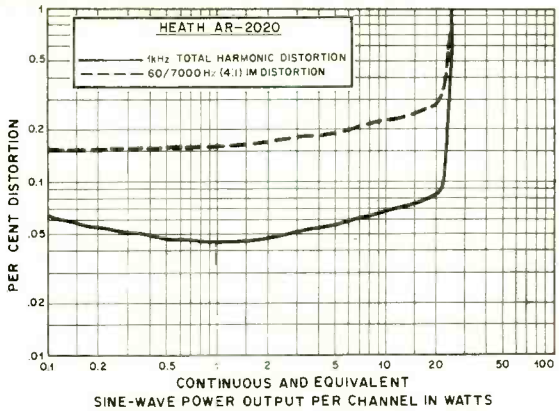
Laboratory Measurements. As with most Heathkit receivers, the Model AR-2020 is meant to be aligned and adjusted without the need for external test instruments, using the STEREO indicator lamp in lieu of a multimeter. Our test unit appeared to perform satisfactorily after following the alignment procedure without instruments detailed in the kit's assembly manual. We then followed the instrument alignment procedure on the tuner before proceeding to perform our laboratory measurements.

In our tests, the FM tuner had an IHF usable sensitivity of 2.5 µV in mono, with an excellent limiting curve that yielded a 50-dB S/N ratio with only a 2.9-µV signal input. In stereo, the usable sensitivity was 5.0 µV, and a 55-µV signal was needed for a 50-dB S/N ratio. The receiver does not employ interstation noise muting or automatic stereo/mono switching on FM. The STEREO light and multiplex decoder are functional for all inputs exceeding about 2 µV.

The FM distortion was 0.5 percent in mono and 0.66 percent in stereo. The ultimate noise quieting was 63 dB in mono and 57 dB in stereo. Other FM performance parameters, all of which were good for a low-priced receiver, include a 1.9-dB capture ratio, 47-dB AM rejection, and 71-dB pilot carrier suppression. We were unable to measure the alternate-channel selectivity and image rejection owing to the presence of the non-defeatable afc. In

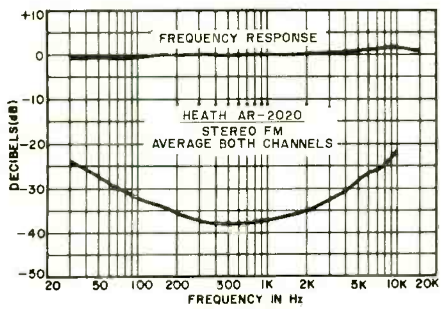






spite of the lack of muting, the interstation noise was not objectionable, and tuning for low distortion was not critical.

The stereo FM frequency response was ±1 dB from 30 Hz to 15,000 Hz. Channel separation was better than 22.5 dB over that range and exceeded 35 dB through the middle-frequency range. The AM tuner sound was like most we have heard—acceptable though far from high-fidelity in its frequency response. The lack of an external AM antenna terminal prevented us from making AM frequency-response measurements.



The audio section of the receiver was excellent, easily surpassing its ratings. With all four channels driven simultaneously into 8-ohm loads at 1000 Hz, the output waveform clipped at about 22 watts/channel. The THD was less than 0.1 percent (typically about 0.07 percent) from 0.1 watt up to about 21 watts, and IM distortion increased smoothly from 0.16 percent at 0.1 watt to 0.3 percent at 20 watts.

Unlike most receivers, the distortion in the AR-2020 was almost unaffected by frequency or power output over a wide range. From 1.5 watts to 15 watts, and from 20 Hz to 20,000 Hz, the distortion was typically between 0.06 and 0.08 percent. It never exceeded 0.1 percent.

The tone controls use feedback cir-

cuitry, with a sliding bass turnover frequency and a rather considerable range of ±17 dB in the bass and ±15 dB in the treble ranges. The RIAA equalization was very accurate, within ±1 dB from 30 Hz to 15,000 Hz. With the channel level controls set to their midrange positions (−11.5 dB), 10 watts output required a 0.48-volt input (AUX) or 5.8-mV input (PHONO). The corresponding S/N measurements, referred to 10 watts output, were 86 dB and 76 dB—both exceptionally good.

Phono overload, in spite of the relatively low phono preamplifier gain, occurred with only 38 mV of input signal when the internal PHONO ADJ sensitivity controls were set according to instructions for maximum gain. As Heath points out, reducing these control settings can allow phono inputs of many volts to be accommodated without distortion, but the relatively low gain is further reduced when this is done.

The relatively limited dynamic range of the receiver makes it advisable to avoid the use of cartridges with unusually high output levels. Fortunately, the receiver's low noise level makes it practical to operate the volume and level controls at higher-than-normal settings without excessive hiss, minimizing the possibility of overload distortion.

The IC matrix decoder is a second potential source of distortion; it overloads at phono inputs of 25 mV with the recommended internal control settings. We suggest reducing the matrix gain somewhat, at least to the point where the dynamic range matches that of the phono preamplifier.

Assembling the Kit. Ten circuit board assemblies are employed in the AR-2020 kit. Seven of them plug into an eighth "master" board. The remaining two, for the tuner and volume/tone controls, mount separately from the other boards. The plug-in assemblies save a lot of time, as does the familiar Heath prefabricated cable harness for interconnecting the various parts and subassemblies and the fact that most of the controls and switches mount directly on the tone board.

Carefully following the step-by-step assembly procedure in the kit's manual makes building the kit practically mistake-proof. A determined newcomer to kit building could probably assemble the receiver with good results on his first try.

Working carefully, the kit took us about 26 hours to assemble.

User Comment. The AR-2020 receiver makes effective use of current IC technology. It uses a single IC for the entire FM i-f amplifier, another for the limiter/quadrature detector, and a third for the multiplex demodulator. The audio section is more conventional, employing just one IC for the phono preamplifiers of both input channels and another for the matrix decoder. (Although it is not stated anywhere, the IC is for the standard SQ matrix.)

The FM tuner delivers excellent performance. It has been some time since we have seen a quality FM tuner without a tuning meter and interstation muting. Fortunately, the AR-2020's afc system makes tuning easy. In its power capability and general quality of the audio section, the AR-2020 outclasses most other low-priced 4-channel receivers.

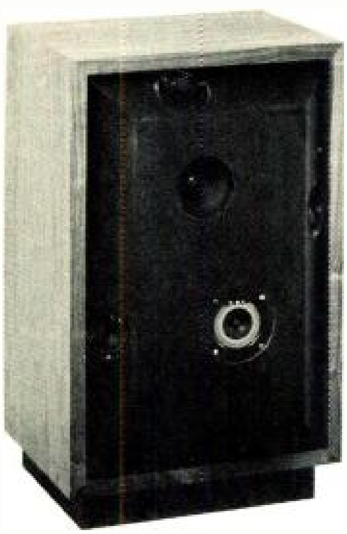
We were surprised at the receiver's lack of tape monitoring facilities. It has 4-channel recording outputs and inputs, but both cannot be used simultaneously for listening to a tape while making a recording.

As the test results reveal, the AR-2020 is a good receiver, honestly and conservatively rated. For someone who enjoys kit building, the AR-2020 certainly provides the most receiver for the money.

CIRCLE NO. 5 ON READER SERVICE CARD

DESIGN ACOUSTICS MODEL D-6 SPEAKER SYSTEM
(A Hirsch-Houck Labs Report)

Seven-driver, three-way system



EXTERNALLY, the Model D-6 speaker system from Design Acoustics appears to be quite conventional. Its walnut-finish wood cabinet measures 24½ in. by 16½ in. by 13¾ in. (62.23 cm × 41.91 cm × 34.93 cm) and weighs about 30 lb (13.6 kg). This is about as conventional as the D-6 gets.

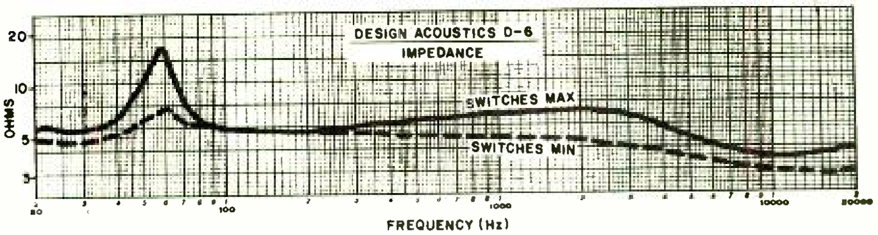
Within the modernistic cabinet, seven drivers are employed in a three-way system. A 10-in. (25.4-cm) woofer is mounted on the rear panel of the enclosure, along with its damped ducted port. A 5-in. (12.7-cm) midrange driver faces forward. Rounding out the speaker complement are five 2½-in. (6.35-cm) tweeters, one facing forward and the remaining four mounted on the bevelled edges around the perimeter of the front panel. The speaker arrangement in the D-6 is designed to yield a 180° dispersion in both the horizontal *and* vertical planes to provide a hemispherical listening area coverage.

The crossover frequencies in the speaker system are located at 800 Hz and 2000 Hz. A pair of switches on the rear of the enclosure permit the listener to select between an anechoic flat response or to reduce the levels of the woofer and/or tweeter by about 3 dB to permit compensating for room acoustics and speaker location.

This speaker system can be positioned either horizontally or vertically almost anywhere in a listening room. The only requirement is that the rear panel, on which the woofer is mounted, must be at least 2 in. (5.1 cm) from the wall. The impedance of the system is nominally 8 ohms. An amplifier of at least 20 watts (minimum) is recommended for driving the system.

The retail price of the D-6 speaker system is $249 for the walnut-finished version or $299 for the rosewood-finished enclosure. Optional 2¼-in. (5.72-cm) bases for using the speaker system in a floor-standing location are $15 per pair.

Laboratory Measurements. When



we measured the frequency response of the D-6 speaker system in a normal "live" room with the tweeter and woofer switches set high, the result was quite smooth. The response rose slowly with increase in frequency so that the output at the highest frequencies was about 5dB to 8 dB higher than the bass and midrange levels. Setting the tweeter level switch to its attenuator position reduced the output by about 5 dB at frequencies beyond 2000 Hz to provide an overall frequency response that was exceptionally flat — within ±2 dB from 45 Hz to 15,000 Hz.

The low-frequency output was measured both in front of the woofer and at the port opening. The "crossover" between the woofer and the port radiation occurred at 55 Hz. The overall bass response, a combination of the radiation from the woofer and the port, was excellent — within ±2.5 dB over a frequency range of 43 Hz to 600 Hz. It was ±1 dB from 50 to 600 Hz. The low-frequency (woofer) switch reduced the output by about 3 dB at frequencies below 800 Hz in the attenuate position.

We measured the bass distortion with our microphone directly in front of the woofer. Consequently, our figures do not reflect the low-distortion distribution of the port at frequencies below 55 Hz. Even so, the distortion measured less than 3 percent down to 50 Hz, reaching 5 percent at 40 Hz and, ultimately, 10 percent at 35 Hz. The results were essentialy the same whether we used a constant 10-watt drive or a constant acoustic output of 90 dB sound-pressure level (SPL) measured at a distance of 1 meter from the speaker. A measurement that could include the outputs of both the port and woofer would most likely have shown even lower distortion.

The tone-burst response was uniformly good. With both level switches set to maximum (anechoic flat), the impedance of the speaker system was 5 to 8 ohms at most frequencies up to about 5000 Hz. It fell to 4 ohms in the 10,000-Hz to 20,000-Hz range and increased to 16 ohms at the 58-Hz bass resonance. With both switches set to their attentuation positions, the 58-Hz peak was reduced to 7 ohms, and the system impedance was lowered at most other frequencies, falling as low as 3.5 ohms at frequencies beyond 10,000 Hz. Hence, we deem it inadvisable to use a D-6 speaker system in parallel with another speaker system on the same channel. This might result in too low an impedance for many amplifier outputs to accommodate.

User Comment. In our simulated-versus-live recorded listening test, the D-6 speaker system was 100-percent perfect at *any* point in our listening room! (For this test, the controls were in the anechoic flat positions.) This is the *only* speaker system in our experience to achieve this status. Not only were the highs "on the nose," but the important midrange portion of the audio band was reproduced with no coloration that we could detect by ear or by measurement. The bass range was clean and solid and so well-matched to the sound of the other drivers that there was no hint of transition from the angled forward-facing tweeters to the rear-facing woofer.

For our listening tests, the speaker systems were located a few feet from the nearet wall. Placement closer to a wall or in a corner would boost the bass response, which was impressively powerful in our listening tests. (Presumably, this is why Design Acoustics has provided a switch with which to attenuate the lows, if necessary, to preserve balance.) The D-6 was fairly efficient, requiring ony about 1 watt of drive power to generate a 90-dB SPL measured at a 3-ft (91.44-cm) distance from the speaker system.

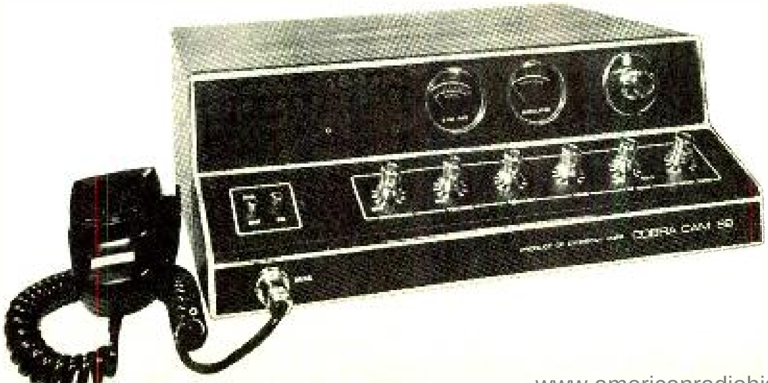
Omnidirectional speaker systems (or quasi-omnidirectional hemispherical radiating systems like the D-6) are usually tolerant of any location placement in a listening room. But they are perhaps more responsive than conventional speaker systems to the absorption characteristics of the room. For example, our listening/test room is moderately "live" and has a hard floor so that even the downward-angled tweeter contributed significantly to the total output energy of the system. It is conceivable that a heavily carpeted floor coud absorb much of the output from the lowest tweeter, but since at maximum this would amount to only about 20 percent of the total high-frequency output of the system, the loss would go unnoticed.

In short, the Model D-6 easily ranks among the finest speaker systems we have heard. It is not easy to describe its sound character without resorting to such overworked — but communicative — adjectives as "open," "airy," "neutral," "uncolored," and the like. These and many others surely apply to the D-6. After listening to this speaker system for a while, the colorations heard from many other systems stand out like a sore thumb.

CIRCLE NO. 65 ON READER SERVICE CARD

DYNASCAN COBRA CAM 89 CB TRANSCEIVER

Console-style base station with PA feature



THE Dynascan Corp. Cobra CAM 89 is a somewhat different kind of AM base-station CB transceiver as a result of its console-like design and greater number of controls than is usually the norm. Except for the channel selector, the controls are located in a row across the front panel's lower half that slopes away at about a 30° angle. These controls are for microphone gain (DYNAMIKE), VOLUME and power on/off, Squelch, Tone, rf Gain, and Delta Tune.

The transceiver also features two toggle switches. One turns on and off the automatic noise limiter (anl), while the other switches the system to either CB or PA operating mode. External speaker jacks are provided for PA operation and the receiver.

Operation on all 23 channels is facilitated by a crystal frequency synthesizer and a large channel selector switch. Two meters are provided. One meter indicates relative output power on transmit and signal strength on receive. The pointer of the other meter swings up-scale with the speech signal and indicates when 100-percent modulation has been reached.

The Dynascan Corp. Cobra CAM 89 CB base-station transceiver retails for $240.

The Receiver. Double conversion to 11,275-kHz and 455-kHz i-f's is used in the receiver with a ceramic filter for selectivity. The sensitivity measured 0.5 µV for 10 dB (S + N)/N with 30 percent modulation at 1000 Hz. Adjacent-channel rejection was a minimum of 45 dB, and overall bandpass, with the tone control set at its midpoint was 450 to 3500 Hz. Image rejection was 56 dB. The squelch threshold range was 0.3 to 10,000 µV, while the agc provided a 7-dB a-f output change with a 20-dB, or 1- to 10-µV, r-f input change. The output change was 4 dB with a 60-dB (10- to 10,000-µV) input change. An S9 reading was obtained with a 1000-µV input signal.

The extremely good effectiveness of the automatic noise limiter (anl) could readily be heard simply by switching it on and off in the presence of impulse noise. With the anl on, the overall a-f volume dropped 8 dB with r-f signals near 1 µV and 4 dB with signals above 10 µV.

Advancing the tone control attenuates the response at the high-frequency end of the receiver's a-f range, while slightly increasing the low-frequency response. This allows the user to tailor the voice quality to his liking. At maximum high-frequency attenuation, the overall level of the voice output drops somewhat.

The r-f gain-control setup is unusual. Instead of varying the circuit gain at an amplifier stage, a diode-type attenuator varies the signal level to the antenna input of the r-f amplifier.

For PA service, a class B, a-f output stage provided 4 watts of output power with 7 percent distortion at the start of clipping, using a 1000-Hz test signal and an 8-ohm speaker load. Depending on the control setting, 3 to 4 watts of output power was obtainable on receive with a 1-µV input signal. We also observed that low audio frequency distortion was considerably less than is usually the case.

A conventional frequency-synthesis system employs several nominal 23.5- and 14.9-MHz crystals in conjunction with conversion crystals cut to 11.730 MHz on receive and 11.275 MHz on transmit.

The Transmitter. The transmitting setup is a customary one, with the carrier supplied by a frequency-synthesis system and passed through a spurious-response filter. The carrier then goes to two r-f stages and the power-output amplifier, which has the usual output-matching network with a TVI filter. The power-output amplifier is collector-modulated by the receiver's audio output amplifier.

With 100-percent modulation, 3.5 watts of carrier output was measured, exhibiting only 2.5 percent distortion at 1000 Hz. By raising the speech input, or microphone gain, 6 dB above that required for 100-percent modulation, the positive peaks continued to rise. This resulted in an upward carrier shift and 10 percent distortion with the positive-peak level equivalent to what would normally be needed for a 4-watt carrier output. At the same time, the negative peaks crossed over, causing the adjacent-channel splatter, with a test tone, to be down nominally 40 dB. On the other hand, with voice modulation and the microphone gain control set for the correct modulation level (as indicated by the panel meter), the splatter can be held to better than 60 dB down.

The transmitter's meter scale is calibrated to indicate 100-percent modulation with a *steady* tone. However, due to the damping characteristics of the meter movement, proper 100-percent modulation with voice is indicated by an average swing to near the center of the scale. Too much microphone gain and continually kicking the meter's pointer to the 100-percent point results in over-modulation and undesirable splatter. The overall frequency response was 350 to 2850 Hz at the 6-dB points, while frequency tolerance held to within 350 Hz.

CIRCLE NO. 66 ON READER SERVICE CARD

DATA PRECISION MODELS 134 AND 245 DIGITAL MULTIMETERS

Bench and portable models challenge analog instruments

GOING digital is the "in" thing these days in multimeter design. More and more manufacturers are switching to easily read and interpreted digital displays, abandoning the traditional analog meter movement with its crowded scales and wide room for error both in electrical characteristics and the user's interpretation. The Data Precision Model 134 digital multimeter, retailing for $189, is an excellent example of the type of instrument that offers the most by going digital.

The Model 134 DMM features a ½-in. (1.27-cm) high 3½-decade display. The bright orange gas-discharge display employs a seven-segment format that is easy to read over a wide viewing angle and from a long distance. The numeral segments cleanly abut at the corners to produce digits without the breaks common to some other types of seven-segment display systems.

With a + sign implied, the DMM displays a − sign when negative voltages are being measured. Couple this with the instrument's automatic polarity sensing system, and you can well understand how convenient the Model 134 can be when measuring voltages and currents of different polarities.

Functions. The Model 134 DMM is designed to measure dc and ac voltages, direct and alternating current, and resistance. Two rotary switches dominate its front panel to the right of the display window. One switch is for function selection, while the other sets the range. The only other accessible control is a ZERO potentiometer; this is used for setting the display to zero when the instrument is switched to the resistance function.

Four ranges, going from 1 to 1500 volts full-scale, are provided for the dc voltage measurements. Resolution is 1 mV on the 1-V range. Accuracy is a very good 0.2 percent full-scale, ±0.2 percent of reading, except on the 1000-V range where the figures are 0.5 percent full-scale, ±0.5 percent of reading.

Four ranges, going from 1 to 1000 V full-scale, are also provided for measuring ac voltages. The useful frequency range for measuring ac voltages is 50 Hz to 1000 Hz, but the DMM will measure voltages at frequencies up to about 5000 Hz at slightly reduced accuracy. The basic accuracy on the ac ranges is 0.7 percent full-scale, ±1 percent (±2 percent on the 1000-V range) of the reading. Input impedance is 10 megohms, shunted by 60 pF.

Current in both the ac and the dc modes can be measured in four ranges from 1 mA to 1 A full-scale, with 1 μA as the least significant digit. Under measurement conditions, the nominal voltage drop across the DMM is 100 mV, and current-reading accuracy is 0.5 percent full-scale, ±0.8 percent of reading.

For resistance measurements, six decade ranges (from RX0.1 to RX10M, using the kilohm position of the function switch) provide readings of 199.9 ohms to 19.99 megohms full-scale. The least significant digit is 0.1 ohm. Test current is 10 mA on the lowest range, reducing to 1μA on the 1-megohm range. (Test current on the 10-meghom range is 100 mA.) The maximum open-circuit voltage is 15 V, and accuracy is 0.5 percent full-scale.

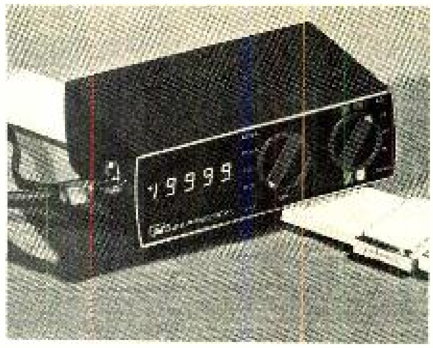
The DMM is fully overload-protected on all ac and dc voltage ranges to 1500 V. On the resistance ranges, overload protection is to 250 V, while on the current ranges, protection is to 3 A.

This bench-size instrument measures 8⅞ in. deep by 7⅛ in. wide by 3½ in. high (22.5 x 18.1 x 8.89 cm). It weighs 4¼ lb (about 2 kg).

Test Results. We tested the Data Precision Model 134 DMM against our voltage and resistance standards and found it to perform well within its rated specifications. In the actual-use test, the DMM underwent steady use for several hours a day over a period of seven weeks. At the end of that time, we retested the instrument to discover whether or not it had drifted out-of-spec.; it hadn't.

More out of curiosity than for any other reason, we took a look inside the DMM to see what Data Precision, formerly an OEM-only company, was offering for the money. We were pleasantly surprised to see only high-quality materials and workmanship employed throughout, including a complicated printed-circuit switching arrangement. For the $189 list price, we expect so see the Model 134 DMM replacing many traditional analog instruments in professional test facilities and on home workshop benches.

Another Data Precision DMM. While we were testing the Model 134, Data Precision sent us their Model 245 DMM ($295). This battery-powered multimeter is one of the most compact we have ever seen (second only to Hewlett-Packard's Model 970A DMM to our knowledge). It measures only 5½ in. wide by 3½ in. deep by 1¾ in. high (14 x 8.9 x 4.45 cm) and weighs 1.3 lb (0.59 kg). In spite of its very compact size, this new DMM features 4½ decades of 5/16-in. (8.25 mm) seven-



segment gas-discharge readouts and full range/function capabilities.

Four ranges each are available for alternating-current, direct-current, ac-voltage, and dc-voltage measurements. Five ranges are set aside for resistance measurements. For both ac and dc voltage, measurement capability is provided for 1.9999 to 1000 V full-scale. The current ranges go from 1.999 mA to 1.999 A full-scale. And for resistance measurements, the ranges go from 1999 ohms to 19.999 megohms full-scale.

On the dc-voltage ranges, input resistance is 1000 megohms on the 1-V range and 10 megohms on all other ranges. In ac, input impedance is 1 megohm, shunted by 60 pF. The frequency response in the ac-voltage function is 30 Hz to 50,000 Hz. When measuring current, the voltage drop is 100 mV. Finally, test curent in the resistance function is 1.8 mA on the low range, dropping to 0.35 μA on the 10-megohm range.

While the Model 245 DMM will prove very useful on a service bench, it really shines as a field-service instrument. Its built-in rechargeable battery supply makes the multimeter completely independent of line power. The cells will deliver up to six hours of operating time with a full charge. Recharging from the ac power line with a recharger/ac power supply (provided with the DMM) from no charge to full charge can be accomplished overnight.

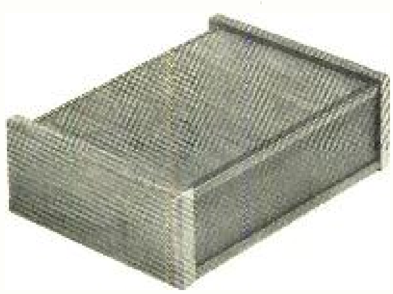
For bench use, Data Precision has not sacrificed one important nicety. Built into the bottom of the multimeter's case is a small tilt leg. Flipped down, it tilts the front upward at a comfortable viewing angle.

One interesting thing about the Model 245 is that each instrument comes with its own final-acceptance booklet in which the test technician signs his name to verify that certain tests and calibration have been performed. Some of the things he signs for are a 12-in. (30.5-cm) drop test, a 1000-V test of the 1-V range, application of 117 V at 60 Hz to the ohmmeter section of the instrument, and an eight-hour burn-in at 45° C.

CIRCLE NO. 67 ON READER SERVICE CARD

MALLORY MODEL CA3 ULTRASONIC ALARM

Twenty-foot range, no-wiring system



THERE are many ways to keep an electronic "eye" on doors, windows, and other entrances into a factory, store, or home. Most "security" systems employ some form of direct wiring between a number of sensors scattered around the area to be kept under surveillance and a main control unit. For those people who do not wish to go through the mess and bother of wiring up a system, there are ultrasonic alarms that have sensor, electronics package, and sounder or other trip indicator all in one package.

In essence, an ultrasonic security system "floods" the area to be kept under surveillance with a high-frequency sound that is beyond the range of human hearing. Any motion within the secure area disturbs the ultrasonic sound pattern. The system senses the disturbance and triggers on, energizing a horn, a buzzer or bell, or a light. A good example of an all-in-one ultrasonic alarm system is the Model CA3 from Mallory. It retails for $139.95.

The alarm provides coverage at up to 20 ft (6.1m) away in a conical pattern measuring about 90° wide in front of the built-in transducer. All operating controls for the system are located on the rear apron. There is a HORN ON/OFF switch and a STANDBY/INSTANT/DELAY switch, as well as a response speed control. In addition to the controls, the rear apron accommodates a 120-volt ac, 3-ampere outlet into which a bell, buzzer, siren, lamp, or other signalling device can be plugged. Finally, there are six screw-type lugs, arranged in three pairs for: REMOTE RESET and OPEN and CLOSED SWITCH LOOPS.

In the three-position switch's STANDBY position, the system is on but cannot be tripped. In INSTANT, the alarm immediately trips upon detection of an intruder, while in DELAY, a 30-second alarm delay permits the user to exit the premises before the alarm arms.

The alarm device can be either the system's built-in horn or any device rated at up to 300 watts plugged into the rear-apron outlet. Once the alarm trips, it remains energized for about 2 minutes, after which it shuts off and automatically rearms itself. The variable-response control allows the response to movement to be set fast or slow.

The screw-type lugs permit the use of some optional devices with the basic alarm system. A pair of wires terminated in a normally-open push-button switch can be connected to the REMOTE RESET terminals to permit the alarm to be reset from a location outside the protected area. Panic switches, thermostat devices, mat switches, etc., can be connected to the OPEN LOOP contacts to provide a variety of services. And normally closed devices—like magnetic window and door switches—can be connected to the CLOSED LOOP contacts to provide perimeter protection.

The model CA3 ultrasonic alarm requires only 3 watts of power for its circuitry, plus whatever extra power is demanded by the devices plugged into the rear-apron outlet.

User Comment. We tested the Model CA3 alarm in various environments. In our shop, we verified that the range was indeed about 20 ft. However, we also noted that this could be extended by a good percentage if the alarm is used in a hard-walled area, probably as a result of the ultrasonic energy bouncing between the hard walls in the hallway in which the test was performed. The sensitivity control permitted us to adjust the system to respond to only a slight intrusion.

As with all ultrasonic detection systems, this one affected some animals—specifically, cats and dogs. But we can also report that this system did not affect our remote-controlled TV receiver as some others have done in the past.

We also tried using the system as a light turn-on device, plugging an ordinary lamp into the socket on its rear panel. When we entered our darkened home, the alarm tripped (with the internal horn disabled for this application) and turned on the lamp to light our way. With the alarm system powering the lamp for its usual 2 minutes, we had plenty of time to find the wall switch without tripping over furniture.

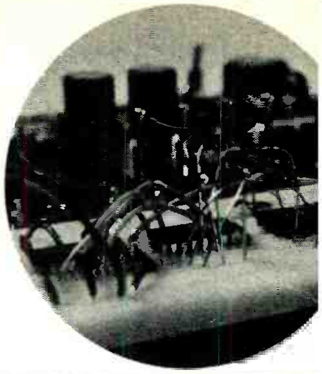
The housing of the alarm itself is attractively styled, with wood-grain vinyl-clad metal top and bottom panels and real wood end pieces. The front panel is a dark anodized fine mesh metal. In short, it will blend well into any furniture setting.

CIRCLE NO. 68 ON READER SERVICE CARD

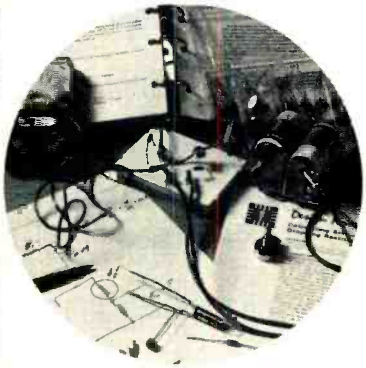
Communications Engineering

Aeronautical & Navigational

Television Engineering



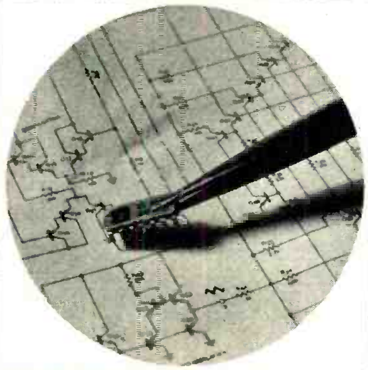
Automatic Control Engineering



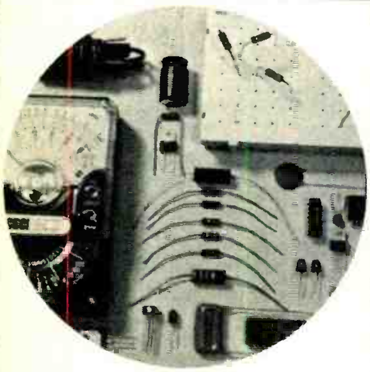
Missile & Spacecraft Guidance

Radar & Sonar Engineering

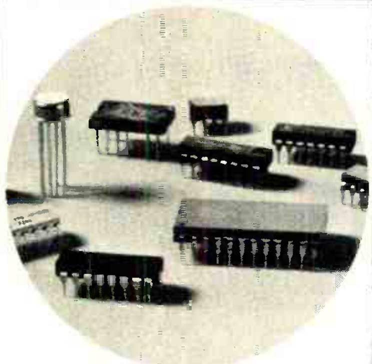
Digital Communications



Industrial Electronics



Microwave Engineering



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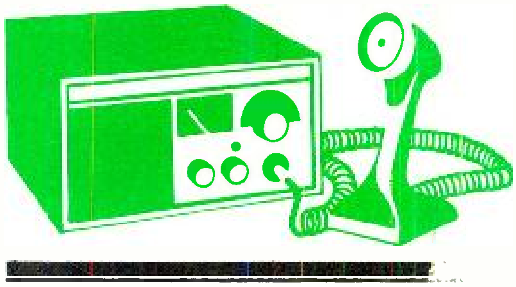

CB Scene

By Len Buckwalter

MAYDAY—PAN—SECURITY

ACCORDING to regulations, d... have an emergency unless ... know the exact meaning of these t... terms: Mayday, Pan and Secu... They're of French origin and desc... the exact degree of distress.

- Mayday means *immediate* da... of loss of life or property.
- Pan says danger with n... mediate threat.
- Security is a warning about s...

So if your boat capsizes, the c... plodes or you're lost in the wood... may be saved by a French Legio... who happens to be an expert in inter-national communications law.

This bit of nonsense was pro... when I received a large plasti... imprinted on both sides with ... 1000 words of radiotelephone ... ating procedures. Designed ... posted in full view, it prescribes ... official way to summon help. The pu... lisher slanted it to the boatman, ... also suggests a CB'er might be... from his condensed version of ... Geneva Convention on telecommun... cations. It may make an excellent con... versation piece for admiralty law... but is hardly what you need in real l...

In a tight situation, a CB radio ... summon police, Coast Guard, fire de... partment, doctor, ambulance or al... most anyone else to the rescue. A... speedy call, say the rescuers, is cru... because the toll of death and inju... closely tied to the time that passes be... tween the radio call and when help arrives. That time can be extre... brief if you pick up the mike and su... mon help moments after the accident. And there's the rub! *You* might b... the victim and be unable to press the magic button, utter "Mayday" (or whatever appropriate term) to scramble rescuers to your aid.

Meanwhile, a wife, husband, pre-teen child, your maiden aunt, boss or other passenger may have surviv... ...e injury. Maybe ...k on the CB rig ...ion can appear ...g to the unin-...rd, with 61 dif-...s, is hardly the ...ral is that a CB ...ver if only one ...'s how to use ...what you can ...nsider, first, ... to call for ...anning the ...

... terms men-... visely allows ...sed to attract ...s immediate ...ty. The Com-... he body of CB ...st of the usual ...mission time, ...s you may call ...rgency com-... can get on the ...ou believe will ...ckler for rules, ...all "Mayday," ...erm will be un-... hat happened ...ess flares were ...rg struck—and ...s on a nearby ... Plain language ... predicament, ...s exact as pos-...elp you need, is ...nique on CB. ...als use the in-...all listening on ...night and hear-...ained operator, ...mmoned help ...rely said: "Will ...me answer this ...

... that problem of ...omeone knows ... radio in an emergency. It is folly to venture into some situations without one or more passengers knowing how to call for help, whether aboard a boat at night, during limited visibility or while cruising beyond sight of land. Certain driving conditions also multiply the risk, like crossing a desert or a desolate, unpopulated part of the country. If you go camping, CB also reduces the danger following an accident in an isolated region.

In most cases, a simple demonstration to a non-CB'er of how to work the radio should be enough insurance. Be sure to clinch the lesson by having the student actually take the mike and, without assistance, correctly set up the dials and switches for the call. Another successful system I've tried, where nontechnical people must operate electronic equipment, is a simple placard fastened on or near the equipment. For a CB set, it can be as uncomplicated as:

(1) Turn VOLUME up
(2) Turn SQUELCH clo[illegible]
(3) Turn CHANNEL SE[illegible] "9"
(4) Press button on [illegible] while talking

The foregoing shoul[illegible] so that it's appropriate [illegible] course. Point out whe[illegible] tions are located and [illegible] be obvious to anyon[illegible]

Has anyone been [illegible] foresight? I recall [illegible] Doris Day, in an old [illegible] took over the contr[illegible] and, following instr[illegible] flew the mighty plan[illegible] safe, landing. The st[illegible] less outlandish whe[illegible] real-life pilot died at [illegible] small airplane with [illegible] aboard—none of whom could fly. Tragedy was averted when the dead pilot's wife grabbed the controls and was talked down to a non-lethal crash by someone on the ground. Like Doris, the woman was no pilot, but knew how to work the radio.

There are many wa[illegible]
Which one is the rig[illegible]

CB Telphone? "I have need to talk over my mobile CB rig through a touch-tone phone system," writes a reader from Tuscon, Arizona. At some time, we all have that need. What greater electronic luxury could there be than using a mobile CB rig on land or water to make a conventional telephone call, with no phone patch or other intermediary. Just tap some pushbuttons on the rig to dial the desired number, then wait for the ring at the other end of the circuit. It would link your CB set to any telephone in the world. What are the chances of getting such an accessory?

Hams are already using the system on the 2-meter band. Called "autopatch," it's done with a simple encoder attached to the transceiver. It creates a pair of audio tones for each digit (or other dialing function) and modulates them onto the carrier. At the receiver end, a decoder processes the signals for feeding the telephone line. In operation, the autopatch system is remarkably like speaking over a regular phone.

But CB'ers will probably have to wait many moons before they can enjoy the benefits of an autopatch. Its purpose in ham radio is direct access into the telephone dialing system solely for emergency or other special communications. It is *not* authorized for personal use. For example, a ham stuck on a paralyzed freeway may not dial home and say, "Hold the hamburger, dear, I'll be late for dinner."

Another barrier to the CB autopatch is purely technical. It calls for much home-brewing and interconnection of equipment—which is a ham's province, but a CB'er's pitfall. The possibility of commercially built autopatch for CB is also remote because it would be contrary to FCC law for CB to compete with an existing system that is already licensed to provide mobile telephone service (e.g., Ma Bell). Unless someone can prove that direct phone access for CB would be in the public interest, there is little chance it would meet with approval. So the convenience of phoning from a car is still restricted to hams and those blocking VIP limousines. ◈

Solid State

EXPERIMENTING WITH LIGHT EMITTING DIODES

LED'S—light emitting diodes—are being used in ever-increasing numbers by hobbyists and experimenters as well as by original equipment manufacturers. Physically small, lightweight, available in several colors, rugged, easily installed, efficient, and with a virtually unlimited service life, they are ideal visual indicators.

As pilot lamps, LED's are rapidly displacing incandescent bulbs despite a somewhat higher initial unit price. The difference in device cost is deceptive, however, at least as far as original installations are concerned. Where an incandescent bulb is used as a pilot, one must provide a socket, mounting bracket and, usually, a colored lens or jewel and suitable mounting. In contrast, a LED can be wired directly and permanently in place and, generally, has its own integral lens. When the *total* installed cost is considered, then, a LED may prove less expensive, in many cases, than an incandescent lamp, while offering the advantages of low power drain and long life.

Probably, simple pilot installations account for the majority of present LED applications. If you feel that LED's can be used *only* in such applications, however, you may be in for a surprise.

Put on your thinking cap and consider their unique electrical characteristics: they are basically diodes, their power requirements are nominal, and they are tolerant of a broad range of currents. A typical low-cost unit is capable of supplying a useful light output with currents as low as 10 mA, while accepting maximum currents of up to 50 mA without damage. These characteristics permit LED's to be used in a variety of valuable, interesting, and practical projects, both individually and in conjunction with other solid-state devices. Several of many possible LED applications are illustrated schematically in Figs. 1 through 3.

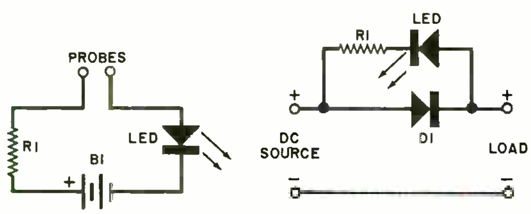

Fig. 1. Circuit (A), left, is continuity checker; (B), right, polarity reversal alarm.

The simple continuity checker circuit illustrated in Fig. 1A can be assembled at minimum cost in a single evening. A standard probe body, a small metal box, or even a large plastic vial can be used for housing the project. The battery may be two or more penlight cells or even a 9-volt transistor battery, while *R1*, a half-watt resistor, has a value chosen to limit the short-circuit current to between half and three-quarters of the LED's maximum rating. Typically, a 1.6 volt, 50-mA LED, used with a 9-volt battery, would require a 240- to 330-ohm resistor.

In operation, the instrument is used just as one would use an ohmmeter for checking the dc continuity of circuit wiring, terminal connections, switch contacts, and even components, such as coils, transformers, loudspeakers and relays. The LED lights if there is a continuous dc path between any two terminals to which the test leads are applied.

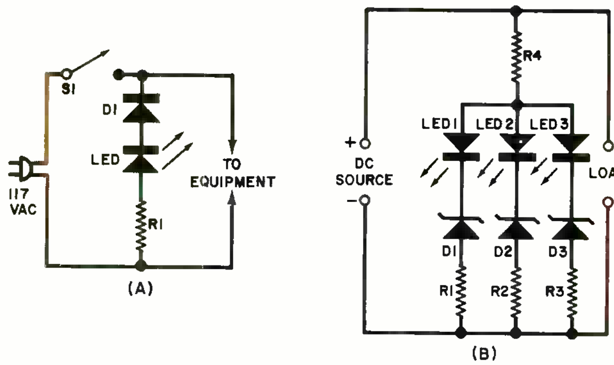

Fig. 2. Two useful applications: (A) Line pilot for ac; (B) voltage monitor for dc.

Unlike many inexpensive commercial continuity checkers, this unit will provide a positive indication even if the circuit's resistance is moderately high. An experimental model assembled using a 9-volt battery and a bargain-package LED provided a useful output with test resistances of up to 3000 ohms.

A useful variation of the polarity reversal protection circuit discussed in our August column is shown in Fig. 1B. Here, the protective diode is shunted by a LED in series with current-limiting resistor *R1*. With correct dc polarity applied, diode *D1* acts as a virtual short, supplying power to the equipment (load). If the supply polarity is reversed accidentally, *D1* acts as an open circuit, preventing equipment damage, while a small reverse leakage current, limited by *R1*, flows through the LED, illuminating this device and signalling the operator.

This circuit may be assembled in an external case attached between the equipment's supply terminals and the dc power source or, if preferred, built into the protected equipment.

Despite their low voltage ratings and dc power requirements, LED's can be used as ac line pilots and low-level night lights (in place of neon bulbs). Simply add a small rectifier diode *(D1)* and a current-limiting resistor *(R1)*, as illustrated in Fig. 2A. Generally, *D1* would be a 200-volt silicon rectifier, the LED a 1.6-volt, 50-mA (max) type, and *R1* a 10,000-ohm, 2-watt resistor.

You can use the inexpensive voltage monitor circuit given in Fig. 2B with any type of equipment in which dc supply voltages are critical. Typical examples are small aircraft radio gear, precision test instruments, and some types of medical electronic equipment. Standard LED's are used in conjunction with zener diodes *D1* to *D3* and current-limiting resistors *R1* through *R4*. The zener values are chosen for the minimum, optimum and maximum voltages which can be tolerated by the equipment, taking into account the voltage drops across the LED's and the series resistors.

Assuming that *D1* is chosen for the low-voltage limit, *D2* for the optimum voltage, and *D3* for the maximum voltage, the three LED's will light in a varying pattern to identify supply voltage conditions. With optimum voltage applied, *LED1* and *LED2* are illuminated. If all three are dark, the supply voltage is either too low or absent, while if only *LED1* lights, the voltage is above the minimum, but below the optimum value. Finally, should all three light, the voltage is at or above the high limit.

With suitable circuit component values, the LED voltage monitor is capable of maintaining a constant check on dc supply voltages to within a half-volt, or better, in practical installations.

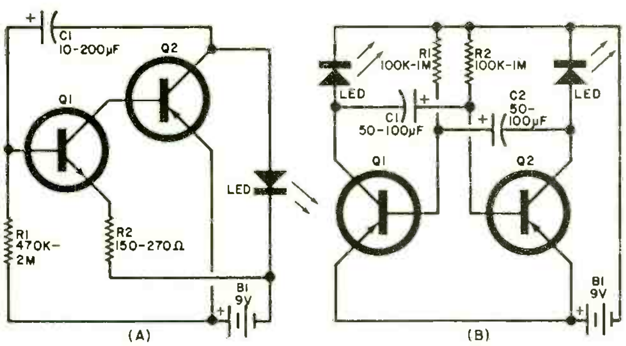

Fig. 3. LED flasher circuits: (A) relaxation oscillator; (B) alternate blinker.

Unlike incandescent lamps, which have a characteristic thermal time lag, LED's can be flashed at rates of less than 1 Hz to many kHz, permitting their use in visual timers or metronomes, toys, opto-couplers, alarms, and similar projects. Any of several techniques may be used to provide an attention-getting repetitive flash. The simplest employ a single special-purpose device, such as a UJT, PUT or MISER. However, quite acceptable results can be obtained using low-cost general-purpose transistors, as found in bargain assortments. Two practical circuits are illustrated in Fig. 3.

The complementary relaxation oscillator shown in Fig. 3A features direct-coupled npn *(Q1)* and pnp *(Q2)* transistors, with the LED serving as the output load. Capacitor *C1* provides the feedback necessary to start and maintain oscillation. The circuit's repetition rate (frequency) depends on the transistors' characteristics, on the component values, and on the supply voltage. If desired, the npn and pnp devices may be interchanged, provided all other dc polarities *(C1,* LED, and *B1)* are reversed.

You can use this circuit as a simple flasher or as a visual timer or metronome, by making one of the frequency determining components variable (such as *R1*).

While the exact component values will vary with the transistors' characteristics and the supply voltage, good starting values for circuits using small general-purpose transistors are shown at Fig. 3A. Generally, the larger the feedback capacitor*(C1)* and the base bias resistor*(R1)*, the lower the flashing rate, and vice versa.

An alternate flashing action is provided by the collector-coupled multivibrator circuit given in Fig. 3B. This is an especially good circuit for use in toys, with the LED's serving, say, as the flashing eyes of a clown or similar character. Although pnp devices are shown, npn types may be used simply by reversing all dc polarities. With a given pair of transistors and a fixed supply voltage, the circuit's repetition rate is determined by the values chosen for *C1*, *R1*, *C2* and *R2*. The greater the R-C time constant, the lower the flashing rate.

The circuits described are but a small sampling of those which can be developed using LED's. All were bench-tested using inexpensive 1.6-volt, 50 mA red devices.

Perhaps the most interesting of the new LED devices is the RLC-200 series introduced recently by Litronix, Inc. (19000 Homestead Road, Vallco Park, Cupertino, CA 95014). These devices feature an internal current-regulator IC, permitting their use with 4.5 to 16 volts, without an external current limiting resistor.

Reader's Circuit. The "Wail/Whoop" siren generator circuit given in Fig. 4 offers interesting possibilities whether or not you operate an emergency vehicle. If you're a student, you might consider its use as part of a Science Fair project. If you're part of a rock group or involved in amateur theatricals, it could prove useful for special sound effects. It should make a fine alarm source for an intrusion or burglar detection system. And even if you're not involved in any of these, it's worth tackling.

Submitted by reader Max W. Hauser (1712 Francisco St., Berkeley, CA 94703), the generator features a pair of readily available IC's and is designed for operation on a standard 12-volt dc power source. Max writes that he designed and built the system a little over a year ago.

In operation, a voltage-controlled oscillator, *IC2*, serves as the basic signal source. Its mode of operation is established by selector switch *S2*, while its instantaneous frequency is determined by the voltage applied to its control terminal (pin 5).

With *S2* in the WAIL position, *IC2*'s frequency is controlled by a ramp voltage developed by a network consisting of *R10, C4,* and *C11.* As *S1* is depressed and released, *C4* charges and discharges, changing the control voltage applied to *IC2* and causing a corresponding change in frequency, first rising, then dropping in pitch.

When *S2* is switched to its WHOOP position, *IC2* is controlled by a low-frequency sine wave developed by op amp *IC1A*, connected as a modified Wien bridge oscillator (C1, R4, C2 and R7). The frequency determining feedback bridge develops a signal of about 5 Hz, establishing the cyclic whoop rate.

The characteristic triangular output of *IC2* is shaped into an approximate sine wave by a second op amp, *IC1B,* serving as a nonlinear buffer amplifier. Feedback diodes *D3* and *D4*, in conjunction with shunt resistor *R17*, determine the final output waveform

Max has specified standard components in his design. If preferred, individual type 741 op amps may be used for IC1A and IC1B in place of the 558. All diodes are general purpose types. Except for *C1* and *C2*, which should be either Mylar or polystyrene types and the 15-volt electrolytics, all other capacitors may be either low-voltage ceramic or conventional paper units. Switch *S1* is a momentary contact, NO, spst pushbutton switch, and *S2* is a spdt toggle, slide or rotary switch.

Parts layout and lead dress should not be overly critical as long as good wiring practice is observed and all signal-carrying leads are kept short and direct. Either a suitable etched circuit board, perf board, or point-to-point wiring techniques may be used for duplicating the design. After assembly, checking and preliminary test, *R17*'s value may be changed for an optimum sine-wave output signal. Max indicates that this is the only critical component in his circuit, and suggests that some builders may prefer to substitute a 100,000-ohm trimmer potentiometer for the 56,000-ohm fixed value unit to insure ease of final adjustment.

According to Max, the "Wail/Whoop" generator delivers an output signal of approximate 1 volt, p-p. This is adequate to drive any standard audio amplifier/loudspeaker system. If preferred, of course, a separate power amplifier may be provided just for the generator. In his tests, Max found that a 1-watt commercial modular amplifier supplied an output level quite satisfactory for his applications.

Device/Product News. Every now and again, yours truly is taken to task by an irate reader or manufacturer (not to

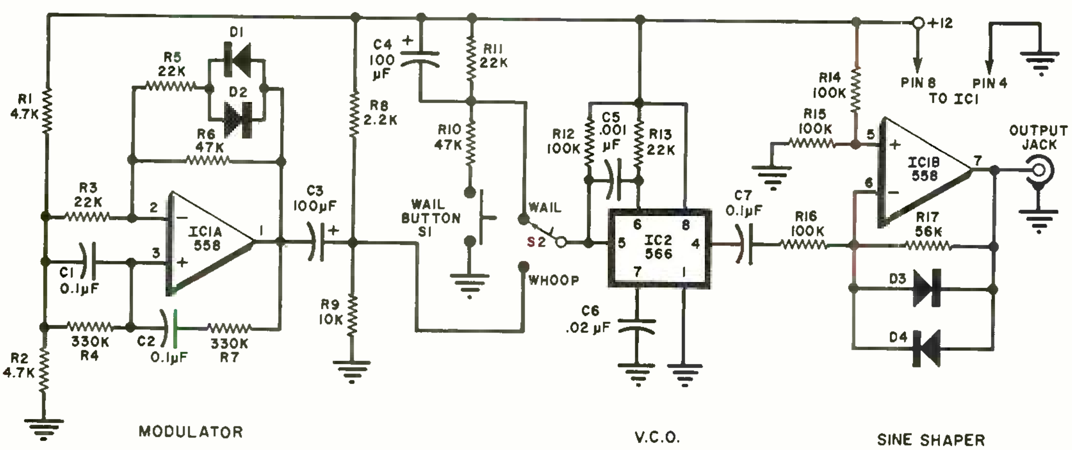

Fig. 4. Wail/Whoop generator circuit uses just two IC's Output is about 1 V.

mention our Editorial Director) for failing to mention a specific new device. Unfortunately, so many new solid-state devices, products and related components are introduced in any given month that it would be impossible to cover them all in the space available, even if the column were doubled in length and devoted entirely to brief discussions of new products. Quite often, a new device of spectacular interest must be omitted simply because it is too costly for average use (would you believe over $300.00 for a single IC?), too complex to describe adequately in a few paragraphs, or is offered only to OEM's (original equipment manufacturers) who purchase in large quantities. My goal, generally, is to offer a representative sampling of new products covering as broad a range as is feasible to insure touching upon (nearly) everyone's special interests. Our featured selections this month, for example, include both discrete and IC devices suitable for linear and digital applications.

From Texas Instruments, Inc. (P.O. Box 5012, M/S 308, Dallas, Texas, 75222), comes news of four new silicon power transistors and several interesting new IC's.

Offered in two series, TI's new power transistors are npn devices. Designated the TIP63, TIP64 Series, and the TIP65, TIP66 Series, these new units are available in TO-66 and TO-3 plastic packages respectively.

Featuring V_{ceo} breakdown voltages ranging from 300 to 350 volts and a continuous power dissipation of 20 watts at 25°C case temperature, the TIP63 and TIP64 series are high-voltage, medium-power units designed for both industrial and consumer applications. The TIP65 and TIP66 Series are horizontal TV deflection transistors designed for line-operated CRT deflection circuits; the units feature 1200- and 1400-volt C-E off-state voltage ratings, 1.5-ampere rated collector current, and fast switching with a typical fall time of 0.7 μs at 1 ampere.

Designated types SN76701, SN76702, SN76710, and SN76711, TI's new IC's are designed for varactor tuned TV applications. All four units are supplied in 16-pin plastic DIP's. The SN76711 is a logic control circuit for 16-channel systems, the SN76710 a similar device for 14-channel applications. Types SN76701 and SN76702 are analog voltage switches. In practice, one SN76701, one SN76711, and three SN76702 devices, used together, could form a complete 16-channel TV electronic tuning system.

Suggesting that it is suitable for use in oscillators, switching regulators, series regulators, converters, and inverters, RCA (Solid State Division, Box 3200, Somerville, NJ 08876) has announced a new epitaxial-base npn silicon transistor designed especially for use in high-current, high-speed switching circuits. Identified as type 2N6500, the unit is rated for a V_{ceo} of 120 volts and a continuous collector current of 4 amperes, with a total saturated switching time of less than 1 μs. It is supplied in a TO-66 package.

If you're working with digital designs, there's good news this month from your friends at Motorola, Inc., Semiconductor Products Division (P.O. Box 20924, Phoenix, AZ 85036). Not only have the boys from Phoenix introduced three new MECL 10,000 IC's, but they've announced substantial price cuts on many of the standard items in the line, with some reductions ranging up to 45 percent. The new MECL 10,000 devices include the MC10153L quad latch (negative clock), the MC10178L binary counter, and the MC10212L high-speed dual 2-NOR/1-OR gate. All three devices are supplied in 16-pin ceramic DIP's. ◈

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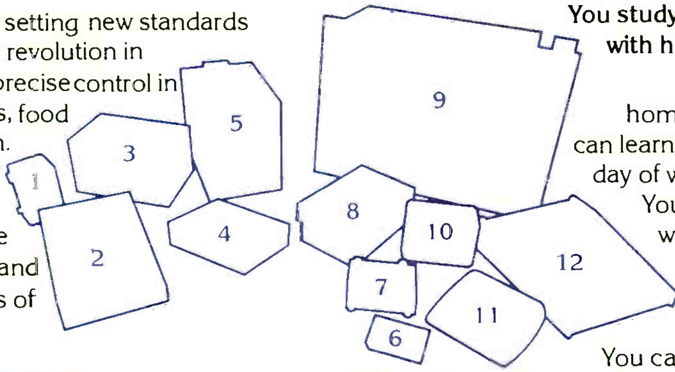

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MAC'S SERVICE SHOP

Electronic Geriatrics

By John T. Frye, W9EGV, KHD4167

BARNEY, returning from lunch, held the door of the service shop open for a frail, stooped man making a shuffling exit. The latter thanked him with a tired smile and then turned around creakily in the doorway to say in the cracked voice of age, "Do the best you can, Mac. I'll expect no miracles. That little set's pretty old—but then so am I!" The old man's lips were still curled in a sardonic smile as he turned around and left.

"It must be tough, getting old," Barney mused as he plugged in his soldering iron.

"Yep," Mac agreed, starting to remove the back of the small portable TV set the last customer had brought in. "Age takes its toll of both men and electronic gear. Did you ever stop to think that you and I are, in a way, in the electronic geriatrics field?"

"Come again?"

"Geriatrics is that branch of medicine dealing with the problems and diseases of old age and aging people. Here in the shop we're concerned with the problems and component failures that occur in aging electronic equipment. Much of our work, like that of the doctor, is concerned with diagnosis; and, like him, we employ a wide variety of techniques to pinpoint the cause of the symptoms our 'patients' display."

Black Boxes and Surgery. "Both the doctor and the technician often employ the 'black-box' approach. The doctor introduces various drugs and dyes into his patient and then traces their course through the body with X-ray or other means and measures the quantity and quality of these substances showing up at the various body outputs. From this, he deduces the level of functioning of various body organs. We do the same thing and call it 'signal injection' and 'signal tracing.' If we cannot pinpoint the difficulty with this black-box method, both of us resort to exploratory surgery.

"Yes, every day you and I perform surgery—some minor and some radical—there on the bench. The surgeon removes obstructing gallstones, kidney stones, emboli, and intestinal masses. We seek out and correct open circuits that block current flow. Doctors give a transfusion of whole blood to anemic patients. We give an electron transfusion by replacing a depleted battery. The doctor is likely to give a 'shot' of cortisone into a sore and inflamed joint. We give a 'shot' of contact cleaner from an aerosol can to smooth out an erratic control or tuner. We, too, perform 'transplants' that are sometimes rejected. Any technician who has substituted for an unobtainable exact duplicate power transformer and has seen the replacement start to smoke and has smelled the unmistakable odor of scorched insulation and shellac knows exactly what I mean."

"Yeah," Barney interrupted, getting into the metaphorical spirit, "and don't forget our patients also need proper nutrition and exercise. Try feeding 60-hertz equipment on 25 hertz, and you've got electronic dyspepsia no Alka-Seltzer will cure; or let a hi-fi or TV set sit around idle in a damp basement for a few months, and it is ready for a trip here to our hospital."

Factors Hastening Aging. "Several factors hasten the aging process of electronic equipment," Mac said. "You've just mentioned dampness which, accompanied by dust, invites arcs in high-voltage circuits, arcs that soon form a carbonized path to bleed away current and overload high-voltage rectifiers and flyback transformers and lead to the breakdown of these components. Heat is another aging element. It melts the seals on capacitors, allowing moisture to enter and cause these units to have a high dc leakage. Heat raises the ambient temperature of transformers, resistors, transistors, IC's, and other components above their rated temperature and contributes to their premature failure. Heat also has a bad effect on many pc boards, rendering them brittle and causing them to warp and crack and break the printed conductors etched in them.

"Incidentally," he said, tossing a plastic slide rule over to Barney, "here's a *Circuit & Conductor Calculator* put out by the G.T. Schjeldahl (pronounced 'Shell Doll') Company of Northfield, Minnesota. With it you can calculate the temperature rise above 20° C. ambient for various currents through an etched conductor of a given thickness and a given width. You can also determine the ohms/1000 ft for a conductor of that width and thickness. Schjeldahl, a major manufacturer of flexible printed circuits such as those used under the dashboards of modern cars, is giving these calculators away free, as long as they last, to people who write for them on company letterheads. Hey, why are you grinning like a Chessie cat?"

"I was just thinking you hadn't mentioned the thing that ages electronic equipment faster than anything else I know; namely, kids! How many times do we get TV sets or hi-fi's in here in which the little monsters have run pencils through both speaker grilles and cones? How many times have we fished pennies, bobby pins, bubble gum, and crayons out from under stuck turntables? We both know how hard kids are on TV tuners and tonearms. They spin the former like a roulette wheel and wrestle with the latter when it is trying to go through its change cycle. I'm trying to forget the TV sets that come in with the knobs broken off or lost, the transistor radios that have been dropped into the bathtub or the ocean, and the tape recorders that have had Cokes spilled through their innards. Some of the things kids do to abuse electronic equipment is enough to make a strong man cry."

"Spoken like a confirmed bachelor!" Mac said, smiling. "However, I've got to admit I've noticed a tremendous difference in how long radios, TV sets, hi-fi's, and tape recorders last in different households; and the homes in which electronic equipment seems to need a minimum of service are invariably those in which there are no children or ones in which the parents have the small-fry under firm control. But let's change to a more pleasant subject. Suppose we try to write a prescription for long life of electronic gear."

Prescription for Long Life. "Operate the equipment from a proper power source. When operating on ac, that means making sure both the frequency and the voltage are as specified. When operating on dc, that means making sure you use the proper batteries *properly installed*. And when the equipment is not going to be used for a while, get those batteries out of there, no matter how 'leak-proof' they are claimed to be. What we see here in the shop reveals the danger of placing too much blind faith in that claim.

"Protect the equipment from temperature extremes. That means not leaving it on the dash or on the deck behind the rear seat of a closed car sitting in the sun, not locating it near a heat register or radiator or above a cookstove or oven, not failing to see it has ample ventilation when operating, and not placing it directly in the recurrent blasts of cold air from an adjacent air conditioner. Rapid temperature cycling is possibly even harder on electronic equipment than is a sustained elevation of temperature.

"Treat electronic apparatus gently. Just because the impact-resistant case of your transistor radio does not break when you drop it doesn't mean the radio has not suffered 'internal injuries.' Such a jar often breaks the speaker loose from its moorings or the tuning capacitor loose from the pc board. The board itself may be cracked by the violent flexing resulting from the jar. In this case, the bright edges of the conductor fracture may maintain current flow across the break for a few weeks until those edges become oxidized; then the radio 'just quits playing for no reason at all.' Finally, don't let children abuse electronic equipment. Teach them to change TV channels gently, to let the automatic record changer do its thing without interference, and to shut the equipment off when they are not paying attention to it."

"Leaving the TV set down for a week or so when it conks out may get the point across to the rambunctious kids," Barney suggested. "Let 'em miss a few episodes of Bat Man."

"Now let's not get carried away," Mac demurred. "After all, *we* have to make a living, and the Supreme Court has handed down decisions against cruel and inhuman punishment. There's one more thing: if you want to keep your TV set or hi-fi from having a 'stroke,' it's still an excellent idea to pull the line plugs during a thunderstorm. A nearby bolt can induce a surge of voltage into the power lines that can leap across the open on-off switch contacts and do all kinds of havoc before you hear the thunder clap."

"We *are* extending the potential life of electronic equipment, though," Barney pointed out. "Using solid state cuts down on the damaging heat such equipment produces internally. Transistors and IC's, properly protected from overloads and transients, have a very long life—so long, in fact, that it has never been measured accurately. Solid-state components are much more resistant to mechanical damage than are tubes. And you, with your long gray beard, know much better than I the improvements that have extended the life of other electronic components."

"Thanks a bunch for that 'long gray beard' crack," Mac replied. "You're right, though, in that no Johnnie-come-lately in electronics can fully appreciate the accuracy and reliability engineered into modern resistors, capacitors, coils, and transformers. I still remember those triple-section 8 μf wet electrolytic capacitors the size of a large fruit can that, after the little black nipple of an expansion seal had rotted, spilled electrolyte all over your bench every time you turned the chassis on edge. The first 'dry' electrolytics were not much better. The essential electrolytic moisture readily evaporated from the square or rectangular paraffin-coated cardboard cases and left the capacitors really dry—and useless. Heat quickly melted the sealing wax from the ends of cardboard cases of paper tubular capacitors and let in the moisture. To get away from this, some manufacturers potted paper units in tar and placed them in metal cases riveted or bolted to the chassis. For a period we had metal-cased paper capacitors and cardboard cased electrolytics!

"Resistors were not nearly so accurate, reliable, and compact as the ones we have today. Carbon units were all about two inches long and 3/16" in diameter, with no insulation. With age, they made great excursions in resistance. The only way you could get stability in resistance was to go to wirewound units. Candohm made metal-encased, wirewound bleeder resistors that were riveted to the chassis to provide heat-sinking. This was better in theory than in practice, in my experience. After a radio containing these resistors was out a couple of years or so, most of the sections of the bleeder resistor were bridged with individual wirewound units."

"I'd like to throw in just one more thing," Barney said.

"Shoot."

"I've always heard that a doctor who treats himself has a fool for a doctor and a fool for a patient. That goes, doubled in spades, for the fellow who tries to repair modern complicated electronic circuitry without the necessary knowledge and equipment. Nothing can shorten the life of a color TV set faster than some heavy-handed homebrew servicing." ◈

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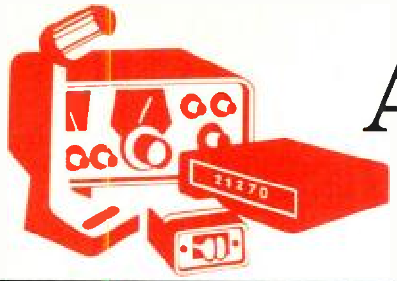


Amateur Radio

By Herber S. Brier, W9EGQ

GETTING STARTED IN AMATEUR RADIO

BY INTERNATIONAL agreement, Amateur Radio is a noncommercial radiocommunications service used by over 600,000 licensed persons around the world (over 250,000 in the United States). They are interested in radio techniques, intercommunications, and technical investigations from strictly a personal viewpoint and without pecuniary interest. Amateurs (otherwise known as hams) operate their own radio stations on over a dozen bands of frequencies in the radio spectrum from 1700 kHz into the gigahertz region. International amateur communications must be in plain language and are limited to technical remarks relating to tests or to personal information too unimportant to be sent by commercial facilities. Communications on behalf of third parties are strictly forbidden.

These restrictions may be modified by agreements between individual governments, however. The United States, for example, has agreements with Canada, Israel, Jordan, Liberia, and virtually all South and Central American countries to permit their amateurs to handle unimportant third-party essages and emergency traffic relating directly to the safety of life and property. The third-party messages are often in the form of "phone patches," which are conversations carried on interconnecting telephone lines and the radio equipment. In addition, the United States and about 43 other countries have reciprocally agreed to allow amateurs to operate in each other's territories.

In the United States, the Federal Communications Commission issues amateur licenses in five classes. The lowest class is the 2-year, nonrenewable Novice license, which requires passing a 5-wpm code test and a written examination on elementary radio theory and regulations. It authorizes code operation with a 75-watt transmitter in segments of the 3.5-, 7-, 21-, and 28 MHz amateur bands. The highest class is the 5-year, renewable Extra license which requires a 20-wpm code test and a very comprehensive written test. All citizens and resident aliens who have filed their intention to become citizens are eligible to apply for the license. The Novice license is issued by mail and is free of charge; but all other amateur licenses are issued for a $9.00 fee (which may go to $10.00 soon).

Rather than review here the mechanical steps necessary to apply for a license, we suggest that you obtain a copy of *The Radio Amateur's License Manual*, which is $1.00 from the American Radio Relay League, Inc. (ARRL), Newington, CT 06111. It may also be bought in many stores that sell amateur equipment. The Manual contains the complete text of the FCC regulations, complete instructions for applying for any class of license, and study guides to preparing for the required examinations.

Other publications valuable to the prospective amateur are *How to Become a Radio Amateur* ($1.00 from ARRL); *The Radio Amateur's Handbook*, ($4.50 from ARRL); and *Radio Handbook*, 19th edition, by William I. Orr, W6SAI, which is $14.95 and can be obtained from Radio Publications, Inc., Box 149, Wilton, CT 06897, or from most equipment dealers.

Except for specifying the technical standards that signals must meet and the frequencies for each class, the FCC regulations require only that U.S. amateur transmissions must not be commercial, secret, profane, or cause unnecessary interference to other stations or services. Also, emergency communications relating directly to safety of life and property have priority over all other communications.

On the Air. Most amateurs start their careers with a Novice license so that they can get "on the air" with a minimum of effort and expense and enjoy their hobby while studying for a higher class. Some, however, who are particularly allergic to the code, prefer to try for a Technician class license. This, like the Novice license, is available by mail and requires passing a 5-wpm code test. However, it has a written examination of the same scope at the General class and authorizes all amateur privileges on the amateur frequencies above 50.1 MHz, except between 144 and 145 MHz.

On the other hand, many Novices soon discover that code or CW operation has a peculiar fascination of its own. They also have so much fun working each other, exchanging QSL (confirmation) cards, ragchewing, and making new friends that they frequently neglect to study for a new license until their Novice ticket is about to expire. Surprisingly, there is not as much difference between what interests the amateur newcomer and the higher class (license-wise) old-timer as you might think. Of course, the latter may have acquired a little more operating skill and more equipment, but most of them are still interested in ragchewing about every subject under the sun—and DX chasing.

At first glance, the above evaluation of the interests of the average amateur seems to dispute their reputation as being leaders in pushing back the frontiers of electronics. Not at all! We still have the same numbers of dedicated experimenters that we always had. They are transmitting and receiving slow-scan TV picture in the low-frequency phone bands, launching communications satellites that extend the range of low-power vhf stations to other continents, and carrying out other activities that will influence communications in the future.

No-Code 220-MHz Phone. As long as amateur operator licenses have been issued in the United States, a proficiency in Morse code had been a prerequisite. Although international

King Hussein (WJ1) of Jordan is a famous amateur radio operator.

regulations have waived the code requirement for operation above 144 MHz for decades, the FCC has strongly resisted any suggestions that the U.S. join other countries in issuing code-free, amateur vhf licenses. However, in an all-day meeting last May between officials of the Amateur and Citizens Radio bureau or the FCC and the ARRL, the FCC revealed that it is considering the establishment of a new 220-MHz "Communicator" class license, with a written examination covering elementary phone theory and amateur regulations, but no code test!

There are already 43 petitions to modify the amateur licensing structure on file with the Commission; and they will have to be considered when it holds formal hearings on the matter. So don't look for a no-code license to appear tomorrow. Government processes just don't move that fast. Incidentally, one of the other petitions on file advocates the reduction of the General class code speed requirement to 10 wpm, as it was in 1931.

New Logging and Call-Letter Rules Effective July 10, the FCC revised section 97.103 of the amateur regulations. Logs of fixed and portable amateur stations are now required to show only locations and dates of any operations, signatures of visiting control operators, and copies of third-party traffic. Mobile stations do not have to log contacts, but repeater-station logging requirements have not been modified. In announcing the more liberal logging rules, the FCC pointed out that, although it is no longer a legal requirement, a detailed station log is valuable in the event a station is accused of some rule violation.

In Docket 20092, the FCC has proposed that, by paying the $25.00 special call-letter fee, any Extra class operator may request any currently unassigned set of call letters, including a "2-letter" call, in his area—but only one "2-letter" call to a customer, even if he has more than one amateur stations. In the same docket, special *in-memoriam* call letters (for example, a special call letter assigned to a club in honor of a deceased member) will be eliminated. Interested parties have until Oct. 9 to file comments on docket 20092 (16 copies) and until Oct. 24 to file replies.

Coming events. Two of U.S. amateurs' biggest annual contests will occur in a few weeks: the CQ World-Wide DX Contest and the ARRL Sweepstakes. The rules summarized below are sufficient for casual participation, but we suggest you request the complete rules and score sheets from the sponsors if you intend to enter into serious competition. Include a legal-size, stamped (20¢), self-addressed return envelop with your request. The World-Wide DX Contest will run from 0000 GMT, Saturday, to 2400 GMT, Sunday; by phone on Oct. 25 and 26, and CW, Nov. 22 and 23. Use any amateur bands to work as many DX stations and zones as possible, exchanging signal reports and zone number with each station worked. (A zone map is included with the rules and entry forms.) Each station may be worked only once per band. Total score is computed by multiplying the total number of contacts (points) by the total of zones and countries worked. Enquiries and entries should be sent to: CQ WW DX Contest, 14 Vanderventer Ave., Port Washington, N.Y. 11050.

The ARRL Sweepstakes will take place from 1500 GMT, Saturday, to 0300 GMT, Monday, for CW on Nov. 2-4 and for phone on Nov. 16-18. Exchange "message preambles" with each station worked: contact number; precedence (A, if power under 200 watts; B, if over 200 watts); call letters; check (last two digits of year licensed); place (ARRL section). Each station may be worked only once per band. Total score is the number of contact points multiplied by number of ARRL sections worked. A section map is included with the SS package; and they are also listed in the front of each issue of *QST* magazine. Suggested frequencies: 3.55-3.65, 7.05-7.1, 14.05-14.1, 21.05-21.1, 28.05-28.1 and 3.85-3.95, 7.225-7.275, 14.25-14.3, 21.3-21.4, 28.6-28.8 MHz. Novices must remain in Novice bands. The address is Sweepstakes, ARRL, Newington, CT 06111.

The ARRL 160-meter contest will probably be held December 6-8; the 10-meter contest on Dec. 14-15. Then comes *CQ*'s 160-meter contest on Jan. 25-26, 1975, though we have not received official notice of these.

Signoff. The is the first of a new series of quarterly feature columns on Amateur Radio in Popular Electronics. Your comments will be most welcome. ◈

Test Equipment Scene

By Leslie Solomon

A DMM TURNED FREQUENCY COUNTER

DIGITAL multimeters (DMM's) are finding their way on to an ever-increasing number of test benches as more and more electronics servicemen and hobbyists come to appreciate the advantages of the unambiguous digital readout. Another digital test instrument that is equally useful on the test bench is the frequency counter. Unfortunately, you don't see as many of these around since, if an economic factor is involved, most people will choose a DMM first.

At this point, we would like to introduce you to a circuit that, when added to the front end of your DMM, will turn it into a frequency counter. It won't have all of the advantages of a good commercial frequency counter; but in building and using it, you will learn a lot about analog and digital processing.

In building the circuit shown, we used components that we had on hand or that are readily available from surplus dealers. Essentially, the input op amp squares up the signal and drives a monostable multivibrator. When the multivibrator is triggered, the constant-amplitude, fixed-width output pulses are summed in an op amp rectifier that produces a dc output proportional to the frequency of the input.

A 709 was used as the input squarer simply because we had it on hand. A 741 could be used, but its upper frequency is limited. The front-end circuit of a frequency counter (FET and Schmitt trigger) could be used instead of the 709. Actually all that is needed is a decent input impedance and the capability of squaring up the input to whatever frequency is desired.

The width of the output pulse of the 74121 multivibrator is determined by a selectable time constant. For example, when measuring low audio frequencies, you can start with a 0.1-µF capacitor and a 5000-ohm potentiometer. As you go up in frequency, drop the value of the capacitor in decade steps but use the same value of potentiometer. Incidentally, the circuit shown was used to cover the audio range from a few Hz to about 100 kHz. The values can be changed to reach almost any other frequency within reason.

The 741 output op amp is an integrator that accumulates the pulses and delivers a dc voltage proportional to the number of pulses received. This is then measured on the 2-volt dc range of the DMM.

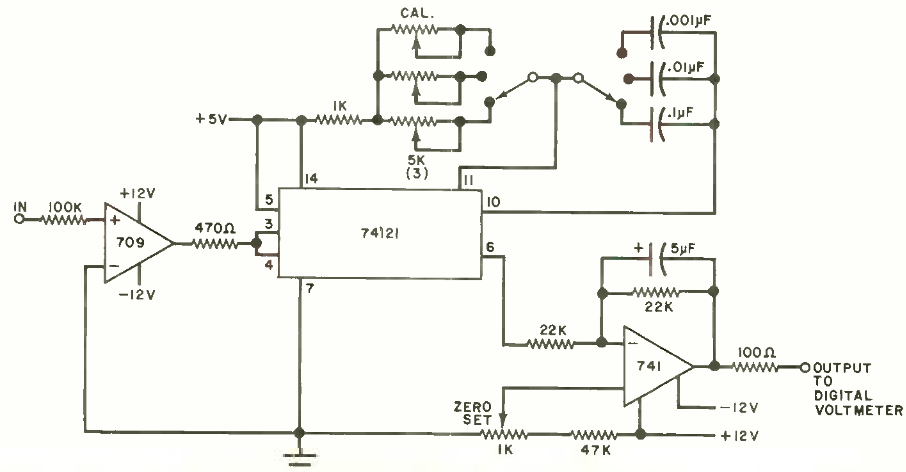
Setting up the circuit is simple. Short the 709 input to ground and adjust the zero-set potentiometer (on the 741 input) until the DMM indicates zero. It will be possible to adjust this control from some small negative voltage, through zero, to some small positive voltage. Once set, this control does not have to be adjusted for any other range, except for some slight drift in the 741 circuit with time.

Using 0.1 µF as the timing capacitor, set the input frequency to 1 kHz. Then adjust the calibrate potentiometer associated with that capacitor until the meter indicates 0.100 (assuming the DMM has a 3½-digit capability). Now as the input frequency is varied, the DMM will display the frequency, except for the decimal point.

Keep in mind that this is not a construction project, but is meant only to introduce you to frequency counting at low cost. A conventional dc voltmeter can be used as the output indicator; and, in conjunction with a decent audio generator, the meter scale can be calibrated for frequency. Once you discover how useful it is to be able to measure frequencies, you will wonder how you can get along without this piece of test equipment. (Incidentally, now that you know how to make a frequency-to-dc converter, give some thought to making a dc-to-frequency converter so that you could use a frequency counter as a dc voltmeter.)

LCD Readouts. Liquid-crystal displays (in wristwatches, DMM's, etc.) are of two types: those that appear as non-mirrors on a mirror background and field-effect displays that appear as dark elements on a light background. Unfortunately, neither of these can be seen in the dark—although there have been some suggestions that tiny incandescent lamps could be used. On the other hand, the LED display is good in the dark but gets "washed out" in daylight.

Recently, we had the pleasure of seeing a new type of display. It is a tritium-powered backlighted field-effect liquid crystal that appears as conventional dark digits on a light background in daylight, but is backlighted with a soft green glow (due to the tritium) in the dark. Developed by D. Gene O'Quinn, this soft green glow is not the result of afterglow due to exposure to bright light (as with watch dials) but comes from the tritium itself. The amount of radioactivity is very slight, and should power the readout for many years. The most likely first use will be in wristwatches with other applications to follow. ◈



Hobby Scene

Where to get Parts

In answer to many letters, here are some addresses of suppliers of semiconductors (and other components). The hobby enthusiast should have a collection of their catalogs for locating parts for projects.

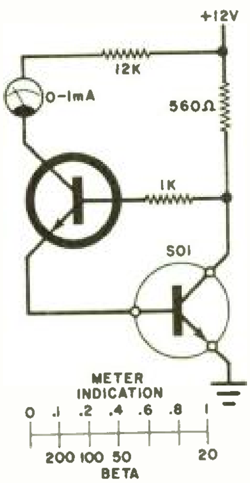
First, the larger mail order houses, some of whom also have retail stores in large cities: GC Electronics (Calectro), 400 S. Wyman St., Rockford, IL 61101; Radio Shack, 2617 W. 7th St., Fort Worth, TX 75107; Allied Electronics Corp., 2400 W. Washington Blvd., Chicago, Il 60612; Burnstein-Applebee, Dept. PE, 3199 Mercier St., Kansas City, MO 64111; Lafayette Radio Electronics, P. O. Box 10, Dept. 35014, Syosset, NY 11791; Olson Electronics, Dept. IQ, 260 S. Forge St., Akron, OH 44327.

Others, perhaps not as large but excellent sources of semiconductors, where you may find hard-to-get IC's and other special items, are: Solid State Systems, Inc., P. O. Box 617, Columbia, MO 65201; Altaj Electronics, P. O. Box 28592, Dallas, TX 75228; Poly Paks, P. O. Box 942E, Lynnfield, MA 01940; Solid State Sales, P. O. Box 74A Somerville, MA 02143; Tracy Design Corp., 15870 Schaefer, Detroit, MI 48227; Digi-Key, P. O. Box 126, Thief River, MN 56701; Delta Electronics Co., P. O. Box 1, Lynn, MA 01903; Babylon Electronics, P. O. Box J, Carmichael, CA 95608.

Checking Transistor Beta

Q. ***I know there are many transistor checkers around, but what I am looking for is a cheap way to determine beta. Is there a really simple way?***

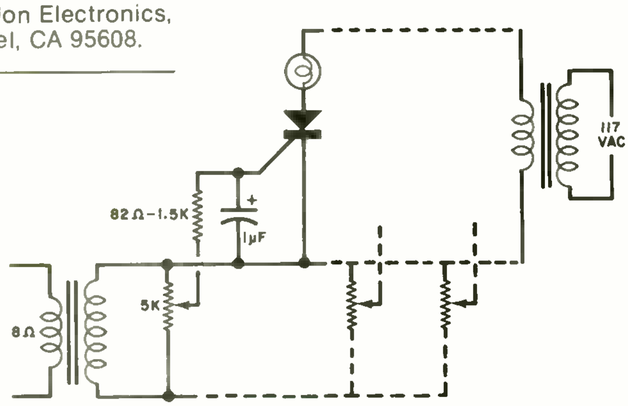
A. Try this circuit for npn transistors. When you plug an unknown transistor into the socket (*SO1*), the circuit will automatically stabilize its collector current at 20 mA. Read the value of beta on the meter using the conversion scaling. For pnp's, be sure to use a pnp to source the current, and use −12 volts for V_{cc}. Almost any transistor can be used as the current source.



Simple Color Organ Circuit

Q. ***Although you have published many circuits for color organs in the past, I never built one because they were either too complicated or I didn't need one at the moment. Now, I thought I would like to try experimenting with the idea. What simple, basic circuit could I start with to build a color organ?***

A. A basic (reduced to the minimum) color organ circuit is shown here. The reversed transformer takes the speaker output from an audio system and drives the SCR's. Gain is adjusted by the potentiometers. You can try various filters in the gate lead of each SCR or just vary the value of the resistor in series with the potentiometer arm. Be sure to use an isolating transformer for safety. Select the lamps and the transformer to match the rating of the SCR's.



Electronics Library

THE NEW WORLD OF ELECTRONIC MUSIC

by Walter Sear

Explained in this book are the fundamentals of acoustics, electricity, magnetism, sound recording, electronic sound generators, filters and amplifiers as a background for a practical description of electronic music, and the equipment that is used in creating the "new" music. This book is a broad outline guide for the music student, musician, and serious music listener with an interest in both electronically and acoustically generated music. The book is non-electronic in nature, but it contains much useful information on the electronic music medium for electronics hobbyists who want o get started in a new area of experimentation.

Published by Alfred Publishers, 75 Channel Dr., Port Washington, NY 11050. Soft cover, 131 pages. $4.95.

BASIC PRINCIPLES OF DIGITAL COMPUTERS

By Vester Robinson

This book is devoted to developing an understanding of the basic principles upon which computers and other digital equipment are based. It starts with a broad view of the whole computer field and then goes on to individual topics, such as mathematics, circuits, logic, and functional components. Finally, it assembles these topics to form a whole system, analyzes the system in some detail, and develops the principles of programming. Not only are binary, octal, decimal, and hexadecimal systems explained, but conversions among them are also illustrated. Each chapter ends with review exercises, answers for which are given at the back of the book.

Published by Reston Publishing Co., Inc., P.O. Box 547, Reston, VA 22090, Hard cover. 422 pages. $13.95.

LINEAR CIRCUITS FOR ELECTRONICS TECHNOLOGY

by Gary M. Miller

Practical up-to-date material on the electronic circuits used in communication systems includes power supplies, all types of amplifiers, oscillators, and new IC's. The use of complicated equivalent circuits is minimized in the discussions; instead, practical approximations allow complex amplifiers to be fully understood while yielding accurate results. Power supplies are covered early in the book so that the reader can better understand their effects on the circuits subsequently studied. A survey of communication systems is also included. The math level prerequisite does not include calculus.

Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 332 pages. $13.95

TRANSISTOR CIRCUIT APPROXIMATIONS, Second Edition

by Dr. A.P. Malvino

This is a revision of an already successful textbook that covers the fundamentals of transistor circuit analysis. Featuring an 'ideal transistor" approach, the text utilizes approximations of the most significant aspects of transistor action. Four new chapters—dealing with FET's, special diodes, latching devices, and optoelectronic devices—have been added to this new edition. More problems appear at the end of each chapter as well. The book is suited for students in community colleges, 4-year colleges, technical institutes, and industrial training programs. Algebra and basic electricity are the prerequisites.

Published by McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020. Hard cover, 512 pages. $10.95.

HANDBOOK OF IC CIRCUIT PROJECTS

by Jim Ashe

This new book tells how to use those low-cost IC's you have been reading about in practical, simple projects that were once too complicated or expensive to be of general appeal. The book presents 33 projects in eight broad categories. The categories cover a wide range of interests: hobby electronics, hi-fi, automotive, SWL'ing, amateur radio, science and electronics, and linear and digital testing. The book leads off with an introduction to the IC and ends with three appendices that cover the device and IC's used in the projects, IC literature for the amateur, and IC suppliers.

Published by Tab Books, Blue Ridge Summit, PA 17214, 224 pages, $7.95 hard cover; $4.95 soft cover.

BEYOND SHORTWAVE

This new booklet from the Worldwide TV-FM DX Association (WTFDA) is an introduction to the world of DX'ing above 30 MHz. It starts off with propagation basics, then proceeds to separate chapters devoted to TV, FM, uhf, and vhf radio. The text is illustrated and includes information on such topics as meteor scatter reception, choosing DX equipment, photographing TV-DX, improving FM reception, and listening to "private" uhf and vhf communications.

Published by WTDFA, P.O. Box 163, Deerfield IL 60015. Soft cover. 32 pages. $1.00.

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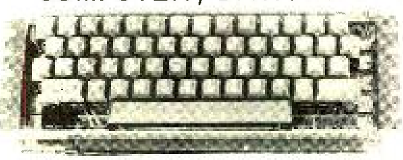

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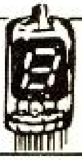

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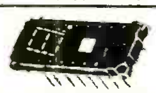

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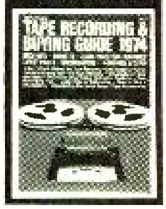

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