Electronics World

MAY, 1968
60 CENTS

TUNING & DAMPING BASS-REFLEX ENCLOSURES

COMMUNICATIONS VIA TOUCH • THE CO_2 LASER

BATTERY-POWERED CARS: Fact or Fantasy

EXTREMELY HIGH VOLTAGE D. C. POWER TRANSMISSION

New Solid-State COLOR-BAR GENERATORS

E-V 1122 30-watt stereo amplifier
$94.00

E-V 1159 FM/stereo tuner
$94.00

E-V 1180 30-watt FM/stereo receiver
$176.00

Sorry! We've just shot the bottom out of stereo prices!

We think we're about to explode the current notions about how much high fidelity should cost (or—more accurately—how little).

First, we resisted the temptation to take any shortcuts in the development of these new components . . . unless you count our computer, used to design new circuits in a fraction of the time needed by ordinary methods.

And we kept each component simple and easy to use, yet complete. Not that we stuck to just plain vanilla. You'll find thoughtful touches like an accurate zero-center FM tuning meter and combination balance control/stereo-mono switch included, for instance.

Finally, we knew that quality had to start high—and stay high. That's why we built spanking-new facilities, staffed with skilled craftsmen, and provided them with the most modern production equipment . . . an inspired combination.

The result? A new 30-watt stereo amplifier and a sensitive FM/stereo tuner, each priced well under $100.00. and the E-V 1180 receiver that combines these two components for even greater savings—just $176.00. Each built in the U.S.A. and each one warranted free from defects in materials and workmanship for two years. A warranty we'll back to the hilt.*

Listen to these exciting new components soon . . . now at most leading independent high fidelity showrooms. Critically compare them and you'll find that our bargains offer you more in the bargain!

*We don't expect much need for warranty service—but we're ready. Once the unit arrives at our factory or authorized service station, any defects we discover are repaired or replaced with no charge for parts, labor, or return transportation. Other repairs at nominal cost. Fair enough?

Electro-Voice®

A SUBSIDIARY OF GULTON INDUSTRIES, INC.

high fidelity speakers and systems • tuners, amplifiers, receivers • public address loudspeakers • microphones • phonograph needles and cartridges • organs • space and defense electronics

CIRCLE NO. 114 ON READER SERVICE CARD

ELECTRO-VOICE, INC., Dept. 584N
629 Cecil Street, Buchanan, Michigan 49091

Please send free literature on Electro-Voice high fidelity electronics and speakers.

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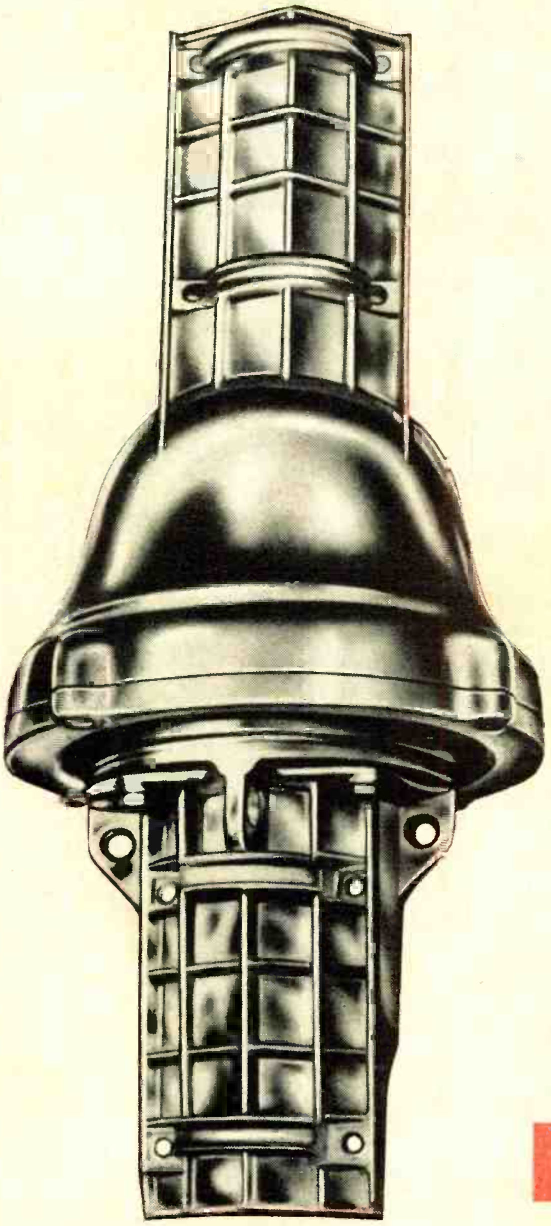
Never ask a lightweight rotor to do a heavyweight's job.



Selling your customer a lightweight rotor when he has a large antenna array just doesn't make sense. Especially since you can offer him an alternative: the heavy-duty "Bell Series" rotor, from CDE.

Available in both automatic and manual forms, this rotor is designed specifically for large, heavy antenna arrays... designed specifically for unmatched fringe-area reception... designed to give your customers the finest color TV reception possible. In fact, this is the *only* heavy-duty rotor available.

We call it the Bell Series because of its completely weatherproof, die-cast aluminum housing. You'll call it rugged because it has 4 to 5 times the stalling and braking torque of any other rotor! This means *any* antenna will turn, even under the most adverse weather conditions... and that your customers will get terrific color or black and white reception despite high winds or heavy icing. Great FM reception too!

The Bell Series rotor: one-of-a-kind built for one-of-a-kind performance!

CDE CORNELL-DUBILIER

CIRCLE NO. 117 ON READER SERVICE CARD

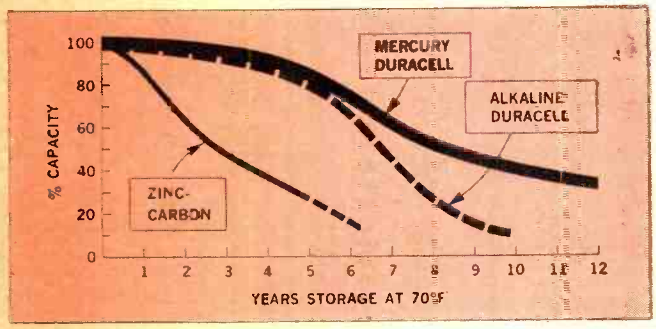
MALLORY Tips for Technicians

Tips on selling batteries

Just about every customer who walks into your shop, or whom you see on a service call, is a prospect for batteries. You can get yourself more sales and profits from battery business, by recommending Mercury Duracell® and Alkaline Duracell batteries—the *different* high energy batteries made by Mallory.

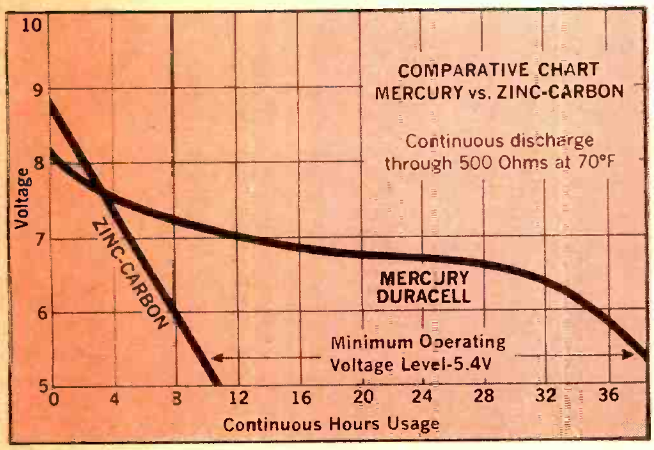
Here are some facts about batteries that can help you trade customers up to today's best values in portable power.

Which batteries are best for transistor radios? At the relatively low drain service in most radios, Mercury Duracell batteries are generally the best buy. They actually cost about 15% less per hour of service than ordinary zinc-carbon types. And they give you better listening; their output voltage stays constant throughout life, so you don't drop into the high distortion part of the transistor characteristic. Next best are Alkaline Duracell batteries. Both Duracell types have the further advantage of extremely long shelf life—no appreciable drop in power even after two years. So they can sit idle in a radio instead of dying even when not used, like ordinary batteries.



How about cameras? For the electric eye devices which automatically adjust exposure, there's nothing like Mercury Duracell batteries. They last over a year, and produce highly accurate voltage required for this job. For built-in flash and for electric drive of movie cameras, Alkaline Duracell batteries are far superior to ordinary types. They drive 4 to 5 times more movie footage, and fire about three times more flashes.

What's good for tape recorders? Motor drive is a fairly heavy drain job . . . ideal for Alkaline Duracell batteries. These outlast zinc-carbon by 2 to 5 times in portable recorders.



Flashlights? Toys? For ordinary flashlight duty, the old zinc-carbon is hard to beat. But if you're apt to use a light continuously for long periods, Alkaline Duracell batteries can give steady lighting for up to 10 times longer than zinc-carbon. And they're much safer for emergency use, because they don't die in a few months on the shelf. Toys are real high drain duty; here Alkaline Duracell batteries are a real bargain, for they outlast zinc-carbon types by 5 to 8 times.

Sell your customer on the greater value of Duracell batteries, and you'll make twice as much profit per sale. Get the story on the new Mallory battery merchandise displays from your nearby Mallory distributor. Or write Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM *"What else needs fixing?"*

CIRCLE NO. 104 ON READER SERVICE CARD

THIS MONTH'S COVER is related to our lead story on the new solid-state color-bar generators. The RCA 14-in portable color-TV receiver is displaying a normal color-bar pattern from one of the generators. The small unit atop the set is the B & K Model 1242; the larger one is Sencore's CG-141. At the extreme left, the top generator is the Hickok GC 660; the bottom one is the RCA WR-502A. In front of the TV set, the top generator is the Leader LCG-387; the bottom one is the Knight KG-685. At the right of the receiver, the upper unit is the Amphenol Model 865; while the lower generator is the Conar 680. For complete technical details and prices on these and other color-bar generators, see the table in our lead story . . . . Photograph by Dirone-Denver.

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Electronics World

MAY 1968 VOL. 79, No. 5

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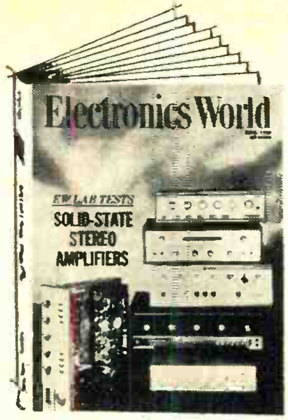
Electronics World: Published monthly by Ziff-Davis Publishing Company at 307 North Michigan Ave., Chicago, Illinois 60601. One year subscription $6.00. Second Class Postage paid at Chicago, Illinois and at additional mailing offices. Subscription service and Forms 3579: Portland Place, Boulder, Colorado 80302.

COMING NEXT MONTH



SPECIAL FEATURE ARTICLE: EW LAB TESTS HI-FI AMPLIFIERS

Hear those sharp, snapping clicks of the castanets as the flamenco dancer whirls through his feruca? You'll be able to understand why you do. . . . or don't when you read next month's feature article on the new **solid-state stereo amplifiers**. Most of the popular models, in finished and kit form, will be covered. A large, easy-to-read table, which lists complete up-to-date specifications, test results, as well as cost, is included for use by the hi-fi buff and the "sometimes" listener. Get the very best—in components and information—by checking this story.

ELECTRONIC IMPLANTS
Survival of the "not so fit" is possible because medical electronic instruments are making it so. Electronic implants have become part of some people's everyday lives. They gather, measure, and transmit physiological information for external evaluation and control.

TRADE SECRETS: THE COURTS AND YOU
Scientific and technical personnel on the move from one job to another should stop, take a good look, and see if they're protecting their own rights and those of their former employer. An increasing number of employees and their corporate employers are being sued over so-called "privileged" information.

1968 FM-STEREO CAR RADIOS
Servicing those new FM receivers in the 1968 model cars is not as difficult as you think. This round-up article covers the FM-stereo units made by Bendix, Delco, and Motorola. It discusses their similarities and their differences and gives technicians some helpful service hints.

EARLY WARNING SYSTEMS FOR EARTHQUAKES
Seismographs help locate the source of an earthquake too late to help those in danger. Many scientists are using newly developed equipment and techniques to forecast earth tremors. Some of their methods and equipment are discussed.

All these and many more interesting and informative articles will be yours in the June issue of ELECTRONICS WORLD . . . on sale May 16th.

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CIRCULATION OFFICE
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EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however publisher assumes no responsibility for return or safety of art work, photographs, or manuscripts.

ELECTRONICS WORLD (May, 1968, Vol. 79, No. 5). Published monthly at 307 North Michigan Avenue, Chicago, Illinois 60601, by Ziff-Davis Publishing Company—also the publishers of Airline Management and Marketing, Boating, Business & Commercial Aviation, Car and Driver, Cycle, Flying, HiFi/Stereo Review, Modern Bride, Popular Electronics, Popular Photography, Skiing, Skiing Area News, and Skiing Trade News. (Travel Weekly is published by Robinson Publications, Inc., a subsidiary of Ziff-Davis Publishing Company.) One year subscription rate for U.S., U.S. Possessions, and Canada, $6.00; all other countries, $7.00. Second Class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash.

By FOREST H. BELT /Contributing Editor

Certified Electronic Technicians

There's a new catch-phrase and title around the television repair industry. It is *Certified Electronic Technician*, and don't be surprised if you begin seeing proud technicians who have qualified for the title putting *CET* after their names on business cards and in advertising.

The title sprang up as a part of a program instituted by the National Electronic Association (NEA) to certify that its members were qualified to service television receivers. The idea behind the program is to convince the American consumer that competent technicians are available. Set owners complain of poor servicing ability among technicians they call for repairs; a CET has proven his technical know-how through a closely monitored examination, and NEA plans to point this out to set owners through a national publicity campaign.

The idea has worked out so successfully in its early runs that the NEA quickly expanded it to include all service technicians who have four or more years of training and experience; membership in NEA is not required. Anyone interested in taking the examination may contact NEA Certification Program, 5302 W. 10th Street, Indianapolis, Indiana 46224. The exam is given (preferably in groups) by an NEA member in the locality, and there is a $5 charge. If the examinee flunks, he may brush up and take the exam again without additional charge. Each technician who passes is awarded a framed certificate and a wallet card, and is assigned a serial number in his state of residence. The newspapers and radio-TV stations in his town are notified of his certification, along with an explanation of what certification signifies.

Thus far, only 19 states have Certified Electronic Technicians. Indiana has the most, Kentucky is second, with California, Iowa, and Michigan running a near-tie third. Other states with CET's are Connecticut, Georgia, Illinois, Kansas, Minnesota, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Texas, and Washington. NEA certification is an excellent example of an industry effort to improve the image of television servicing by concrete proof of qualification instead of empty claims.

Diagnostic Clinics for TV Sets

Something unusual in television servicing has quietly begun to happen. TV owners in some cities can take their TV receivers—black-and-white or color—to a diagnostic clinic. There, neatly uniformed technicians run a whole series of tests that reveal the operating condition of practically every critical circuit in the set. The owner is given a detailed report of what's wrong, and an estimate of the cost to repair. If the cost seems too high, the customer is free to take the set somewhere else for service, paying the clinic only a basic diagnostic fee. Prices for repairs are not cut-rate, but are reasonable in the opinion of most customers, very few take their repairs elsewhere.

A young engineer named Royce Evans first put the idea into practice, in Fort Wayne, Indiana. He owned an ordinary TV service shop and wanted to make it profitable. What he came up with was the diagnostic-clinic idea and a "sure-fire" way to diagnose troubles throughout the entire TV set. He formed a company, *Tele-Quick Corporation*, and is now franchising his special Diagnostic Centers all over the country. So far, Centers are operating in Fort Wayne, Ind.; Indianapolis; Nashville, Tenn.; Clearwater, Fla.; and Gulfport, Miss. Others are opening soon in Baltimore, Denver, and Southern California. This is a good idea that will no doubt be copied—both well and poorly—as the Centers begin to spread.

Integrated Circuit in a TV Tuner

It was inevitable, although not expected this soon. Nevertheless, *Oak Manufacturing Co.* (division of *Oak Electro/Netics Corp.*) has built a v.h.f. tuner that uses a thick-film (hybrid) integrated circuit. The IC itself is inside a tiny matchbox-size module that fits neatly on top of the mechanical-tuning/frequency determining assembly that is familiar in present tuners. Over-all performance is electronically comparable to other modern tuners, and price will be about the same or only slightly higher.

The IC module is a sealed unit. It contains 3 transistors, 10 resistors, and 15 capacitors (some integrated, some chip) to form a complete r.f. amplifier-oscillator-mixer combination. Asked about serviceability, *Oak* officials pointed out that the IC module—which will net for about $3—could be replaced in the customer's home. If the alignment screws of the tuner are not tampered with, a replacement module can be inserted and connected without upsetting tuner alignment.

In the models to be offered soonest, the IC module is combined with another innovation: printed-circuit inductors that are part of the switching assembly. Together, the two offer exceptional stability of adjustment; once aligned, these tuners stay aligned.

In another new design, *Oak* has combined u.h.f. and v.h.f. tuning into a single solid-state tuner. Although the company has been experimenting with varactor-tuned u/v tuners (this column, February 1968, page 23. "Radio-TV Tuned with Potentiometer"), the newest one is still mechanically tuned, but in a special way. Unorthodox switching allows using the same variable elements for u.h.f. and v.h.f. tuning. R.f. amplification is included in both u.h.f. and v.h.f. operation, and the noise figure at u.h.f. is lower than in previous tuners. Probably the most significant achievement, from the standpoint of the set owner, is the capability for detented u.h.f.; a special mechanism provides 12 pre-set v.h.f. channels and 12 selectable pre-set u.h.f. channels.

Speaking of varactor-tuned TV tuners, we've learned that *Standard-Kollsman* has one, but technical details haven't been made available to us as yet.

High Voltage Without X-Rays

The worst generator of color-TV x-rays is the high-voltage regulator tube, with the high-voltage rectifier running a distant second. One cure already tried is a method of regulation that is part of the horizontal deflection system; at least it eliminates the shunt-type regulator tube.

Another step has been taken with a solid-state high-voltage rectifier system developed by *Varo, Inc.* of Garland, Texas. Used in a voltage-multiplier circuit—also from *Varo*—special rectifiers develop both the CRT high voltage and the focus voltage. The chief objective is an all-solid-state color-TV, but the no-x-ray bonus is welcome, coming on the heels of all the adverse newspaper and broadcast publicity about x-rays from color sets.

Others have developed solid-state rectifiers that withstand the high inverse voltages found in flyback-developed high-voltage systems, but prices have been too high. A new fast-recovery diffused silicon device, with the voltage-multiplier circuit, is expected to be cheaper than the equivalent tubes. Now, a solid-state picture display is all that stands between the industry and an all-solid-state TV set. Some such displays are in the works, but brightness is still too low.

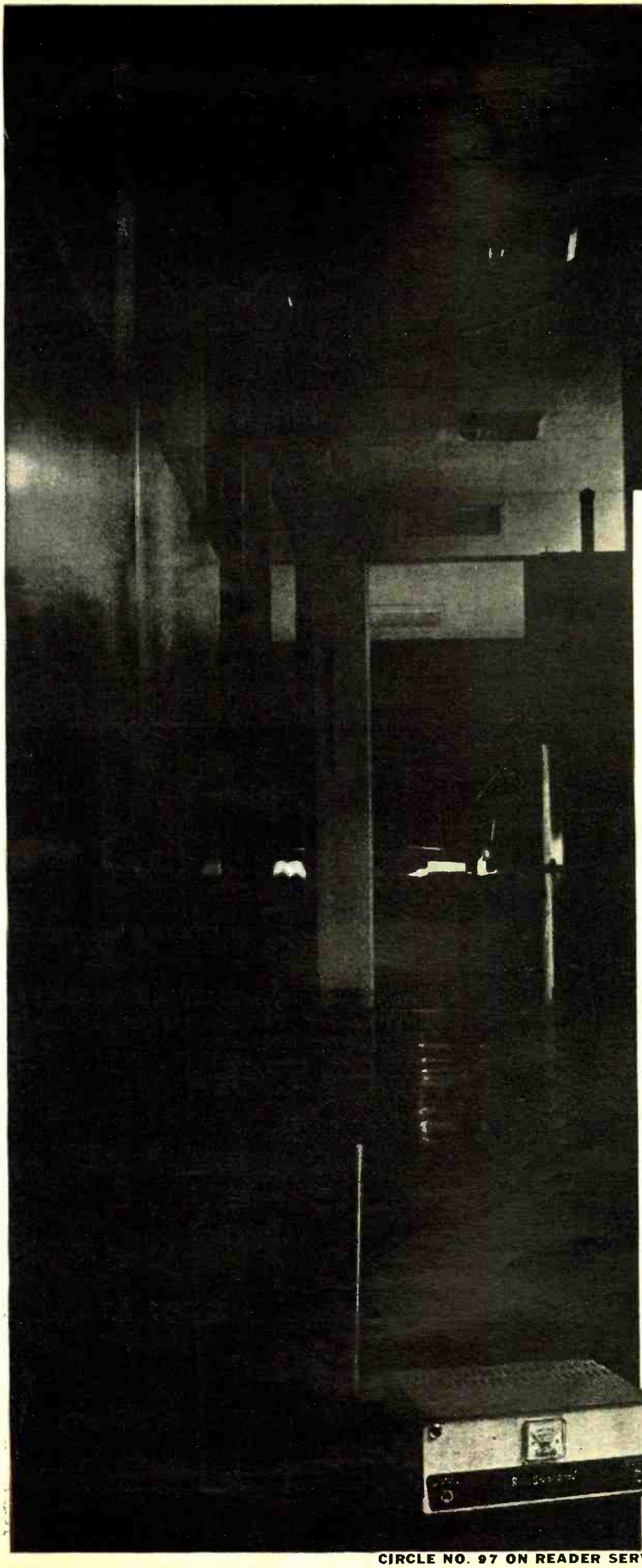
X-Radiation Measurement

The U. S. Public Health Service finally let the industry get a closer look at the instrument it was using to make the controversial x-ray measurements in Florida and in Washington, D.C. The unit uses six Geiger-Mueller tubes, arranged in two rows. The chief advantage is sensitivity. The tubes cover about 240 square inches and can get a usable indication quicker than the *Victoreen* instrument that has been the industry standard. At 5 cm from the surface of a TV receiver, the PHS instrument can detect levels of radiation as little as 0.05 mR/hr—only a tenth of the maximum limit for color-TV receivers set by the National Center for Radiological Health (NCRH).

In another development, Victor P. Bond, M.D., PhD., associate director of Brookhaven National Lab, and chairman of the Radiation Bio-Effects Advisory Committee of NCRH, says the probability of harmful effects from color-TV x-radiation is (in his words to *Television Digest*) "vanishingly small". This supports our contention (this column, February 1968, page 23, "Chasing X-Rays", and April 1968, page 13, "The X-Ray Credibility Gap") that there has been little to worry about all along from the soft x-rays emitted by color sets. Bond says, and many of his radiologist colleagues in the American College of Radiology support him, that even with a markedly defective receiver and prolonged exposure at very close range, there is no likelihood of any significant or even detectable medical effects, either genetic (passed along to offspring) or somatic (affecting the exposed individual).

Flashes in the Big Picture

ITT has a one-gun, one-phosphor CRT that produces different colors from mere changes in beam current. Problems remain before it can be used for color-TV, but it is a step. . . . Balance of payments concern is likely to affect import sales this year. No tariff restrictions expected, so soon after being relaxed, but publicity about b-o-p problems may influence retail buyers. . . . Declining interest rates in money market may reflect at retail level soon. Could give mid-year assist to consumer electronics sales . . . Remember new *Westinghouse* on-screen color-TV tuning aid? *Matsushita* offers similar one, using green stripe on screen, which narrows to indicate best tuning. . . . . *Philco-Ford* developed three integrated circuits that together form a complete AM-FM radio; only tuning element need be added. . . . . . By mid-year, one-fourth of TV sets in the U. S. will be color. ▲



WHAT KILLS CRIME WAVES?

MICROWAVES!

NEW RADAR SENTRY ALARMS, THE FLOOR-TO-FLOOR, WALL-TO-WALL, SOLID-STATE BURGLAR TRAP

Thousands of Radar Sentry Alarms protect businesses, homes and institutions from coast to coast. In installation after installation, they've proved their ability to stop crime before it starts. And now there's a new solid-state model that fights crime even more effectively.

How Radar Sentry Alarms Stop Intruders

The Radar Sentry Alarm is simple, yet foolproof. Completely solid state, its main components are a control unit and a remote detector. A very stable oscillator generates microwaves (400 MHz) which are radiated out into the protected area by the remote detector—actually an antenna. Each remote detector saturates a 5,000 square foot area, floor to ceiling. Because the oscillator is connected directly to the antenna, it is very sensitive to changes in load. Any human movement in the area will change the antenna load (small animals will not). This change will be reflected back into the oscillator, changing the frequency by a few Herz. The frequency change is amplified by a series of 8 transistor stages, detected, and used to close the alarm relay.

No burglar can thwart this system. Cutting off the power, sets off the alarm. In case of power failure, the Radar Sentry Alarm automatically switches to built-in rechargeable cadmium battery operation. And, if a burglar tampers with the unit during the day, it sounds a fail-safe alarm.

Radar Sentry Alarms can be used with on-location police-type sirens to frighten off burglars, as a silent alarm with direct connection to police headquarters, or as a fire alarm.

New Solid-State Radar Sentry Alarm

The newest Radar Sentry features solid-state circuitry throughout. It is more sensitive, more reliable, virtually impregnable to false alarms. It is easier to service and maintain, because the heart of its electronics is a single printed-circuit module. If there is a problem, the complete module is simply pulled out, and a new one plugged in. Instant repair; no lapse in security.

Growing crime rate means big business opportunities

In 1968, the crime rate is expected to soar. Businesses, homes, factories and institutions all want protection. The crime boom means a business boom for you.

---Break into the Burglary Business Today---

RADAR DEVICES MFG. CORP.
22003 Harper Avenue, St. Clair Shores, Michigan 48080

Please tell me how I can have a business of my own distributing Radar Sentry Alarm Systems. I understand there is no obligation.

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Address__________

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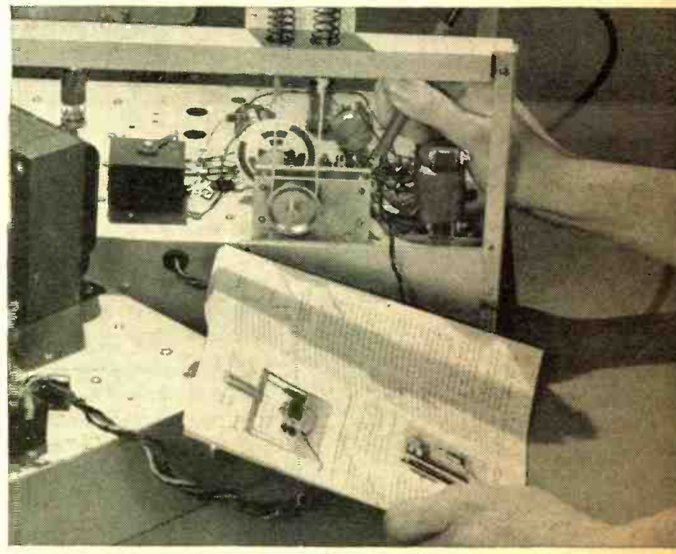
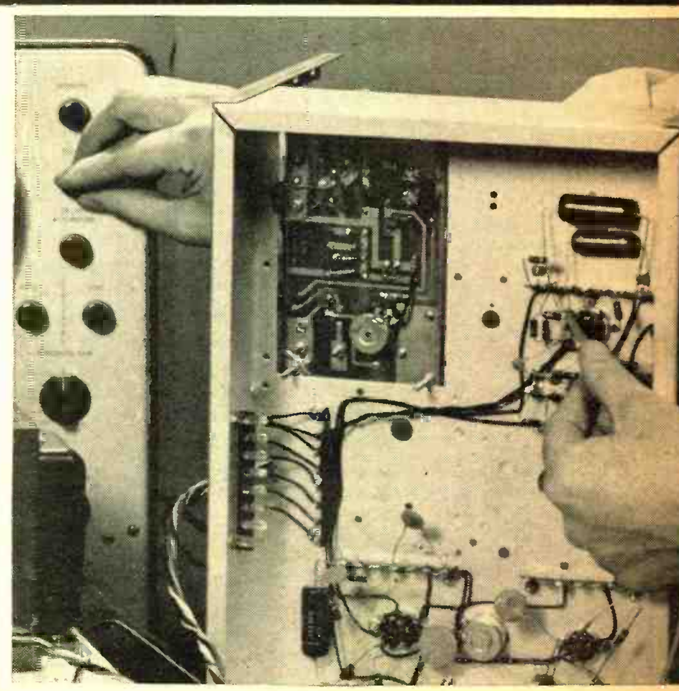
2 NRI "Bite-Size" Lesson Texts Program Your Training

Reading is a necessary part of any training program, but it takes a great deal of stamina to wade through a 300-page technical textbook. Every NRI course is condensed into "bite-size" texts that are simple, direct, well-illustrated, averaging an easily-digested 40 pages. These are "programmed" with NRI training equipment you build, experiments you perform, to bring to life the fundamental laws of electronics, the theory, the training of your choice. You are always kept well supplied with these books, NRI does not require you to "pay as you go."



3 You Get Practical Experience With Actual Electronic Equipment

NRI does not leave the practical side of Electronics to your imagination. Electronics becomes a clear, understandable force under *your* control as you build, experiment, explore, discover. NRI pioneered the concept of home-lab training equipment to give you 3-Dimensional knowledge and experience. Every kit is designed by NRI to demonstrate principles you must know and understand. Kits contain the most modern parts, including solid state devices. NRI invites comparison with equipment offered by any other school, at any price. Prove to yourself what nearly a million NRI students could tell you . . . that you get more for your money from NRI. Mail postage-free card for your NRI Color Catalog. No obligation. No salesman will call.



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19 Bands of mood and special-situation music...

11 Bands of unusual, hard-to-find sound effects...

MADE WITH PHOTOGRAPHERS IN MIND

Photographers are travelers . . . are parents . . . are sportsmen . . . are restless experimenters with the unusual. And so the editors of POPULAR PHOTOGRAPHY have produced this second volume of unusual music and sound effects expressly to match the activities and moods in the most popular types of pictures shown in slide and home movie shows. These are melodies and sounds selected from the vast resources of the Capitol Record Hollywood Library to fit the special needs of photographers. The 30 bands of "Sound For A Picture Evening, Vol. II" supplement but do not duplicate any of those in the first edition of this popular record.

A POPULAR PHOTOGRAPHY EXCLUSIVE

The "Sound For A Picture Evening, Vol. II" album has been produced by the editors of POPULAR PHOTOGRAPHY exclusively for our readers and is prepared by the Custom Services Division of Capitol Records. This outstanding album, which cannot be purchased in any store, is available by mail only to the readers of Popular Photography and other Ziff-Davis magazines.

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There are 19 bands of mood and special-situation music . . . 11 bands of unusual, hard-to-find sound effects.

MOODS: Majestic, Backyard Nature, Experimental, Mysterious, Music of the Spheres • NATIONAL PORTRAITS: Vive la France, German Village Band, Soul of Spain, American West, English Countryside, Buon Giorno, Italia •

SOUND EFFECTS: Bass Drum, Bassoonery, Cathedral Bells, Galloping Horses, Zoo Noises, Children at Play, Cocktail Party, Birds on a Spring Morning, Outboard Motor, Oars in Water, Skis on Snow, Trumpet Fanfare, Solo Violin • SPECIAL PURPOSE MUSIC: Music From Silent Movies, Music for Slow-Motion Movies, Music for Speeded-Up Motion, Music for Stop-Motion Movies, Underwater Music, Music for Old-Time Footage.

For photographers with wanderlust, you'll find the "National Portraits" to be authentic melodies to go with your vacation pictures of England, France, Germany, Italy, Spain and the American West.

There are also those special bands to accompany the kind of pictures sportsmen take: The sound of galloping horses, of boat motors, of skis on snow, of oars in the water. You'll even find other-worldly mood-music chosen especially to go with underwater pictures.

Experimental photographers will find the electronic music ideal accompaniment for abstract pictures. The music for stop-motion, slow-motion and speeded-up-motion pictures is fanciful and imaginative in helping to present the unusual scenes being portrayed on your screen. And there is even mood music to convey the visual grandeur of ancient museum relics and photographs of the stars and planets.

To these add many other tracks of carefully selected music and sounds—and you have "Sound For A Picture Evening, Volume II."

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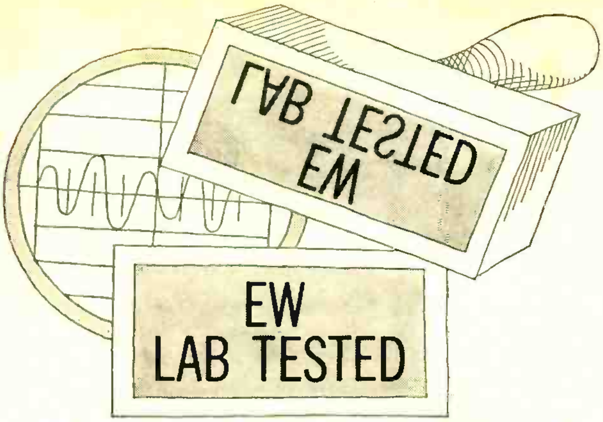


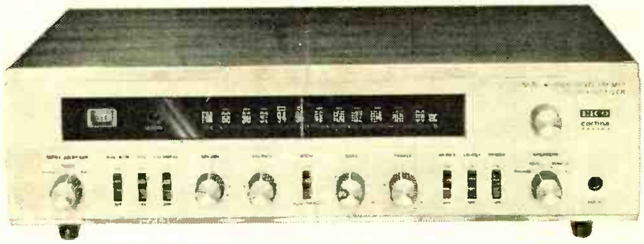
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Eico 3570 "Cortina" Stereo Receiver
BSR TD-1020 Tape Deck/Preamp

Eico 3570 "Cortina" Stereo Receiver

For copy of manufacturer's brochure, circle No. 30 on Reader Service Card.



WHEN we reported on the *Eico* "Cortina" stereo amplifier in the December, 1967 issue, we commented on its compactness, attractive styling, and high-quality performance at a modest price. Another component of the "Cortina" series is the 3200 FM-stereo tuner, similar in size, style, and price to the 3070 amplifier. (See our report in the March, 1968 issue.) Both units have been combined into a single-chassis integrated receiver, the Model 3570, which is the subject of this report.

Since the Model 3570 is literally a "3200 plus a 3070", our comments and test results for the receiver apply equally well to the individual components, and *vice versa*. The only shared portions of the receiver are the chassis and power supply; the circuit boards are the same ones used in the separate tuner and amplifier.

The Model 3570 is an all-silicon solid-state receiver, measuring a compact 4⅝" high × 15¾" wide × 9½" deep. It is one of the most compact receivers we have seen. The total audio output is rated at 30 watts continuous into 8-ohm loads, or 50 watts IHF dynamic-power output. Into 4-ohm loads, the output is 40% greater, and into 16 ohms it is slightly more than half the power available into 8 ohms.

The receiver is highly flexible, with a full complement of control functions. In addition to the volume and balance controls and the tone controls, it has high- and low-cut filters, switchable loudness compensation, a front-panel headphone jack, and an output selector for operating either or both of two pairs of speakers. The speakers can be cut off entirely for headphone listening. There are inputs for tuner, phono, and a high-level "Aux" source. A separate tape-monitor switch allows monitoring from a three-head tape machine while recording, or simply playing back from any tape deck.

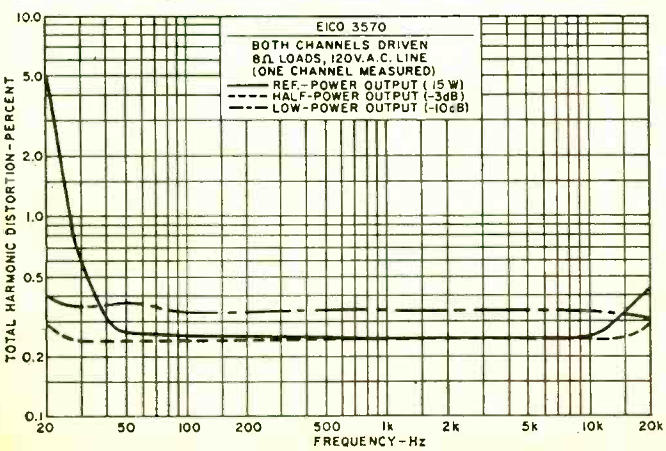
The tuner section has a grounded-base r.f. amplifier, a mixer, and a separate oscillator. Unusual among transistorized tuners is the availability of a.f.c., which is applied to the oscillator through a voltage-variable capacitor. We found the a.f.c. to be unnecessary, due to the excellent stability of the tuner, and it can be switched off if the user prefers.

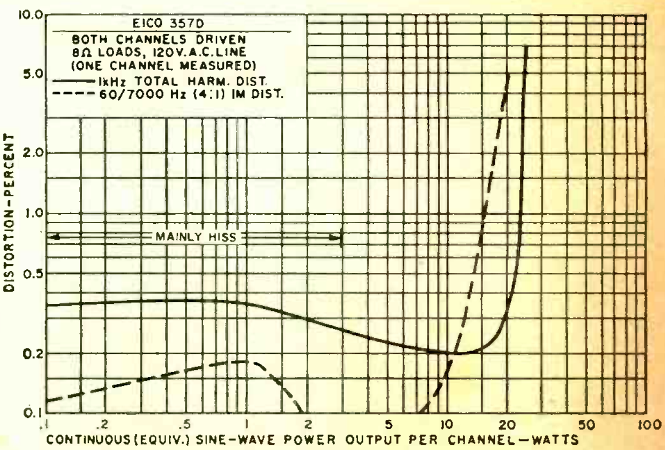
On a separate circuit board is the four-stage i.f. amplifier, with double-tuned transformers, followed by a ratio detector. A separate detector diode, driven by the third i.f. stage, supplies a.g.c. to the first i.f. stage. In a novel application of reflex circuitry, the first i.f. amplifier also acts as a d.c. a.g.c. amplifier. Its emitter current operates the tuning meter, and supplies a.g.c. to the r.f. stage.

Eico uses a simple, yet highly effective multiplex circuit. Following a 67-kHz SCA trap, a single transistor stage separates the 19-kHz pilot carrier from the composite signal. After amplification, the pilot carrier is doubled to provide a 38-kHz carrier for the 4-diode balanced modulator. In this stage, the composite signal is converted to left- and right-channel outputs.

The rectified pilot carrier is amplified in another stage, lighting a bulb in the collector circuit when a stereo broadcast is received. The audio outputs, after deemphasis and filtering to remove 19-kHz and other undesired fre-

(*Continued on page* 81)





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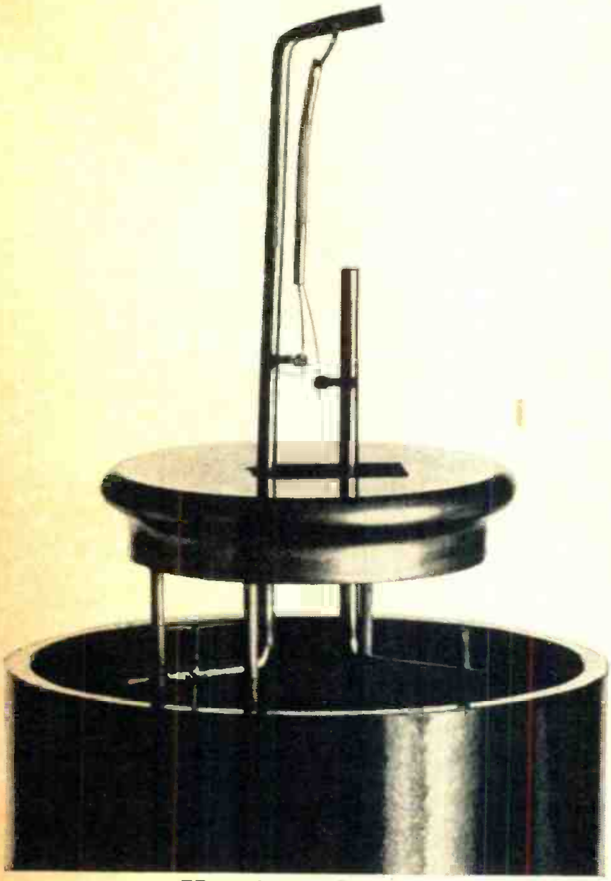
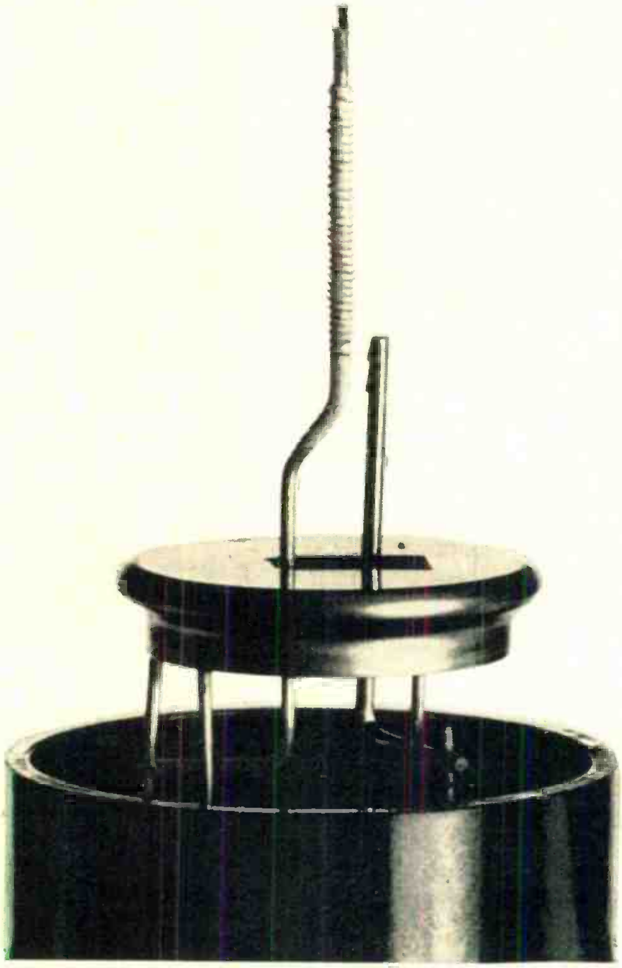


How it used to be.



Our new 3CU3

Take a look at our new "Posted filament" design.

There's no delicately suspended heater-cathode system. There's no need to heat up a metal sleeve and then an oxide coating.

It takes less than a second for the 3CU3 to start rectifying full swing.

In case of a break, there's no way for the 3CU3's filament to fall against the anode, creating a short and knocking out other components in the circuit.

The 3CU3's filament is always perfectly centered. It emits electrons uniformly in every direction. From a much larger surface than in the old design. There's no suspension post in the way to create an "electron shadow" that cuts down the plate current.

The uniform electric field around the rigid support reduces high voltage stresses. Arcing and its resulting troubles are eliminated.

The 3CU3 is interchangeable with 3A3 and 3A3A high voltage rectifiers. And it's made exclusively by Sylvania.

The 3CU3 is just one of a new "posted filament" family which includes the new 3BL2 and 3BM2. They're designed for use in new color TV sets. These tubes are especially good for transistorized TV where their fast warm-up fits in with the "instant on" feature of solid state circuitry.

The new construction has higher reliability and longer life and should give you fewer and less troublesome callbacks.

From the outside you can hardly tell it's changed.

SYLVANIA

GENERAL TELEPHONE & ELECTRONICS

Reflections on the news

If You Missed. . . .

the IEEE show this year, you may be unaware of some new developments. In the past, IEEE has been severely criticized for its handling of the technical sessions, both in quality and convenience to conference attendees. This year the number of sessions was reduced from 72 to 49. Other so-called attractions were added—tutorial courses with textbooks and notes furnished, workshops, display-demonstrations, plays, and film shows. Did this improve the show's technical quality? We think it'll require more effort and reforms than this to give the show the prestige it once had, but this column was written before the meeting and like many others, we're busy looking and listening for reactions.

This year the trend among many of the "Big Boys" to smaller exhibits continues. But the IEEE claimed there were more exhibitors (over 700) this year than last. West Germany and Denmark were added to the list of foreign countries showing. Some of the new products included: aircraft safety equipment by *Marconi Company Ltd.;* function generators and X-Y recorders by *Honeywell;* two new image orthicon tubes for TV cameras by the *Tokyo Shibaura Electric Co., Ltd.* (*Toshiba* engineers claim these tubes have a service life of up to 3000 hours, 600 hours is average); CRT's from *Fairchild-Du Mont;* digital printers from *Victor Comptomatic Corp.;* new versions of microwave equipment were shown by *Gabriel Electronics;* miniature reed relays by *Magnecraft Electric Co.;* and numerous ferrite components, motors, communications, and biomedical electronic equipment from 15 Canadian exhibitors.

The Air Inside. . . .

the new Madison Square Garden was supposed to be the purest anywhere, but the electricians hadn't gotten around to hooking up the air cleaning system by the time Bob Hope opened his USO show in the main arena on February 11th. Consequently, the system which is supposed to keep air fresh, odorless, and contaminate-free, received its big test on March 4th, when Joe Frazier met Buster Mathis for the heavyweight boxing title. Some people thought the air-cleaning system was as big a winner as Frazier.

The system, which is called Cosa/Tron (Control of Secondary Air Electronically), is unlike conventional air conditioners in that it does not "temperature condition". According to the manufacturer, *CRS Industries Inc.*, it is not a filter, collector, or an electrostatic precipitator, but a de-ionizing device which neutralizes the space charge of the secondary air within a room and the primary air entering the room.

The primary air (part outside air and part return air), which represents 1/10th of the air in circulation at any given moment, is passed through a mechanical filter or conventional air conditioner. It is then directed to an assembly which contains a number of electrodes over which the air flows. Static particle charges in the air (air contaminated by cigarettes, internal combustion engines, or industrial systems contain particles which have positive space charges) are neutralized by a pulsed d.c. voltage which varies in frequency from 60 to 300 Hz and amplitudes up to 25 kilovolts. The neutralized air particles combine with the contaminated air within a room to reduce its particle space charge by 70 to 80%.

Madison Square Garden is just one big building, but if air pollution in the cities continues to rise at its present rate, we may find ourselves living in glass-domed enclosures with air cleaned by systems like this.

Computers. . . .

are helping to make personal privacy a luxury we no longer enjoy. The rapid growth of electronic technology has caused us to leave a trail of easily accessible records from the moment of birth to death. Files are maintained by banks, credit services, insurance investigators; and city, county, state, and federal agencies have our school records, property holdings, assessments, licenses—for dogs, businesses, and marriages—as well as our military records, income, and court records. All of this data is being stored in some computer's memory bank.

In an address before the Boston Bar Association's Committee on Automation, Richard I. Miller, a lawyer and management consultant, warned that new techniques in data storage and retrieval have outdistanced laws which control the misuse of "private" information. According to Mr. Miller, "it is no longer a question of whether information about individuals is quickly and inexpensively available, but when, by whom, and under what circumstances". To protect both citizen and country, Miller proposes the following technological and legal controls: (1) cryptographic device for transmission lines carrying personal information; (2) security measures for data storage; (3) regular audits of stored contents; and (4) devices that record who requested information. Legally, he says, the law has to be amended. Agencies or individuals requesting information should be required to tell the person involved what information was obtained and for what reason; public authorities must be prevented from passing personal data to third parties without just cause; and a liability must be established for the dissemination of false information.

Shortly, the Bureau of Census will mail to one-fourth of the U.S. households a 50-question, 20-page questionnaire about such nonessential public knowledge as "Do you own an air conditioner?" "What is the condition of your plumbing?" "Do you share a shower, and if so, with whom?" All of this information will be fed to computers and eventually you might get a form letter from the government asking why you are the way you are. Failure to answer the questions may bring a $100 fine and 60 days in jail. Congressman Jackson Betts of Ohio doesn't like the situation one bit and is trying to introduce a law (HR10942) which would limit the "must answer" questions to essentials such as name and address, sex, date of birth, race, marital status, and number of visitors at the time of the census. Representative Betts thinks that the Census Bureau has overstepped its constitutional authority. If you agree with him, write Representative Jackson Betts, Room 2310, Rayburn House Office Bldg., Washington 20515 and tell him so.

Metallic Moon Dust, . . .

iron, aluminum, and magnesium may make up a considerable portion of the moon's ground cover. This is the theory of Dr. Kuan H. Sun, a scientist at *Westinghouse Research Laboratories* and an authority on the effects of radiation on materials in space. He predicted the existence of metal powders on the moon's surface before the magnet on the Surveyor V spacecraft indicated the presence of magnetic dust.

The metals may prove to be both a help and a problem for future lunar astronauts. They may be able to separate the iron (magnetically) and use it for building purposes, and burn pulverized magnesium and aluminum for fuel and heat. On the other hand, it could be catastrophic. Remember the Apollo space capsule fire that took the lives of Astronauts Grissom, White, and Chaffee a little more than a year ago? Metal powders can burn spontaneously in a pure oxygen atmosphere and astronauts re-entering the Lunar Module will have to be careful not to bring moon dust in with them. Perhaps a super vacuum cleaner should be part of the Apollo equipment.

Tax Dollars for Underseas. . . .

technological development may soon be on a par with the aerospace industry. The first hint of how important future underwater research activity will be was given by President Johnson in his State-of-the-Union message and, more recently, by Senator Hiram Fong of Hawaii. Exactly how much money will be allocated for ocean studies depends, of course, upon events in Viet Nam.

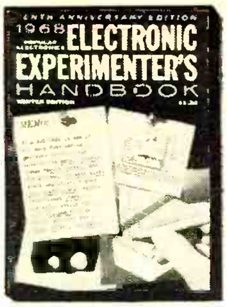
The Environmental Science Services Administration (ESSA) has plans to explore 2500 feet of ocean bottom off the coast of Georgia, South Carolina, and Florida. The Navy Department's Facilities Engineering Command has awarded a contract to the *North American-Rockwell* Ocean Systems Division for feasibility studies and possible construction of one-atmosphere living structures on 600, 2500, and 6000-foot ocean bottoms. *Westinghouse Electric Corp.* is working on the technical details of the oceanographic program.

If only a portion of the projected underwater research and development work is realized, it'll take up much of the anticipated cutback in the space program. In addition, it'll provide a growth area for business investments and a burgeoning labor market for scientists, engineers, and technicians.

An Electric Truck. . . .

of a sort, is being performance-tested by the Army Tank Automotive Command. For a number of years, the Army has pushed electronic vehicle development as a possible solution to one of its most serious logistic problems. In Viet Nam, for example, large numbers of fighting men spend a lot of time trucking up gasoline to other trucks, jeeps, and tanks bogged down on muddy roads.

This truck is not a true electric vehicle because it uses a 302-cubic-inch, six-cylinder gasoline engine to drive an a.c. generator. The generator provides power to six electronically commutated brushless motors mounted at the wheels of the vehicle. Engineers at the *Delco-Remy Division* of *General Motors*, who developed the truck, say that the electric drive system can propel the truck at speeds of 50 miles per hour with a seven-ton load. In its present state of development, the vehicle is more expensive than conventional types, but mileage per gallon is greater. In addition, the electronic control system enables each wheel to be driven individually. Thus it could be a boon for military men, farmers, and construction workers whose trucks often get stuck in mud holes. For the story of new developments in electric commuter-cars, see "Battery-Powered Cars: Fact or Fantasy" on page 39 of this issue. ▲



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How to get into

One of the hottest money-making fields in electronics today—servicing two-way radios!

HE'S FLYING HIGH. Before he got his CIE training and FCC License, Ed Dulaney's only professional skill was as a commercial pilot engaged in crop dusting. Today he has his own two-way radio company, with seven full-time employees. "I am much better off financially, and really enjoy my work," he says. Read here how you can break into this profitable field.

More than 5 million two-way transmitters have skyrocketed the demand for service men and field, system, and R&D engineers. Topnotch licensed experts can earn $12,000 a year or more. You can be your own boss, build your own company. And you don't need a college education to break in.

HOW WOULD YOU LIKE to start collecting your share of the big money being made in electronics today? To start earning $5 to $7 an hour... $200 to $300 a week... $10,000 to $15,000 a year?

Your best bet today, especially if you don't have a college education, is probably in the field of two-way radio.

Two-way radio is booming. Today there are more than *five million* two-way transmitters for police cars, fire department vehicles, taxis, trucks, boats, planes, etc. and Citizen's Band uses—and the number is still growing at the rate of 80,000 new transmitters per month.

This wildfire boom presents a solid gold opportunity for trained two-way radio service experts. Many of them are earning $5,000 to $10,000 a year *more* than the average radio-TV repair man.

Why You'll Earn Top Pay

One reason is that the United States Government doesn't permit anyone to service two-way radio systems unless he is *licensed* by the Federal Communications Commission. And there simply aren't enough licensed electronics experts to go around.

Another reason two-way radio men earn so much more than radio-TV service men is that they are needed more often and more desperately. A home radio or television set may need repair only once every year or two, and there's no real emergency when it does. But a two-way radio user must keep those transmitters operating ~~at all times,~~ and *must* have their frequency modulation and plate power input checked at regular intervals by licensed personnel to meet FCC requirements.

This means that the available licensed experts can "write their own ticket" when it comes to earnings. Some work by the hour and usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses. A more common arrangement is to be paid a monthly retainer fee by each customer. Although rates vary widely, this fixed charge might be $20 a month for the base station and $7.50 for each mobile station. A survey showed that one man can easily maintain at least 100 stations, averaging 15 base stations and 85 mobiles. This would add up to at least $12,000 a year.

Be Your Own Boss

There are other advantages too. You can become your own boss—work entirely by yourself or gradually build your own fully staffed service company. Instead of being chained to a workbench, machine, or desk all day, you'll move around, see lots of action, rub shoulders with important police and fire officials and business executives who depend on two-way radio for their daily operations. You may even be tapped for a big job working for one of the two-way radio manufacturers in field service, factory quality control, or laboratory research and development.

How To Get Started

How do you break into the ranks of the big-money earners in two-way radio? This is probably the best way:

1. Without quitting your present job, learn enough about electronics fundamentals to pass the Government FCC Exam and get your Commercial FCC License.
2. Then get a job in a two-way radio service shop and "learn the ropes" of the business.
3. As soon as you've earned a reputation as an expert, there are several ways you can go. You can move *out* and start signing up and servicing your own customers. You might become a franchised service representative of a big manufacturer and then start getting into two-way radio sales, where one sales contract might net you $5,000. Or you may even be invited to move *up* into a high-prestige salaried job with one of the major manufacturers either in the plant or out in the field.


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The United States of America

Number P1-20-6400

FEDERAL COMMUNICATIONS COMMISSION

RADIO TELEPHONE OPERATOR LICENSE

FIRST CLASS

(General Radiotelephone Certificate)

This certifies that TOMMY WILLIS DUFFY

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PLACE AND DATE OF ISSUANCE: BUFFALO, NEW YORK SEPTEMBER 11, 1963

DATE AND TIME OF EXPIRATION: SEPTEMBER 11, 1968 AT THREE O'CLOCK A. M., EASTERN STANDARD TIME.

SPECIAL ENDORSEMENT: SHIP RADAR ENDORSEMENT - SEPTEMBER 11, 1963 - BUFFALO, NEW YORK

ISSUING OFFICER

Federal Communications Commission

(Licensee) (Secretary)

NOT VALID UNTIL SIGNED

SPECIMEN

THIS COULD BE YOUR "TICKET" TO A GOOD LIVING. You must have a Commercial FCC License to service two-way radios. Two out of three men who take the FCC exam flunk it... but nine out of ten CIE graduates pass it the first time they try!

The first step—mastering the fundamentals of Electronics in your spare time and getting your FCC License—can be easier than you think.

Cleveland Institute of Electronics has been successfully teaching electronics by mail for over thirty years. Right at home, in your spare time, you learn electronics step by step. Our AUTO-PROGRAMMED™ lessons and coaching by expert instructors make everything clear and easy, even for men who thought they were "poor learners." You'll learn not only the fundamentals that apply to all electronics design and servicing, but also the specific procedures for installing, troubleshooting, and maintaining two-way mobile equipment.

Get Your FCC License... or Your Money Back!

By the time you've finished your CIE course, you'll be able to pass the FCC License Exam with ease. Better than nine out of ten CIE-trained men pass the FCC Exam the first time they try, even though two out of three non-CIE men fail. This startling record of achievement makes possible the famous CIE warranty: you'll pass the FCC Exam upon completion of your course or your tuition will be refunded in full.

Ed Dulaney is an outstanding example of the success possible through CIE training. Before he studied with CIE, Dulaney was a crop duster. Today he owns the Dulaney Communications Service, with seven people working for him repairing and manufacturing two-way equipment. Says Dulaney: "I found the CIE training thorough and the lessons easy to understand. No question about it—the CIE course was the best investment I ever made."

Find out more about how to get ahead in all fields of electronics, including two-way radio. Mail the bound-in postpaid reply card for two FREE books, "How To Get A Commercial FCC License" and "How To Succeed In Electronics." If card has been removed, just send us your name and address on a postcard.

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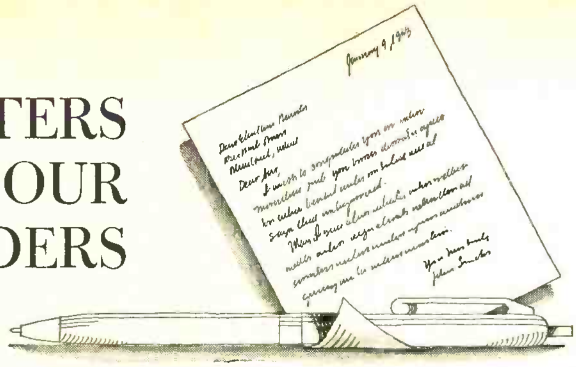


X-RADIATION FROM COLOR SETS

To the Editors:

Your article entitled "Color-TV in the Marketplace" (January, 1968) notes that the recommendation of the National Council on Radiation Protection (NCRP) for television receivers of 0.5 mR/hr at 5 centimeters from any accessible surface is barely above natural background radiation. Natural background is normally in the range of 0.01 to 0.02 mR/hr. Thus, the recommendation of the NCRP is actually 25 to 50 times the level of natural background.

I am also enclosing a copy of the testimony presented by the Director of the National Center for Radiological Health before the Senate Commerce Committee relative to Senate Bill 2067. The testimony documents some of the results obtained by our Electronic Products Radiation Laboratory on color television receivers.

ROBERT L. ELDER, Sc.D.
Asst. to the Center Director
Dept. of Health, Education, and Welfare
Rockville, Md.

* * *

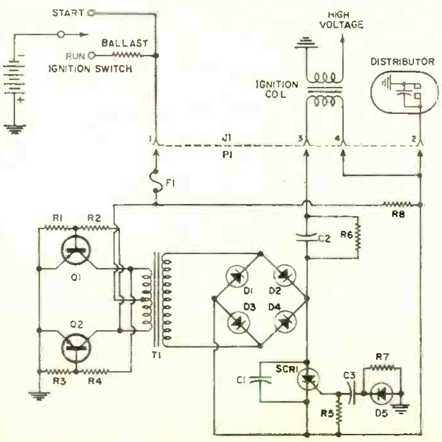
C-D IGNITION SYSTEM

To the Editors:

Quite a few of your readers have asked about converting the capacitive-discharge ignition system described in my article in the November, 1967 issue of ELECTRONICS WORLD to 6-volt electrical systems and to positive-ground electrical systems.

Both of these conversions are simple and the performance in either case will be equal to the original version.

The schematic diagram shows a positive-ground system. The negative pulse from the distributor is applied to the cathode of the SCR (or thyristor), and then the operation of the circuit is the same as the original circuit. All component reference designations and values are the same as in the original circuit. The external wiring diagram will be the same as the original, except that the "+" sign indicated on the coil should be changed to "—".



For a 6-volt system, the appropriate circuit diagram for either positive or negative ground should be followed, but several component values must be changed. *R2* and *R4* are changed from 250 ohms to 150 ohms, 5 watts; *R8* is changed from 50 ohms to 25 ohms, 5 watts; and *F1* is changed from 6¼ amperes to 8 amperes.

I have been unable to locate any reasonably priced catalogue item transformer that is suitable for the 6-volt system, so the best solution appears to be to remove turns from the 6.3-volt filament transformer specified for the 12-volt system. All the filament transformers I have seen are wound with the filament winding on the outside, so it is a simple matter to remove turns. The transformer I used had 17 turns each side of the center tap, and when this was reduced to 10 turns, the power supply put out about 425 volts with 7 volts input. Transformers from other manufacturers may have a few more or less turns, but the turns should be reduced in about the same proportion, or 10:17.

After the transformer is modified, it should be tested on a.c. as a step-down transformer. With 117 volts a.c. on the line voltage winding, the low voltage winding should put out about 3.7 volts. Of course, if the line voltage is slightly different from 117, the low voltage should still bear the same relation to the line voltage as the ratio 3.7:117.

BILLY F. CAWLFIELD
Dallas, Texas

We have had quite a few requests for this type of information and we apologize for our delay in publishing it. We have published a letter from another reader that gives somewhat the same modifications in our March "Letters" column. Author Cawlfield has been *waiting to test the circuit shown here at extremely low temperatures. He tells us that the operation of the circuit shown was just as reliable at a temperature of 40° below zero as at normal room temperature.*

One of our readers has reported that the system's performance could be improved considerably at high engine speeds by adding a point-bounce filter in the gate circuit of the SCR. Such a filter is installed between C3 and the gate electrode of SCR1. It consists of a series television video peaking coil having an inductance of about 220 μH along with two shunt .0005-μF capacitors to the low side of R5. Also, resistor R7 should be shunted with a 1000-ohm resistor.—Editors

* * *

INCENTIVE LICENSING FOR HAMS

To the Editors:

The article "New Incentive Regulations for Hams" in your December issue starts off in fairly good shape. However, toward the end it tails off rather badly and it's ground zero on page 62. I can't imagine where the comment regarding Australian hams and "tube-type converter or transmitter" could have arisen. From personal experience, Australian hams use exactly the same equipment we do; in addition, there are no high-power transistors currently available for amateur transmitters. Even more to the point, I had a letter of inquiry from Australia asking where parts could be obtained for a one-tube converter I designed and described in one of your previous issues.

Except for that, it was a good issue as usual.

K. H. Sueker, Marketing Mgr.
Semiconductor Div.
Westinghouse Electric Corp.
Youngwood, Pa.

The comment referred to was: "For instance, in Australia if any of their 6000 amateurs attempted to construct a tube-type converter or transmitter he would have a lot of official (and unofficial) explaining to do."—Editors

* * *

HOLOGRAPHY MATHEMATICS

To the Editors:

In your "Mathematics of Holography Process" (March issue, p. 43) the term "exp," which stands for *exponential function*, should not have been shown as a subscript. This term appears in quite a few of the equations, and it refers to the following rather than the preceding terms.

Edward Foster
Milwaukee, Wisc.

We knew about the error and made the correction, unfortunately, just a little too late to catch our entire print run.—Editors

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STRENGTH OF UHF SIGNAL AT RECEIVING ANTENNA LOCATION	Strength of VHF Signal at Receiving Antenna Location: NO VHF	VHF SIGNAL STRONG	VHF SIGNAL MODERATE	VHF SIGNAL WEAK	VHF SIGNAL VERY WEAK
NO UHF		CS-V3 $10.95	CS-V5 $17.50 / CS-V7 $24.95	CS-V10 $35.95	CS-V15 $48.50 / CS-V18 $56.50
UHF SIGNAL STRONG	CS-U1 $9.95	CS-A1 $18.95	CS-B1 $29.95	CS-C1 $43.95	CS-C1 $43.95
UHF SIGNAL WEAK	CS-U2 $14.95	CS-A2 $22.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95
UHF SIGNAL VERY WEAK	CS-U3 $21.95	CS-A3 $30.95	CS-B3 $49.95	CS-C3 $59.95	CS-D3 $69.95

NOTE: In addition to the regular 300 ohm models (above), each model is available in a 75 ohm coaxial cable downlead where this type of installation is preferable. These models, designated "XCS", each come complete with a compact behind-the-set 75 ohm to 300 ohm balun-splitter to match the antenna system to the proper set terminals.

THE FINNEY COMPANY

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CIRCLE NO. 110 ON READER SERVICE CARD

COLOR GENERATORS Reach the Solid State

By FOREST H. BELT
Contributing Editor

Improved stability, more reliability, longer life, cooler operation, light weight, and portability are the direct result of using transistors and IC's in a new generation of color-bar generators. Here is a complete directory of what's available, along with how the various units operate and compare.

TRANSISTORS are supplanting tubes in most home-electronics test equipment. Improved manufacturing control has eliminated much of the nonuniformity among transistors of identical types, making it possible to build predictable circuit designs; formerly a working prototype didn't necessarily mean that the production model would perform consistently. New types of transistors, too—notably MOSFET and unijunction types—have opened other avenues of approach to some of the design problems inherent in solid-state test equipment.

Perhaps the one instrument which has benefited the most from this trend to transistorization is the color-bar generator. A unit that the service technician can carry into the home for convergence adjustments is the one that pays for itself the soonest. The size and weight advantages of solid-state design are part of the answer.

Early transistor color-bar generators suffered from instability. It was difficult to keep the patterns steady on the screen of a color receiver. There are models still around that have this problem. The counting (divider) circuits keep jumping off-frequency—down-counting by some unwanted factor instead of by the intended one. Some designers include controls to allow the operator to reset the counter's dividing frequencies—occasionally on the front panel with a knob, but usually at the rear or side as a screwdriver adjustment.

Changes in the temperature around the transistors is the chief factor contributing to this instability, and therefore some designers have tried to control that environment. Other solutions for unsteady patterns include temperature-compensation in the circuits themselves. And there is the idea of designing a circuit so stable that parameter changes in the transistors can't cause a frequency shift in the divider.

All these approaches are used in recent solid-state color-bar generators (see the above photo). As a result, most modern color-bar generators can put a stable pattern on the screen within a reasonable (15-minute) warmup, even from a below-freezing start. That's important to the home-call service technician.

Knowing how an instrument works often helps in understanding where and how to use it. The major applications are, of course, obvious, but the finer techniques that distinguish the expert from the mechanic are often the result of familiarity with the instrument. So, first, take a brief look inside a typical color-bar generator.

What's In Them

The principal use of a color-bar generator in the home has little to do with color reception, oddly enough. Its video patterns are used for convergence. They are: thin vertical lines, thin horizontal lines, crosshatch containing both, and dots (formed at the intersections of the crosshatch and displayed without the lines). Some generators add special video displays.

The color bars themselves are seldom used outside the service shop. There, they make a good tool for analyzing operation and adjustment of the chroma section in color receivers. Teamed up with an oscilloscope, the color generator is the focal instrument for troubleshooting color stages in a set.

Fig. 1 illustrates how the various patterns are typically produced. The video patterns and the sync pulses are initiated by a 189-kHz crystal oscillator. The pulses are integrated in a shaper to form the vertical lines. At the 15,750-Hz horizontal sweep rate of a TV set, the 189-kHz signal produces 12 video "pips" on each raster line. In the full raster the pips form 12 thin white lines that run from top to bottom (vertical).

The 189-kHz signal also triggers a multivibrator that operates as a frequency divider, firing only on every sixth pulse. The output is 31.5 kHz which, in turn, triggers two other counting multivibrators—a 5-divider and a 2-divider. The 2-divider output is at 15,750 Hz and this is shaped into horizontal sync pulses.

The divider output is fed to a 7-divider, which down-counts the 6300-Hz signal to 900 Hz. Properly shaped, the 900-Hz pulses can make a pulse of video 15 times during each raster scan from top to bottom (each field). If the pulses are wide enough—about 64 μs—each one occupies one full line of each raster field. The gate circuit forces each video line to begin exactly at the left of the raster. The re-

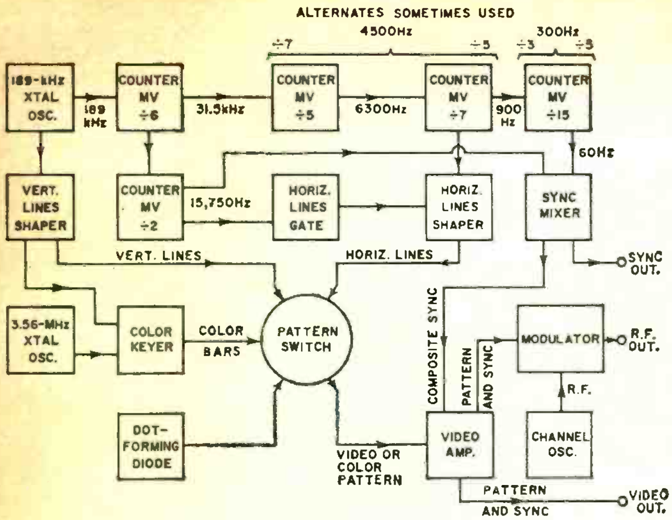


Fig. 1. Basic operating blocks of most color-bar generators.

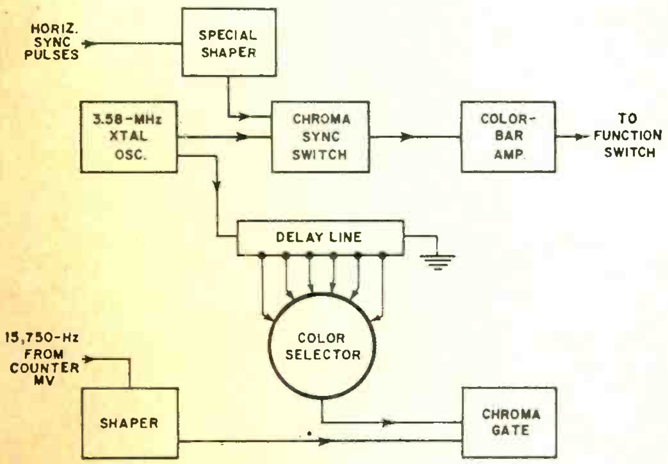


Fig. 2. Single-bar NTSC display is generated by this method.

sult is 15 horizontal bright lines that appear on a darker field.

The pattern switch mixes the vertical and horizontal video lines to display a crosshatch. For dots, a diode clipper chops out the lines in a crosshatch, leaving only the intersections showing.

In the divider chain, a 15-counter divides the 900-Hz signal to 60 Hz, which is made into vertical sync. Sometimes two dividers are used, to reduce the span of the down-count. A combination shaper-mixer stage puts the composite sync signal together.

The rainbow pattern most color-bar generators produce is originated by the offset-subcarrier method. A 3.563795-MHz crystal (called 3.56 for short) generates the signal. When it is mixed with the 3.579545-MHz (3.58) signal generated in a color receiver, the result is a continuous 360-degree phase shift that extends exactly across each horizontal line because the two signals are just 15,750 Hz apart. The effect on the color demodulators in the receiver is to produce a color-hue change from one end of each line to the other. Looking at the raster as a whole, a viewer sees the full "rainbow" that goes from a reddish-yellow at the left to green at the right, ranging through gradual shades of red and blue on the way.

All rainbow displays nowdays are keyed, or gated, so the technician can see accurately at what point along the raster lines each color is situated. The photo on the cover shows a TV receiver with a normal keyed-rainbow pattern. The black bars are formed by interrupting the colored rainbow display every few microseconds along each raster line, and driving the raster dark for the same number of microseconds. The result: alternating bars of color and black, with each successive bar from left to right bearing the rainbow color that would be in the space on the screen even if the color signal weren't keyed.

In Fig. 1, the keying is accomplished in a simple way. The color keyer uses sharpened signals from the vertical-lines shaper to block the offset subcarrier (3.56 MHz) signal. Time constants in the keyer stage are such that the signal is allowed through again after about 2.5 μs. Just 2.5 more microseconds later, the next pulse comes along and cuts the color off again for another 2.5. The alternating bars of black and color are the result, each bar being about 2.5 μs wide along the lines of the raster.

All the patterns, or the elements to form them, are fed to the pattern switch. It selects the signal(s) to form the desired pattern. Whatever is selected goes to a video amplifier, where it is mixed with the sync signal. A few generators make the composite video or color-bar signal available directly from this point. The composite signal is also fed to a modulator where it is mixed with an r.f. signal at some TV-channel picture-carrier frequency. A few generators also have the sync signal brought out to a separate jack where it is available independently for testing in color sets with separate video and sync detectors.

The other type of solid-state chroma generator (another name for the color-bar generator) is called a single-bar NTSC type. Its video-pattern functions are the same as in the keyed-rainbow just described, but the manner of generating the color-bar signal is different. In fact, the display itself is different.

Fig. 2 is a block diagram of just the color-bar section of a single-bar NTSC generator. The signal produced is more like a station signal than the keyed-rainbow signal is, in that it contains a color-sync burst on the horizontal-sync pedestal and the color is generated by phase-shifting a 3.579545-MHz signal. It also contains the proper amount of brightness-component signal. A crystal oscillator furnishes the signal which is fed to a delay line. Taps on the delay line permit the selection of whatever phase of signal is desired; that phase determines the color produced when the signal is demodulated in a color receiver.

To put the color signal into the form of a bar, a gating stage is used. Specially shaped pulses from the 15,750-Hz source are fed to the chroma gate stage, which blocks the color signal for the first few microseconds of each line, leaving the left side of the screen black. Then the gate stage allows the color signal through to the color-bar amplifier for about 40 μs; on the color-TV screen, color is visible. The gate then blocks color again, and the right side of the screen is dark. The screen pattern can be seen in Fig. 3. The bar in the center is in color.

Meanwhile, the color-sync burst signal is developed in a switching stage. The 3.58-MHz signal is turned on for a few cycles just at a time to coincide with the back porch (pedestal) of each horizontal sync pulse. (That is where the burst rides in a TV-station color signal, too.) Beyond the color-bar amplifier, mixing and distributing the color signal is carried out as in a keyed-rainbow unit.

So What's New?

Well, several things, and most of them are designed to optimize stability. A few specifics illustrate the continuing concern with this particular bugaboo.

For one thing, as was mentioned earlier, transistors are improved. The earliest solid-state designs used cross-coupled and emitter-coupled two-transistor multivibrators for counting. With any small temperature change, one transistor would shift characteristics in a manner different than the other. Some of these instruments were slow to warm up to stability and then a slight breeze from an open window might throw them off again.

More recently, the newly developed unijunction transistor was incorporated by some designers. Their very nature

MAKE & MODEL	POWER BATT.	POWER A.C.	R.F. CHANNELS	SOUND CARRIER	OUTPUT R.F. (μV)	OUTPUT VIDEO Vpp	COLOR PATTERNS KEYED RAINBOW	COLOR PATTERNS NTSC BAR	COLOR PATTERNS OTHER	H LINES	V LINES	VIDEO PATTERNS CROSS-HATCH	DOTS	SINGLE DOT	CROSS-HAIR	OTHER	GUN KILLERS	DIMENSIONS H (in)	W (in)	D (in)	WT. (lb)	PRICE WIRED ($)	KIT ($)
SOLID-STATE MODELS																							
AMPHENOL 865	12 AA CELLS	✓	3 or 4		50k		✓		1-bar variable / 3-bar	15	20	15 × 20	300	Movable	Movable		✓	6⅝	9¼	5	4	139.95	—
B&K 1242		✓	3 or 4		5k		✓			13	9	13 × 9	117				✓	2¼	7	9⅜	3	99.95	—
CONAR 680	4 D CELLS	✓	2 only or 3 only	✓	50k		✓			15	20	15 × 20	300	✓	✓	single H line / single V line	✓	3	10	9	5	114.50	83.50
EICO 380		✓	3	✓	50k	10		✓		13	10	13 × 10	130					8½	5¾	6⅜	4	169.00	—
HICKOK GC660		✓	3, 4, or 5	✓	50k	2	✓			18	18	18 × 18	324				✓	10⅜	10¾	5	6¼	179.50	—
KNIGHT-KIT KG-685		✓	3, 4, or 5	✓	10k	2	✓			13	9	13 × 9	117			stair-step	✓	4⅝	12	9⅝	12	—	89.95
LEADER LCG-387		✓	5 or 6		10k		✓					11 × 14	154		✓			2¾	6¾	4¾	3¼	[illegible]4.50	—
LECTROTECH V6-B		✓	3, 4, or 5		100k		✓			13	9	13 × 9	117				✓	3½	7⅝	9	5½	99.50	—
RCA WR-502A	4.2V MERC.		3	✓	10k		✓			13	10	13 × 10	1[illegible]0				✓	6½	7½	4	4	169.00	—
SENCORE CG10	8 C CELLS		3, 4, 5, or 6		2k		✓			13	9	13 × 9	117				✓	3	10¼	8½	5½	89.50	—
SENCORE CG141		✓	2 thru 6	✓	2k		✓			13	9	13 × 9	117	Movable	Movable		✓	10¼	9½	4	9	149.95	—
LECTROTECH V7		✓	3, 4, or 5		100k		✓			13	9	13 × 9	117				✓	7½	8¼	12⅞	13	189.50	—
TUBE MODELS																							
HEATH IG-62		✓	2 thru 6	✓	100k	10	✓			15	12	15 × 12	180			shading bars		8½	13	7	11	—	67.50
HICKOK 661		✓	3 and 4		50k	2		✓		15	20	15 × 20	300					11	15	8⅛	18½	349.50	—
RCA WR-64B		✓	3 or 4	✓	50k		✓					14 × 9	126				✓	10	13½	8	13¼	189.50	—

Hybrid (includes tubes). Also includes vectorscope.

Table 1. Listing of solid-state and tube-type color-bar generators along with some of their characteristics.

made these semiconductor devices ideally suited to down-counting, because slight changes in bias controlled the triggering closely. But that very sensitivity was found to be a detriment—the trigger point shifted around with temperature. A number of models used them and still do, but only carefully engineered circuits offer enough stability to be satisfactory.

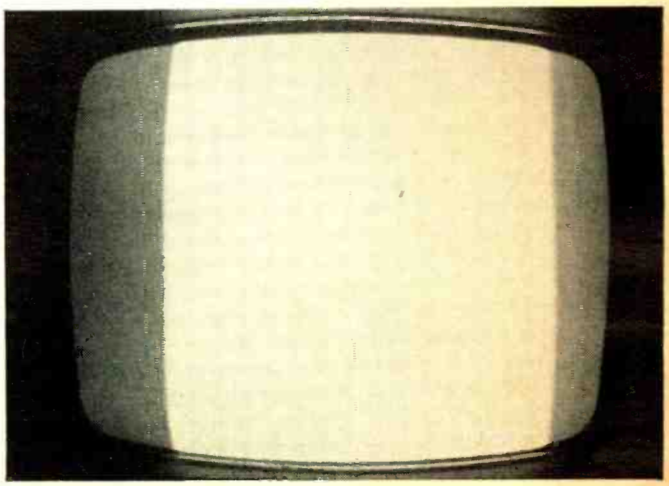
Most of the instruments introduced in the past year have gone back to the twin-transistor multivibrator. A production engineer can now buy a batch of transistors, demanding certain specifications of the supplier, and get units that have reasonably uniform characteristics. Hand-picked matching of multivibrator pairs is no longer necessary for acceptable stability.

And yet, in some parts of the country, the instruments are still subjected to extremes of heat and cold. In a Midwestern and Northern winter, for example, a generator hauled around in a service truck gets pretty cold. That makes warm-up time lengthy—if not impossible, for home service calls. To overcome that kind of trouble, the temperature inside the case of one model is thermostatically controlled; a heating element assures a constant ambient temperature for the counters, a quick warm-up time from any likely degree of cold, and steady patterns after warm up.

Temperature-compensating components are sometimes included in the counter circuits themselves. Another way is to design each divider stage so it isn't very temperature-sensitive in the first place—not always an easy thing to do.

In certain battery-operated color-bar generators, a zener diode on the d.c. supply line to the counters keeps battery

Fig. 3. Wide center bar is color, chosen by generator switch.



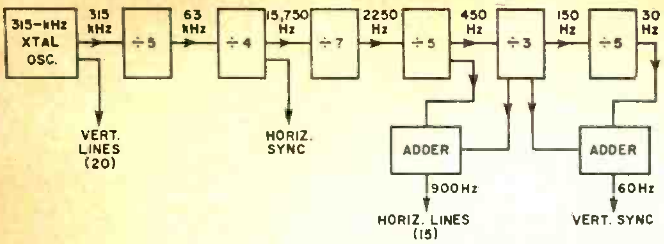


Fig. 4. Low counting rates help stability. If dividers don't generate exact frequencies needed, adder/synthesis can be used.

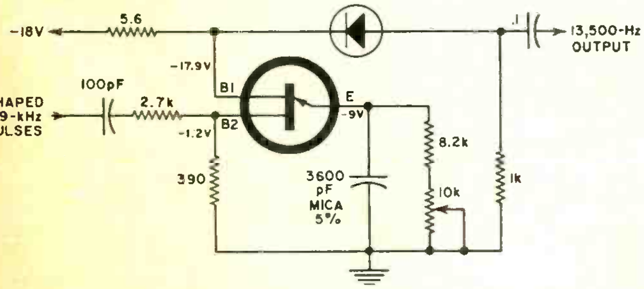


Fig. 5. Unijunction transistor as color-generator down-counter.

freshness from becoming a factor in pattern stability. In a.c.-operated models, regulation is equally important if the counter circuits are at all sensitive to voltage. In one new color generator, a mercury battery is used for power. Its constant-voltage discharge characteristic is considered adequate regulation for the counter circuits, which are themselves carefully stabilized.

Battery operation is not new, and several of the new generators include it. This freedom from the power cord is one of the more popular features for the home-call color-TV technician. Some recent instruments have both an a.c. power supply and battery provision.

Recent Solid-State Color Generators

The accompanying chart (Table 1) lists most of the available models of color-bar generators, and presents their most important features in condensed form. It includes a few tube-type models for reference, but the trend is to solid state. The following elaborations on features, therefore, relate only to transistorized instruments. They represent manufacturers who have given us data on their most recent models as of press time.

Amphenol—Newest version from this manufacturer is the Model 865 "Color Commander." A keyed-rainbow type, it has two special color-bar displays, not available—to our knowledge—on any other instrument. One is a three-bar color display for adjusting demodulators; it has R—Y (90°), B—Y (180°), and inverse R—Y (270°) bars, in that order. The other display is a single color bar, but its hue can be adjusted by a front-panel knob to any color phase from 30° to 300°. This model also generates two special video-pattern displays: One is a single dot that is movable to any spot on the color-TV screen—the center for static convergence or any other location for checking dynamic convergence. The other is a two-line crosshair pattern, both lines of which are movable and can be made to cross at any point on the screen; the object is also to improve convergence checking. The Model 865 is one of the units that operates from both a.c. and batteries.

Internally, the Model 865 isn't as simple as the "typical" unit of Fig. 1. For example, the crosshatch pattern is generated by special mixing stages, and dots are produced by altering certain connections inside those stages to accentuate intersections while blanking the rest of the crosshatch lines. Extra circuitry is required, too, for special color-bar patterns and for movable dots and lines.

The counters are different from those in most, too. Fig. 4 shows the difference. A 315-kHz crystal oscillator is used instead of 189-kHz. The counting sequence is therefore different. The most practical reason for so many stages of counting is greater stability—there is less tendency for a divider to skip a count when it is dividing by some low factor (3 to 7) instead of a higher one (15, for example, as in Fig. 1). Also, starting from 315 kHz, one of the intermediate rates is 15,750, which makes it unnecessary to have a separate counter for horizontal sync and timing pulses. To develop horizontal lines, however, an extra stage is needed for adder-type mixing to create the required 900-Hz pulses. Another adder creates vertical sync.

B&K—The Model 1242 is another keyed-rainbow unit. This one uses unijunction transistors—four of them. Unijunction transistors are stable in the right configuration, and certainly contribute to instrument simplicity. A unijunction and a few resistors do the job that, in multivibrator stages, takes two transistors and over a dozen resistors and capacitors. Fig. 5 shows the circuit of a unijunction counter. Actually, as used in the 1242, this one is a controlled oscillator, triggered by every 14th pulse of its input. The natural frequency of the stage is determined mainly by the time constant of the variable resistor in the emitter lead, working with the 3600-pF mica capacitor. The diode is part of a circuit that aids stability with high down-count factors; the one shown in Fig. 5 is shaping the output pulses for the stage that follows.

Two of these locked unijunction oscillators are controlled directly from the 189-kHz crystal circuit. One works at 15,750-Hz, and the other at 13,500 Hz. From the latter, a 900-Hz unijunction oscillator is triggered on every 15th pulse. That signal, besides making the horizontal video lines, locks a 60-Hz unijunction stage for vertical sync.

The a.c.-only power supply is transistor-regulated, with a zener diode for reference. The unijunction circuits are voltage-sensitive, and regulation is necessary. The use of a precision mica capacitor in the emitter time-constant circuit (Fig. 5) is deliberate, an attempt to avoid any significant temperature-inflicted time-constant changes that would affect pattern stability. Other features and patterns of the 1242 are standard.

Conar—The Model 680 is the first color generator we know of that uses integrated circuits. Sixteen Type 914 digital IC's are used in the counting circuits. Besides the usual displays, single-dot and single-crosshair patterns are provided, but they are stationary. A single vertical line and a single horizontal line are included. The color display is keyed-rainbow. The station-channel oscillator is crystal-controlled and comes with either channel 2 or channel 3—but not both. Most other generators have a coil that can be tuned between either of two or more channels, but their frequency is not so closely controlled as with a crystal. For power, the instrument can operate from either a.c. or four size-D (regular) flashlight batteries. The a.c. power supply is regulated by a series transistor, referenced to a zener diode.

Eico—The Model 380, an all-transistor unit introduced about 2 years ago, is the only solid-state generator in our table producing an NTSC-type display. It generates a single wide bar of color on the color-set screen and a switch on the instrument lets the technician choose any one of 10 phases of chroma signal for that bar. Some of the ten are NTSC "colors", but others are signal phase references, like R—Y, B—Y, I, Q, and so forth. An eleventh position of the switch produces a bar of white (Y or luminance signal only), which is fine for rough checks of the gray scale or purity.

Two features of the 380 are its variable line- and dot-size controls and its pattern-sync controls. The first is a dual control; one knob affects thickness of vertical lines in the video patterns and its concentric knob affects the thickness of horizontal lines. By their effect on lines, the two controls also change the size of dots. The second feature is also a dual-knob control, one of which adjusts the vertical sync of the instrument and the other the horizontal sync. The two can make up for any normal instability that occurs in the counters during warmup.

Unijunction transistors are included in this model, as in others introduced during that period. *Eico* has a new model, the 385, but we were unable to get data in time for this article. It is solid-state, and we have heard it will sell for about $100. The new Model 385 will be available in kit form at a lower price, whereas the Model 380 is available only in a factory-wired version.

Heath—The present *Heathkit* model is a tube instrument, introduced several years ago. A new unit, expected to bow later this year, will be solid-state. We have been unable to get a model number or details of its design.

Hickok—The Model GC660 is a keyed-rainbow generator, introduced some months ago; it has unijunction transistors in the counting circuits. One trick used to improve stability is more counting stages, with none of them dividing by a very large factor. The initial timer is a crystal-controlled 378-kHz oscillator. The first stage is a cross-coupled multivibrator—a down-counter by a factor of 2; the output is 189 kHz. That is followed by a series of unijunction dividers: by a 6 factor, to 31.5 kHz; by a 5 factor, to 6300 Hz; by a 5 factor to 1260 Hz; by a 3 factor to 420 Hz; and by a 7 factor to 60 Hz. From the 31.5-kHz counter, a 2-factor divider creates the 15,750-Hz horizontal sync and timing pulses. Vertical lines are formed from the 378-kHz pulses, shaped of course; that high frequency is why there are 18 lines, so many more than usual. Instead of the 900-Hz horizontal-line signal of most generators, a 1260-Hz signal is used in the Model GC660; the result: 18 horizontal lines instead of the usual 13 or 15. The Model GC660 is a.c. powered only, and regulation is employed.

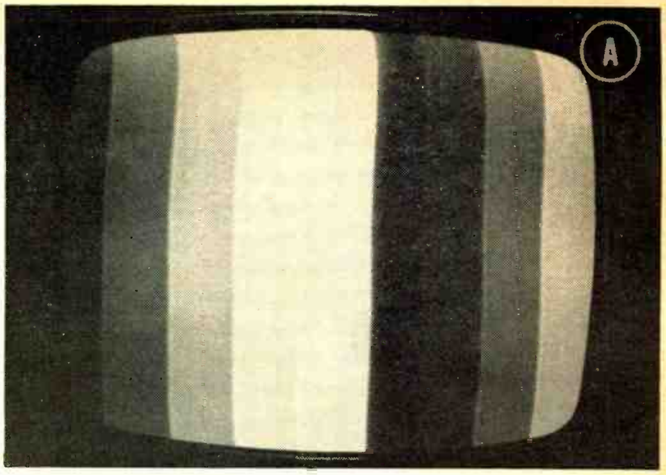
Knight-Kit—Another keyed-rainbow generator, the Model KG-685 color-bar generator uses unijunction transistors for counting. A unique feature of this instrument is the stairstep signal that produces various shades of gray for gray-scale tracking tests. Fig. 6A shows a set with this pattern on its screen. A stairstep signal is generated just following the 189-kHz oscillator, using a transistor and a pair of diodes. Its video waveform is shown in Fig. 6B, so you can see how the rising steps of voltage drive the color CRT to successively lighter bars, then start again at black and go through another set of steps. The other video patterns are approximately standard, as is the color-bar display.

The a.c. power supply is transistor-regulated, with a zener diode reference. In conjunction with the color-gun killer, pin jacks are brought out to the front panel of the KG-685. As long as the color-CRT guns are not cut off by any of the switches, a scope or v.t.v.m. can be connected to any of the test jacks and the gun-killer leads make test connections without going to the rear of the receiver.

Leader—A relative newcomer to the field, the imported LCG-387 incorporates a number of unorthodox approaches to accomplishing the functions of a color-bar generator. Although familiar cross-coupled multivibrators are used predominantly for timing and down-counting, diode logic circuits are the heart of the LCG-387's system of combining (synthesizing) the several signals into the patterns selected by the front-panel switch. Repetitive modular construction is used in the counter and logic circuits; many of them are alike.

The a.c. power supply is regulated by two transistors, referenced to a zener diode. Considering that the entire unit contains 50 transistors and 78 diodes, the LCG-387 is a study in miniaturization. Its bulk is less than any other color-bar instrument—less than 90 cubic inches and barely over three pounds.

No separate vertical or horizontal lines are developed, only crosshatch and crosshair patterns. There is a multiple dot pattern. The color-bar display is the standard keyed rainbow.



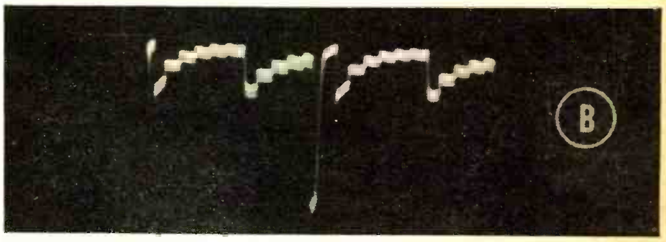


Fig. 6. (A) Stairstep pattern is for checking gray-scale tracking. (B) Waveform shows two "stairs" between each horizontal pulse.

Lectrotech—Introduced about two years ago, the V6-B is an a.c.-powered keyed-rainbow generator, using unijunction transistors for all the divider circuits except the first—the one that steps the frequency down from 189 kHz to 31.5 kHz. For it, a cross-coupled multivibrator is used. The patterns generated by the V6-B, both video and color, are standard. A distinctive feature is a panel control for adjusting the thickness of the horizontal lines displayed, making them as little as one or as much as four raster-lines thick. There is also a special control, recessed at the rear of the instrument, to control the relative brightness of the horizontal and vertical lines; it is adjusted with a screwdriver to bring them to approximately equal intensity in any display.

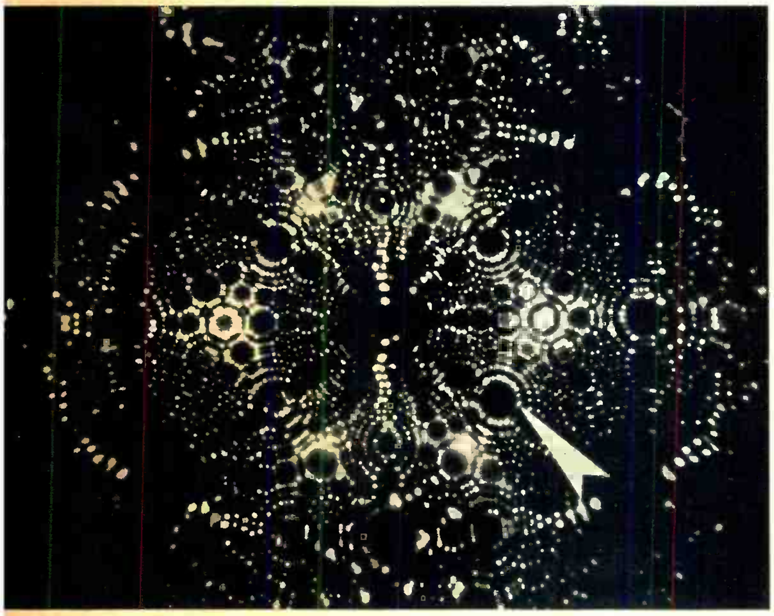
RCA—After many years with the pioneering WR-64 series of keyed-rainbow generators, *RCA* has brought out a new one; the Model WR-502A "Chro-Bar." This one is solid-state, keyed-rainbow, and operates without power line, from a single 4.2-volt mercury battery.

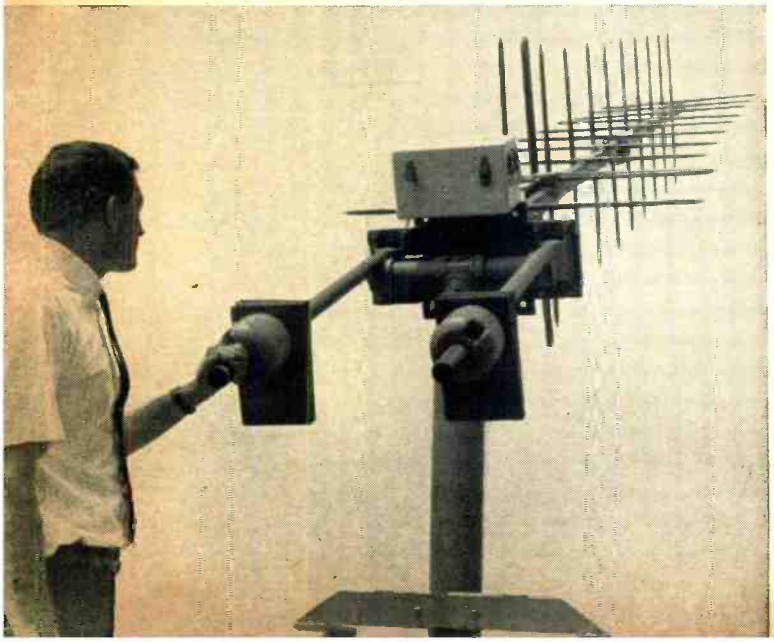
Multivibrators are used for all counting. Of the 20 transistors used throughout the unit, 17 are of the same type—*RCA* 40232 (SK 3020). The other three are 40238's.

The method of generating video signals is similar to that shown in Fig. 1, but there are important differences. The main timing oscillator is crystal-controlled at 189.645 kHz. The first down-count factor is 4, and the multivibrator output is 47.411 kHz. The next is 3, and yields the horizontal sync frequency, which in this unit is 15,802.7 Hz. (Scanning with the WR-502A is by a 264-line system instead of the common 525-line interlaced system.) A 5-count multivibrator generates a 3951-Hz signal, which is further divided by 6 to reach 659 Hz—which signal is used to generate eleven horizontal video lines. Of course, the vertical video lines are formed from the main 189.645-kHz timing signal. The 659-kHz signal is down-counted to 59.9 Hz for vertical sync.

The odd horizontal sweep rate necessitates a slightly different-than-usual frequency for the offset subcarrier. The subcarrier must differ from the 3.579545-MHz receiver reference by the horizontal-line frequency, which in this case is 15,802.7 Hz. The subcarrier crystal in the WR-502A is therefore cut to 3.563742 MHz instead of the usual 3.563795 MHz. (*Continued on page 64*)

RECENT DEVELOPMENTS IN ELECTRONICS



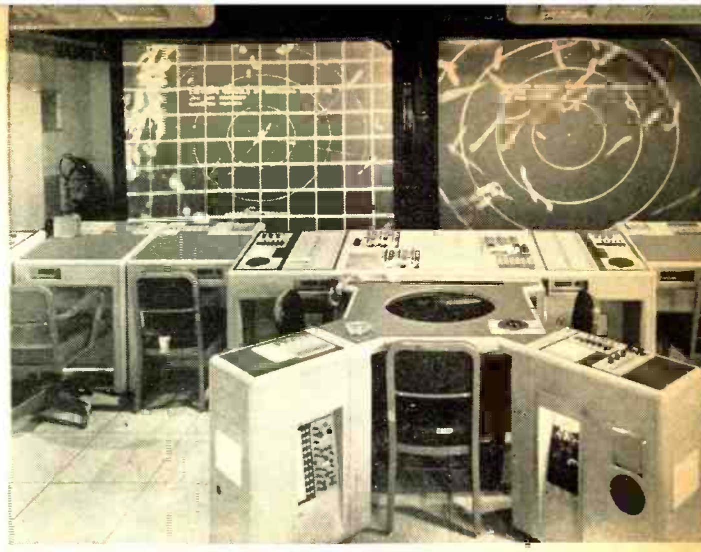


Electro-Optical Helmet Gun Sight. (Top left) This helicopter pilot is able to aim his weapon by merely moving his head and looking at his target. His hands are left completely free to carry out vital flying tasks. The system knows where the pilot is looking by tracking photodetectors mounted atop his helmet with invisible light beams that are aligned with the helicopter's reference system. The photodiodes are set parallel with the eyepiece axis. Information on the helmet's position is fed into a digital computation device that calculates the firing angles to a target and then commands the selected weapons to be swung in the proper direction. After spotting his target, all the pilot need do is press the trigger on his control stick and the guns swivel to his line of sight so he can fire. The system grew out of a four-year study and development program by Honeywell. First units of the system are already in production for use in the U.S. Army's new Cheyenne helicopter.

Field-Ion Electron Microscope Views Single Atom. (Center) A powerful new microscope that can focus on a single atom and then identify it produced this picture of a tungsten atom (shown by arrow). The lensless electron microscope is a major refinement of the field-ion microscope invented in 1956. Although the older microscope magnified metal atoms from two to five million times so that their image could be seen on a fluorescent screen as a cluster of luminous dots, it did not reveal their chemical identity. With the new instrument, the image of a single atom can be moved to a tiny "probe hole" in the viewing screen. The atom is then evaporated from the whisker-like tip of the sample in the form of an ion which then travels through the hole into a "time-of-flight spectrometer". By recording the time it takes for the ion to drift through the yard-long spectrometer, it can be identified by its mass. In contrast to this, the most powerful electron microprobe now in use needs at least 100,000 atoms in order to make an analysis. The new atom-probe field-ion microscope, as well as the original such instrument, was developed by Professor Erwin Mueller, along with his associates at The Pennsylvania State University.

Satellite-Relayed Voice Communications for Aircraft. (Left) The cross-polarized yagi antenna shown was used recently at the ground terminal in a test that demonstrated the feasibility of satellite-relayed communications for helicopters. The satellite relay used was the NASA ATS-1. An Air Force helicopter with v.h.f. FM radio equipment participated in the test. Communications were established between the aircraft and a NASA ground station located near Rosman, North Carolina (a distance of 600 global miles), and another NASA ground station located near Toowoomba, Australia (a distance of 8400 global miles). Advances in communication satellite technology, especially in the use of operating frequencies in the v.h.f. and u.h.f. bands, permit use of relatively simple radio equipment.

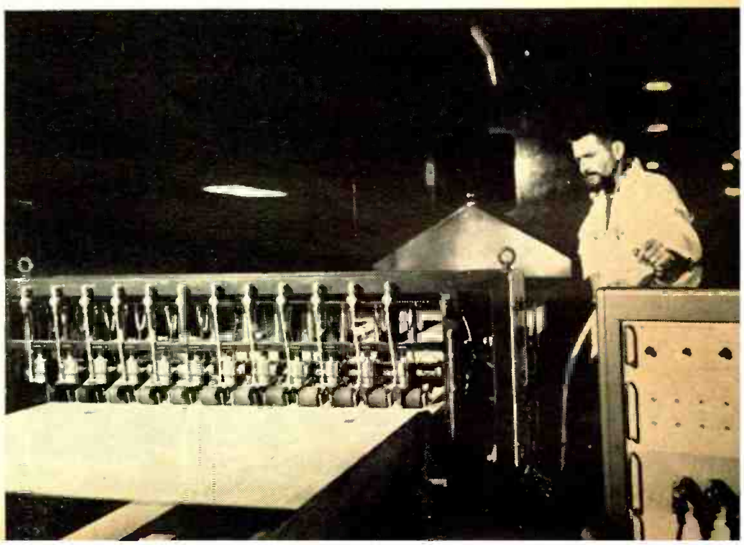
Large-Screen Air-Traffic Display. (Right) Two 9 by 12 ft displays show all the visual information used by controllers in handling air traffic in and out of the three major and sixteen satellite airports around New York City. The screens show composite information combining radar, computer alpha-numerics, and video mapping patterns. Four special high-resolution Eidophor TV projectors operating at 945 scanning lines are employed. Projectors are located behind the two screens. The display has been installed at the J. F. Kennedy International Airport in New York City by TNT Communications Inc.



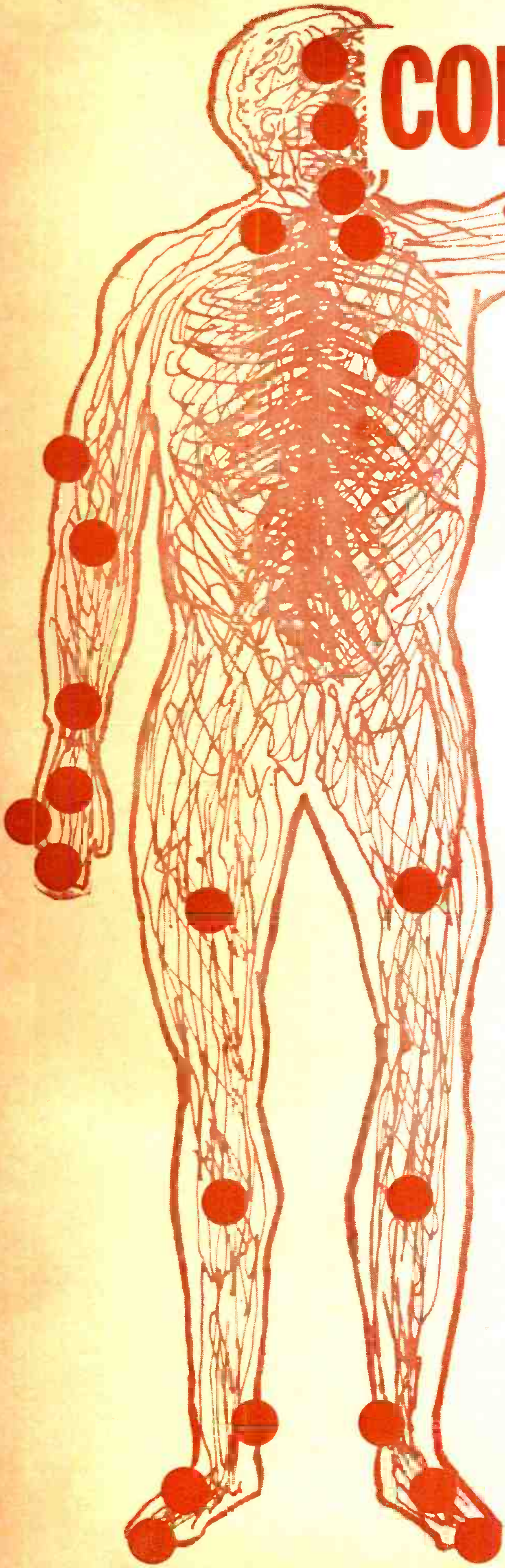
Computers for the Classroom. (Center) Students at three Santa Barbara (Calif.) district high schools are using a centrally located computer, linked by telephone lines, to solve algebra and physics problems. Not only does this save time and avoid tedious problem-solving, but, more important, it demonstrates computer applications to the students. More than 50 physics and 70 algebra computer programs were developed by the high school teachers for the project. To obtain access to the computer, a student dials the telephone number serving it. Then, the teletypewriter in the classroom is linked to the computer so that the student can enter his data. The equipment was installed by General Telephone Co. of California.

Ultrasonic Plywood Blister Detector. (Below right) The twelve rubber-tired wheels rolling over the surface of the sheet of plywood shown contain ultrasonic transducers. When these transducers and the associated electronic equipment at the right locate a blister (where there is no glue or no wood), one of the twelve nozzles next to the wheels sprays the defective area with red paint. The system, developed by Automation Industries, is the first application of ultrasonic inspection techniques to the woodworking industry. The system operates at about 480 lineal feet per minute and can handle sheets ranging from 3/8 to 1 1/8-in thick. Blisters as small as 2 inches in diameter can be accurately located by the ultrasonic technique.

ETV Teamed Up with Computer. (Below left) Some 70 Roman Catholic teachers in Brooklyn and Queens, N. Y. are staying after school to take an educational television course with the help of a computer and a speaker-equipped push-button telephone. After watching a lecture on the TV set in her classroom, the teacher places a call to an IBM computer located 50 miles away to request further information. The computer then sends back a pre-recorded voice-message in response to each query by the teacher. It also selects a related still picture stored in a slide projector at the Diocese's ETV studios in Brooklyn. The picture is then transmitted by the educational television station and it then appears on the TV set at the same time.



COMMUNICATIONS *Via Touch*



By L. GEORGE LAWRENCE

Tactile systems may provide an answer to some space-age communications problems. Research into the theory has been stepped up by both military and industrial groups.

IN a tumbling spacecraft, an astronaut may have to perform a hundred tasks before he brings his capsule under control—all the while attempting to maintain communications with Flight Control. Deep sea divers who have been given helium-oxygen mixtures produce unintelligible words that sound like ducks quacking. In both cases, a communications system that didn't depend on the spoken word or visual recognition would be a help.

Recently, military and space scientists have accelerated research into the utilization of the skin as a tactile communications receiver or as an interface between men and machines. Studies have shown that the skin of a normal adult contains some 1.2 million pain, 700,000 pressure, 250,000 cold-spot, and 30,000 hot-spot receptors. Of these, the pressure receptors are the most useful for tactile communications purposes. The hot and cold receptors are "out" because rapid temperature cycling equipment is not available; and obviously, the use of the pain receptors borders on barbarism.

The most developed of tactile communications systems is still very primitive. Scientists have much to learn about the human nervous system. Whether a sensation is "hot" or "cold" or whether it is "pressure" or "pain", is determined deep within the nervous system and it requires great concentration on the part of the subject to differentiate them.

Tactile Stimulators

The tactual sense can be stimulated in various ways but most of the practical methods require mechanical aids and electrical forces. Of the mechanical skin stimulators, vibrating solenoid plungers and airjets create the most useful sensations. However, they have an audible output which can distract the user from his other duties and, thus, have a disadvantage.

Tactual sensitivities at various points of the body are shown in Fig. 1. The tongue and tips of the fingers are the most sensitive to tactual stimuli. In these areas, the receptors are closely spaced.

The data of Fig. 1 was obtained with a touch compass, or "Tasterzirkel", developed by E.H. Weber in Germany about 1834. The device, which resembles a compass with sharp points, is placed atop the skin and, by noting the spread of its two legs, it is possible to determine the proximity of those receptor points which discriminate between two distinct impressions. A bent piece of wire will serve the same purpose. Pressing its two ends against the upper leg makes the sensation of both impressions seem like one;

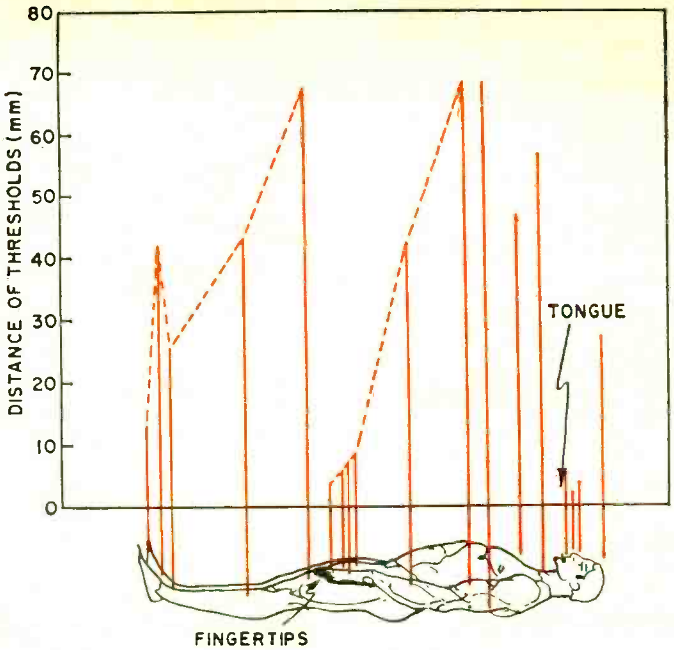


Fig. 1. Tactual sensitivities, expressed in millimeters of displacement, about various points on the human body.

whereas two similar impressions on the tongue can readily be sensed as two distinctly different points of touch.

However, since both the tongue and tips of the fingers are "out" as far as the attachment of mechanical appendages is concerned, it is necessary to use a more convenient, though less sensitive, part of the human body.

Fig. 2 shows the attachment of a solenoid-type driver to the arm. The device consists of a vibrating plunger and bias magnet which is activated by pulses from a simple relaxation oscillator. This scheme represents a one-point-only stimulation mode. A Morse code can be transmitted—but little else. However, its basic simplicity makes it ideal for emergency applications.

A fairly complete set of data, especially letters of the alphabet, can be transmitted *via* chest-mounted matrices which contain a large array of identical stimulators. The signaling matrix can be computer or manually controlled to spell out the letter facsimiles. Fig. 3 shows matrices for 96-bit frames and illustrates the letters L, V, and A. With this technique, a trained subject can recognize approximately 15 characters per second.

Airjet devices have also been used to transmit tactual signals. In Fig. 4, compressed air is fed into computer-steered solenoid-activated valves. In both systems it is possible to improve the skin's critical threshold sensitivities by stimulating an adjacent region at the same time.

Tactile Dimensions

The precise area of skin-felt sensations is difficult to investigate and data cannot be derived directly by extrapolating values obtained through the application of Weber's touch compass or esthesiometer.

Mechanical vibrations, unlike static pressures applied to the skin, do not stay "within bounds" and, unless the vibrators are suitably spaced, two or more vibratory inducers acting simultaneously will feel like one. Although a split-second time difference is all that's needed to restore the sensation of two local impressions, the electronic equipment needed to accomplish the time delay can be extensive.

Compared to sinusoidal input vibrations (Fig. 5A), clicks or pulses affect a smaller skin area. But because there are as many skin types as there are types of faces, a combination

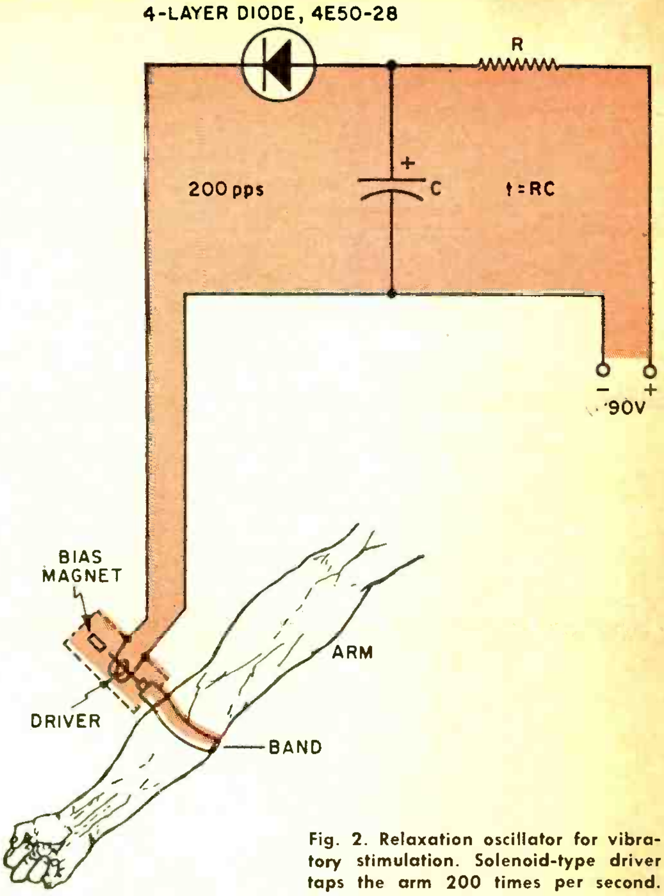


Fig. 2. Relaxation oscillator for vibratory stimulation. Solenoid-type driver taps the arm 200 times per second.

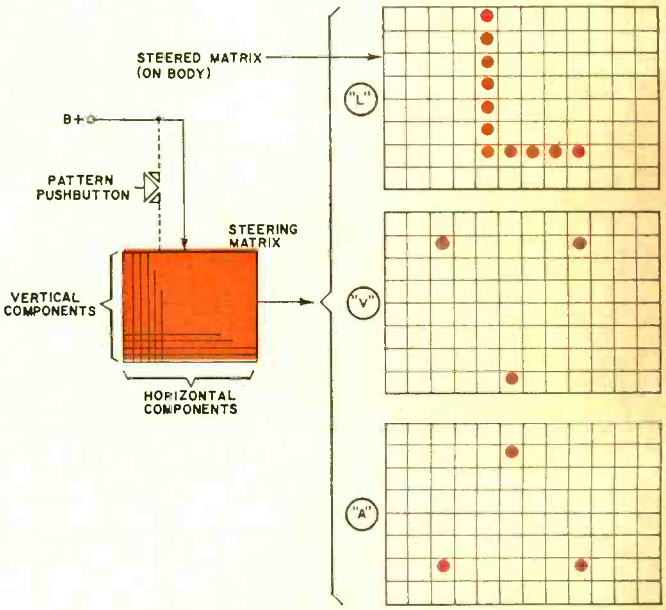


Fig. 3. Steered matrix system for tactual stimulation. Complex letters must be transmitted (L for example) as complete units. Simple letters such as "A" are sent as abstract facsimiles.

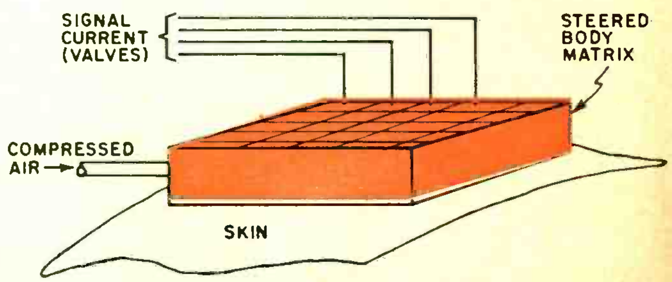


Fig. 4. Signal patterns from steered body matrix atop skin are produced by airjets with electrically activated valves.

of Figs. 5A and 5B would be most desirable for the untrained subject.

In the fingers, the biological system's internal noise level may be so high that it masks any and all sensations applied to it by an artificial skin inducer.

However, since fingers are easily accessible, scientists are trying to train these appendages to do essentially what the ear's tympanic membrane does—to distinguish sound patterns and pitch. In one experiment where human speech was amplified and applied to the fingers, the subject, with 30 hours' practice, was able to recognize one out of every two words.

Since tactile stimulators generate considerable mechanical force, care must be taken to keep the intensity of the stimulus within safe limits. In the regions of the chest, plunger or trip-hammer vibrators have stimulus amplitudes ranging from 50 to 400 microns. Under these conditions, the subject can discern some 15 intensity steps.

There are, for all practical purposes, no abrupt changes in sensitivity from one small spot of skin to the next. Sensitivity and thus discrimination can be increased by cooling or heating the skin with an ethyl-chloride spray or an infrared lamp. Heating is more comfortable and produces an immediate awareness of a change.

It should be kept in mind that the application of tactile signaling systems forces the living skin to learn a new language which is quite alien to its natural purpose.

Applications

If five vibrators are placed along a line of the skin of the forearm, 2 centimeters apart, and the amplitudes of vibrations adjusted so that they feel equally intense when activated separately, only the vibrator in the array's center will be felt (Fig. 6) when all are activated simultaneously. *Pitch* sensations of the other units will be completely inhibited. Strangely enough, the intensity of the inhibited outside vibrators increases the *loudness* of the vibrator in the middle. Von Bekesy describes this interaction as "funneling". Unfortunately, in standard communications tasks, this phenomenon cannot be tolerated since it leads to a loss of system resolution.

For a tactile communications system to be practical, the apparatus must be designed so that it will not be handicapped by the normal neural inhibition processes. Since this is an extremely difficult problem, the designer should avoid complex coding and, if possible, sensory cues of different frequencies. In most emergency situations, it is unreasonable to expect a harassed individual to pay close attention to various tactile codes and modifications of pitch patterns. In most critical situations, the single-unit, "on-off" stimulator is the only answer.

Electronic steering of tactile skin contactors can be accomplished by various keying modes. Fig. 7B shows the electronics for the "Vibrotactor", developed by the author as an emergency signal for astronauts.

The device consists of a solenoid-type plunger mechanism equipped with d.c. excitation bias. The activation interval is determined by positive pulses applied to the gate of the silicon controlled rectifier (SCR). In the diagram, the system is shown in abbreviated form. During "on" time, the a.c. portion of the solenoid winding is energized and the skin contractor vibrates. The pulse (*Continued on page* 80)

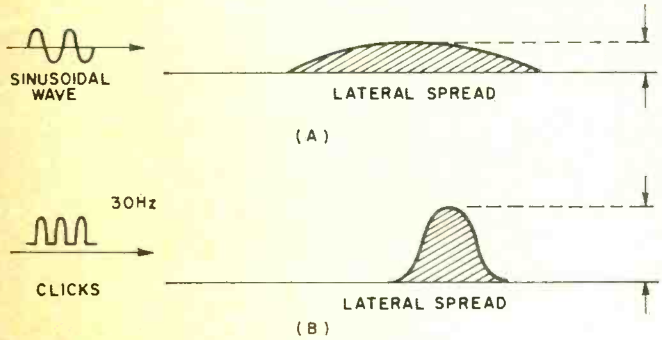


Fig. 5. The magnitude of the sensations from clicks is more intense over a smaller area than those from sinusoidal inputs.

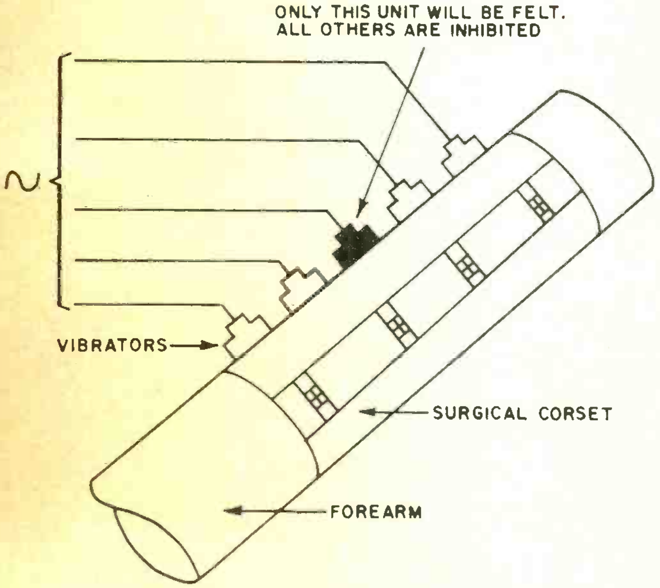


Fig. 6. In a five-unit inducer array, only the center unit will be felt. Other vibrators contribute to the intensity of feeling.

Fig. 7. If the Vibrotactor's drive pulse is too short, a pulse stretcher can be used to extend baseline and drive solenoid.

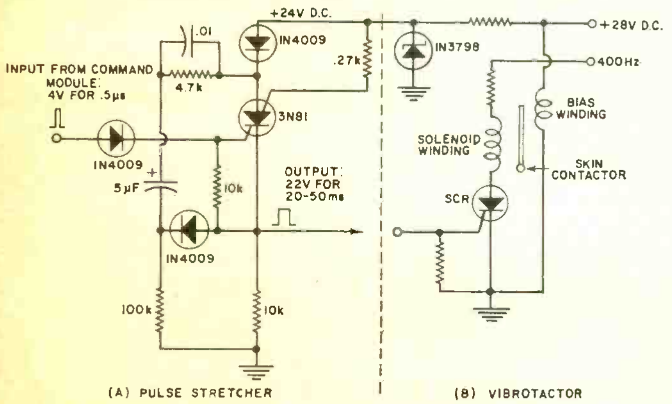
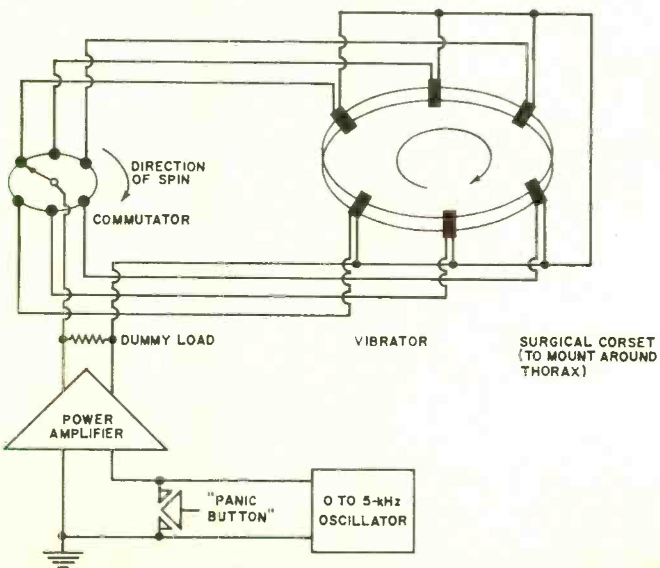
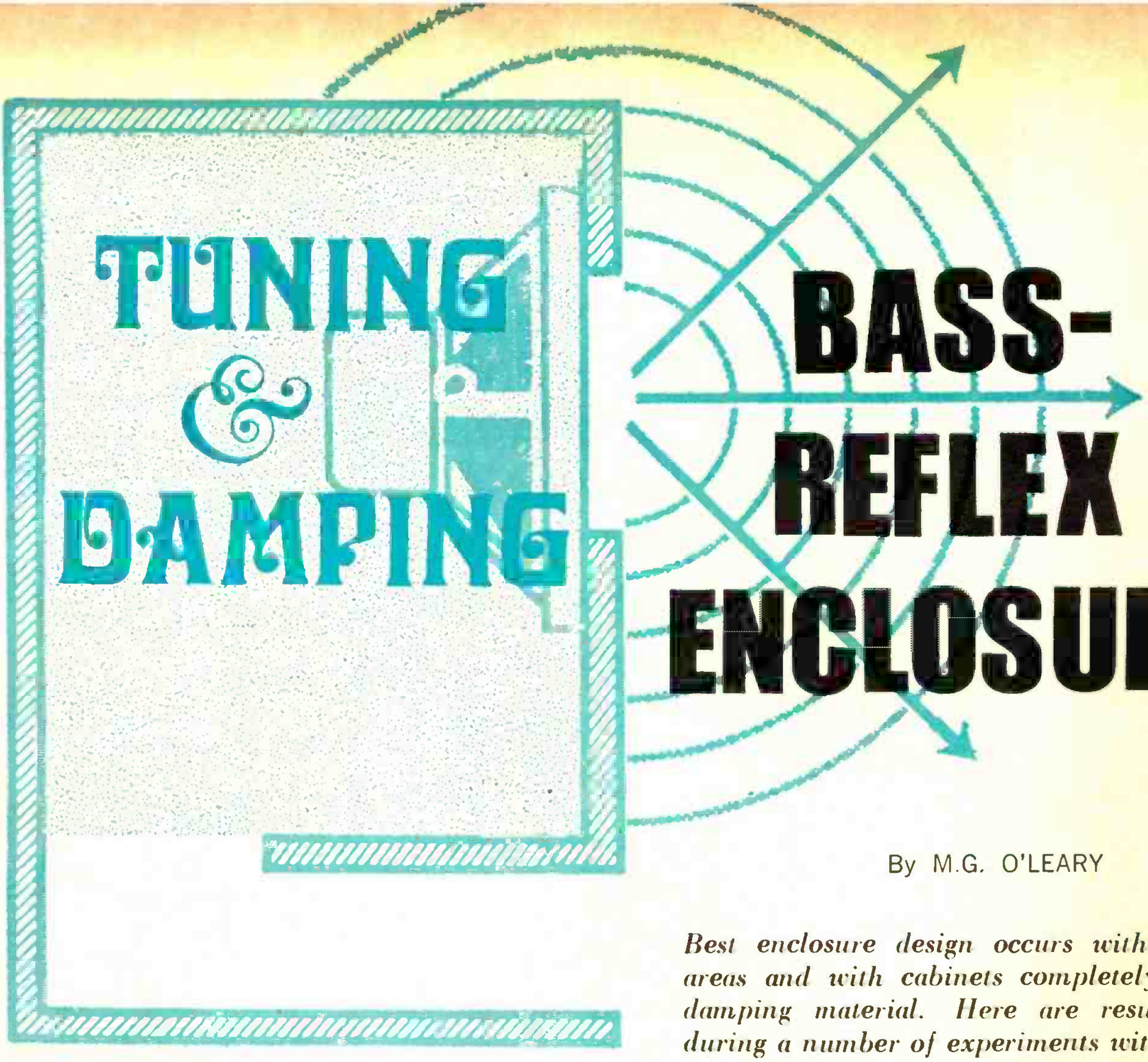


Fig. 8. Thorax-mounted tactile spin inducer can create an artificial whirl in a human observer. Device is suitable for some aeronautical and astronautical warning systems.





TUNING & DAMPING BASS-REFLEX ENCLOSURES

By M.G. O'LEARY

Best enclosure design occurs with larger port areas and with cabinets completely filled with damping material. Here are results obtained during a number of experiments with enclosures.

THE author purchased two expensive 12-inch coaxial speakers of high repute with the intention of mounting them in bass-reflex enclosures custom-adjusted for optimum performance. Plenty of information is available on designing and building such enclosures, less on testing the results, and practically nothing on what to do next if the test results indicate that the promised performance has not been obtained.

Of all the literature providing design data, two articles were chosen. The first reference (p. 38) is a comprehensive presentation which not only relates cabinet volume, port size and frequency, but also, on one large nomogram, port aspect ratio and duct length. The second reference article is concerned mainly with smaller-sized cabinets and ducted ports, but it introduces a contradiction to the commonly recommended "the bigger the cabinet, the better the bass". It stipulates that for each speaker there is one optimum size enclosure and presents precise information on how to determine the optimum size.

The author's speakers have a free-air resonance of 40 Hz. Working into an enclosed box of 1 cubic foot volume, the resonant frequency rises to 93 Hz. According to the second article, the optimum cabinet size for such speakers is 5500 cubic inches (about 3¼ cu ft). While larger enclosures could be tuned properly, a flabbier bass could result. Nevertheless, a 4-cubic-foot cabinet was chosen for test purposes on the assumption that the results obtained would still be valid in a relative sense for other sizes of cabinets. What was wanted was information on how to adjust enclosures to give optimum performance rather than a precise enclosure design.

The British literature also yielded some information on the internal damping of cabinets. One article[3,4] concerned a labyrinth-type of enclosure internally filled with long-fiber wool. Others[5,6,7,8] show how small reflex cabinets could be designed to be almost completely resistive if they were pressure-filled with wood-wool or other similarly acting materials, such as kapok or Terylene quilt batting (similar to Dacron filling for quilts).

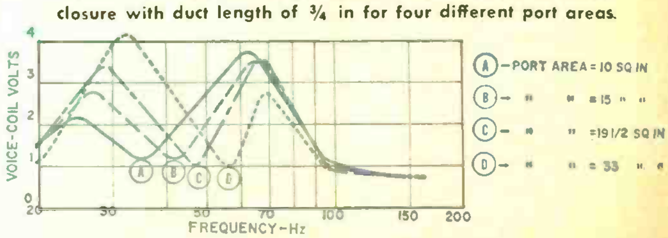
The test cabinet walls were 1½ inches thick—except at the port periphery which had been cut back to give a duct length of ¾ inch. All internal faces but the front one were lined with at least one inch of under-carpet felt.

The first step in the test program was to find the correct port area. The following data from the design article[1] shows the cabinet resonance for an enclosure volume of 4 cu ft with a port duct length of ¾ in:

Port Area (sq in)	10	15	33	75
Port Aspect Ratio	0.9:1	1.7:1	2.7:1	3:1
Cabinet Resonance (Hz)	40	47	61	76

While it appeared that a 10-square-inch port area was what would be required to match the 40-Hz resonance of

Fig. 1. Voice-coil voltage (which varies directly with impedance) of a 40-Hz speaker mounted in a 4-cu-ft bass-reflex enclosure with duct length of ¾ in for four different port areas.



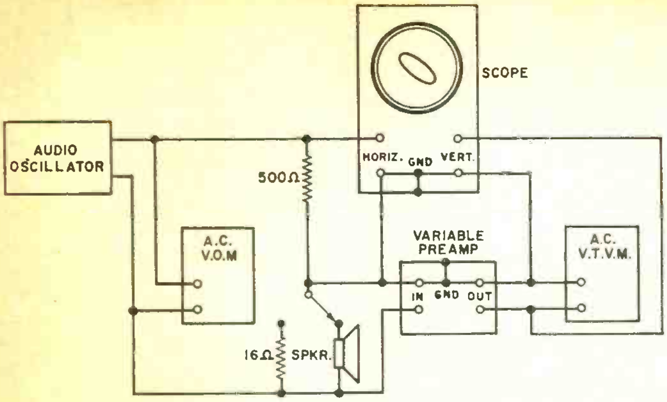


Fig. 2. Test setup used for impedance, phase measurements.

the speakers, it was decided to check the effects of varying the area; 10, 15, 19½, and 33 square inches being selected.

For each test setting a relative impedance curve was plotted by feeding the 6000-ohm output of a sine-wave generator directly to the voice-coil and measuring the voltage. Fig. 1 shows the plotted results. In all cases the double-humped bass-reflex curve was obtained. But the effects of too small or too large a port area are also clearly illustrated. As the port area is increased: (1) the low-frequency hump becomes higher and its frequency increases; (2) the high-frequency hump becomes lower and its frequency increases; and (3) the valley frequency increases markedly.

Despite the fact that the design data indicated a port area of 10 square inches, examination of the test results suggests a port area of 15 square inches as being best. Even though the high-frequency hump was higher than the low-frequency one, the valley frequency was close to the loudspeaker resonant frequency of 40 Hz.

We wanted to check the British claim that by filling up reflex enclosures with damping material, low-frequency phase shift could be reduced to negligible proportions, thus easing the problems of the amplifier-speaker instability.

Impedance & Phase Measurements

It was thus decided to use a little more sophisticated set-up in order to read off actual voice-coil impedances and at the same time provide phase-shift information. Crowhurst[9] was the inspiration for the test setup shown in Fig. 2. By setting the gain of the preamp and using the 16-ohm calibrating resistance, the v.t.v.m. reading could be brought to indicate ohms directly. Phase-shift readings were qualitative ones made by comparison with accurate phase-shift patterns on the oscilloscope.

Tests were made on the cabinet with different port openings and varying amounts of Terylene batting and kapok damping material. The results can best be appreciated graphically by examining the figures to be discussed below.

Wood wool is hard to obtain and difficult to use; thus, it was not tested. Kapok tends to compact together, and it was well "teased out" before being used. The Terylene batting comes in sheets 78 inches × 100 inches × ½ inch. It is very light and when held up, one can almost see through it. Terylene is a synthetic fiber chemically similar to Dacron. The material used in these tests was obtained in Canada under the name "Bonded 100% Terylene Fibrefill Quilt Batt". In the United States, the equivalent Dacron product is "Mountain Mist Dacron, Filling for Quilts" and is available in leading department, variety, and chain stores.

Results of the Tests

Most bass-reflex construction articles recommend not only lining the cabinet to absorb standing waves, but also various methods of damping the "Q" of the system. A common recommendation is to shroud the back of the speaker with a fiber glass blanket or other sound-absorbent material. This was tried using three ½-inch layers of Terylene batting as the shrouding material. The results are shown in Fig. 3. This damping causes both humps to be reduced and the lower-frequency hump to drop from about 90% to 80% of the height of the higher frequency hump.

The port area was then increased to 20 square inches and this brought the two humps back to the same height—at the same time moving the valley from 42 Hz to 44 Hz. Also, as shown in Fig. 3B, the phase-angle curves are not significantly changed by this amount of damping. However, worthy of note is the evidence that as damping is added, the port area should be increased to maintain the lower hump response. This is much more clearly shown by Fig. 4 where the lower hump almost disappears when the cabinet is filled with Terylene batting.

Fig. 5 shows the results of progressively more damping in a cabinet where the need for a larger port area had been anticipated by an increase from 15 to 33 square inches. Not only does increased damping reduce the relative height of the lower hump but the frequency of this hump increases as well. Simultaneously the frequency of the higher frequency hump is reduced, but only slightly.

The port area of the test enclosure was now increased to 75 square inches and the results of damping are shown in Fig. 6. Fig. 6A depicts the same cabinet conditions, except for port area size, as does Fig. 5C. Similarly, Fig. 6B compares with Fig. 5D. The larger port area not only changes the relative size of the humps as expected, but also increases the frequency of both the humps and also the valley, as predicted in Fig. 1.

Fig. 7 shows what happens when kapok is used as damping material instead of Terylene batting. Kapok turns out to be very potent—even with as little as is required to just fill the cabinet. The impedance curve indicates a cabinet having too much damping or too small a port. We could not make the 75-square-inch port larger, and any less kapok would have been impractical in this application. Thus kapok was dropped as an alternative for this cabinet.

Figs. 3B and 8 show the phase-angle conditions for empty-cabinet, shrouded-speaker damping, and two conditions of filling the cabinet with Terylene batting. The shroud damping has no material effect on phase, but the Terylene batting shows a marked reduction of phase angle between the two frequency humps. This should be a definite advantage even though the phase in the 20-Hz and 70 to 150-Hz areas has not been improved. However, for this 4-cubic-foot enclosure, no damping conditions gave significantly better phase-angle reduction than those of Fig. 5C.

Narrowing the Choice

At this stage it was decided that the best damping conditions should be determined in order to have one choice of this type for further comparisons with empty cabinets and speaker-shrouding damping. The choice narrowed down to those conditions represented by Figs. 5C and 6B. While the latter had the largest port, which suggested better extreme bass response, its humps were at 42 Hz and 66 Hz compared with 32 Hz and 62 Hz for the Fig. 5C conditions. The latter promised a smoother bass. Additionally, the former had much more Terylene batting packed into the cabinet, a condition which might give rise to "choking" on heavy passages, a state of affairs where the damping material restricts the air behind the speaker to the point where it causes nonlinear cone excursions and distortion.

Since phase-angle results were similar, the only hesitation we had in choosing the Fig. 5C conditions was the possibility of poorer bass response. Listening tests soon dispelled any fears on this score. The writer has not yet heard any reflex enclosure which gave a smoother, deeper, or cleaner bass response than this one. Later, the results of tone-burst

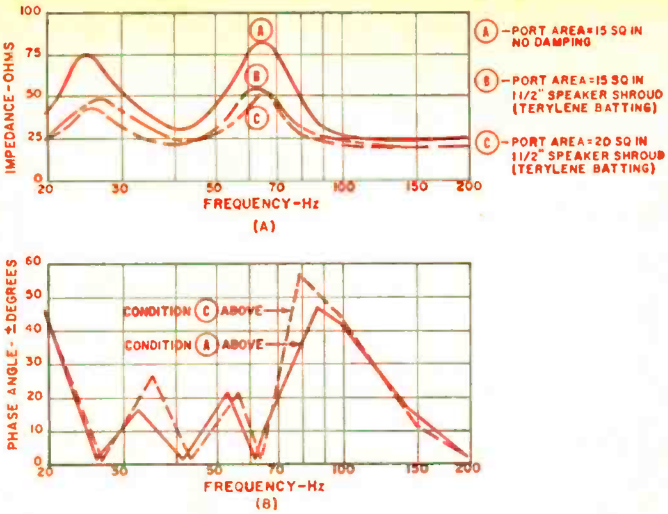


Fig. 3. Effect on (A) impedance and (B) phase angle of shrouding rear of speaker with 1 1/2-in thickness of Terylene batting.

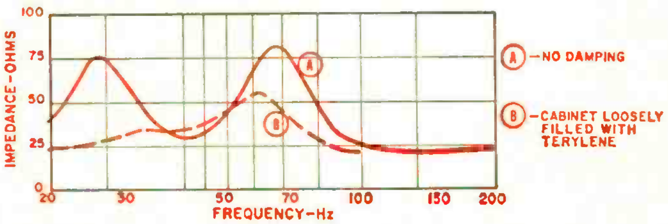


Fig. 4. Effect of loosely filling the 4-cu-ft cabinet having a port area of 15 sq in with Terylene or Dacron batt.

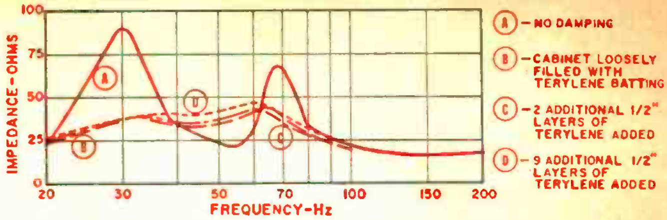


Fig. 5. Effect of adding various amounts of damping material to the 4-cu-ft cabinet with a port area of 33 square inches.

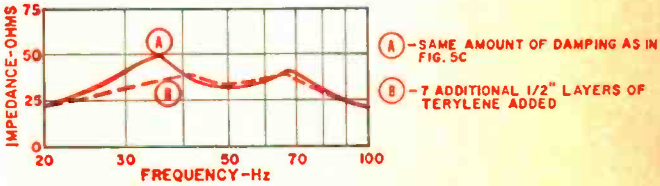


Fig. 6. Effect of adding various amounts of damping material to the 4-cu-ft cabinet with a port area of 75 square inches.

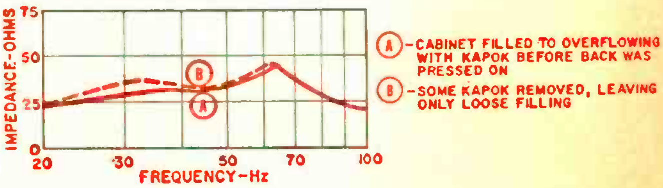


Fig. 7. Effect of adding various amounts of kapok damping to the 4-cu-ft cabinet with port area of 75 square inches.

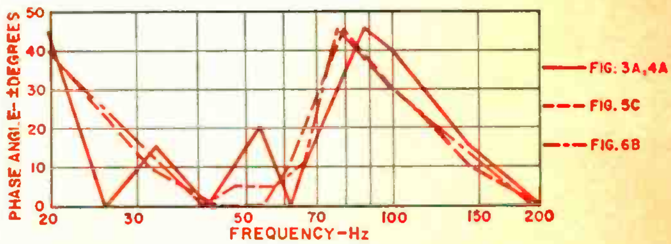


Fig. 8. Phase-angle curves relating to previous curves.

tests for various cabinet conditions will be presented. At this stage it should be mentioned that neither of the Fig. 5C and 6B conditions showed any superiority over the other in tone-burst tests.

The conditions represented by Fig. 5C were thus chosen as those to represent a bass-reflex enclosure with damping material of optimum design.

Dacron or Terylene batting are certainly the easiest to use of all the damping materials readily available. Fig. 9 shows the test cabinet being filled. Holes are cut in the batting to allow for the speaker. The material should be laid in place layer upon layer until the desired amount has been introduced. The minimum should be just enough to barely fill the cabinet without any compression. The maximum can be any greater amount that will still allow the back of the cabinet to be screwed in place.

Tone-Burst Tests

Since listening tests are difficult enough to interpret under A-B conditions, and impossible when alterations are required between tests, a test was sought which might give some sort of qualitative or quantitative comparison among the various damped conditions. What we wanted to find out was whether our damping experiments had any beneficial results in reducing speaker hangover. Accordingly, experiments were conducted using tone-burst tests.

Room resonances make it impossible to interpret oscillograms of microphone pick-up of loudspeaker response to tone bursts. Oscillograms of voice-coil voltages when tone bursts are fed to it through a hi-fi amplifier are hard to interpret due to amplifier damping and other effects.

The arrangement of Fig. 10 was finally adopted. Purists will probably condemn this system as being meaningless, quantitatively. However, it has a valuable qualitative value, and results support this. While the burst is "on", the scope is measuring burst generator output into the loudspeaker load. When the burst is "off", the only thing that it can measure is any voice-coil-generated voltages into the 100-ohm impedance of the generator. Hangover tendencies are thus detected and Fig. 11 is testimony to the fact that these exist in abundance. *(Space limitations prevent us from showing any more than a sampling of the large number of tone-burst waveforms taken by the author.—Editor)* One hundred ohms is very much higher than the usual output impedance of a typical high-fidelity amplifier and hence, in the latter

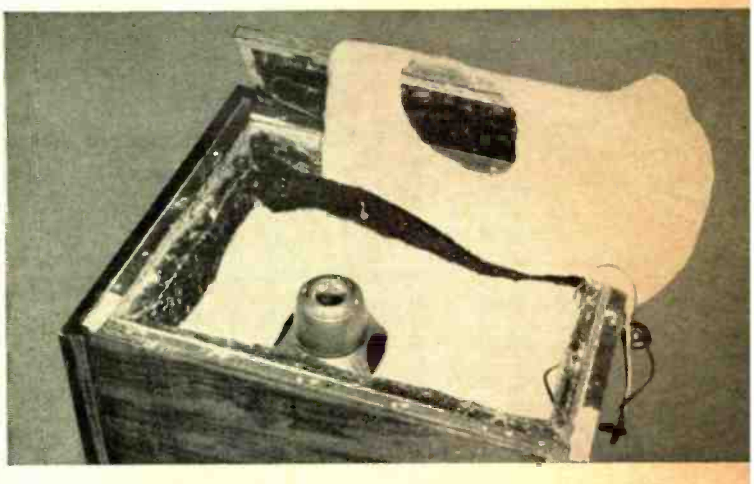


Fig. 9. Damping material is shown here being added to → test cabinet. Note the 1/2-in thick layer draped over back with hole cut to accommodate speaker. One layer of damping material is added to the next until enclosure is filled.

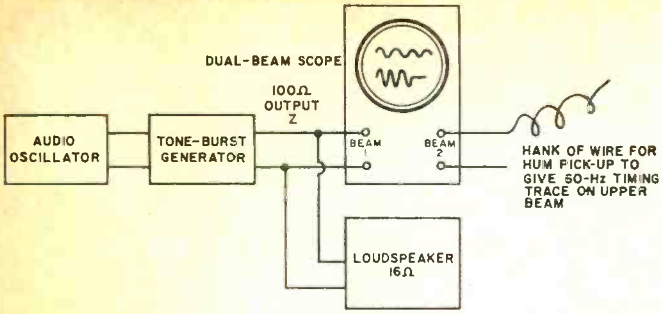


Fig. 10. Arrangement used for tone-burst measurements.

case, hangover tendencies in the loudspeaker are pretty well damped out. However, the smaller the hangover before amplifier damping, the better the end result after damping is introduced.

It was found that this experimental arrangement was not very sensitive to any coloration resulting from high-frequency bursts. It really only responds to frequencies in the region of the bass resonances of the system being studied. Fig. 11 tells the story and quite clearly illustrates the reduced hangover tendencies of the Terylene-batting damped system. The shrouding type of damping is shown to be much less effective in reducing hangover tendencies. The "off" portion of the curve can be determined by finding the breaks in the trace. At any rate, if the "off" portion is impossible to determine, it is certainly clear that there exists a tremendous hangover tendency.

These oscillograms *(as well as many others taken but not shown here—Editor)* certainly reinforce the previous evidence of smoother impedance curves and reduced phase angles in favoring the filling of the enclosure with damping material. Listening to the final system, represented by Fig. 5C, is convincing. The bass is certainly present without bass-boost, and is clear and smooth.

Conclusions

1. Filling a bass-reflex enclosure with damping material gives desirable results in smoothing out the impedance curve, reducing phase shifts and hangover, and in improving speaker loading.

2. Damping significantly alters the tuning of the enclosure. Final tuning should not be carried out until the desired amount of damping has been applied.

3. Damping may be an easier way of tuning reflex cabinets than port alterations. A broad tuning range is available between the minimum practical amount of damping material and that amount which would seem to indicate the maximum tolerable limit of damping material compression.

4. A suggested method for final tuning is to first enlarge the port to about 2½ times its empty-cabinet area, and subsequently add Terylene or Dacron quilt batting until a desirable impedance curve has been obtained. If too much batting is required, a portion of the port should be blocked off and the procedure repeated. ▲

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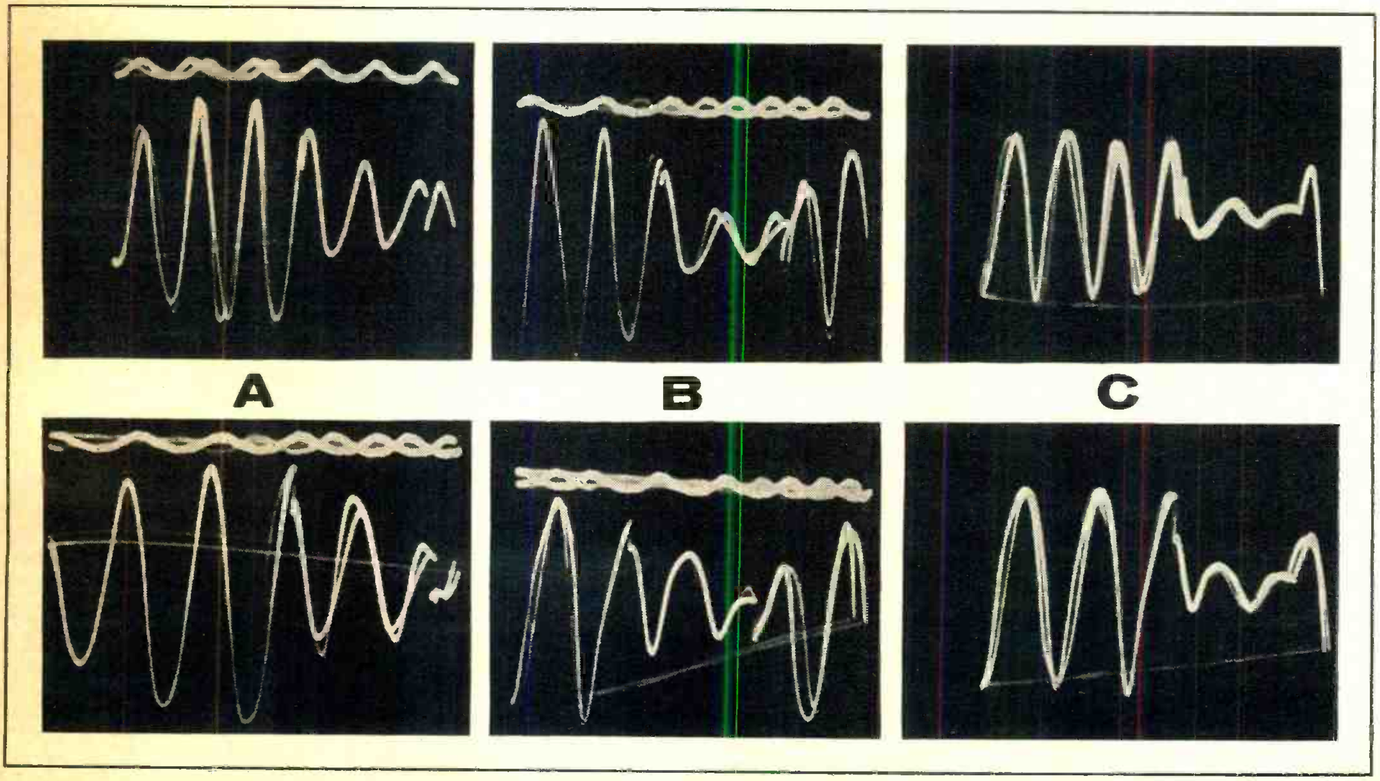
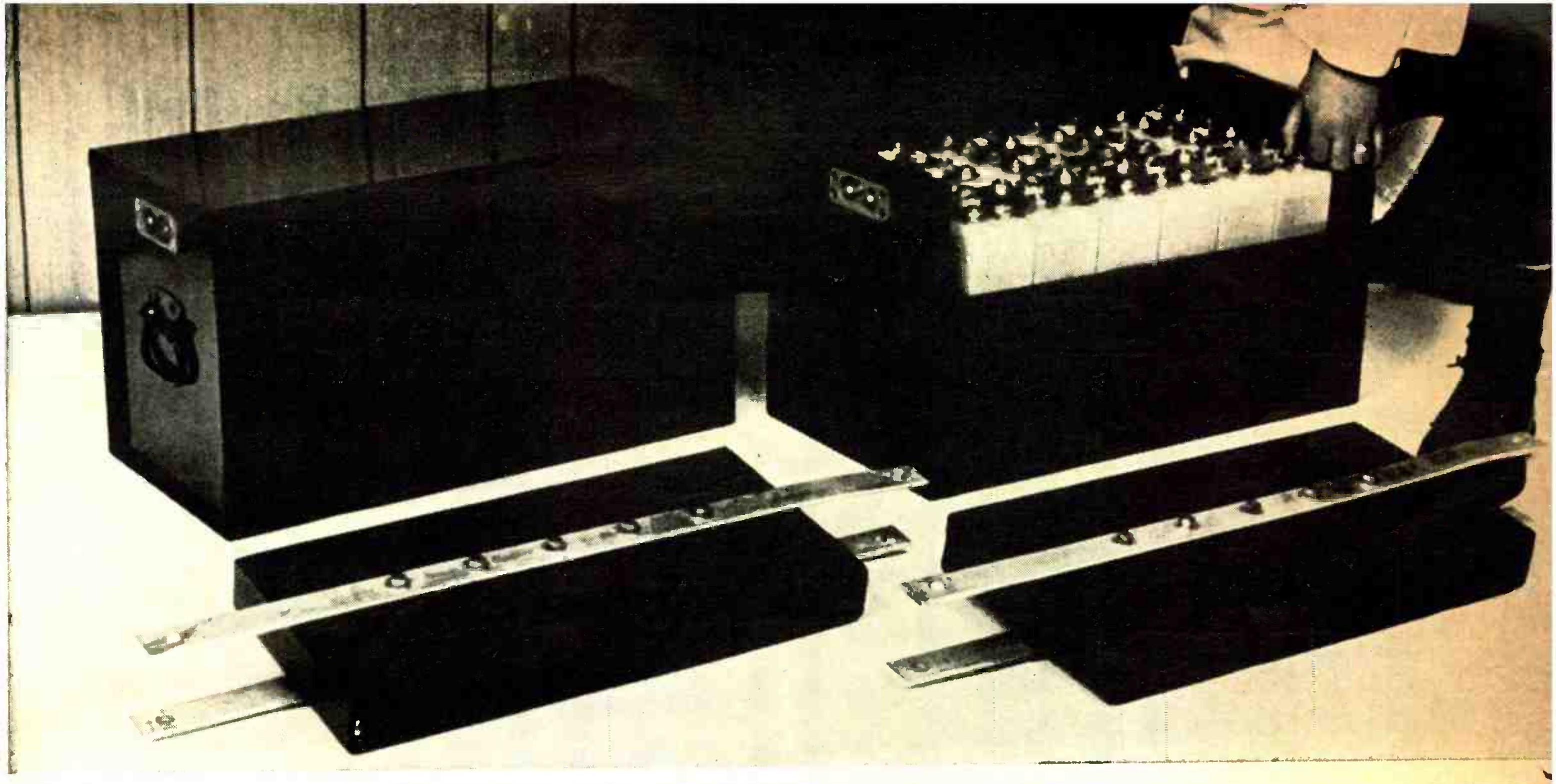
Fig. 11. Tone-burst waveforms of undamped and damped bass-reflex speaker systems. Frequency used was 77 Hz at an 11-Hz rate for the top three waveforms and 55 Hz at an 11-Hz rate for the bottom three. The small upper waveforms are 60-Hz hum pickup used for timing purposes. (A) Speaker in 4-cu-ft undamped cabinet with 15-sq-in port area. (B) Port area increased to 20 sq in and rear of speaker shrouded with 1½-in thickness of Terylene batting, as per Fig. 3C. (C) Port area increased to 33 sq in and entire cabinet filled with Terylene batting, as shown in the curve of Fig. 5C graph.





Two lithium-nickel fluoride power packs (rear) can energize the "Amitron" for 150 miles. The flat bipolar nickel-cadmium units (foreground) are for acceleration.

BATTERY-POWERED CARS: Fact or Fantasy

By W. J. EVANZIA/Associate Editor

Recently several auto makers announced they were developing electric cars. Their problems today are the same as in 1900: winning public acceptance and finding adequate power source.

WE may have become so accustomed to the smell and taste of gasoline fumes and to the feel of a powerful engine in front of us that we can't give it up. At least, not in favor of a quiet, low-powered, non-air-polluting automobile such as an electric car.

Powering automobiles by electricity is not a new idea. Electric cars were available before the development of the internal combustion automobile engine. But, they couldn't take us far enough and fast enough so they didn't last. Recently, the electric car, or a version of it, has been reborn and several manufacturers are working on development models. Some of them, however, would like to prove that the electric car is as impractical today as it was yesterday.

Probably the biggest hurdle the electric car must overcome is the power source. Batteries of reasonable size, with long life and high energy transfer rates, are needed to make the electric car practical. *Gulton Industries, Inc.* is tackling the battery problem and has teamed with *American Motors Corp.* to provide a power system for the *AMC* "Amitron" commuter car.

Without a doubt, the regenerative braking technique, or more properly defined, the system which uses braking energy to recharge the propulsion battery, is the most significant new feature of the *Gulton*-designed power system. An equally important new device is the lithium-nickel fluoride (Li/NiF_2) battery which will provide the main propulsion energy for the "Amitron".

Brakes Make Power

Almost all of an urban automobile operator's driving time is spent accelerating or coming to a stop. An idea of

Table 1. Driver activity during average urban automobile trip.

ACTION		PERCENTAGE TIME
Idle		15%
Cruise		16%
0-20 mi/h	6.9%	
20-30 mi/h	5.7%	
40-50 mi/h	3.4%	
Acceleration		36.7%
0-20 mi/h	1.1%	
0-25 mi/h	10.6%	
15-30 mi/h	25.0%	
Deceleration		32.3%

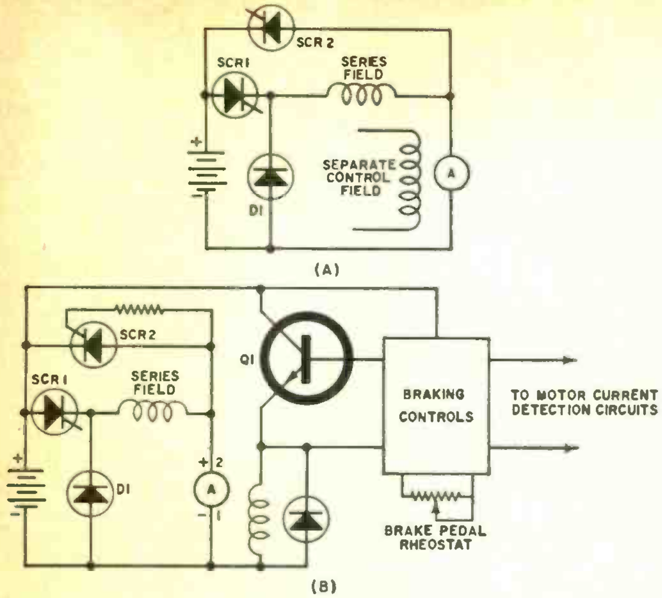


Fig. 1. (A) Basic circuit connections for a regenerative braking system. (B) Circuit diagram for controlled braking. During normal drive, SCR1 directs power to the motor. When brakes are applied, the shunt field feeds energy to the battery via SCR2.

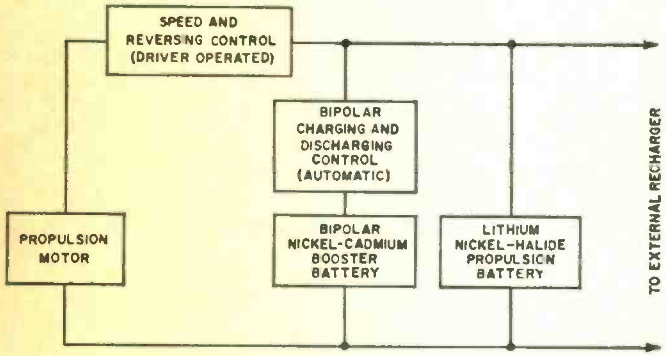


Fig. 2. Control system for the hybrid battery supply of the AMC electric car. The lithium nickel-halide propulsion battery charges bipolar unit while the automobile is cruising.

how much time is involved in these various maneuvers is shown in Table 1. Much of the energy dissipated in slowing the car or bringing it to a stop can be used to recharge the batteries and thus extend the driving range of the car.

As an example, consider the case of a 2500-pound electric vehicle moving along at 35 miles per hour, and requiring 5 kilowatts to maintain cruising speed. The mass of the vehicle is 2500 (lbs)/2.205 (lbs/kg) = 11.34×10^2kg. At 35 mi/h, the velocity is 35 × 1.4667 (ft/sec/mi/hr) × 0.3048 (meter/ft) = 15.6 meters/sec. The National Safety Council says that it requires 120 feet or 36.6 meters to bring a vehicle this heavy to a full stop. If we were to assume that the speed is reduced linearly, the average velocity is 7.8 meters/sec and the time required to come to a full stop is 4.7 seconds. Thus, the vehicle's kinetic energy ($\frac{1}{2} mV^2$) is 1.38×10^5 joules.

If all this energy were available for charging purposes, the 1.38×10^5 joules would equal EIt, where E is the battery voltage during the charge period (180 volts for the lithium battery), t is 4.7 seconds, and I is 163 amperes. At the 5 kW power rate, 1.38×10^5 joules could power the car an additional 28 seconds, or a distance of about ¼ mile. Using a figure of 24 stops per hour, the range of a vehicle traveling 35 mi/h could be extended 30 miles over a five-hour period. In other words, regenerative braking has the capability of extending the vehicle's range 25 to 50%.

It must be kept in mind, however, that in the regenerative mode the car's drive motor becomes a generator. Fig. 1A shows the basic motor braking operation. Current flows from the armature through the controlled rectifier, *SCR*2, and recharges the battery. The amount of current flowing back into the battery is given by $I = (E_g - E_{SCR2} - E_b)/R$ where E_g is the generator voltage, E_{SCR2} is the voltage across *SCR*2, and E_b is the battery voltage. The generator's voltage (E_g) is equal to $k\varphi\omega$ where k is a constant, φ is the control field's flux density and ω is the angular velocity of the armature. Since the angular velocity is proportional to car speed, the equation may be rewritten $k \varphi v$.

The function of the regenerative brakes is not to stop the car, but to return as much energy as possible to the battery system. The generator loads the brake system and absorbs the previously wasted braking energy while slowing the vehicle down. At some minimal speed, the braking force is eliminated by the motor and the operator has to depress the mechanical brake pedal fully to stop the car. But since kinetic energy is proportional to the square of the velocity, reducing the car's speed by one-fourth will absorb 90% of the initial braking energy. The motor-generator/mechanical brake mixture can stop a car in 3 seconds.

Fig. 1B is a typical regenerative braking control circuit. When the driver depresses the brake pedal, he causes transistor *Q*1 to conduct. This in turn passes current through the shunt field and generates a voltage at the armature terminals 1 and 2. When the generator voltage exceeds the battery voltage, *SCR*2 fires and current flows into the battery at a rate determined by the equation for *I*.

Parallel Operation

According to Steve Charlip, Research Section Head at *Gulton Industries*, two battery systems will power the *AMC* electric car. "A lithium-nickel fluoride battery", he said, "will provide energy for cruising while a bipolar unit will provide the high peak power necessary for acceleration." Fig. 2 is a simplified diagram of the proposed parallel battery system while the graph of Fig. 3 shows the operating points of each unit. Table 2 lists some of the characteristics of the *Gulton*-developed lithium propulsion and the bipolar nickel-cadmium booster batteries.

While cruising (at a speed of about 35 miles per hour), the motor and other electrical systems in the car draw about 50 amperes from the lithium battery. At this time, the battery's terminal voltage is 100 volts and the 69-cell (1.45 volts per cell) nickel-cadmium booster is on trickle charge. However, when the car accelerates, up to 450 amperes may be required. During the speed-up process the lithium battery's potential drops, and the discharge control senses the increasing load and connects the nickel-cadmium battery in parallel with the lithium unit. In the beginning, the bipolar unit's terminal voltage drops sharply, but as the load continues to increase, it declines slowly. After the period of acceleration has passed, the charge control disconnects the nickel-cadmium battery from its on-line position and reconnects it for charging by the lithium unit.

One of the prime movers of lithium battery development has been Dr. Robert Shair, head of electro-chemical research at *Gulton*. He claims that the NiF_2 batteries will push the *AMC* car 150 miles without the necessity for recharging. This is 68 miles farther than the estimated range for the sodium-sulphur power unit being developed by the *Ford Motor Co.* for its electric car.

Briefly, this is the manner in which the lithium-nickel halide cell is made. An expanded metal screen of Monel 400 is used for the nickel fluoride electrode's substrate. The lithium electrode uses pure nickel. The two are separated by a polypropylene fabric. In a mineral-oil base, a blend of 90 mole percent lithium metal powder and a 10 mole percent of conductive carbonyl nickel powder is mixed to the consistency of a paste. The binder is carboxymethyl cellulose dissolved in dimethyl sulfoxide (DMSO). Cell cases and covers are made from molded polypropylene.

The paste is applied to the Monel screen and the plates passed through two doctor blades, after which they are dried in warm moist air. Then they are compressed at two tons per square inch pressure. The coating cycle is repeated until 0.05 inch of dry mix builds up on the plates.

The voltage of a single lithium-nickel fluoride cell, under no load, is 3.2 volts. This is considerably higher than the 1.82 volts of a silver-zinc cell, the 2.2. volts of a lead-acid cell, and the 1.28 volts of a nickel-cadmium cell.

Prototype lithium batteries have achieved energies of 100 watt-hours per pound. This is by far the most efficient of the common battery types—nickel-cadmium has an efficiency of 16 watt-hours per pound, silver-cadmium produces 2 watt-hours per pound, and silver-zinc has an efficiency of 45 watt-hours per pound. Lead-acid batteries have efficiencies of only 10 watt-hours per pound.

The bipolar nickel-cadmium battery derives its name from its electrode configuration. The positive element of one cell and the negative element of the next cell are placed on two sides of a conducting thin sheet called the substrate. When bipolar electrodes are stacked in series, they are positioned so that a positive electrode surface and a negative electrode surface of adjacent plates face each other with a battery separator and electrolyte between them.

Recently, the Cornell Aeronautical Laboratory completed one of the most intensive and in-depth mass transportation studies ever conducted. Again, air pollution as well as traffic congestion were motivating forces behind the research. The study was called "Metrotran 2000" and its primary concern was to develop a balanced metropolitan or "megalopolitan" transportation system for the year 2000.

Significantly, perhaps, the study called for the development of the Urbmobile—a system that blended in a small electric car, the flexibility and privacy of an automobile with the high capacity and speed of a train. In the CAL Metrotran concept, the Urbmobile's car would be driven like an ordinary automobile and powered by an electric storage battery on city and suburban streets. Between cities, the Urbmobile would travel at 60 or 70 miles an hour on rails like a train with power provided by a third electrified rail. Guidance and control would be fully automatic while the car rides the rail.

In its present design, the Urbmobile has 850 pounds of lead-acid batteries with a capacity of 12,500 watt-hours. This energy source is representative of present battery development, but coincidently, the CAL researchers see the evolution of other secondary energy sources—notably those using sodium-air, sodium-sulphur, and lithium-halogen combinations—as pushing electric car development. Any of these futuristic power sources could reduce battery weight to well under 200 pounds while maintaining the same peak power output and driving range as lead-acid cells.

Certainly, electronic control techniques for electrically powered vehicles have been proven and are available. And, it would appear that an adequate power source (in terms of state-of-the-art) is well along in development. However, if the electric car is to be a success, it might require a battery other than as we know it. For it is unlikely that the American driving public will be impressed by the necessity for constantly recharging batteries or by the car's limited range—it matters little if the distance is 75, 150, or 200 miles—between charges. Some scientists are attempting to develop fuel cells as power supplies for automobiles, others are looking to atomic energy for that "get up and go".

But, the electric car may be the "impossible dream" for Americans. Perhaps, like the "taste" of cigarettes, it'll prove almost impossible to eliminate the idea of speed and power from our minds. But something will have to be done. Highways and city streets are already choked with poisonous-fume-spewing vehicles. Electric cars may not be the complete answer to our traffic congestion and air pollution, but . . . if they aren't what is? ▲

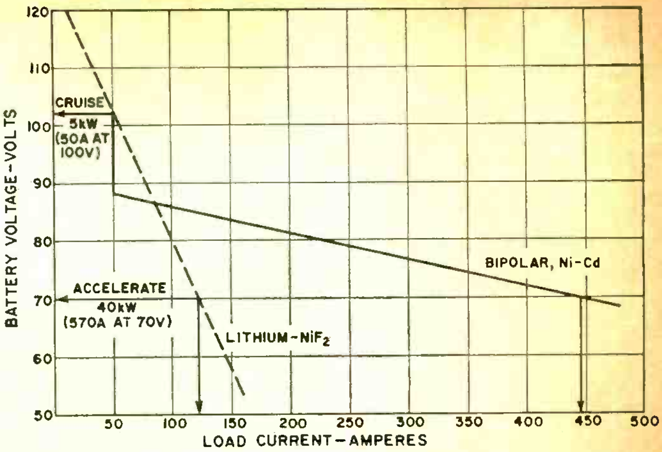
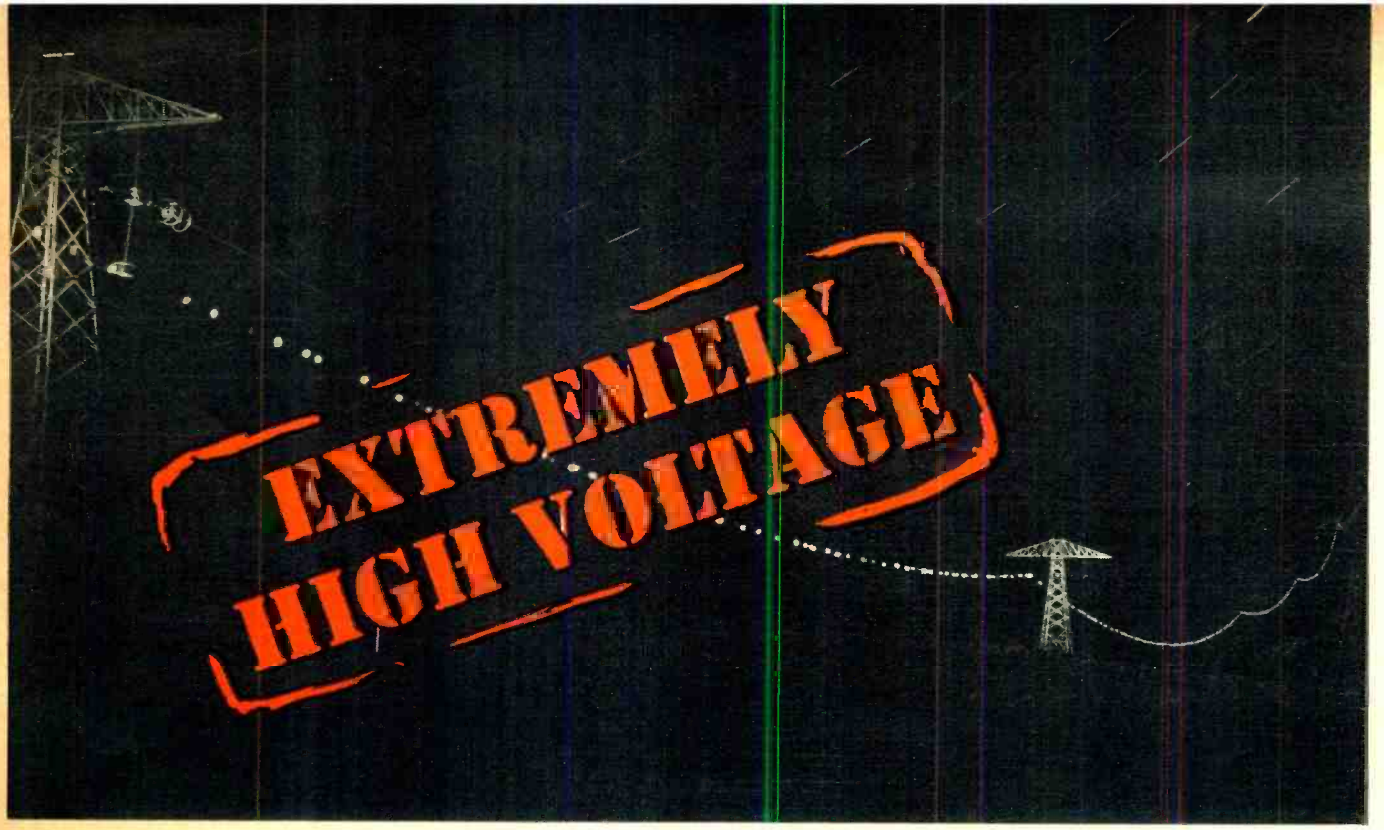


Fig. 3. Voltage-current relationship for a 250 amp-hour lithium battery and a 100-in^2 bipolar nickel-cadmium booster battery.

LITHIUM BATTERY	
Purpose	To provide a lightweight, high-energy battery
Characteristics	15 Whr/lb of energy; sealed and rechargeable
Weight	Two units 75 lbs each
Dimensions	23½"x13½"x12" each unit
Storage Capacity	225 ampere-hours at 100 volts
Energy Output	8 kilowatts for cruising (10 kW maximum)
BIPOLAR NICKEL-CADMIUM BATTERY	
Purpose	Specially constructed nickel-cadmium batteries for extremely high power applications
Characteristics	Sealed and maintenance free; long-lived and rechargeable; capable of delivering 800 watts of power per pound of battery
Dimensions	24"x12"x8"
Storage Capacity	10 ampere-hours
Energy Output	40 kilowatts

Table 2. Characteristics of Gulton propulsion and booster batteries.

Prototype Li/NiF_2 cells have yielded up to 0.2 Ah/in^2 of electrode area. Operating potential is 2.0 volts average.



This photo shows the corona on a high-voltage d.c. test line operated by the Bonneville Power Administration near The Dalles, Oregon. Streaks in sky are produced by stars and are result of time exposure.

D. C. POWER TRANSMISSION

By EDWARD A. LACY

The major part of the Pacific Northwest-Southwest Intertie, now being built by the Federal Government, City of Los Angeles, and six private utilities, uses EHV electrical transmission. Here are system characteristics and advantages.

THE Federal Government, the City of Los Angeles, and six private utilities are building the Pacific Northwest-Southwest Intertie, which promises to be this country's largest single electrical transmission development. Surprisingly, the major part of this 800,000-volt system will use direct current.

Not to be outdone, the Russians have announced that they are considering building a 1,500,000-volt d.c. system to transmit 5,250,000 kW of power. And, considering their past performance, they just may be able to build it—their Volgograd-Donbass d.c. transmission line has been operating since 1964 at 800,000 volts. The Intertie, however, won't be in operation until 1969.

Are the Russians ahead of us in this new technology? It has been pointed out that the Russians were conducting extensive research into d.c. power transmission at the Direct Current Institute in Leningrad as long ago as 1957. Even before that, they had an experimental d.c. line in operation between Kashira and Moscow, a distance of 70 miles.

In all fairness to U.S. engineers, it should be noted that Russia's large hydro complexes are located at great distances from their load centers. With such problems of distance, which U.S. engineers usually don't have, it was only natural that the Russians turned to EHV and d.c.

Whether the Russians are ahead or behind us, there is no denying that direct current has been a controversial subject among power engineers in the U.S.

In 1962, a prominent group of engineers, who had best not be identified for their short-sightedness, reported that "d.c. development has been given appropriate consideration in this country. And," they concluded, "the only reason for building an overhead EHV d.c. line in this country at the present time would appear to be for experimental study. . . ."

That same year, however, engineers at the Bonneville Power Administration, a part of the Department of the Interior, received Congressional approval to build an extra high voltage direct-current test center at The Dalles, Ore.

Experience gained with this center enabled Government engineers to report in 1964 that the use of a high-voltage direct-current transmission line as a part of the Pacific Intertie would be financially feasible and would pay for itself over its service life.

But there was a catch. It seems that American manufacturers didn't have the necessary know-how and experience in high-voltage d.c. to undertake such a system. On the other hand, Secretary of the Interior Stewart Udall felt that it was in the national interest to encourage American firms in the development of this new technology. So the contract negotiated for the 11-state Intertie allowed *General Electric* to team up with the Swedish firm of *Allmanna Svenska Electriska Aktiebolaget* (or *ASEA* for short), which had built most of the free world's direct-current power transmission systems.

Although relatively unknown in the U.S., *ASEA* is one of the world's oldest and largest electrical equipment companies.

Its interest in direct current goes back to the 1920's when work was begun in earnest on the crucial item in direct-current power transmission systems—the mercury-arc rectifier, trying to bring its power ratings up to the point where it could be used for power transmission.

As currently developed, the mercury-arc rectifier consists of the following major components: a pool of mercury used as a cathode, control grid, grading electrodes, and anodes.

The control grid allows the rectifier to function as an inverter, that is, change d.c. to a.c. This is accomplished by delaying the firing point in the cycle to the appropriate point. The grading electrodes, when connected to an external voltage divider network, insure that there is a uniform voltage distribution along the path of the arc. Without such electrodes, high-power rectifiers of this type would not be practical since the voltage distribution would be so high in the vicinity of the anode that arc-backs would occur. The final element is the anode, which may be one of several connected in parallel for higher current.

The rectifiers which *ASEA* and *G-E* are to provide for the Pacific Intertie will be rated 133,000 volts at 1800 amperes. Connected in a three-phase full-wave bridge rectifier circuit, they will provide 400,000 volts negative with respect to ground and 400,000 volts positive with respect to ground. Power engineers express it as ±400,000 volts, which of course makes a potential difference of 800,000 volts between lines.

Advantages of EHV

Extremely high voltages like these are used for one very simple reason—as the voltages get higher and higher, the cost of lines and terminal equipment goes up approximately in direct proportion, but the power capability of the line increases as the square of the voltage. Thus, a 700-kV line will carry nine times as much power as a 230-kV line, but will cost only three times as much.

In a typical EHV d.c. system, a three-phase alternating-current generator produces the power to be used, just as in a system which is entirely a.c. This three-phase voltage is then transformed up to extremely high voltages. The mercury-arc rectifiers change the a.c. to d.c. at the same high voltages. The d.c. is then transmitted to the approximate point where it will be used and is then changed back to a.c. by more mercury-arc rectifiers. Step-down transformers then reduce the voltage to a safe level for final distribution to the ultimate user.

The user, of course, is never aware that his power was in the form of direct current for many miles and probably couldn't care less. However, he may notice that his power bill is lower because d.c., in many cases, can be transmitted over long distances at a lower cost than a.c. Bonneville's engineers state that d.c. lines cost approximately $100 per kV-mile whereas a.c. lines cost approximately $225 per kV-mile.

One of the reasons that d.c. is less expensive for power transmission is that only two lines are required rather than the three which would be needed for economical a.c. transmission. This means that you spend less for cable, you need fewer insulators, your towers can be smaller and thus you need less right-of-way (which can be pretty expensive near cities). Also, EHV d.c. lines don't need expensive high-voltage shunt reactors and series compensators as do EHV a.c. lines.

Against the reduced costs of line and right-of-way must be added the costs of the mercury-arc rectifier terminal stations, which are not inexpensive. Nevertheless, when the transmission lines get longer than about 300-500 miles, d.c. lines start getting competitive with a.c. lines. For the Nelson River EHV d.c. project to be built in Manitoba, Canada, engineers have calculated that d.c. will be 15% cheaper than a.c.

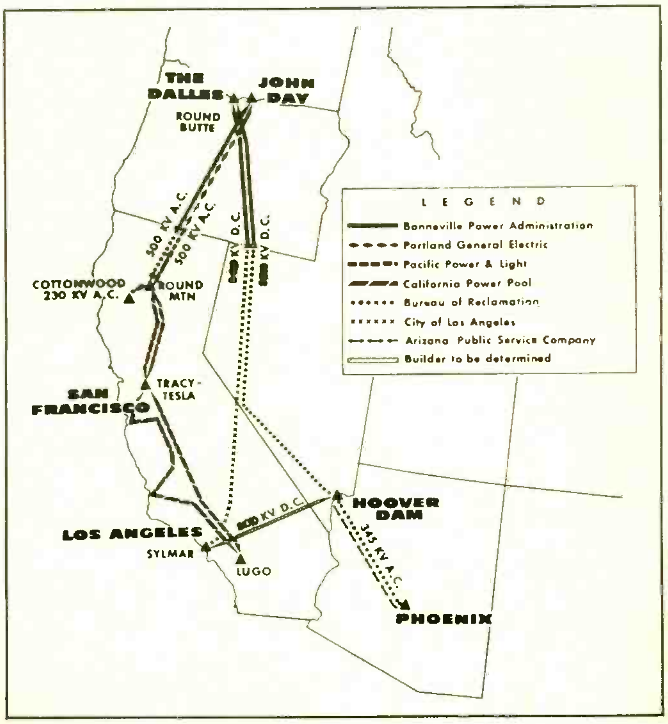
It is possible that the cost of d.c. systems may be cut drastically by using the earth or sea as a return line for the current and using only one overhead line. (This would be impossible with a.c. because of inductance effects.)

When it was first proposed for d.c. systems, it was thought that stray earth currents in an earth return would make buried cables and metallic pipes corrode and interfere with railroad signaling circuits. Fortunately, engineers have discovered that the direct current flows through the interior of the earth and doesn't affect the surface, except in the immediate vicinity of the electrodes.

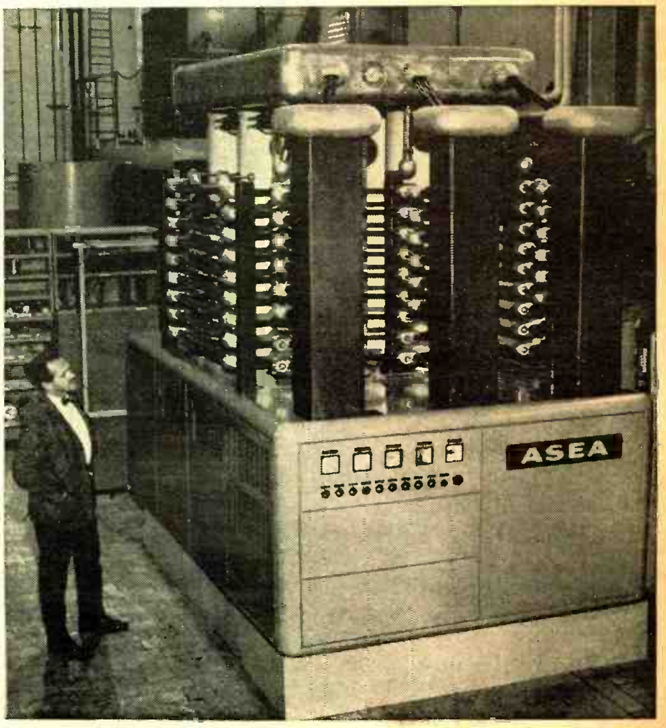
Whether or not the earth return is used on a regular basis, it can be used in an emergency. For example, if one line goes out for some reason, say from a lightning strike, the d.c. system can use an earth return as an emergency conductor. While the system output will be cut in half, one half is better than none.

Still another advantage of EHV d.c. is apparent when it is used to interconnect two a.c. sys- (*Continued on page* 69)

Fig. 1. Map showing the Pacific Northwest-Southwest Intertie.

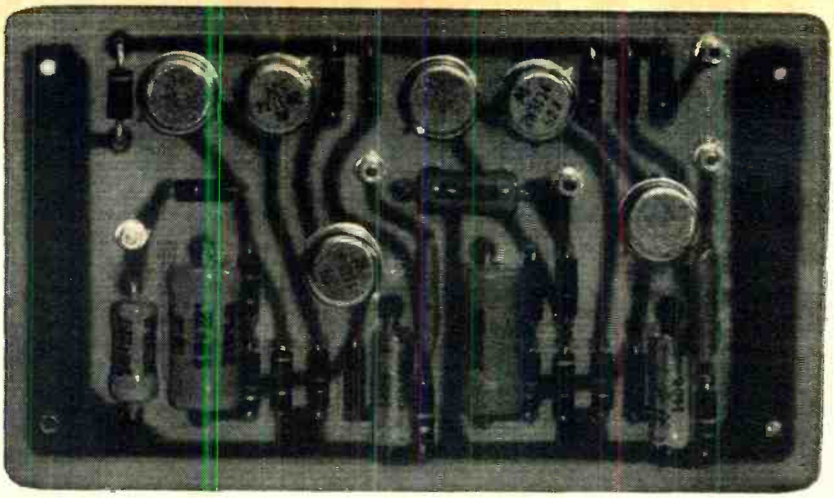


Prototype of 6-anode mercury-arc rectifier for Pacific Intertie.



The Engineer's STEREO PREAMP

By JAMES G. HOLBROOK
Senior Engineer, Varian Associates



Top view of the printed-circuit version of the stereo preamp.

Theory, design, and testing of a preamp for magnetic phono cartridges is covered. Pole-zero terminology is employed in the circuit design.

THIS article presents the theory, design, construction, and testing of a simple but extremely high-quality stereo preamplifier for magnetic-type phonograph cartridges which use RIAA equalization. The circuit has been designed to appeal primarily to engineers, technicians, and the more serious music enthusiasts who can appreciate the many small points considered.

We will use pole-zero terminology here, as this is well understood generally by engineers. If necessary, a good review can be had by consulting a reference such as "Laplace Transforms for Electronic Engineers" (second edition) by J. G. Holbrook, published by *Pergamon Press*, New York and London, 1966.

The RIAA transfer function $Z_T(s)$ completely describes the shape of the required compensated gain curve. It is easy to show the gain curve graphically, but this serves no purpose as the graph cannot be used for creating design information except for approximate cut-and-try methods.

In terms of complex frequency s, the RIAA transfer function is given by:

$$Z_T(s) = \frac{K(sT2+1)}{(sT1+1)(sT3+1)} \quad (1)$$

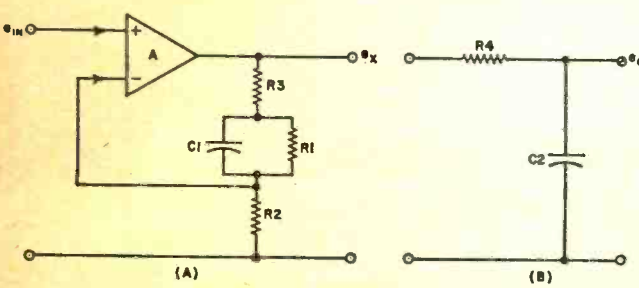
$T1$, $T2$, and $T3$ are the critical time constants and are specified as:

$$T1 = 3180\ \mu s,\ T2 = 318\ \mu s, \text{ and } T3 = 75\ \mu s \quad (2)$$

Since equation (1) is second-order, network theory indicates that a minimum of two reactive elements will be required in the frequency-compensating network. For our initial discussion, however, let us examine the feedback arrangement shown in Fig. 1A.

A is a high-gain feedback amplifier, where the + sign represents a non-inverting input terminal and the — sign is an inverting input terminal. Our justification for examining this network is based on past experience; the ultimate justification will be based on final results.

Fig. 1. (A) Basic feedback arrangement. (B) Additional section.



When we analyze Fig. 1A, the complex gain e_X/e_{IN} is found to be:

$$\frac{e_X}{e_{IN}} = \frac{\left[\frac{R1+R2+R3}{R2}\right]\left[\frac{sR1C1(R2+R3)}{R1+R2+R3}+1\right]}{sR1C1+1} \quad (3)$$

If we let

$$\frac{R1+R2+R3}{R2} = K, \quad (4)$$

$$\frac{R1C1(R2+R3)}{R1+R2+R3} = T2, \quad (5)$$

and

$$R1C1 = T1 \quad (6)$$

then equation (3) can be rewritten as:

$$\frac{e_X}{e_{IN}} = \frac{K(sT2+1)}{(sT1+1)} \quad (7)$$

Now suppose we start at e_X and add one additional *RC* section to Fig. 1A as in Fig. 1B. If we now define

$$R4C2 = T3 \quad (8)$$

then

$$\frac{e_{OUT}}{e_X} = \frac{1}{sT3+1} \quad (9)$$

and the complete transfer function e_{OUT}/e_{IN} becomes the product of (7) and (9), or:

$$\frac{e_{OUT}}{e_{IN}} = \frac{K(sT2+1)}{(sT1+1)(sT3+1)} \quad (10)$$

It is permissible to multiply these directly, since the amplifier output impedance is essentially zero, and hence there is no loading effect of *R4C2* on the previous network.

Since (10) is identical with (1), we see that the three time constants are given by equations (5), (6), and (8). We know the time constant values from the RIAA standard, so we can write:

$$\frac{R1C1\ (R2+R3)}{R1+R2+R3} = 0.000318 \text{ second}, \quad (11)$$

$$R1C1 = 0.00318 \text{ second}, \quad (12)$$

and

$$R4C2 = 0.000075 \text{ second} \quad (13)$$

By choosing two of these values, equations (11), (12), and (13) are solved algebraically. Solutions are: $R1 = 15{,}000$ ohms, $R2 = 120$ ohms, $R3 = 1600$ ohms, $R4 = 2200$ ohms, $C1 = 0.22\ \mu F$, and $C2 = 0.033\ \mu F$. Values are selected which are available as standard parts.

The Preamplifier Circuit

Now that we have determined a suitable feedback network, let us investigate the basic amplifier. First consider the basic circuit shown in Fig. 2. Only the d.c. potentials are involved; no signals are applied.

The a.c. signal will eventually appear at point *E*, and thus this point should be free to have the maximum possible swing either side of its static position. This means that the d.c. bias at *E* should be exactly one-half the B+ value for light loading—in this case, +3 volts. The output can thus swing down 3 volts to ground and up 3 volts to B+ before any clipping can occur.

The base of *Q*3 will always be about 0.6 volt more positive than point *E*, and since this is also the collector of *Q*2, *Q*2 will be operating at about +3.6 volts. This is permissible since there is no local feedback in the emitter of *Q*2 and the emitter-base voltage of *Q*2 is also about 0.6 volt.

The emitter-base voltage of *Q*2 is also directly across *R*3 and therefore the current in *R*3 is:

$$i_c = 0.6/R3 \qquad (14)$$

The base current in *Q*2 is very small compared with the current in *R*3, and thus i_c is the collector current of *Q*1. Since the base current of *Q*1 is negligible compared with i_c, there is only the one current through *Q*1 and this same current is drawn from point *E* through *R*5. We will not be concerned with the exact voltage across *R*5 as long as it is small.

Now as a first approximation, ignoring the drop across *R*5, we can say that the emitter voltage at *Q*1 is the same as the output voltage at point *E*. Moreover, since the emitter voltage *B* is a replica of the voltage at *A*, we see that *E* is identical to *A*. With regard to d.c., *E* will always adjust itself to be a duplicate of *A*. In our final schematic, we will naturally set *A* somewhat higher than +3 volts to allow for the drop across *R*5 and the *Q*1 emitter-base.

If an a.c. signal is coupled into point *A* through a capacitor, the output *E* will follow the input. However, if point *B* is heavily bypassed to ground, then the full open-loop gain comes into play; in this circuit, this will ordinarily measure about 1000 or more.

In considering the total open-loop gain, we note that the gain of the output stage is unity. The entire open-loop gain is thus divided between *Q*1 and *Q*2. We know the d.c. collector current I_C in each stage, and we know from the general transconductance formula that:

$$g_m = qI_c/kT \qquad (15)$$

where *T* is temperature in degrees Kelvin, *q* is electron charge in coulombs, and *k* is Boltzmann's constant in joules/°K.

For normal ambient temperatures, this reduces to:

$$g_m = 39\ I_c \qquad (16)$$

(Example: In any reasonably modern transistor, a 1-mA collector current corresponds to a transconductance of 39,000 micromhos.)

Since the stage gain is:

$$\text{gain} = g_m R_L \qquad (17)$$

we conclude that the first stage gain should be about 20 and the second stage gain about 80, or total open-loop gain of about 1600. The exact value is relatively unimportant.

The Complete Amplifier

We now combine the basic amplifier with the RIAA feedback network to give the complete schematic in Fig. 3. Only one channel is shown. However, the second channel is exactly the same, and both channels fit onto the one board referred to in the parts list. This board measures 2 × 3½ inches, which includes adequate free area at the edges for mounting.

Both channels connect on the board to one zener diode (point *X*); also, the *R*10 resistor is common to both. Otherwise there is no interaction. Readers who so wish may of course omit both the zener and *R*10 and operate both channels directly from a 6-volt d.c. source. One word of caution, however—the 6-volt source would have to have a low impedance, otherwise there would be signal leakage

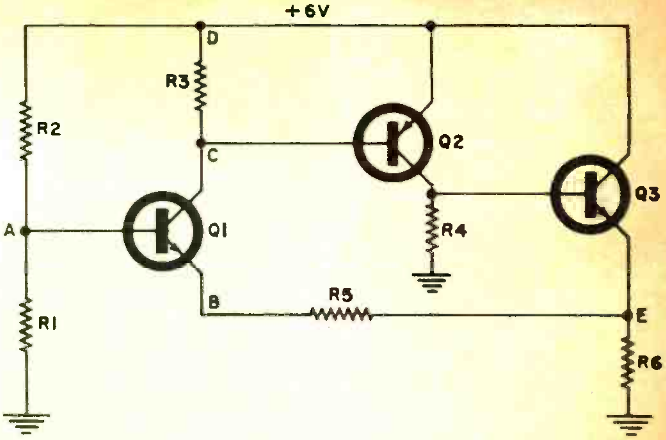
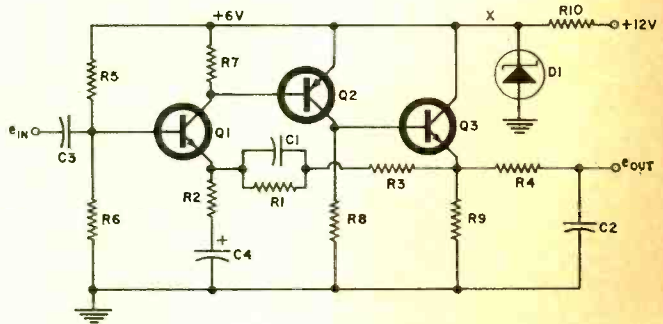


Fig. 2. Basic d.c. circuit of preamp with no signals applied.



R1—15,000 ohm resistor
R2—120 ohm resistor
R3—1600 ohm resistor
R4—2200 ohm resistor
R5—56,000 ohm resistor
R6—220,000 ohm resistor
R7,R9—4700 ohm resistor
R8—10,000 ohm resistor
R10—1000 ohm resistor
(All resistors are ¼ W, 5% carbon.)
C1—0.22 μF, 80 V capacitor
C2—0.033 μF, 80 V capacitor
C3—1 μF, 25 V capacitor
C4—22 μF, 15 V capacitor
D1—1N4735A 6.2 V, 1 W zener diode
Q1,Q3—2N1711 transistor
Q2—2N3134 transistor
(Epoxy-glass etched boards, drilled and gold-plated, are available from Mr. Royal Roberts, P.O. Box 821, Los Altos, Calif. 94022 @ $5 each by return airmail, postpaid.)

Fig. 3. Complete schematic diagram of the phono preamplifier.

between the two channels. The resistor-zener combination will prove to be adequate decoupling from almost any source. Zener impedances vary considerably from unit to unit, and in some cases it may be desirable to bypass the zener with a 100-μF, 20-volt external capacitor. If necessary, this is easily done when the board is mounted.

The technical reader will observe that the d.c. output impedance is about 2200 ohms. This is a convenient value and also makes it impossible to damage the unit if the output is accidentally shorted. The output has approximately 2.5 volts d.c. present, but there will seldom be any need to use a blocking capacitor here, as practically all amplifiers are a.c.-coupled at the input.

If a gain control is used between this unit and the following amplifier, it should be 25,000 to 100,000 ohms, and no blocking capacitor is needed. Lower values may cause distortion and higher values may increase noise.

As with all such preamplifiers, one must take care with all ground connections and signal leads to avoid ground loops which might easily cause oscillations. The preamplifier itself is unconditionally stable and will not be adversely affected by temperatures as high as 130° F.

For readers who do not wish to use the layout shown in the photo, any compact arrangement with equivalent parts may be used. Almost any good modern transistors of reasonably similar characteristics may be used in place of the 2N1711's and the 2N3134, but these are good choices and readily available at low cost.

Input impedance is approximately 50,000 ohms. When the magnetic cartridge level is 5 to 10 millivolts the output is suitable for any normal audio power amplifier. ▲

The CO_2 LASER

By JOHN H. McELROY / Physicist, Space Optics
National Aeronautics and Space Administration

Carbon-dioxide lasers are probably the most exciting development in the laser field. They are about 200 times more efficient than most other laser types and can produce as high as 3000 watts continuously.

WHEN a technical man confronts a new device, two questions are likely to occur to him. First, how much power output can it supply? Second, how much power must be supplied to the device? In the laser field, the carbon-dioxide laser has the best answers. And, after the mass of propaganda which accompanied the birth of the laser some seven years ago, the carbon-dioxide laser is the first solid indication that the laser may begin to live up to early predictions.

What are the CO_2 laser's answers to the questions mentioned above? To the first question, the CO_2 laser produces a continuous infrared beam which may reach multi-kilowatt power levels. The power of such a beam is difficult to comprehend. When an unfocused 30-watt CO_2 laser beam is directed at a sheet of ¼" thick asbestos, the beam requires only seconds to burn its way through. A 100-watt beam literally melts away the asbestos that tries to block its path and, in less than three seconds, an 800-watt beam can burn through a four-inch-thick fire brick. The answer to the second question may sound less spectacular, but it is no less significant. The CO_2 laser produces these dramatic powers at efficiencies approaching 25%. Since most laser systems have efficiencies in the range of a fraction of a percent, this is a highly important breakthrough.

The CO_2 laser also possess two other important attributes. One of these is its relative simplicity in comparison with other lasers. Only the most modest laboratory facilities are required to produce a 10- or 20-watt laser. Second, the laser wavelength is able to pass through the atmosphere with relatively little loss. Because the CO_2 laser radiates at a wavelength of 10.6 microns (within the highly transmitting 8 to 13 micron energy "window"), interest has been re-awakened in laser communications.

Unfortunately, there are also disadvantages associated with the CO_2 laser. The five principal disadvantages are: invisibility of the beam, detector problems, materials problems, physical size, and modulation difficulties.

Some Problems

The invisibility of the infrared beam makes mechanical alignment of systems employing it a difficult task. However, this particular disadvantage might be regarded as an advantage in certain military systems.

A second disadvantage of the CO_2 laser is that most detectors do not work well at the 10.6-micron wavelength. In fact, available detectors do not perform as well as some photomultiplier tubes used with visible lasers. In addition, they require liquid helium or, at the very least, liquid nitrogen cooling.

Obtaining suitable materials for use at 10.6 microns is also a difficult problem. Relatively few substances pass infrared radiation well and those that do are apt to be hygroscopic and mechanically weak.

A fourth disadvantage of high-power CO_2 lasers is their physical size. One multi-kilowatt unit constructed by the U.S. Army is 178 feet long; other units in the 700-watt to one-kilowatt range are from 30 to 50 feet in length.

The fifth disadvantage of the laser is the difficulty in modulating the beam. Modulators are still in an early stage of development, but are being studied intensively.

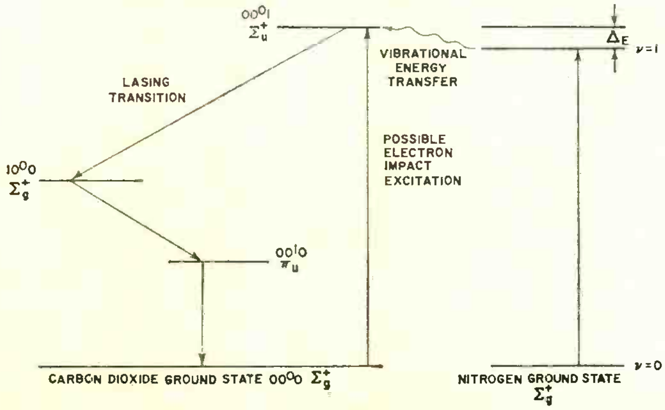
To overcome these disadvantages, public and private organizations are devoting huge sums to CO_2 laser research.

An Energy Converter

The theory of operation of the CO_2 laser may be easily understood if a few basic principles are applied. First, the CO_2 laser, or any other laser, is fundamentally an energy conversion device, that is, it converts electrical energy into infrared energy. To understand the laser, it is necessary to examine the manner in which energy is changed.

Laser action depends upon the establishment of a "population inversion." This merely means that, within the substance which is to be forced to "lase," the number of molecules or atoms in one energy state is greater than the number in a lower energy state. To understand what this implies for the CO_2 laser, refer to the left side of Fig. 1. This diagram shows a simplified view of the permitted energy levels for the CO_2 molecule. To produce lasing, molecules must be raised to the 00^01 energy level. The number of molecules which have been raised (excited) to this level must exceed the number in the next lower energy level, the 10^00 level. The designations employed for the various energy levels are those used by spectroscopists and their

Fig. 1. To produce lasing, the energy level of a CO_2 molecule must be raised from the ground state to the 00^01 energy level.



Bright Beams of Energy

exact meaning need not be of concern, they may be regarded simply as labels for the energy levels.

The energy of a molecule is determined by four component energies: electronic, translational, rotational, and vibrational. Only the rotational and vibrational energies are involved in the CO_2 laser action. Rotational energy refers to the rate at which the molecule is spinning or tumbling. Vibrational energy is contained in minute vibrations of the atoms which make up the molecule with respect to one another. A molecule can have resonant vibrations or modes similar to the cavity modes of microwave resonators.

The carbon-dioxide molecule is a linear molecule with two oxygen atoms symmetrically positioned about the carbon atom. There are three dominant vibration modes for the CO_2 molecule: symmetric stretching mode, asymmetric stretching mode, and bending mode. The symmetric stretching mode is diagrammed in Fig. 2A. This figure shows how the atoms in the CO_2 molecule change position as the molecule vibrates. As time progresses, the carbon atom stays fixed and the oxygen atoms move in and out, remaining equal distances from the carbon atom. The asymmetric stretching mode is shown in Fig. 2B. The two oxygen atoms vibrate in-phase with one another, while the carbon atom vibrates 180° out-of-phase with them. The final vibrational mode, the bending mode, is shown in Fig. 3. This mode merely represents a flexing back and forth by the molecule.

Changes Energy Levels

The energy level diagram of Fig. 1 shows the vibrational energies of the CO_2 molecule. The rotational levels have been omitted, but they may be visualized as sub-levels within each of the vibrational energy levels. When energy is supplied to the molecule, it may be raised to the 00^01 energy state. Because of certain characteristics of the molecule, it can remain in this state without decaying to a lower state for a relatively long period of time. Therefore, if the gas is highly excited, a large population of molecules in the 00^01 state may result. Of equal importance are CO_2 molecules which have been raised to the 10^00 energy level, or which fell to that level from the 00^01 state. These quickly decay to the ground state through an intermediate state, the 00^10 level. The combination of a long-lived upper state and a short-lived lower state makes the attainment of a population inversion between the 00^01 state and the 10^00 state a relatively simple matter.

Once the population inversion has been obtained, the gas acts like a charged capacitor. It is only necessary to supply a trigger to initiate discharge of the stored energy. Just as the amount of charge stored in a capacitor determines how much energy can be withdrawn from it, the degree of population inversion controls the intensity of the laser energy.

The trigger which releases the energy stored during the population inversion is the process of stimulated emission. In fact, the word "laser" is an acronym formed by the words *l*ight *a*mplification by *s*timulated *e*mission of *r*adiation. Stimulated emission is simply the process by which a photon possessing the appropriate amount of energy strikes an excited atom or molecule and causes it to decay. The atom emits a second photon which accompanies the original photon as it passes out of the atom. Since one photon enters the excited atom or molecule and two photons leave it, amplification has occurred. In the specific case of excited CO_2 molecules, stimulated emission occurs when a photon, possessing an amount of energy equal to the difference between the 00^01 and the 10^00 states, strikes an excited molecule and triggers it, causing it to decay from the 00^01 to the 10^00 state. The energy of the second photon is equal to the energy of the original photon which triggered its emission. Thus, two photons would trigger the emission of other photons and, in this manner, create a cascade of photons, each having the same amount of energy. And, since each photon would have the same energy, each would have the same wavelength. In this way, if replenishment of the

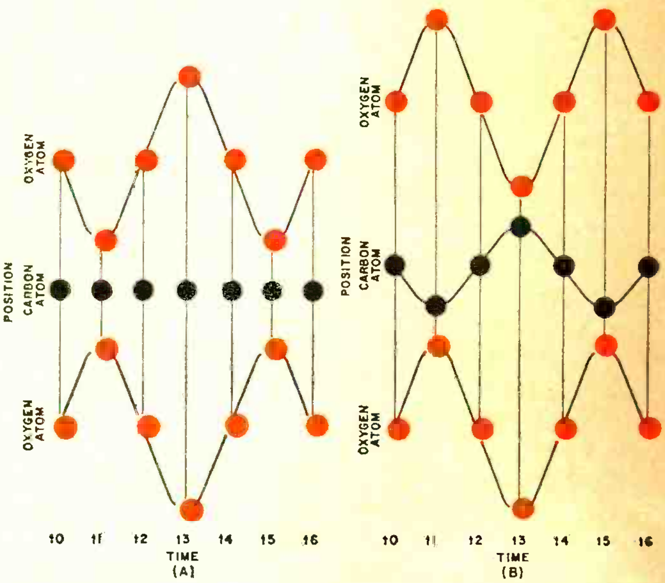
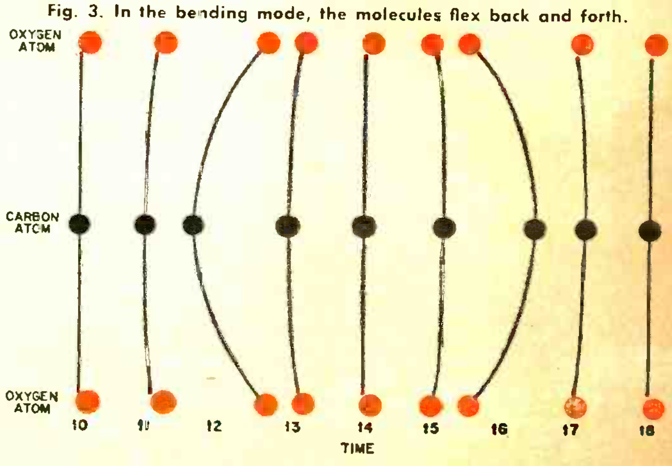


Fig. 2. (A) In the symmetric stretching mode, the oxygen atoms move back and forth equidistant from the molecule's carbon atoms. (B) In the asymmetric stretching mode, two oxygen atoms are in-phase with each other, out-of-phase with carbon atom.

Fig. 3. In the bending mode, the molecules flex back and forth.



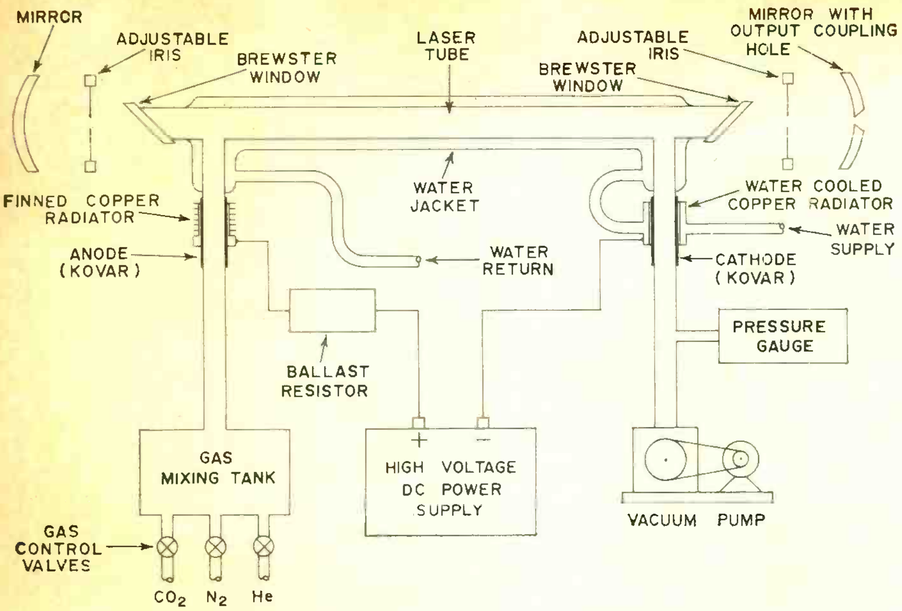


Fig. 4. A typical CO_2 laser has five sections: an excitation source, an optical resonant cavity, a laser tube, a gas-flow system, and a tube cooling system. This particular laser system was built by NASA.

upper lasing level by the excitation source is assumed, a continuous beam of radiation can be generated at a particular wavelength.

Population Builder

With the background developed in the preceding paragraphs, it is now possible to understand the operation of the CO_2 laser. The excitation source continually raises molecules from the ground state to the 00^01 state. This is represented by vibrations in the asymmetric stretching mode and, because of this state's long life and the short lifetime of the next lower state, the 10^00 state (which represents vibrations in the symmetric stretching mode), a population inversion is built up. "Lasing" then occurs through the stimulated emission of photons which accompanies the decay of molecules from the upper lasing level to the lower lasing level. Upon reaching the lower level, the molecules relax *via* a bending mode vibration in the 00^10 state and fall to the ground state.

Although the first CO_2 lasers employed only carbon dioxide, it has since been found that there are two additives which enhance power output. The first additive is nitrogen. By happy coincidence, nitrogen has an easily reached, long-lived energy level that is very close to the upper lasing level of the CO_2 molecule. And because the levels are close, energy can be easily and efficiently transferred between their molecules. Therefore, the addition of nitrogen aids in populating the upper lasing level. The second additive is helium. It aids in the depopulation of the lower lasing level and also helps populate the upper level. The cumulative effect of the two additives is an enhancement of the population inversion and, consequently, an increase in the laser's power output. Although there have been experiments with other mixtures, the vast majority of CO_2 lasers use a mixture of carbon dioxide, nitrogen, and helium gases.

Typical System

The basic construction of the CO_2 laser is uncomplicated and there appear to be no obstacles to the production of rugged units suitable for field use. The CO_2 laser usually consists of five sections: excitation source, optical resonant cavity, laser tube, gas flow system, and tube cooling system. A typical short CO_2 laser is shown in Fig. 4. This particular laser was designed by Harold E. Walker of NASA's Goddard Space Flight Center. Although the electrode spacing is only twelve inches, it is capable of supplying two watts of power. It will be used in the following discussion to show the construction of a CO_2 laser.

Examining Fig. 4, it is seen that the three gases are combined in a mixing tank and pumped through the laser tube by a simple mechanical vacuum pump. The gas within the laser tube is ionized by the application of a high direct voltage. A ballast resistor is placed in series with the d.c. power supply. This keeps the power supply's input impedance constant during the tube's discharge period. It would also have been possible to use high-voltage a.c., rectified a.c., or r.f. power from a small transmitter, but d.c. is simple to use and produces a constant lasing action. To simplify construction, separate electrodes were not employed in the tube. Instead, the Pyrex-to-Kovar seals that serve as connections to the gas flow system are used as electrodes. Due to the positive ion bombardment, the cathode tends to run very hot, therefore, it is cooled by a slow flow of tap water. A simple radiator provides ample air cooling for the anode.

The laser tube is made from Pyrex and Brewster-angle windows are cemented to both ends of the tube to polarize the output beam. The tube is mounted between two gold-coated mirrors which form the optical resonant cavity. One of the mirrors has a hole drilled through its center to provide the laser output. Adjustable irises are mounted in the cavity to permit selection of the desired laser mode. Notice that the laser tube is surrounded by a water jacket. As mentioned earlier in this article, a small population in the lower lasing level is necessary for a strong laser action. Heat raises the population level. The addition of helium counteracts the thermal effects to a degree, but a rise in gas temperature negates the effect of the helium. This necessitates water cooling the laser tube.

New Applications

Since 1964, when the first report of a CO_2 laser appeared, CO_2 laser applications have remained in a very primitive state. However, a number of possible uses have been suggested, and some of the more interesting ones are discussed in the following paragraphs.

Many attempts were made to drill and machine various metals such as aluminum, copper, steel, Kovar, nickel, rhenium, and others with CO_2 lasers. In general, the attempts were unsuccessful at power levels of 20 watts and below, but some limited success has been attained at higher powers. Studies are not yet completed. Most metals are highly reflecting at a wavelength of 10.6 microns so that the bulk of any energy directed at the metal is simply turned away. In addition, most metals are good conductors of heat. These two facts make laser metalworking very difficult.

While most efforts with metals have not met with success, the application of the CO_2 laser to operations on cloth, certain glasses, ceramics, and plastics seems to be promising. An English tailoring firm is experimenting with a 40-watt CO_2 laser which is capable of cutting cloth at a rate of more than one inch per second. The laser is useful because its searing action cuts cleanly, heat-sealing the cut edges so that fraying is prevented.

Glasses such as Pyrex, quartz, and other materials with low thermal coefficients of expansion can be either drilled or machined with the CO_2 laser. Other types of glass can be machined, but can crack as they *(Continued on page 77)*

Analog-to-Digital Conversion

By WILLIAM BARDEN

Real-time computer-controlled devices require digital inputs. Three basic analog-to-digital converter techniques are used to change speed, temperature, pressure, and viscosity into equivalent digital values.

WHEN computers are used to control machines making paper, petroleum products, or drugs, physical properties such as temperature, pressure, viscosity, and speed must be converted to a form that the computer can use. This is a function of a group of devices known as analog-to-digital converters. There are three basic types of analog-to-digital (or A-D) converters: position-to-number, time and frequency-to-number, and voltage-to-number. Although differing widely in design, each performs the same function: physical data, or a form of the data, is sampled and encoded to a form acceptable to the computer or control equipment and is then transmitted to the control device.

Physical Quantities, Analogs & Digital Form

The analog of temperature, pressure, speed, and other physical quantities is a form of the quantity that may be easily handled and measured. For example, the speed of a car is represented by the position of the speedometer needle and the angular position of the needle is the analog of the car's speed. A second analog is frequency. Transducers are available which convert a voltage to a frequency analog or to a pulse output. Another common analog is voltage. Voltage can represent temperature (voltage output of a thermocouple), speed (electric tachometer output), or pressure (strain-gage output). There are other useful analogs, but shaft position, frequency, and voltage are the most common.

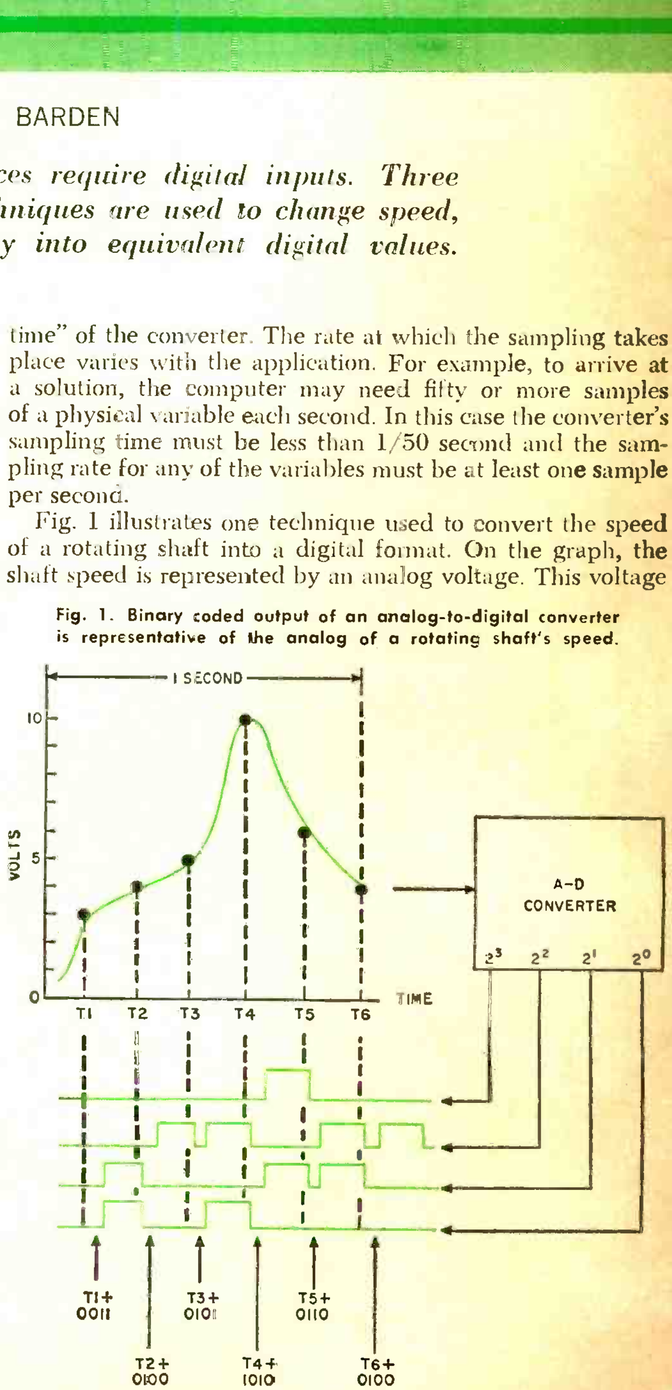
Once physical quantities are changed to a representative analog mode, they can be converted to digital form by the A-D converter. Although the "digital" in "analog-to-digital conversion" could mean ordinary decimal digits, the digits almost invariably take the form of a binary code of one type or another which a computing, measuring, or printing device can interpret. In most cases, natural binary coding is used, but binary-coded decimal or special anti-ambiguity codes are also used.

Sampling

The time required to change a physical variable into a form which the computer can use is called the "sampling time" of the converter. The rate at which the sampling takes place varies with the application. For example, to arrive at a solution, the computer may need fifty or more samples of a physical variable each second. In this case the converter's sampling time must be less than 1/50 second and the sampling rate for any of the variables must be at least one sample per second.

Fig. 1 illustrates one technique used to convert the speed of a rotating shaft into a digital format. On the graph, the shaft speed is represented by an analog voltage. This voltage

Fig. 1. Binary coded output of an analog-to-digital converter is representative of the analog of a rotating shaft's speed.



BINARY	DECIMAL	BINARY	DECIMAL
0000	0	1000	8
0001	1	1001	9
0010	2	1010	10
0011	3	1011	11
0100	4	1100	12
0101	5	1101	13
0110	6	1110	14
0111	7	1111	15

Table 1. Binary number system showing progression from 0 to 16.

	GRAY CODE	DECIMAL EQUIV.
	0000	0
	0001	1
	0011	2
	0010	3
Reflection Line	0110	4
	0111	5
	0101	6
	0100	7
	1100	8
	1101	9
	1111	10
	1110	11
	1010	12
	1011	13
	1001	14
	1000	15

Table 2. The Gray code, a "reflected" binary code. Refer to text.

is the input to the A-D converter. (The A-D converter has four output lines, representing 2^0, 2^1, 2^2, and 2^3—decimal 1, 2, 4, and 8 respectively. If a line holds a positive voltage, a binary 1 is represented. If zero volts is on a line, a binary zero is represented.)

At time $T1$, when the first sample is taken, the analog voltage level is 3 volts and its corresponding digital equivalent is expressed by the state of the converter's four output lines. The 2^0 line is "high", indicating 1×2^0 or a decimal 1; and the 2^1 line is high which indicates 1×2^1 or a decimal 2. The 2^2 and 3^3 lines are "low" and indicate 0×2^2 and 0×2^3 respectively. Therefore, the representative binary voltage is 0011, or decimal 3.

The time between $T1$ and $T1+$ is the converter's sampling time. Between times $T1+$ and $T2$, the binary output is constant. At time $T2$ another sample of the analog voltage is taken and a new binary voltage output of 0100, or 4 volts, is indicated. Four more samples and conversions are made at $T3$, $T4$, $T5$, and $T6$.

In this example, the time interval is one second and during this period six discrete samples are made. When the six sample values are plotted on graph paper, they approximate an analog of the shaft's speed curve.

Position-to-Number Converters

Position-to-number A-D converters convert the angular position of a shaft to digits. The angular position of the shaft itself might be the physical quantity to be measured or it might be the analog of another physical quantity or a combination of both.

Although other types of position-to-number converters are in use, the code-wheel type is perhaps most useful.

Code wheels are discs which are divided into sectors by the code contained on the disc. The position of the wheel with respect to stationary pickups is measured by reading the sector of the disc opposite the pickups. Code wheels have been made using many types of pickups, such as brushes, switches, or photocells. The brush-type pickup is considered in this discussion, although the same scheme is used in the other types.

A natural binary-coded disc is shown in Fig. 2A. The disc is either fixed on the shaft or geared to the shaft rotation. Four brushes, represented by dots in the diagram, are positioned as shown while the paths of the four brushes are concentric rings or channels. Each brush and channel represents one binary order of magnitude: the outside brush represents 2^0, the next 2^1, the third 2^2, and the innermost brush 2^3. The colored portions of the disc are conducting areas and the light portions insulating material.

The disc is divided into pie-shaped wedges called "sectors". When the 0000 sector is under the brushes there is no output. However, when the shaft has rotated to the 0001 sector, the 2^0 brush conducts and a binary 1 is indicated. Further rotation of the shaft causes a progression of outputs from 0000 to 1111, sixteen in all. Greater resolution can be obtained by adding more channels and brushes.

There is a problem which arises with this type of coding, however. Suppose that the shaft has stopped and that the brushes are directly on the line separating the 0111 sector from the 1000 sector. If the innermost brush is slightly misaligned, it may touch the conducting (colored) portion of the disc while the other brushes also remain on the conducting area of the three outer channels. Instead of a correct reading of 0111 (or 1000), a reading of 1111 is obtained, an error of about 180°. Misaligned brushes can cause ambiguous readings at any transition point on the disc. There are two possible solutions to the problem of ambiguity: one involves using multiple sets of brushes with logical selection of the set of brushes to be used while the other involves the use of special codes in which only one bit changes at a time.

One type of encoding disc, using multiple sets of brushes, is the V-brush type. This disc uses two brushes for each channel except for the least significant digit channel which has one brush in line with the centerline of the circle. The other brushes lead or lag the single brush, as shown in Fig. 2B. The more significant brushes are displaced farther and farther away from the centerline. The distance between each set of brushes is equal to the width of the next lower order segment.

The theory behind the V-brush method may be seen from the way in which the binary number system progresses when counting from binary 0 to binary 16. This is illustrated in Table 1.

If any bit changes from a zero to a one, the next higher bit never changes. If any bit changes from a one to a zero, the next higher bit also changes. Therefore, if the nth bit is a zero, the nth $+ 1$ leading brush is read (the nth $+ 1$ bit will not change), and if the nth bit is a one, the nth $+ 1$ lagging brush is read (the nth $+ 1$ bit may change). An external logic circuit chooses the brush that is always squarely in the center area of a conducting or non-conducting portion of the channel. Therefore, no ambiguities arise except in the least significant digit channel.

Gray Code

Special codes can also be used to solve the problem of ambiguity. Since ambiguities are the result of the simultaneous changing of more than one bit, a disc coded so that only one bit changes would eliminate the problem. There are many codes that accomplish this. One of the more common is the cyclic or Gray code. The Gray code (Table 2) is a "reflected" binary code. It is developed in the following fashion. The first two natural binary numbers are noted. The next two numbers are a reflection of these except that the

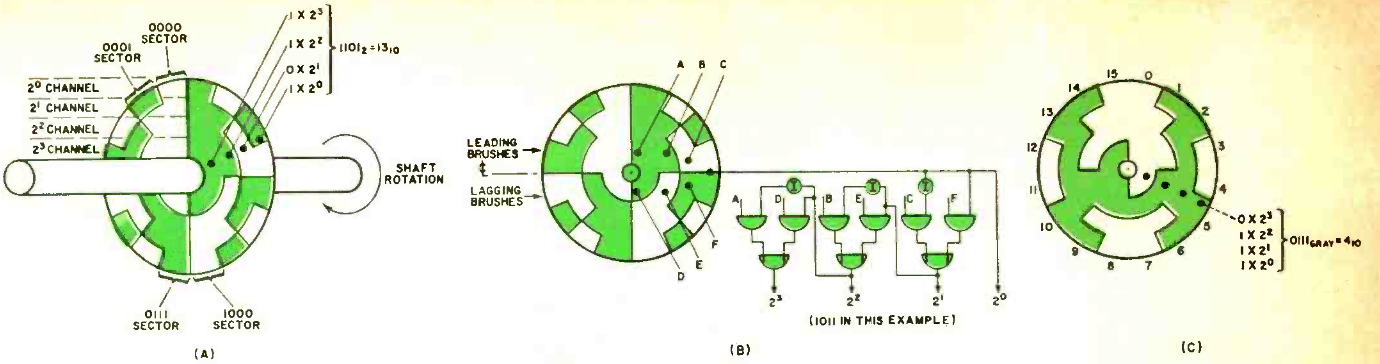


Fig. 2. Code wheels or discs may be used as analog-to-digital converters. (A) The four dots represent brushes. Each brush is equal to one binary order of magnitude. (B) V-brush encoders are sometimes used to reduce ambiguity. (C) Some discs employ special codes to solve problem of ambiguity. Gray code changes one bit at a time.

third digit from the left is changed from zero to one. These four numbers are then used to form a second reflection, with the second digit changing from zero to one, and so on. The result is the code for four bits in Table 2.

A disc incorporating the Gray code and divided into sixteen sectors is shown in Fig. 2C. Notice that only one bit changes at a time in going from one sector to another. The ambiguity problem is solved although the solution requires the use of external logic to convert the Gray code into natural binary.

Time and Frequency-to-Number Converters

It is often necessary to convert time to a digital form. This is especially true when time is used as the input to a "real-time" computing system.

Time intervals may be measured by dividing them into very small increments of known time and counting the number of increments in the time interval. This method is shown in Fig. 3. The measured time interval is between pulses 1 and 2. The first pulse enables the control flip-flop and pulses from the crystal oscillator and shaper are counted by the binary counter. The second pulse disables the gate and resets the control flip-flop. The counter now reads the number of oscillator pulses which passed through the gate during the time interval. If the oscillator frequency were 1 kHz, each pulse represents 1 ms. If the binary counter's 2^3, 2^2, 2^1, and 2^0 outputs read 1, 0, 1, and 0, respectively, the time interval is 10 $\pm$1 ms long. The one count discrepancy arises from the uncertainty of counting a partial pulse.

Frequency, the inverse of time, is also useful as an analog. Pressure, temperature, humidity, and speed are other quantities that can be represented by a frequency analog.

A frequency analog is converted to digital form by a modification of the time-interval conversion technique. However, the unknown frequency pulses are counted with the count gate enabled for a known period of time.

Fig. 4 shows the method of measuring frequency. In this example, frequency is the analog of shaft speed, *i.e.*, the shaft's speed is converted to a frequency output by a magnetic pickup which generates a pulse each time a magnetized spot on the shaft passes the pickup. The pulse output is amplified, squared, and then fed to the binary counter which displays the frequency digitally.

The crystal oscillator's output is a pulse train whose frequency is "divided down" into timing pulses of very long duration. The gate control flip-flop is set by the falling edge of one timing pulse and reset by the falling edge of the next. Therefore, when the control flip-flop is set, the count gate is enabled and the input pulses pass through.

Pulses from the magnetic shaft pickup are only counted during the time the gate is enabled. If the gate has been enabled for one second, the counter indicates the speed of the shaft in r/s for the first sampling period. After the digital count has been transferred from the counter's flip-flops to the computer or recording equipment, a new sample is taken.

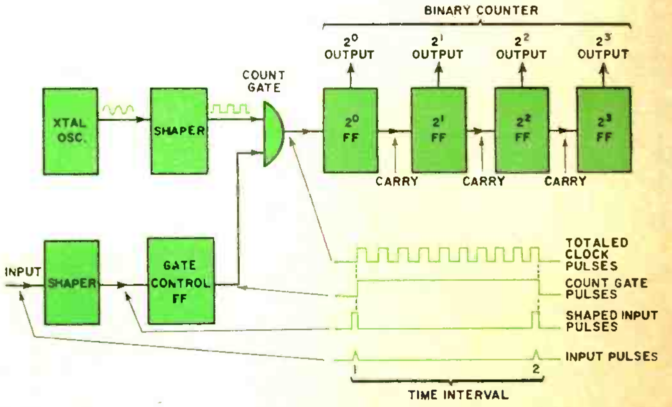


Fig. 3. Time period can be measured by dividing it into known intervals and counting the accumulated pulses in the interval.

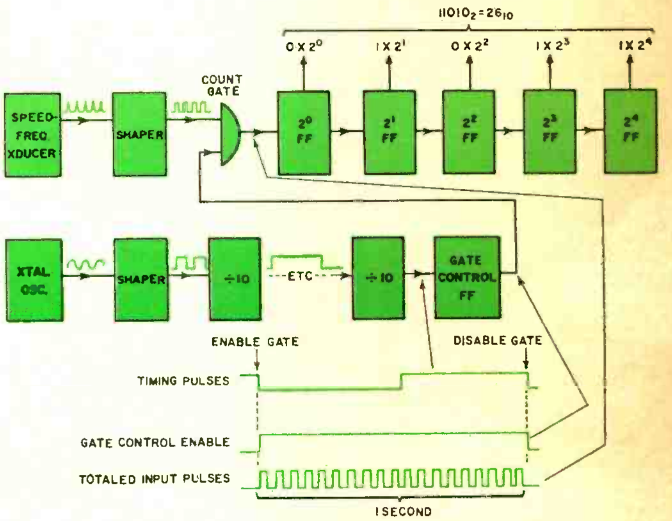


Fig. 4. Frequency is an analog of shaft speed. A transducer emits a pulse for every shaft cycle. The pulses are counted by binary counter which indicates speed in revolution/second.

Of course, sample times may be made much faster than one second by using scaling factors in the gating. For example, if 10 pulses are counted in 1/10 second, a speed of 100 r/s is represented.

Voltage-to-Number Converters

Since voltage analogs are the most common form of analog, there are a large number of A-D converters which utilize voltage inputs. Two conversion methods are discussed here: the ramp and sucessive approximations.

The ramp method of A-D conversion is essentially a voltage-to-time-to-number conversion process and is similar to the time-to-number conversion process discussed previously. This method is employed in many digital voltmeters. As in the

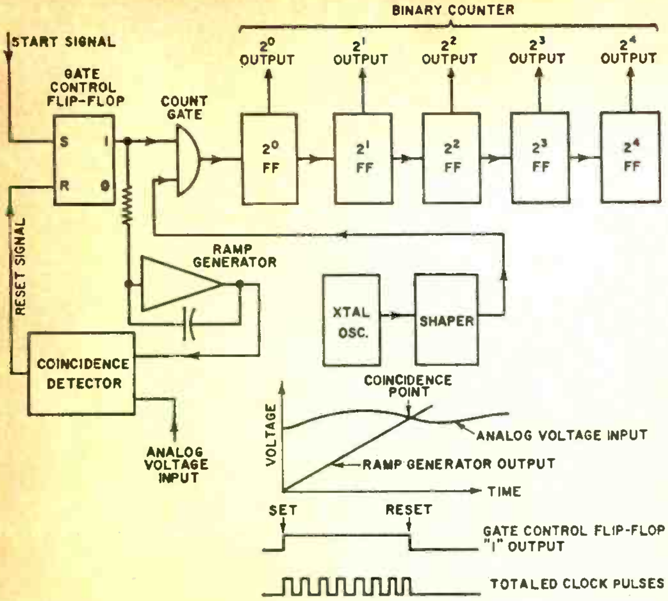


Fig. 5. Digital voltmeters often utilize a ramp generator and binary counter to measure and indicate voltage levels.

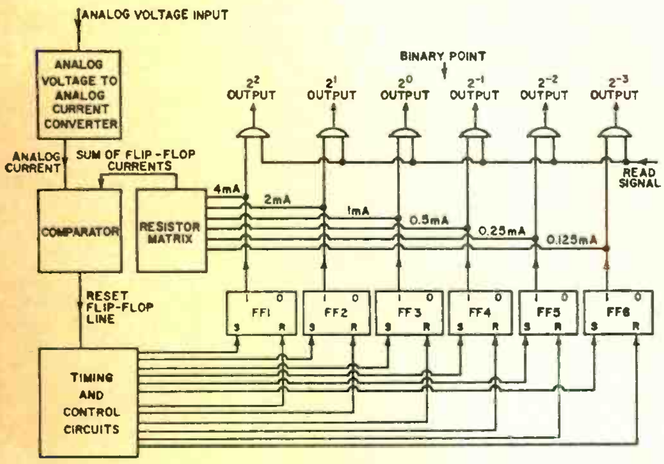


Fig. 6. Voltage can be converted from an analog to a digital form by the successive approximation method. It compares the current generated by the input voltage signal with the currents generated by the flip-flops. The state of the flip-flops represents the digital value of input voltage signal.

time-to-number converter, internal clock pulses are totaled over a period of time. But, unlike the other converter, the count gate is disabled when coincidence is detected between the external voltage and an internally generated voltage.

A block diagram of the circuit is shown in Fig. 5. The gate control flip-flop is initially reset (1 output is false). When the start signal is given, the flip-flop is set and the count gate is enabled. At the same time the flip-flop's set output applies a voltage to the ramp generator, which produces a linearly increasing voltage. When the ramp generator's output matches the analog voltage input (the coincidence point shown on the graph), the coincidence detector resets the gate control flip-flop. This disables the count gate and removes the input to the ramp generator.

During the time the count gate was enabled, clock pulses were accumulated in the counter's flip-flops. The accumulated pulses are proportional to the gate's enable time which is, in turn, dependent on the slope of the output signal from the ramp generator. For example, assume a clock frequency of 100 kHz. If the input voltage is 1.2 volts and the ramp generator output increases at a rate of 1 volt/10 ms, the number of pulses accumulated will be:

$(V_{input}/slope)$ $(clock\ frequency)$ = count or $[1.2/(1/10)]$ 1×10^5 pulses/sec) = 120 pulses = 1111000_2 pulses.

After the count has been recorded by the control equipment, the counter is reset and the command given (manually or automatically) to start another sample. Other variations of this method are possible.

Unlike the ramp method, the successive approximations method is a strict analog-to-digital voltage transformation. One type of successive approximations uses current summation (see Fig. 6). In this system the flip-flops deliver zero current when they are reset and a precise amount of current when set. Actually each flip-flop is connected to deliver exactly one-half the current of its preceding stage. A resistor matrix is used to determine the current values.

The analog input voltage generates a proportional amount of analog current which is used as one of the inputs to a comparator. The other input comes from the sum of the current-generating flip-flops. The method of successive approximations proceeds as follows. Initially, all current-generating flip-flops are reset, then the most significant flip-flop (the one generating the most current) is set. Next the currents produced by the flip-flop and resistor matrix are compared with the input current in the comparator. If the flip-flop current is larger than the analog current, the comparator output goes high and resets the flip-flop; if the flip-flop current is smaller or equal to the analog current, the comparator output is low and the most significant flip-flop remains set. The next most significant flip-flop is now set in the same manner.

The total current from the flip-flops is now compared with the analog current, and the second flip-flop is set or reset depending upon the comparator output. (If the first output were 4 mA, setting the second flip-flop produces a total current of 4 + (½) (4) or 6 mA.) The process is repeated for each current-generating flip-flop. After all flip-flops have been tested against the input current, the state of all the flip-flops represents the digital value of the input current which, in turn, is proportional to the input voltage.

As an example, assume that the analog input voltage range is ±8 volts and that the current produced from the analog voltage is 1 mA/V. If the analog input voltage is exactly 2.8 volts, an analog voltage of 2.8 mA will be produced. The configuration of flip-flops at the end of the conversion will be as follows (assuming the most significant flip-flop generates 4 mA).

Flip-Flop	FF1	FF2	FF3	FF4	FF5	FF6
State	0	1	0	1	1	0
Current (mA)	0	2	0	0.5	0.25	0

↑ Binary point (between FF3 and FF4)

The binary number represented is 010.110 or decimal 2.75, corresponding to the input voltage ± value of the least significant digit.

Analog-to-digital conversion is a necessary process when computers perform real-time or control functions and when digital recording or measuring devices are used to process data. Although not all of the A-D conversion techniques have been covered in this article, the position-to-number, time and frequency-to-number, and voltage-to-number conversions discussed are three of the most widely used methods. Many of the other techniques use these same basic concepts. ▲

(Editor's Note: *The design of high-speed, high-capacity digital systems was pushed by the development of solid-state devices, particularly transistors and integrated circuits. Almost all digital systems, have in the real world, analog inputs which must be converted to a digital language before they are usable. Analog-to-digital converters are being used in aircraft to change air data and synchro information into a form which the computer can use to guide the plane along a prescribed course. Converters are also being used in systems that plot missile trajectories, and in systems that prepare graphical data for computer processing.*)

PIN-POINT RECORD

New thin-film and a ruby laser record smallest data bit ever.

Five-hundred photographs or 10 million data bits on a square-inch strip of magnetic film? Impossible! Very probable, say two researchers at the California Institute of Technology's Jet Propulsion Laboratory. They have succeeded in recording magnetic spots or "bits" with diameters less than a micron (forty-millionths of an inch) on thin films of manganese bismuthide in laboratory tests.

The scientists, Drs. Dimiter I. Tchernev and George W. Lewicki, are researching the laser/thin-film-recording process for the National Aeronautics and Space Administration. They say that success of the process may lead to a substantial reduction in the size of computers on board spacecraft; and when used with television cameras, could store a thousand times more pictures than the present video tape method employed in lunar and planetary photography.

The writing is done with a pulsed ruby laser similar to the type used by eye surgeons to "spot-weld" detached retinas. The laser beam, focused on the film through a microscope, heats up a tiny spot to 360° centigrade. By controlling the beam's strength, the researchers can record a spot half a micron wide. As the heated spot cools, the direction of its magnetization is reversed by the cooler portions of the film around it. At that precise moment, a "bit" of data can be magneto-printed on the film.

Extra-thin film, only 3/100,000 of an inch thick, is used for the recording. It is made by evaporating manganese and bismuth into a mica base.

Two polarizing crystals, polarized light, and a microscope with an enlargement power of 500 are needed to view the recorded bits of information. Depending on the setting of the crystals, the bits are seen either as black spots on a white background, or white on black. The light and dark portions of the film are due to the Faraday effect.

According to the JPL researchers, magnetic film has a very important advantage over regular photographic film—bits can be erased at will and rewritten if necessary.

The technique of using a laser to write on magnetic film is called Curie-point writing. It was named for Pierre Curie, the French scientist who discovered that magnetization vanishes at high temperatures. JPL is conducting other Curie-point writing experiments that are designed especially for spacecraft applications. ▲

JOHN FRYE

Incentive licensing for American amateurs promises to make the FCC's intention into reality by next fall.

UPGRADING AMATEUR RADIO

BOTH Mac and Barney showed signs of spring fever this beautiful May morning. They sat silently side by side on the service bench obviously trying to make the cups of coffee Matilda, the office girl, had brewed last just as long as possible.

"Hey, Barney," Mac finally observed, "you don't look quite so bright-eyed and bushy-tailed this morning as you usually do. Too much heavy dating?"

"Aw no, nothing like that," the youth answered yawning. "I just stayed up until the wee small hours stalking a JT1 station in Mongolia on twenty meters. I wanted him for my DXCC Award which they give for working a hundred or more countries. But I might as well have gone to bed. Either he didn't show or I couldn't hear him."

"You seem to be doing quite a bit more hamming lately. How come?"

"Actually there are a couple of reasons. For one thing, the 11-year sunspot cycle is rising and is supposed to peak by the end of this year. This makes propagation conditions on the short-wave bands excellent. You can hear the whole world pouring in on the 10-, 15-, and 20-meter bands. Early last evening on fifteen meters I was talking with a fellow in India running only 25 watts into the 2E26 final tube of his homebrew single-sideband transmitter, and he had a good strong signal, too. He was getting around 350 miles to the watt, and that's good mileage on any track. When you call 'CQ' on the 10-, 15-, or 20-meter bands these days, you never know if you're going to get an answer from the other side of town or from halfway around the earth.

"But these conditions aren't going to last long. Not only will the sunspot cycle start a five or six year decline after the first of the year, but some people who study such stuff believe there's a long-time trend towards a decline in sunspots. If they are right, conditions may never be as good again during my lifetime as they are right this year. Such being the case, it behooves me to make DX hay while the sunspots shine."

Mac held his nose in not-too-delicate disapproval of Barney's metaphorical mayhem, but the latter just grinned and continued:

"The other reason is that I'm bucking for my Amateur Extra Class license, which requires proof that I can send and receive the code at a speed of 20 five-letter-words a minute; so I'm spending a lot of time on the c.w. bands trying to get my code speed back up."

"I thought you had a certificate testifying to the fact that you could handle 35 words per minute."

"I do, but I got that several years ago when I was a real c.w. hotshot, working daily in c.w. traffic nets. At that time I thought a fellow who used a microphone instead of a key or bug was some kind of a nut. But then I started fooling around with phone just to see how the other half lived, and the first thing you know I was hooked. For the past several years I have been almost exclusively on SSB, and it is downright shameful the way my ability to copy and send decent code has slipped. I'm not kidding myself a bit: it will take several weeks of diligent practice before I can go up and take that 20-words-per-minute exam with confidence. From experience I know I should have at least a 5-words-a-minute margin to take care of nervousness, strange surroundings, etc.; and I find I'm hard put just to *write* twenty-five words a minute with a pencil, let alone copy code that fast."

"I listen in on the ham bands quite often," Mac said, "and I hear some of the boys saying they are sure they can go up and get that Extra Class license whenever they care to. They mention the Code Speed Certificate they hold and express a rather immodest confidence in their technical knowledge. I get the idea they can drop in at the examining office any day they please—say during a coffee break—and pick up that Extra Class license."

"I know what you mean," Barney replied with a grin. "I hear these blowhards, too. But you will notice they keep on and on trying to bolster their sagging egos in this fashion instead of putting their alleged technical knowledge and code copying ability to the test. I hold an Advanced Class license and so must take only the 4B part of the written examination, but let me give you a few representative questions likely to be asked on that exam and see if you would want to tie into them without a little boning up:

"What are A5 and F5 emissions? On what amateur frequencies can these emissions be transmitted?

"Draw a block diagram of an RTTY system showing the function of each stage. What is the proper way of identifying an RTTY transmission?

"A 70-ohm half-wave antenna operating on a frequency of 7300 kHz is to be matched to a 50-ohm transmission line. Calculate the characteristic impedance of a quarter-wave matching section and the physical length of the antenna at the frequency given. What is the s.w.r. between the antenna and the transmission line without a matching section?

"Define the *alpha* cut-off frequency of a transistor. How is this parameter of use in circuit design?

"How are phasing capacitors used in crystal filters?"

"Hm-m-m-m," Mac said. "I see what you mean. As I understand it, you must be ready to answer not only questions pertaining strictly to amateur operation but also questions in the fields of remote control, conventional TV, slow-scan TV, microwaves, etc. In other words, the questions are not necessarily confined to amateur transmitters and receivers."

"That's right, and that makes it a little sticky for the ham who has confined his activity to one phase of amateur operation, such as handling traffic, Dx-ing, bouncing signals off the moon, teletypewriter, or transmitting and receiving TV pictures."

"How would you say the amateurs in general are taking the new incentive licensing regulations. I heard a lot of griping while the idea was still being considered by the FCC."

"All in all, I think things are going surprisingly well. Of course you still hear some static from the diehards, but the rank and file of the amateurs are rising to meet the challenge of the new licensing set-up. Those holding General licenses are working for their Advanced, and the Advanced boys are brushing up on code and theory to get their Extra Class. Hearing the ones who already have their Extra Class licenses coming on the air with their new two-letter calls, which they can request if they have been licensed for twenty-five years and are willing to cough up twenty bucks, sort of gives you the urge. On top of that, the *Radio Amateur's Call Book* is now listing the type of license held by each amateur so the whole world can see just how you rate as a ham."

"What do you, personally, think of incentive licensing?"

"I'm all for it. I always felt doing away with the old Class A license and the privileges that went along with it was a mistake. That destroyed much of an amateur's incentive to improve his operating ability and his technical knowledge. Along with that went a good bit of pride in being a radio amateur. A well-heeled slob who scarcely knew the difference between a.c. and d.c. could buy himself a ready-made kilowatt and a super-duper antenna and become an Instant Mr. Big on the ham bands, and there was no place you could go to get away from him and his rock-crushing signal.

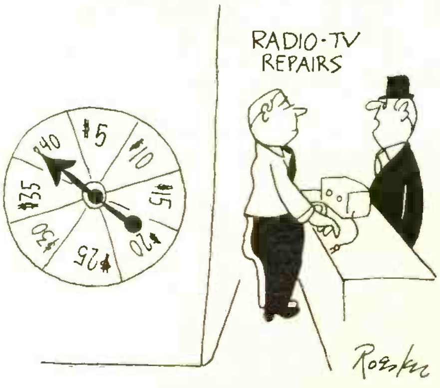
"Now, after November 22nd of this year, he will either have to get himself an Advanced or Extra Class license or stay off those frequencies reserved for holders of these licenses. A year later, still more frequencies will be off-limits to him. And if he *does* study and pass the exams for the higher grade licenses, exposure to all that technical knowledge and the discipline of building up his code speed will chasten him and teach him to use that power in such a way as to command respect instead of contempt.

"But there's more to it than that. American amateurs, because of their sheer number and the high power permitted them, are heard daily in every portion of the globe. To those critical listeners, these hams project the image of America. All too often, I'm afraid, the image has been one of sloppy, careless operating procedure, of hazy technical knowledge, and of an attempt to substitute brute power for skill and efficiency. I'm not expecting any overnight miracles, but I really believe the prodding of incentive licensing will do much to upgrade our image.

"And while I'm on the subject, let me say that I know amateur radio can be a potent force for peace in the world. So would anyone else know this if they would hear, as I do, a Russian arranging a schedule for an American friend to work a rare station in Mongolia; an Englishman making arrangements to meet a ham friend from Brazil who is flying into England on business; an American offering to send some hard-to-obtain parts to another ham in the Congo; and a station in Capetown joyfully accepting congratulations from country after country on the successful heart transplant operation there. And it does me good to hear non-linguistic Americans ending a QSO with a casual *cheerio* for the English, *ciao* for the Italians, *auf wiedersehen* for the Germans, *aloha* for the Hawaiians, *au revoir* for the French, *sayonara* for the Japanese, and something that sounds like *'desveedahnya'* for the Russians. The accents may not be too good, but the effort to say at least a word of the other's language is always well received. Sometimes I think amateur radio is really an international, cost-free, stay-at-home Peace Corps."

"There's another angle," Mac offered. "Before World War II, the holder of an amateur license had a good running start over the competition when applying for a job in electronics, for that license meant he very likely had considerable experience in building and operating electronic equipment. Lately this has not been true because employers found out anyone could memorize the answers to the General Class exam, buy himself a complete factory-made ham station, and operate on the air for years with only a rudimentary knowledge of electronics. Now a prospective employer can be sure the holder of an Extra Class license has the very substantial knowledge and experience required to obtain that license and can act accordingly."

"Yes, and don't forget the FCC specifically stated it was confident the ham who worked to get a higher class license would not then fall back to his former level of competence. They are betting self-improvement will become a habit, and I go along. I read the other day that when the people think about a thing long enough, they usually think right; and we know the FCC considered the matter of incentive licensing a long time before coming to a decision. I and almost all the hams I know personally feel their action was in the best interests of amateur radio." ▲



"Just how do you determine your charges?"

"He's a good worker. I'd promote him right now if he had more education in electronics."

Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

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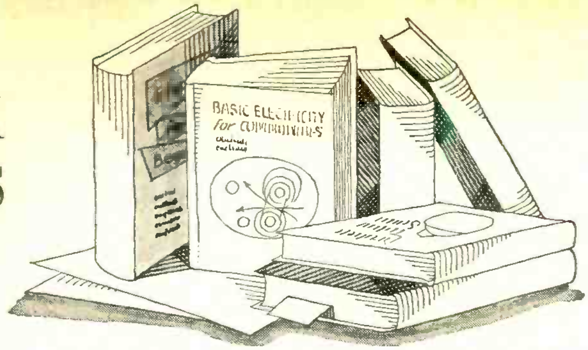
Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.

BOOK REVIEWS



"ELECTRONIC MUSICAL INSTRUMENTS" by Richard H. Dorf. Published by *Radiofile*, 43 West 61st St., New York, N.Y. 10023. 390 pages. Price $10.00.

This Third Edition is, in reality, a completely rewritten and updated version of the author's 1954 text and takes into account all of the many changes which have taken place in the organ field.

The first eight of the 19 chapters are generalized and cover such topics as elements of music, what an organ is, tone generators, keying and coupling, tone coloring, special effects and equipment, sound production and reverberation, and tuning and servicing.

The balance of the chapters deal with specific commercial organs including the *Baldwin, Schober, Thomas, Lowrey, Gulbransen, Wurlitzer, Seeburg, Hammond, Rodgers, Allen,* and *Conn* units. These chapters contain information of interest to engineers and service technicians who work on electronic organs. This section of the book is lavishly illustrated with line drawings, partial schematics, photographs, and tables to make the job of tracking down a circuit fault easier and faster.

The early chapters of the book will be of interest to laymen considering the purchase of an electronic organ since they outline features and options which the prospective buyer will have to consider before making a decision.

* * *

"PRACTICAL COLOR TV SERVICING TECHNIQUES" by Robert L. Goodman. Published by *TAB Books*, Blue Ridge Summit, Pa. 17214. 291 pages. Price $4.95. Soft cover.

This handy little book is written by a practicing technician for practicing technicians and includes many troubleshooting and installation hints which should prove invaluable to anyone called upon to install or service a color set.

The author cites a number of case-histories which he uses to analyze color-TV problems from the antenna terminals to the picture tube. The author also outlines new and helpful techniques for using service test instruments to best advantage and how to use specialized, sophisticated test equipment.

The book includes a special color photo section to assist the service technician in recognizing the correct and incorrect patterns on the screen. In addition to this special section, the book is crammed with photos, scope patterns, partial schematics, tables, and even an 8-page foldout which carries two complete receiver schematics. Practicing technicians should find this little book helpful and its compact size makes it suitable for carrying along on calls.

* * *

"RADIO AND LINE TRANSMISSION" by D. Roddy. Published by *Pergamon Press Inc.*, 44-01 21st Street, Long Island City, N.Y. 11101. 245 pages. Price $6.00 hard cover, $4.50 soft cover.

This volume is part of a larger corpus of technical literature prepared for specific industrial segments in England. This particular volume is addressed to technicians working in telecommunications and is designed to prepare them for the national certificate in their field.

Since the material presented is based on a series of lectures the author gave on the subject, the treatment avoids mathematics as much as possible but the reader will need some algebra, some arithmetic, and know how to deal with trigonometric functions. The author has assumed that the reader has some technical background as he starts out with waves and moves immediately into logarithmic units, speech and music, amplitude modulation, passive components, series and parallel tuned circuits, electro-acoustic devices, semiconductor and thermionic devices, rectifier and demodulator circuits, amplifiers, tuned oscillator circuits, radio systems, line telephony, and line telegraphy.

* * *

"CHARACTERISTICS AND OPERATION OF MOS FIELD-EFFECT DEVICES" by Paul Richman. Published by *McGraw-Hill Book Company*, New York. 145 pages. Price $10.00.

Since the author, who is a senior engineer at *GT&E Laboratories'* Research Center has been intimately associated with MOSFET research and development, this is a no-nonsense, down-to-earth handling of the subject. It is assumed that the reader is either a practicing engineer or at least at graduate school level in his engineering training. For this reason, it has been possible for the author to pack a lot of information into a relatively few pages since it wasn't necessary to cover a lot of background material.

After an introductory chapter, the text covers the basic physics of the field effect, the theory of operation of the MOSFET, the modes of MOSFET operation, the state of the technology, electrical characteristics and circuit parameters, and digital applications for MOSFET's. Three appendices provide information on symbols and notation, constants, and offers a definition of threshold voltage. The text is illustrated, the treatment is mathematical, and each chapter is referenced for further study.

* * *

"ATOMIC LIGHT: LASERS" by R. B. Nehrich, Jr., G. I. Voran & N. F. Dessel. Published by *Sterling Publishing Co., Inc.*, 419 Park Ave., New York, N.Y. 10016. 102 pages. Price $3.95.

For all those who are interested in laser technology but lack the engineering background to cope with scientific texts on the subject, this little volume should be helpful. In everyday language and non-technical terms, the authors—all of whom work with lasers—explain laser applications in the fields of medicine, communications, optics, travel, business, and industry. The text material is divided into 18 chapters with the first four chapters devoted to a discussion of laser technology. The authors next describe some of the various types of lasers—crystal, gas, liquid, and semiconductor—and then delve into a number of present-day applications.

As a basic text for the intelligent and intellectually curious layman, this would be a hard book to beat. Even those in the laser field should derive benefit from a discussion of laser types and techniques other than their specialities.

* * *

"ELECTRONIC INSTRUMENTATION FUNDAMENTALS" by A. P. Malvino. Published by *McGraw-Hill Book Company*, New York. 452 pages. Price $7.95.

Although designed as a classroom text for courses in technical institutes and junior colleges, the author has kept the non-matriculating technician in mind and presented his material in such a way that the book can be used as a home study or self-improvement text.

Since familiarity with all types of test instruments is requisite for any person hoping to make a career in electronics, the author provides both practical and theoretical data on a representative assortment of instruments. While the treatment is somewhat mathematical—algebra and trig would be useful—the level is below that of calculus with advanced concepts explained in familiar language rather than as mathematical concepts. Diagrams, tables, and graphs are used throughout to amplify the text material. A glossary, review questions, and problems are included at the end of each chapter for either classroom or home-study checking of the student's grasp of the material just covered. ▲

14 New Kits From Heath . . .

New! Heathkit Wireless Home Protection System for Your Family's Safety

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Utility Transmitter
for Universal Protection

GD-87
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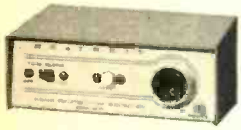

GD-77 Wireless Receiver/Alarm
fail-safe, always alert

Applications Unlimited . . . Customize Your Own System. Here's reliable, low cost, 24-hour protection for your family and property. System warns of smoke, fire, intruders, freezing, thawing, cooling, rising or receding water, pressures . . . any change you want to be warned about. Uses unique new signaling method developed by Berkeley Scientific Labs.; exclusively licensed to Heath. Your house is already wired for this system, just plug the units into any AC outlet. "Load transmission" design (not a carrier type as in wireless intercoms) generates unusual signal that is practically unduplicable in other devices or random noise sources. Solid-state circuitry has built-in fail-safe capability to sound alarm if power fails, if power supply components in any unit fail, or if 50,000 hour bulb in smoke detector fails. Receiver/Alarm has 2800 Hz transistor alarm and receptacle for extra 117 VAC bell or buzzer to extend range, plus rechargeable battery (always kept charged) to sound alarm if power fails. Smoke-Heat Detector-Transmitter capability may be extended to other areas by adding extra heat sensors to its built-in sensor. Utility Transmitter accepts any type of switch or sensor for any purpose; examples: magnetic reed switches for doors and windows to warn of entry; step-on switches for door or driveway; micro switches with trip wire around yard; heat sensors; water pressure switches warn of pump failure; thermal switches warn of freezing in gardens, or thawing in freezers; two wires act as switch to warn of changing water levels in sump-pump wells, pools, etc. Units are small and unobtrusive in beige and brown non-reflecting velvet finish. Any number of units may be used in the system. All units feature circuit board construction; each unit takes only 3 hours to build. Operating cost similar to electric clocks. Invest in safety for your family now with this unique Heath system.

Kit GD-77, receiver/alarm, 4 lbs. **$39.95**
Kit GD-87, smoke/heat det.-trans., 5 lbs. **$49.95**
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(numerous accessory switches available from Heath)

New! Heathkit 2-Channel, 200 Watt SSB Transceivers for CAP, MARS & 160 Meters

Kit HW-18-1
CAP model
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Kit HW-18-2
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less crystals
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CAP model
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Kit HW-18-3
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Good News For CAP, MARS And 160 Meter Ops. This unique series of Heathkit SSB Transceivers was designed with your needs in mind. No more adaptations, no more conversions, no more make-shift rigs. These new transceivers are tailored for your needs with the sensitivity, selectivity, power output and operating convenience that make for effective communications at a fraction of previous costs.

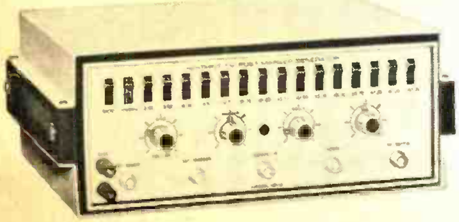
Compare. 200 watts PEP SSB input. 25 watts input with carrier for compatibility with AM stations. Crystal filter sideband generation. 2 channels, switch-selected, crystal controlled. Fixed tuned for easy PTT operation. Transmit and receive freqs. locked together for true transceive operation. Clarifier control adjusts transceiver frequency ±250 Hz. Relayless transmit-receive switching. Local-Distance switch prevents receiver overload from strong local stations. Built-in speaker. PTT mic. & mobilemount included. Carrier & sideband suppression 45 dB. Sensitivity 1 uV. Selectivity 2.7 kHz. 50 ohm coax output. Accessory power supplies (Kit HP-13, mobile, $64.95; Kit HP-23, fixed station, $49.95).

New! Heathkit Solid-State Utility Monophonic Amplifier

Kit
AA-18
$19.95

This amazing little amplifier accepts ceramic phono cartridges, AM tuners, FM tuners, tape recorders, etc., and delivers a solid 4 watts of music power from 20 Hz to over 100 kHz at a low 1.5% THD. Drives high efficiency speakers of 4 to 16 ohms. Ideal for small music system or testing amp. for service shops. Circuit board construction is easiest; just 5 short hookup wires and 6" cable. Single knob tone control. Headphone jack. Pilot lamp. Transformer operated, 120/240 VAC, 50-60 Hz.

New! Heathkit Crystal-Controlled Post Marker Generator



Kit IG-14
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Fast, accurate color TV and FM alignment at the touch of a switch! 15 crystal-controlled marker frequencies. Select picture and sound IF's, color bandpass and trap freqs., 6 dB points, FM IF center freq. and 100 kHz points. Use up to six markers simultaneously. Birdie-type markers. Trace and marker amplitude controls permit using regular 'scope. 400 Hz modulator. Variable bias supply. Input and output connectors for use with any sweep generator. Also has external marker input. BNC connectors. Solid-state circuit uses 22 transistors, 4 diodes. Two circuit boards. Handsome new Heathkit instrument styling of beige and black in stackable design. Until now, an instrument of this capability cost hundreds of dollars more. Order your IG-14 now, it's the best investment in alignment facilities you can make.

Kit IG-14, 8 lbs., no money dn., $10 mo. **$99.95**

New! Low Cost Heathkit 5 MHz 3" Scope

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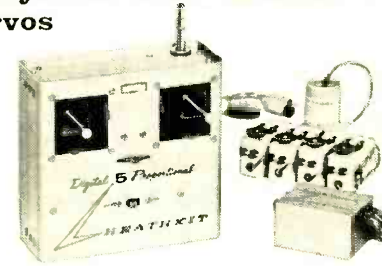
Here is the wideband response, extra sensitivity and utility you need, all at low cost. The Heathkit IC-17 features vertical response of 5 Hz to 5 MHz; 30 mv Peak-to-Peak sensitivity; vertical gain control with pull-out X50 attenuator; front panel 1 volt Peak-to-Peak reference voltage; horizontal sweep from internal generator, 60 Hz line, or external source; wide range automatic sync; plastic graticle with 4 major vertical divisions & 6 major horizontal; front mounted controls; completely nickel-alloy shielded 3" CRT; solid-state high & low voltage power supplies for 115/230 VAC, 50-60 Hz; Zener diode regulators minimize trace bounce from line voltage variations; new professional Heath instrument styling with removable cabinet shells; beige & black color; just 9½" H. x 5½" W. x 14½" L.; circuit board construction, shipping wt. 17 lbs.

See 300 More in FREE Catalog

New! Heathkit/Kraft 5-Channel Digital Proportional System with Variable Capacitor Servos



System Kit GD-47
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This Heathkit version of the internationally famous Kraft system saves you over $200. The system includes solid-state transmitter with built-in charger and rechargeable battery, solid-state receiver, receiver rechargeable battery, four variable capacitor servos, and all cables. Servos feature sealed variable capacitor feedback to eliminate failure due to dirty contacts, vibration, etc.; three outputs: two linear shafts travel ⅝" in simultaneous opposite directions plus rotary wheel. Specify freq.: 26.995, 27.045, 27.145, 27.195 MHz.

System Kit GD-47, all of above, 5 lbs. **$219.95**
Kit GDA-47-1, transmitter, battery, cable, 3 lbs. **$86.50**
Kit GDA-47-2, receiver, 3 lbs. **$49.95**
GDA-47-3, receiver rechargeable battery, 1 lb. **$9.95**
Kit GDA-47-4, one servo only, 1 lb. **$21.50**

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(less cabinet)
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Assembled ARW-15, (less cab.), 34 lbs. . . . $50 dn., $43 mo. **$499.50**

New! Solid-State Portable Volt-Ohm-Meter

So Handy, So Low Cost we call it "every man's" meter. Just right for homeowners, hobbyists, boatowners, CBer's, hams . . . it's even sophisticated enough for radio & TV servicing! Features 12 ranges . . . 4 AC & 4 DC volt ranges, 4 ohm ranges; 11 megohm input on DC, 1 megohm input on AC; 4½" 200 uA meter; battery power; rugged polypropylene case and more. Easy 3 or 4 hour kit assembly. 4 lbs.

Kit IM-17
$19.95

What would you expect to pay for a Vox "Jaguar" Combo organ with a 180-watt 3-channel amp? $1000? $1250? $1500? More?

Kit TOS-1
Organ, Amplifier & Speaker Kits
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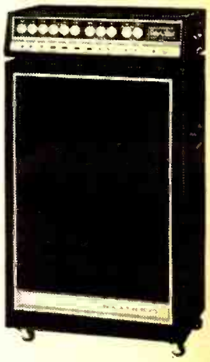


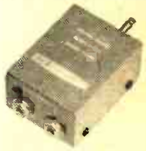
Kit TOS-2
Organ Kit, Assembled Amplifier & Speaker (240 lbs.)
$698.00

You can get both for only $598 during this Special Heathkit Offer!

Now you can get this famous professional combo organ with a versatile high-power piggy-back amp. and matching speaker system for just a little more than you'd expect to pay for the "Jaguar" alone! The Heathkit/Vox "Jaguar" is solid-state; two outputs for mixed or separated bass and treble; reversible bass keys for full 49 key range or separate bass notes; bass volume control; vibrato tab; bass chord tab; four voice tabs (flute, bright, brass, mellow); keyboard range C_2 to C_6 in four octaves; factory assembled keyboard, organ case with cover, and stand with case. Also available separately; you'll still save $150 (order Kit TO-68, $349.95).

The Heathkit TA-17 Deluxe Super-Power Amplifier & Speaker has 180 watts peak power into one speaker (240 watts peak into a pair); 3-channels with 2 inputs each; "fuzz", brightness switch; bass boost; tremolo, reverb; complete controls for each channel; foot switch; 2 heavy duty 12" speakers plus horn driver. Also available separately kit or factory assembled (Kit Amplifier TA-17, $175; Assembled $275; Kit Speaker TA-17-1 $120; Assembled $150; Kit TAS-17-2, amp. & two speakers $395; Assembled TAW-17-2, amp. & two speakers $545).

New! Heathkit Guitar Headphone Amplifier



Kit TA-58
$9.95

Practice your electronic guitar playing in private! Plug this miniature amp. into output jack of guitar and use mono or stereo headphones (4 to 2 megohms). Solid-state circuit has tailored response, automatic on-off switching, powered by battery (not supplied). 2 lbs.

New! Heathkit Solid-State "Fuzz Booster" For Guitar Amplifiers

Kit TA-28
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"Fuzz" is what it's called, harmonic distortion is what it is, and you can add it to your guitar amp with this kit. Transistor circuit is contained in die cast footswitch housing and powered by internal battery (not supplied). Two controls adjust tone and intensity of "fuzz". Build it in one evening. 4 lbs.

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CIRCLE NO. 108 ON READER SERVICE CARD

Solid-State Color-Bar Generators

(Continued from page 29)

The advantages of the unusual sweeping system in the WR-502A, as explained by its designer, are greater stability and cleaner video pattern displays. A built-in meter to check battery voltage, and a switch to cut in a fresh battery (a dual battery holder is used to carry a spare mercury battery), contribute to reliability in the field. The constant-voltage characteristics of mercury cells and the low (22 mA) drain make possible stable operation over a battery life of 100 hours or more.

Sencore—This manufacturer has two solid-state models, the CG10 and the CG141, both keyed rainbow types. As you can see from the chart, the CG141 is the more elaborate (and expensive) of the two.

The CG10 is battery-operated. Its counting circuits are something not seen before in color-bar generators: transistor blocking oscillators. They seem to be as steady in this application as the old-standby blocking oscillator has been in many another piece of tube equipment in years past. A 189-kHz crystal oscillator starts the timing chain. A 12-divider is controlled by a special bistable multivibrator as well as by the 15,750-Hz signal from the first counter; the divider down-counts alternately by factors of 17 and 18, producing an average 450-Hz output from the bistable multivibrator. The 900-Hz signal for horizontal lines is developed by mixing 450-Hz pulses from a second source with the 450-Hz pulses already mentioned. It is this odd way of developing the 900-Hz pulses for horizontal video lines that allows another innovation—variable interlacing. The third counter also has a dividing factor of 15, forming the 60-Hz pulses needed for sync.

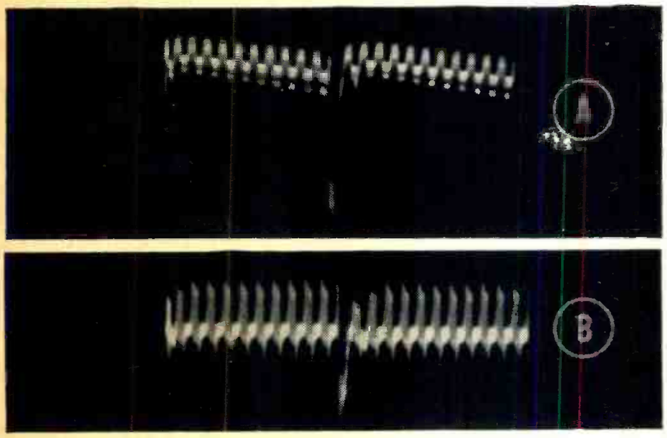
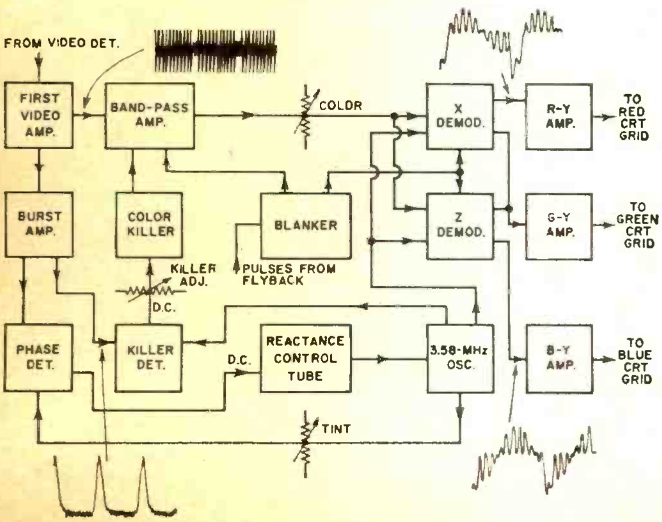


Fig. 7. Keyed-rainbow waveform pattern: (A) as it comes from generator, and (B) as it appears at set's video detector.

Fig. 8. Waveforms in chroma section of color-TV receiver with color-bar pattern applied are strong troubleshooting aid.



The unique feature called interlace is an adjustable delay in the timing of interlocking between the 450-Hz pulses from the second source mentioned—a circuit called a half-line multivibrator—and the 450-Hz (average) pulses from the bistable multivibrator. The adjustment is on the front panel and is turned to make the horizontal video lines start wherever the operator desires. It can blend distinctly separate video lines together to form a single thicker one. Because of the way dots are formed, it can also be adjusted for nice, round dots to make center convergence easy.

The Model CG141 is similar in basic circuitry to the CG10. The same kind of counting is used, but there are some additions in the pattern-combining circuits. The CG141, introduced last year, was the first color generator to offer the movable single-dot and movable crosshair patterns. It is accomplished with special delay multivibrators that determine—according to how the operator sets the controls—where on the screen the single vertical and horizontal lines are positioned, therefore where they intersect. It is, of course, that intersection which forms the movable dot.

The Model CG141 operates from the a.c. line only. It is the only color-bar generator we know of with a thermostatically controlled heating element inside. This is done in the interest of stability and quick warmup. And it is effective. With stable blocking-oscillator counters, a zener-regulated power supply, and almost absolute temperature control ambient to the counting transistors, there is little reason to expect anything but stability.

How Are They Used?

Not much mystery remains to using the video patterns of a color generator for convergence. The dot-line pattern generator antedated color TV. Besides, no home-service or installation technician who values his professional reputation can function without knowing at least the rudiments of convergence. The operation and application of color-bar generators for this purpose is, therefore, familiar to most of our readers.

Fewer technicians know as much about the color-bar pattern as they would like to. The keyed-rainbow display makes an easily indentifiable waveform for tracing through a chroma section with an oscilloscope; the distinctive normal shape is easily compared against shapes discovered at various circuit points, offering significant clues to the nature of any defect. The position of the rainbow patterns' colors, viewed on a color-set screen, is an indicator of correct (or incorrect) phase adjustment in the color-sync section of a receiver. Closer examination of the relative positions of individual bars of color on the screen gives a clue to proper adjustment of the color demodulators. When any of these adjustments is wrong, the color-bar pattern is the standard against which it is corrected.

The keyed-rainbow colors are illustrated in their correct positions on the receiver shown on the front cover. Fig. 7A is an oscilloscope photograph of the keyed-rainbow waveform as it appears coming from the video output of a typical generator. Fig. 7B is of the waveform at the video detector of a color receiver, the rainbow signal being fed into the receiver through the tuner on an r.f. carrier. In both waveforms, the first "bar" after the sync pulse is the color-synchronizing burst and the remaining ones coincide with the bars of color shown on the front cover. Compare them and become familiar with the color sequence. Memorize it; you'll need to remember it if you troubleshoot many color receivers.

Chroma-section troubles yield readily to signal tracing, with the keyed-rainbow generator as the signal source and a scope as the tracer. Starting at the video detector, the technician moves progressively through the band-pass amplifiers, checking the action of various controls and adjustments as he goes. Fig. 8 is a block diagram of the chroma section of one popular color set. It is useful as a guide to the steps of signal-tracing the keyed-rainbow signal.

Significant Waveforms

A few of the most significant keyed-rainbow waveforms are shown in Fig. 8. The waveform at the band-pass amplifier grid contains all the bars, but the horizontal pulse has been chopped out from between each bar sequence. The small-value coupling capacitor that feeds video to the band-pass amplifier will pass the keyed-rainbow information at 3.56 MHz; the 15,750-Hz pulse can't get through.

In the burst amplifier, a keying pulse is dominant in the waveform. That is because the color-synchronizing pulse is the only information that is important; it is visible at the top of the large pulse. As you can see from the waveform, the color bars are subjugated; in some receivers, they may be completely swamped out at this point. The signals fed to the killer detector and phase detector from the burst amplifier need carry nothing but color-sync information.

Both the killer detector and the phase detector that controls the 3.58-MHz oscillator also receive a signal from the 3.58-MHz oscillator. Its waveform isn't shown, but it appears on the scope as a blur of r.f. signal. Moving the Tint control while observing the 3.58-MHz signal entering the phase detector tells nothing, because it is impossible to see any phase shift there with the scope. That phenomenon is best observed on the screen of the picture tube, or in the waveforms at the demodulators.

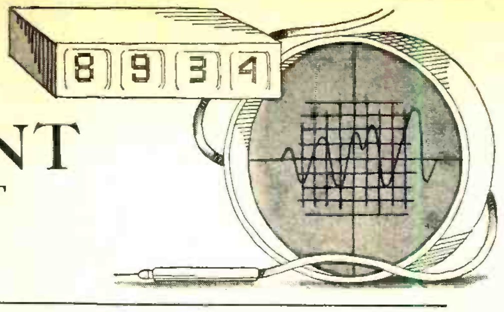
You can trace the color-bar signal through the band-pass amplifier (sometimes there are several stages) with the scope. Beyond the Color control, you can check its action. As you turn it up and down, the amplitude of the color-bar waveform reaching the demodulators should increase and diminish noticeably. You can also check the action of the killer adjustment. Turn it to maximum and the waveform should disappear from the output of the band-pass amplifier; be sure to reset it to the proper operating point after you've checked its action.

The waveforms you see at the output of the demodulators are free from 3.58-MHz signals. They are simply lines representing the rising and falling signal levels at the various CRT grids for each color bar seen on the CRT face. As an example of how to interpret these waveforms, consider the one at the R—Y amplifier. Notice that maximum amplitude is the upward excursion third from left. In a normal color-bar display on the color-set's picture tube, the third bar is the deepest red. In the waveform, the sixth bar is at the zero line and the remaining ones go in the negative direction. On the CRT screen, the sixth bar is blue with virtually no red in it; the remaining ones are some combination of blue and green, with the red gun of the picture tube cut off completely.

Now you can twist the Tint knob back and forth and view the result of its action. If something is wrong with it, the highest amplitude of red will fall somewhere other than at the third bar. When the tint control is at its center of rotation, the third bar should be maximum red, and the sixth bar should fall at the zero line. If you decide to use the demodulated B—Y signal as a reference instead of the R—Y, normal action would place the amplitudes differently; the waveform at the B—Y amplifier shows normal positioning.

It takes practice to become familiar with the appearance of all the waveforms in the chroma section of a color receiver. Those few shown in Fig. 8 are the basic ones. Learn to trace them, and to recognize abnormalities, and you'll cut minutes—even hours—off your troubleshooting time in color sets. The best tool you can have is the steady standard signal from a good color-bar generator. ▲

TEST EQUIPMENT
PRODUCT REPORT



RCA WV-500A Solid-State Volt-ohmmeter
For copy of manufacturer's brochure, circle No. 32 on Reader Service Card.

THE new *RCA* WV-500A "Volt-Ohmyst" is a solid-state, battery-operated electronic volt-ohmmeter, especially designed for stable, drift-free operation. It measures d.c. voltages from 0.01 to 1500 volts, a.c. (r.m.s.) voltages from 0.1 to 1500 volts, a.c. peak-to-peak voltages from 0.5 to 4200 volts, and resistance values from 0.2 ohm to 1000 megohms. Seven overlapping ranges are provided for a.c. and resistance measurements, and eight ranges are provided for d.c. measurements, including a 0 and 0.5-volt range. Accuracy of the meter is ± 3% of full-scale reading.

An input resistance of 11 megohms on all d.c. ranges prevents overloading the circuit under test. The 11-megohm input resistance has the advantage of not being so high as to impair the stability of the instrument.

Special solid-state circuitry is used to assure stable, drift-free operation with minimum effect due to temperature variation. Advantages of solid-state construction include the elimination of warm-up time and a reduction in zero-shift that can occur in tube-operated volt-ohmmeters.

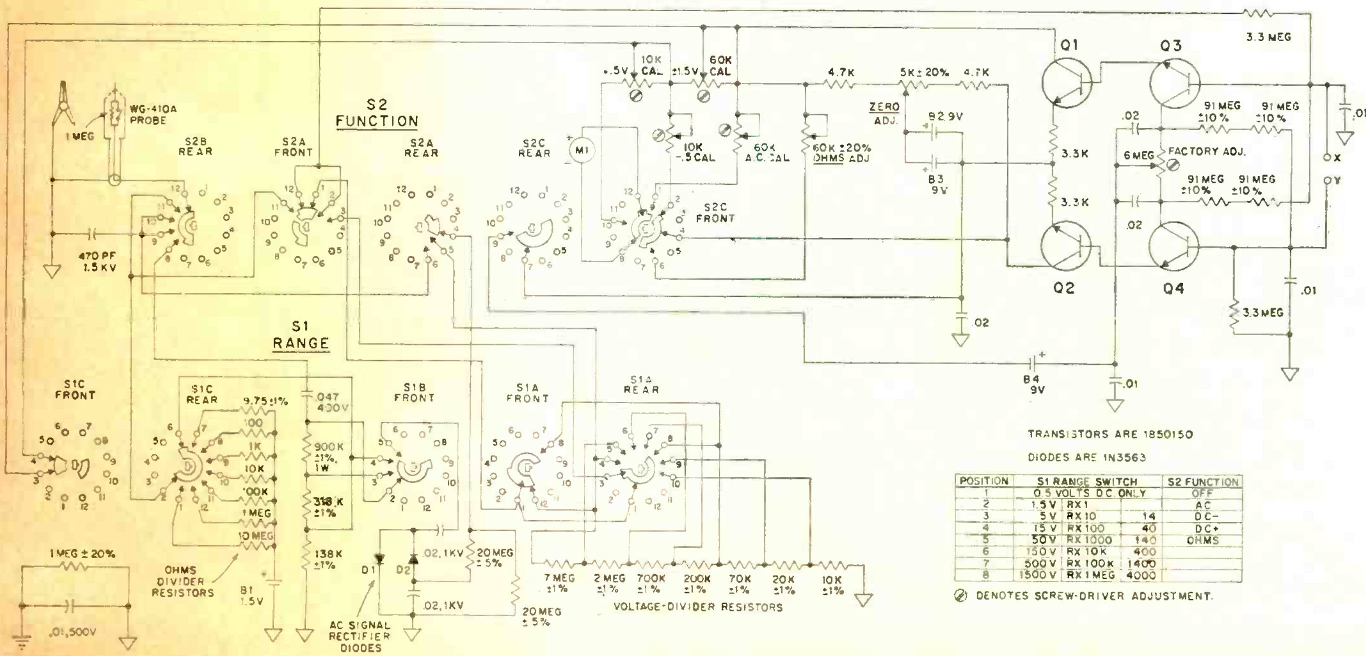
Since the WV-500A is battery-operated, the measuring circuit is completely isolated from the a.c. power line. For this reason, the instrument can be used to make measurements on equipment with high ground potentials—an important consideration in many industrial and laboratory applications.

The operation of the instrument is based on a four-transistor amplifier circuit (see diagram), especially designed for high input impedance with good stability and linearity. The input voltage (from the a.c./d.c. voltage divider or ohms divider) is applied between the bases of *Q*3 and *Q*4, which serve as preamplifiers driving the bases of *Q*1 and *Q*2. The output of *Q*1 and *Q*2 drives the 50-microampere meter that is used.

High impedance is achieved through controlled positive-feedback networks consisting of four 91-megohm resistors. A 6-megohm pot between the collectors of *Q*3 and *Q*4 is used to balance the input. The front-panel Zero control balances the amplifier output with no input signal applied. The 3.3-megohm resistors connected to the two bases of the two input transistors serve to isolate and protect the amplifier circuit. Bypass capacitors prevent a.c. signals from affecting the metering circuit in any way.

The accuracy of the circuit is maintained throughout the usable life of the batteries. The 9-volt output-stage supply batteries, *B*2 and *B*3, are connected in parallel to assure long life. Total battery drain is only about 1 mA. The other 9-volt battery, *B*4, powers the driver transistors *Q*3 and *Q*4, and provides bias to bases of *Q*1 and *Q*2. The current drain from this battery is only a few microamps, so that a stable supply voltage for the input circuit is provided throughout the entire shelf-life of the battery. This, of course, maintains over-all meter stability.

The instrument is completely portable, requiring no external power source. Four batteries are used in all; one 1.5-volt "C" cell and three 9-volt batteries. The unit weighs only 3½ pounds and measures 6⅞" x 5¼" x 3⅛".

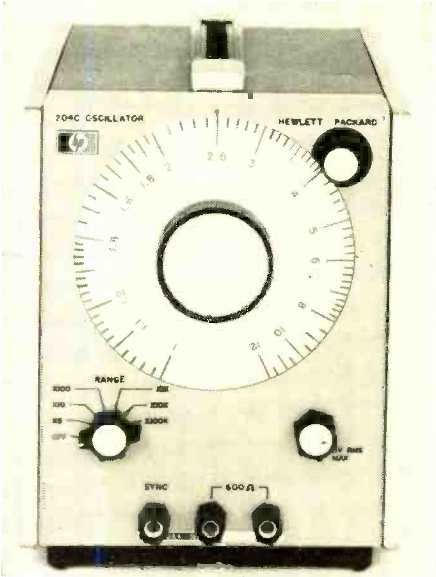


POSITION	S1 RANGE SWITCH			S2 FUNCTION
1	0.5 VOLTS D.C. ONLY			OFF
2	1.5 V	RX 1		AC
3	5 V	RX 10	14	DC−
4	15 V	RX 100	40	DC+
5	50 V	RX 1000	140	OHMS
6	150 V	RX 10K	400	
7	500 V	RX 100K	1400	
8	1500 V	RX 1 MEG	4000	

Optional user price of the WV-500A is $75.00. ▲

Hewlett-Packard
Model 204C Audio Oscillator

For copy of manufacturer's brochure circle No. 151 on Reader Service Card.



When the *Hewlett-Packard Co.* was founded in 1939, its first product was an *RC* Wien-bridge oscillator invented by William R. Hewlett, now *HP* president. In its newest version, the Model 204C oscillator is now advanced in many ways over its several predecessors.

Significant improvements are flatter frequency response (now better than ± 0.5% or ± 0.05 dB) over increased frequency range (now 5 Hz to 1.2 MHz), lower distortion (< 0.1% over the whole range, including the low-frequency extreme in the low-distortion mode), syncability, greater stability, and better human engineering. The dial is recessed for no-parallax setting; complete disassembly for maintenance is a two-minute operation.

Light in weight and compact (it is one-third of a rack-width wide and less than 7 inches high), the new oscillator sells for $250. Three plug-in interchangeable power supplies are offered—a.c. line-operated, battery, and rechargeable battery.

When fed to the instrument's front-panel sync input, any waveform in the oscillator's range will produce an excellent sine-wave output, synchronized in phase. The instrument can thus function as a high-quality tunable filter, or it may be phase-locked to a frequency standard.

The oscillator-amplifier uses a FET input and a FET automatic gain control in the feedback loop to stabilize output and to reduce distortion. Amplifier frequency response is independent of transistor parameters so transistors may be changed without recalibration.

The heart of the oscillator, a classical Wien bridge, has been reconfigured. The tuning capacitors are electrically isolated and the number of sections reduced from three to two. These now appear in the bridge circuit in such a position that their stators are both located at low-impedance points (one at ground, one at amplifier output). The result is lowered stray capacitance shunt effects and greater tuning range. ▲

Hickok Model DMS-3200 DP-170 Digital Ohmmeter

For copy of manufacturer's brochure, circle No. 152 on Reader Service Card.

DIRECT digital display of resistance measurements at very high accuracy is provided by the new Model DMS-3200/DP-170 available from *Hickok*. The new instrument consists of a plug-in unit along with a digital display main frame. It is able to measure resistance from 0.001 ohm to 1000 megohms in ten ranges with an accuracy of ± 0.1 percent. An unusually low power is applied to the resistor under measurement—a maximum value of 1 milliwatt. Four-terminal input, with guard terminal, permits accurate measurement of both extremely low and high resistance values.

All-electronic "Nixie" type display tubes are used for the readout and the decimal-point indication is automatically displayed. A 100-percent overrange capability is provided and display time is variable, with provision for holding a reading indefinitely.

The instrument is fast, simple, and accurate with the minimum possibility of operator error. It is intended for general laboratory use, for calibration of resistors and resistance thermometers, for checking transducers, and for general component inspection.

The unit uses all-solid-state design and employs glass-epoxy printed-circuit boards. It measures 9" x 7" x 13" and weighs 13 pounds. Price is $560.

Also available now is a new digital capacitance meter, the Model DMS-3200/DP-200. Using the same main frame but with a different plug-in unit, this instrument provides digital display of capacitance measurements from 1.0 picofarad to 10,000 microfarads in eight ranges at ± 0.1 per cent accuracy. ▲

EHV D.C. Power Transmission

(*Continued from page* 43)

tems—any faults or damaging power surges on one a.c. system will not be transmitted to the other a.c. system. If such a system had been in use in 1965, it is just possible that the Northeast power failure would not have occurred.

Olov Berglund, executive engineer for *ASEA*, puts it this way: "An h.v. d.c. line will only transmit what it is set to transmit. It will not transfer a fault from the sending end to the receiving end—which a.c. does automatically, without the possibility of the operator checking it."

What About the Future?

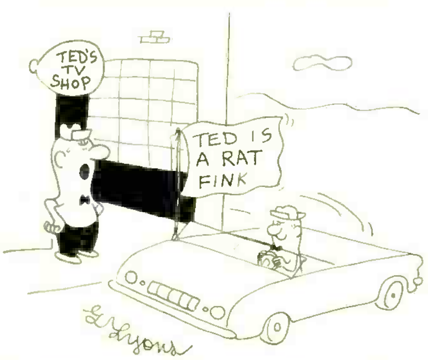
With all of these good things to be said for EHV d.c., what does its future appear to be? To make d.c. even more competitive, it appears that solid-state conversion equipment must be developed.

Some engineers believe that thyristors (SCR's and power-switching diodes), the most likely device to replace the mercury-arc rectifier, will be better and more economical than the mercury-arc rectifier within 5 years. To take advantage of such progress, engineers for the Nelson River project have specified that either mercury-arc rectifiers or thyristors may be used.

Until thyristors become competitive with the mercury-arc rectifiers, terminal stations for d.c. are likely to remain expensive, and EHV d.c. will probably be used only in specific situations where large blocks of power must be transmitted long distances. Tapping off power for intermediate stations would require a terminal station for each tap, which would change the cost situation tremendously.

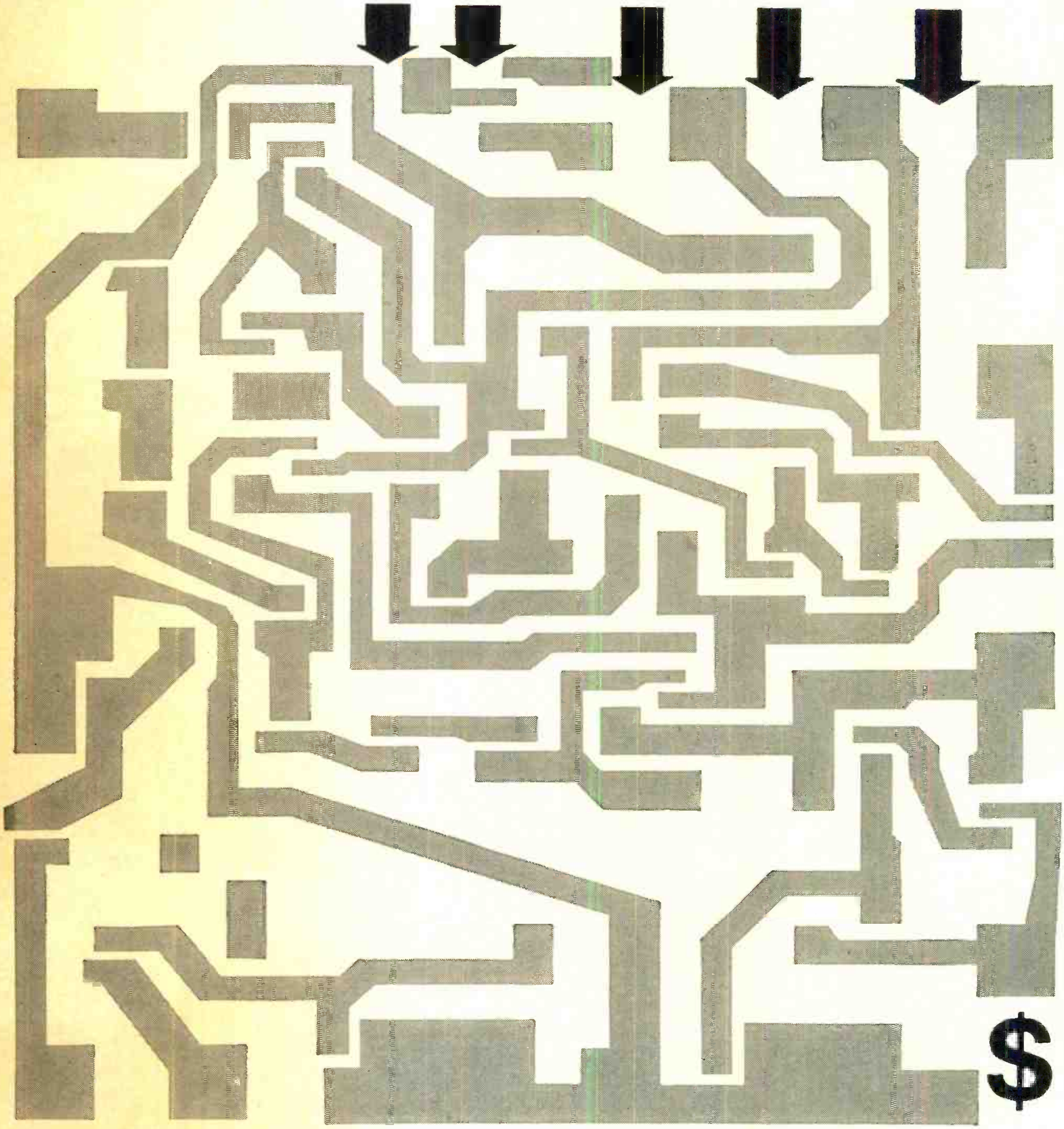
With U.S. power needs doubling every 10 years, it is important that our electric utilities push ahead with new techniques such as EHV d.c.

Back in 1939, J.D. Ross, the first head of the Bonneville Power Administration, predicted that transmission of power from 1000 to 2000 miles would become a comparatively simple matter with d.c. Truly, as Ross said, the possibilities of this new technique of power transmission stagger the imagination. ▲



"Oh, come on, I'll test your tubes free!"

There's more than one road to success.



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LOW-POWER TRANSISTOR SWITCHING CIRCUITS

By IRWIN MATH/ Frequency Electronics, Inc.

Operation and design of several low-power multivibrator circuits employed for digital switching applications.

WITH the advent of transistors, the total power required to operate an electronics circuit decreased substantially. Today, primarily as a result of satellite needs, power requirements have become still smaller and various techniques have been developed to obtain the smallest power drain from the power supply. By becoming familiar with some of these techniques and resulting circuitry, devices can be built that will give the longest possible battery life while maintaining reliable operation.

Emphasis will be on switching (two-state) circuits. In these circuits many kinds of semiconductor devices, such as *p-n-p* and *n-p-n* transistors, unijunctions, SCR's, and diodes—often in various combination—will be employed.

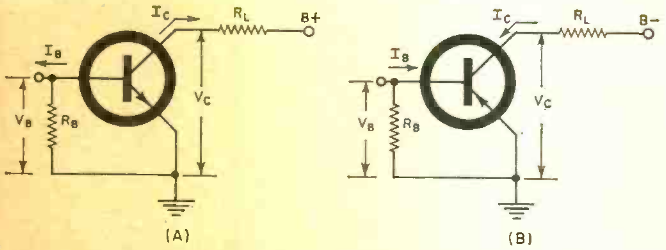
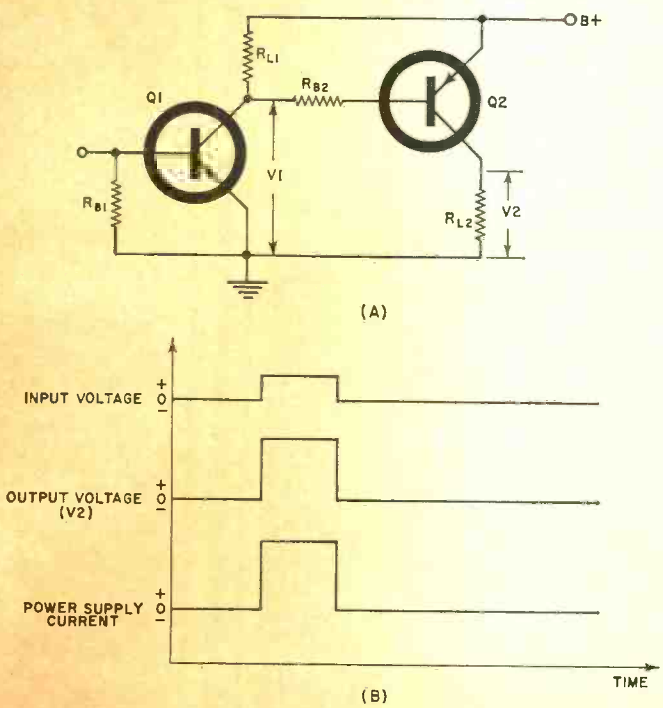


Fig. 1. Basic transistor switch for (A) "n-p-n" and (B) "p-n-p" transistors showing direction of electron flow.

Fig. 2. Two-stage pulse amplifier along with waveforms.



Basic Switch

Fig. 1A is a schematic of the basic transistor switch. When the base voltage (V_B) is zero, the base current (I_B) is also zero and the transistor does not conduct. As a result, I_C is zero and the voltage at the collector (V_C) is equal to "B+". This condition is known as *cut off*. It is important to note that no appreciable current is drawn during this state.

Now, as V_B begins to increase in the positive direction, I_B starts to flow and the transistor begins to conduct. This causes I_C to begin flowing with a resultant voltage drop across R_L, causing V_C to decrease. As I_B continues to increase, a point is reached where there is no longer any increase in I_C. This point is called the *saturation point*. V_C is at its lowest, about 0.1 to 0.8 volt (depending on the transistor), and is known as the saturation voltage. This causes the voltage across R_L to be the full "B+" minus the small saturation voltage. Thus, the transistor can be thought of as practically a short circuit from collector to emitter. In comparison, the cut-off transistor can be thought of as an open circuit.

It should be pointed out that the same situation is also true for a *p-n-p* transistor. In this case, however, the supply must be negative, and the input signal must increase in a negative direction to cause the transistor to conduct. Fig. 1B shows this arrangement. It is interesting to note the electron current flow direction for the *p-n-p* as compared to the *n-p-n*. It is important to understand, however, that the operation is exactly the same for both transistors.

Now with this background information in mind, let's examine the first practical circuit, a pulse amplifier (Fig. 2A). This is a simple two-stage amplifier with three interesting features. No current is drawn when the circuit is not in operation; there is no polarity or phase reversal from input to output; and both input and output signals swing from zero to a maximum—more about this last feature later.

With no positive signal applied to the base of Q1, it is cut off and V_1 is equal to "B+". This causes the base of Q2, a *p-n-p* transistor, to also be at "B+". Since the emitter of Q2 is also at "B+", there is no negative voltage on the base (with respect to the emitter). Therefore, Q2 is also cut off and V_2, the output voltage, is zero. At this time, no current is drawn.

Now let's assume that a positive pulse is applied to the base of Q1. If enough current is present in the pulse, Q1 will turn on into saturation, causing V_1 to drop to a few tenths of a volt. This will, in effect, apply a negative voltage to the base of Q2 (with respect to its emitter), and it, too, will go into saturation. Full "B+" minus the small drop in Q2 will now be applied across R_{L2} and can be taken as an output. The total amount of current drawn during this operation is essentially the current through R_{L1} and R_{L2}. This is easily determined by Ohm's law. For example, if "B+" = 10 volts and R_{L1} and R_{L2} are both 10,000 ohms, then the current is $I = E/R = 10/10$ k= 1 mA through each resistor, or 2 mA total.

In order to be sure saturation will occur, it is important to know the minimum input pulse that can be amplified by this circuit. This is determined by the value of R_{L1} and the transistor specifications. In this example, the saturation current is 1 mA as just calculated. If the d.c. current gain (h_{FE}) of $Q1$ is 100, for example, then all that is required at the base is 1 mA/100 or 0.01 mA.

The value of R_{B2} is also based on this fact. When $Q1$ does saturate, the "B+" is present across R_{L1} and, in order to supply just enough current to the base of $Q2$ to bring it to the saturation point, R_{B2} acts as a current limiter. If the h_{FE} for $Q2$ is also 100, 0.01 mA is all that its base requires. R_{B2} can then be calculated from Ohm's law to be $R = E/I = 10/0.00001 = 1$ megohm. To be sure of saturation, though, it is usually good practice to supply at least 2 to 3 times the base current required. Therefore, in the actual circuit, 330,000 ohms would be used. Then, there would be no doubt that $Q2$ would saturate.

The value for h_{FE} for any transistor can be easily obtained from the data sheet for that transistor as can the saturation voltage and maximum allowable base current. One more point that should be emphasized is the actual choice of the collector load resistor. Since the value of R_L determines the collector current and power-supply current, it is usually advantageous to use large values. A current of 1 mA maximum per stage is usually adequate for good performance and low operating power.

Due to the fact that this amplifier is, in essence, a two-stage common-emitter amplifier, two polarity inversions occur and the output signal has the same polarity as the input. Fig 2B shows this relationship. Notice that the input and output are identical except for amplitude and that current is only drawn when the signal is present.

In many directly coupled pulse amplifiers, the zero level is never obtained. Fig. 3 shows this. Since the output comes directly from the collector of the transistor, when it goes into saturation, the small saturation voltage is present in the output. Usually diodes or special circuitry are used to drop this level to zero. In the amplifier that was previously discussed, the level is true zero, since the *p-n-p* transistor is completely off.

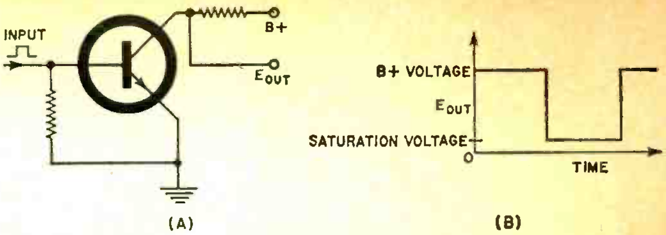


Fig. 3. Conventional transistor amplifier and output.

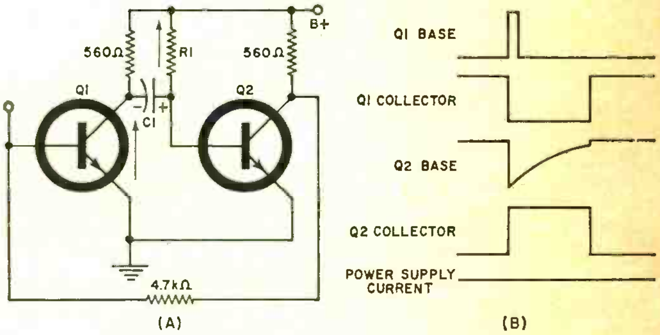


Fig. 4. One-shot (monostable) multivibrator and waveforms.

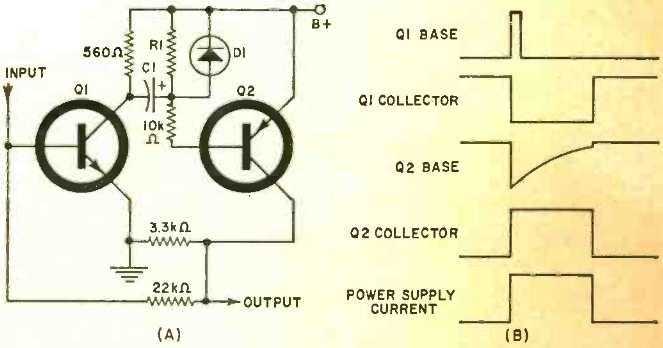


Fig. 5. A low-power one-shot multivibrator and waveforms.

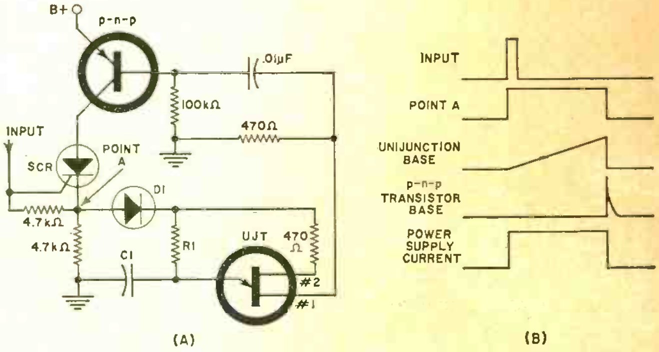


Fig. 6. A long-pulse-width monostable circuit and waveforms.

One-Shot Multivibrator

Now that we have a basic building block, let's go on to examine a couple of other low-power switching circuits. Fig. 4A is a schematic of a typical one-shot or monostable multivibrator. This circuit has the characteristic of supplying an output pulse of constant duration (width) no matter what the width of the input. Such circuits are used for pulse generators, pulse restorers, and electronic timers.

In the circuit shown, $Q2$ is "on" (in saturation) causing the voltage at the base of $Q1$ to be practically zero and $Q1$ is therefore cut off. When a positive pulse is applied to the base of $Q1$, it turns "on", grounding the side of $C1$ connected to the collector of $Q1$, and $C1$ starts to charge through $R1$, as shown. When a capacitor just begins to charge, it acts as a short circuit, therefore the base of $Q2$ is momentarily grounded, and it turns "off". As soon as the voltage across $C1$ reaches the proper level, $Q2$ again turns on and $Q1$ turns off.

The values of $C1$ and $R1$ determine how long it will take for $C1$ to charge and, consequently, how long $Q2$ will remain off. Varying these values will vary the output pulse width. Fig. 4B shows the relationship of these voltages. The problem with this circuit is that when no input pulse is present, $Q2$ is in conduction. If the "B+" value is 10 volts, the current drawn is approximately 10/560 amperes or 18 mA. Let's see how to eliminate this "wasted" current.

Fig. 5A is a schematic of a low-power one-shot multivibrator. Its main feature is that with no input, zero current is being drawn. Operation is similar to the monostable circuit of Fig. 4A except that $Q2$ is a p-n-p transistor. Initially, $Q2$ is cut off since there is no effective negative voltage between its base and emitter. As a result, no collector current flows and the voltage across the 3.3 k resistor is zero. This assures that $Q1$ is also off. At this time, no current is drawn from the power supply.

When a positive pulse is applied to the base of $Q1$, it turns "on", essentially grounding one side of $C1$ as in the standard monostable circuit. The capacitor begins charging through $R1$. This causes the base voltage on $Q2$ to become negative with respect to the emitter and it turns "on", keeping $Q1$ on and producing an output.

Eventually $C1$ charges to a value that causes $Q2$ to turn off. The output then drops to zero and Q1 also turns off. C1 now discharges through the diode and the circuit is back to its starting condition. As in Fig 4A, C1 and R1 determine the width of the output. Fig. 5B shows the voltage and current relationships in the circuit. It is interesting to note how similar these waveshapes are to those of Fig. 4B.

Another interesting monostable multivibrator, and one that can be used for very long duration pulses, is shown in Fig. 6A. In this circuit, an SCR, unijunction transistor, and conventional *p-n-p* transistor are used. Initially, the SCR is cut off and therefore the voltage at point *A* is zero. The *p-n-p* transistor is biased into the saturation region because of the effective negative voltage between its emitter and base. But, because there is no current path through the SCR, no collector current flows at any rate.

Circuit Operation

When the SCR is triggered, it immediately turns "on." The voltage at point *A* now rises to the "B+" level and this voltage is applied to the unijunction circuit through diode *D*1. *C*1 begins to charge through *R*1 until the firing point of the unijunction is reached. At this time the unijunction conducts, producing a positive pulse across the 470-ohm base #1 resistor. This pulse is coupled to the base of the *p-n-p* transistor which momentarily turns off thereby cutting off "B+" to the SCR. Since an SCR is turned off by removing "B+" voltage from its anode, it cuts off and the circuit returns to its initial condition.

In this circuit, *R*1 can go as high as 150 k and *C*1 can go into the fairly high microfarad region, giving output pulse widths of 1 to 5 minutes. The output of this circuit is taken from point *A*. Fig. 6B shows the waveshapes that are produced in the circuit.

Free-Running Multivibrator

We now come to a very commonly used circuit, the astable or free-running multivibrator. This device is used for signal generation, frequency generation, light flashers, and a host of other applications. Fig. 7 is a schematic of the basic astable circuit. At any given time, one transistor is conducting and one is cut off and, therefore, the circuit is always drawing a fixed amount of power.

Fig. 8A is also an astable multivibrator but this time low power techniques have been used. When power is first applied, *Q*1 and *Q*2 are both cut off because the base of *Q*1 has a discharged capacitor between it and ground through a low (in comparison with the base resistor) resistance. The capacitor then begins to charge through *R*1 and *R*2 with the polarity shown. Eventually a point is reached where *C*1 has enough voltage to cause *Q*1 to conduct. This immediately turns on *Q*2 also forcing the capacitor to suddenly discharge through the base-emitter junction of *Q*1 and the cycle repeats. Although current is actually drawn during the entire cycle (the charging of *C*1 does require some current), the amount is substantially less than in the conventional circuit. Fig. 8B shows this varying current as well as the other waveforms in the circuit. It should also be pointed out that the use of low-leakage silicon transistors and a large *Q*1 base resistance-to-*Q*2 collector resistance ratio is necessary for optimum operation of this particular circuit. ▲

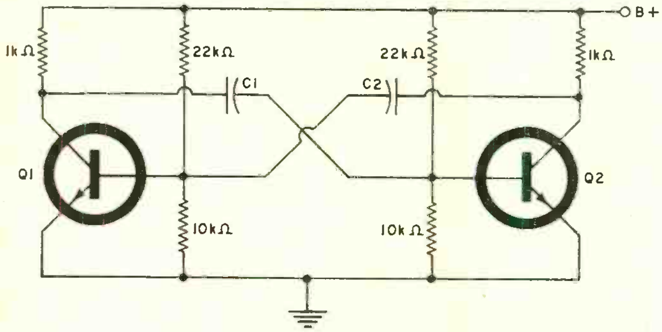


Fig. 7. A basic astable or free-running multivibrator.

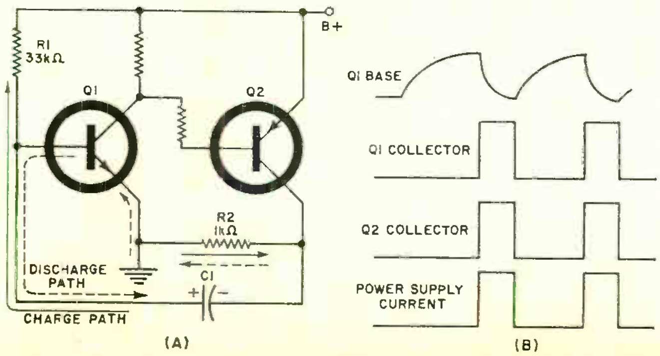


Fig. 8. Low-power astable multivibrator, waveforms.

The CO_2 Laser

(*Continued from page 48*)

cool. Some early work indicates that part of these difficulties may be overcome by using short duration pulses of laser energy instead of a continuous beam. Most ceramic materials can be worked rather easily with the laser, as can nearly all plastics. A promising application in this area is that of slitting plastic-base materials that have a magnetic coating. The magnetic coating on the material wears out cutting blades very rapidly and, as the blades wear out, the edge of the material becomes progressively more and more ragged. This causes waste. The CO_2 laser can cut through such material easily at a high rate (approaching 1000 feet per minute) at relatively low power levels. A CO_2 laser being used in a machining operation is shown in Fig. 5.

CO_2 lasers may also be used to trim deposited resistors. These resistors are formed by depositing a resistive material on an insulating substrate and attaching leads to the resistive element. At present, the finished resistors are trimmed to the desired resistance value by etching or sandblasting techniques. A CO_2 laser can vaporize the layers of resistive material and precisely trim the resistor to the desired value in a much shorter time.

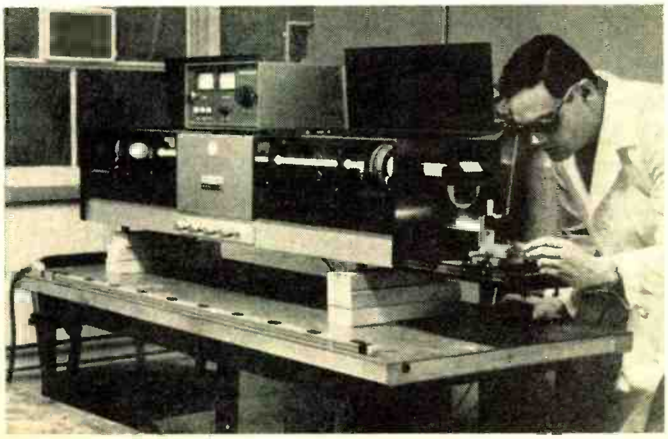
There is also interest in the application of the CO_2 laser to bio-medical research. Although there have been no reports of a successful effort, some of the medical profession is interested in using the CO_2 laser as a bloodless surgical knife that could simultaneously cut and cauterize. One corporation has even conducted experiments on drilling teeth with lasers. The laser drilled holes in teeth with ease but technicians observed a side effect which may prove to be important. When a cavity that has a great deal of decay material in it is irradiated by the laser, it is distinguishable by a yellow flame which shoots out of the hole. After the decay material has been burned away, only an intense white glow remains.

The CO_2 laser is also being investigated for possible use in space communications. A highly efficient CO_2 laser on a spacecraft could provide wideband communications even at interplanetary distances.

Bright Future

In succeeding years the large CO_2 lasers will be reduced to a more practical size. One technique is to "fold" the tube in half or in thirds and use mirrors to couple the beam around the corners. Although they are still relatively uncommon, sealed-tube CO_2 lasers are available. They do not use vacuum pumps or bulky gas bottles. As these and other improvements are made, the CO_2 laser will become more and more common and important. ▲

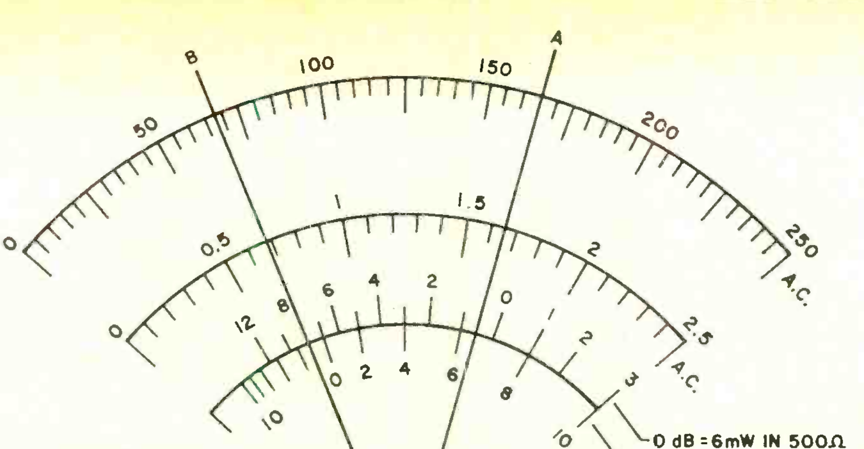
Fig. 5. This CO_2 laser, built by Perkin-Elmer Corp., is being used by scientist to develop techniques to cut materials.



dB's, and how to read them

By ROBERT BALIN

Voltage and power levels, and amplifier gain are often given in large unwieldly numbers. dB's make them easy to calculate.



VOLTAGE RANGE	dB FACTOR
2.5	0
10	+ 12
50	+ 26
250	+ 40

Fig. 1. On this meter face, both the 1-mW and 6-mW reference levels are shown. Most meters have either one or the other. Pointers A and B are given as examples in the text.

IN audio amplifier systems, we often find it necessary to determine the amplitude of a signal in volts, or its power in watts. We may also need to know how much the signal voltage or power has been amplified by one or more of the stages. However, we are not usually as interested in the increase in voltage or the difference between the output and input signals as we are in the gain of the stage or the ratio of the output to input signal. In many amplifiers these gains are often very large, unwieldy numbers.

A simpler, and more meaningful, way to indicate signal voltage amplitude or voltage gain is to state its decibel rating. A decibel is, essentially, a ratio—actually the logarithm of the ratio between two voltages, currents, or powers. Consequently, whenever the unit "dB" is used, a reference level must be either stated or implied. For example, when an output signal is compared with an input signal, the input signal is used as the reference level. Several standard reference levels for voltage and power are widely used in audio applications.

If we wish to determine the signal voltage level or power level, in dB, at any given point in a circuit, we can use the dB scale available on almost any v.o.m. or v.t.v.m. If the instrument carries the notation "0 dB = 1 mW in 600 ohms", it can provide dB voltage readings to a standard voltage reference level of 0.775 volt. When 0.775 volt is placed across 600 ohms, one milliwatt of energy is dissipated. This is shown by: $P = (E^2/R) = (0.775^2)/600 = 1$ mW. Most meters have a decibel scale calibrated and referenced to the 1-mW power level.

Impedances Change Meaning

Voltage-level measurements taken on a meter whose power reference is the 1-mW power level are called dB voltage readings. Usually signal source impedance will not affect these readings. However, when power-level readings are made by the meter, the impedance of the source must be known. For example, if the signal-voltage measurement is made across a 600-ohm source, we can call our dB indication a "dBm" reading (a dBm is a power level unit based on a 1-mW reference power). But, if the signal source has an output impedance of some value other than 600 ohms, a correction factor or conversion formula must be used. Some meter instruction manuals provide a nomogram for this purpose.

To illustrate how to read a decibel scale, let's take a dB voltage reading of an a.c. signal voltage using the simplified drawing of the meter face in Fig. 1. Pointer A indicates that the meter is measuring a 165-volt a.c. signal on its 250-volt a.c. range. To find the dB voltage level of the signal, we first read +6.5 dB on the 1-mW dB scale and add to this the +40-dB range factor indicated on the meter face chart. This adds up to a total of +46.5 dB. We know that our 165-volt signal is 46.5 dB above the 0.775-volt reference level. But where did the +6.5 dB and +40 dB figures come from?

The +6.5-dB reading actually represents the dB level of a 1.65-volt signal referenced to 0.775 volt. This is because the 1-mW dB scale represents the dB levels of corresponding points on the 2.5-volt a.c. range. This is shown by the calculation: $20 \log_{10} (1.65/0.775) = +6.5$ dB.

The +40-dB range factor denotes the dB difference between the 2.5-volt and 250-volt ranges and is shown by the calculation: $20 \log_{10} (250/2.5) = +40$ dB.

Any dB reading on the 250-volt range is, therefore, always exactly 40 dB above, or 100 times greater, than any corresponding reading on the 2.5-volt range.

dBm, a Common Power Reference

If our 165-volt signal happens to be measured across a 600-ohm source, we also have a power level reading of +46.5 dBm, with a 1-mW power reference level being implied. But, if the signal were measured across a source having an output impedance known to be only 8 ohms, such as the impedance of a speaker voice coil, we would need to add or subtract a correction factor from our dB reading to convert it to a dBm reading. This factor relates the two impedances, and can be obtained from the calculation: $10 \log_{10} (600/8) = +18.8$ dB. The correction factor is added to the original dB reading if the impedance used is smaller than our 600-ohm reference, and subtracted if it is greater.

In our example, a 165-volt signal was taken across 8 ohms, and the meter read +46.5 dB (voltage level). By adding the +18.8 dB impedance correction factor to the reading, we can now say that our signal has a power level rating of +65.3 dBm.

Another reference level, "0 dB = 6 mW in 500 ohms" has been used with many older meters. These instruments provide dB voltage readings to a voltage reference level of 1.723 volts and dB power level readings to a reference power of 6 mW if the signal is taken across a 500-ohm source.

The power reference signal level is calculated in the same manner as in the previous example.

If one of these instruments is used to measure the 165-volt signal, we would first obtain a −0.5-dB reading from the 6-mW dB scale, and to this we would add the +40-dB range factor to obtain a total reading of +39.5 dB.

If the signal is received from a source known to have an output impedance of 500 ohms, our signal can also be said to have a power level rating of +39.5 dB above 6 mW.

If the signal is taken across an impedance having a value something other than 500 ohms, an appropriate impedance correction factor must be used. Again, if the signal is taken across an 8-ohm voice coil, we calculate the correction factor as we did before and conclude that it is +18.0 dB. Adding +18.0 dB to +39.5 dB gives a power level rating for the signal of +57.5 dB.

Changing Reference Levels

Although we have shown dB scales for both the 1-mW and 6-mW reference levels on the meter face in Fig. 1, you are not likely to find this in actual practice; conventional meters will either have one or the other. If your meter does not employ the reference level that you prefer to use, there is a simple way to make conversions between them. Notice that the 0-dB point on the 6-mW scale is directly above the +7-dB point on the 1-mW scale, and that 0 dB on the 1-mW scale is directly below the −7-dB point on the 6-mW scale. Since the constant 7-dB difference between the two scales is true for any reading, simply add 7 dB when converting voltage level readings from the 6-mW to 1-mW reference. The 7-dB difference is based upon the two reference voltages involved, as shown by the calculation: $20\ log_{10}\ (1.732/0.775) = 7$ dB, and can be verified by making the voltage measurements on two different meters.

If we wish to convert a dB power-level reading made on a 6-mW instrument into the dBm reading which would have been obtained by measuring the same signal source using a 1-mW instrument, a conversion factor which takes into account the change in both the reference voltage and impedance levels is required. Since power relates both voltage and impedance, the conversion factor can be obtained from the ratio of the two power reference levels. This is shown in the calculation: $10\ log_{10}\ (6/1) = 7.8$ dB. The 7.8 dB difference between a dB (6 mW) and a dBm (1 mW) power level can be verified by noting the difference between the readings obtained in our example on two different meters: 65.3 − 57.5 = 7.8 dB.

Now that you have gone over an example of how decibel scales are used, let's see how you can do on your own. Using the pointer shown in position B, try to answer the following questions:

1. What is the a.c. signal voltage being measured on the 250-volt range?
2. What is the dB voltage level of the signal using the 1-mW reference?
3. What is the signal's dBm power level if it is taken across 600 ohms?
4. What is the signal's dBm power level if it is taken across 1000 ohms?
5. What is the dB voltage level for the same signal using the 6-mW reference?
6. What is the signal's dB (6 mW) power level if it is taken across 500 ohms?
7. What is the signal's dB (6 mW) power level if it is taken across 1000 ohms? ▲

ANSWERS

1. 68 volts	4. +36.8 dBm
2. +39 dB	5. +32 dB
3. +39 dBm	6. +32 dB
7. +29 dB	

Tactile Communications

(*Continued from page* 34)

stretcher (Fig. 7A) is an extra feature since it enables short, rapid, high-frequency pulses with very short time bases to activate the Vibrotactor complex. Pulses or taps of the skin contactor shorter than 0.5 microsecond duration cannot be felt by man.

A different and fairly unique form of tactual sensations is experienced when vibratory signals are applied, in rapid succession, to points located some distance from each other. If, for example, a ring of vibrating contactors is placed around the human body—three across the back of the thorax and three across the front—and energized successively with pulses spaced 0.1 second apart, a pronounced swirling motion can be experienced. The triggering scheme is shown in Fig. 8. A "panic button" is included because the phenomenon is confusing and the subject feels as if he were in the center of a whirlpool. He may also become nauseated.

Systems such as these can be of invaluable help in both aeronautical and astronautical situations. The apparatus can indicate, in a rather personal and direct manner, any deviations from course or orbital trajectories. The possible use of semi-coded signaling is of special significance.

However, it should be kept in mind that only mechanical-type vibratory inducers have been investigated in depth and, to date, no practical stimulators are available.

The response of the human skin to pulsating skin forces is not well defined. Basically, as the frequency of alternating currents applied to the skin is increased, there is a rise in the threshold of sensitivity and the investigator experiences sensations ranging from a mild tingle to uncomfortable pain. ▲

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EW Lab Tested

(*Continued from page* 13)

quencies, go to the amplifier tuner inputs.

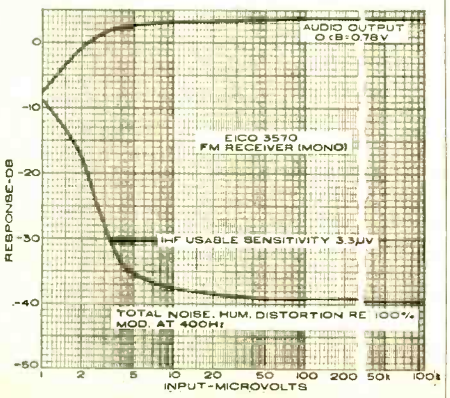
In our laboratory tests, the IHF usable sensitivity of the receiver was 3.3 microvolts. Its distortion (mono) was about 1% at 75-kHz deviation. The stereo separation was better than 35 dB from 250 to 2000 Hz and better than 20 dB from 30 to 8000 Hz. The automatic stereo switching worked well and unobtrusively. The stereo light on the dial face glows on interstation noise, but will not remain lit when a station is tuned in, unless it is transmitting a pilot carrier.

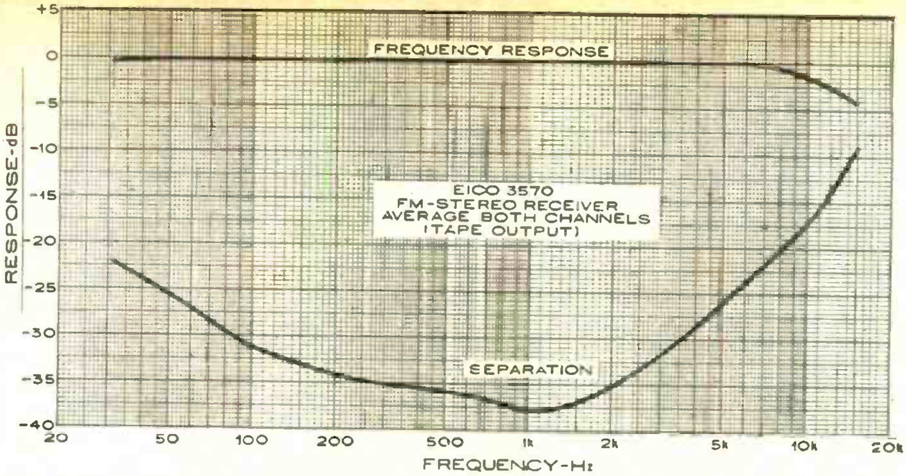
The amplifier performance was measured next. At its full rated output of 15 watts per channel with both channels driven, the distortion was 0.25% from 50 to 10,000 Hz, rising to 0.45% at 20,000 Hz and to 0.65% at 30 Hz. At half power or less, the distortion was between 0.25% and 0.40% over the full 20 to 20,000 Hz range. The 1000-Hz harmonic distortion was under 0.35% up to 21 watts output and the IM distortion was under 0.2% up to 11 watts, increasing to 1% at 15 watts.

The tone-control characteristics permit moderate boost or cut at the frequency extremes without appreciable effect on the middle frequencies. The loudness contours are exceptionally well chosen, being pleasingly subtle in their action and totally free from unnatural coloration. The RIAA equalization was accurate to within ± 0.5 dB from 30 to 15,000 Hz. The filters had rather gradual slopes, which limited their effectiveness, but by the same token did not cause undue loss of program material. Hum and noise were inaudible, being 60 to 67 dB below 10 watts on both phono and high-level inputs.

The power transistors in the receiver are protected by 1-ampere fuses in the individual speaker lines, in addition to the a.c. line fuse. Although we blew the speaker fuses several times during our full-power tests, the amplifier suffered no damage.

Like most *Eico* products, the 3570





is available either in kit form or factory-wired. Kit assembly is simple and straightforward, aided by the use of pre-wired and aligned tuner front-end, i.f., and multiplex circuits. Our instrument alignment failed to improve the performance of the tuner, confirming the manufacturer's statement that the kit builder should not attempt to align the receiver.

The 3570 worked perfectly in our listening tests. Its sensitivity is more than adequate for most listening locations, and the tuner is completely free from fussiness or critical tuning requirements. The sound is as clean as could be desired, and the power output of 15 clean watts per channel is sufficient to drive medium-efficiency speakers in ordinary-sized rooms.

The receiver, which sells for $159.95 in kit form, or $239.95 factory-wired, is an excellent value at either price. We particularly appreciated its small size, which allows installation on bookshelves of standard depth. An attractive walnut-finished, vinyl-clad steel cabinet is included in the price. ▲

BSR TD-1020 Tape Deck/Preamp

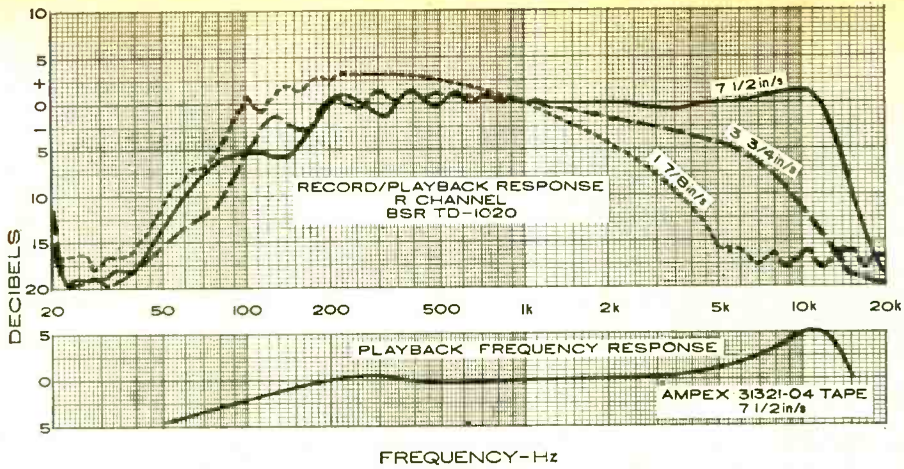
For copy of manufacturer's brochure, circle No. 31 on Reader Service Card.

THE British-made *BSR* TD-1020 stereo tape deck/preamp is a low-priced yet flexible instrument designed to be built into a component high-fidelity system. It is supplied mounted on a walnut base and is designed to be operated in a horizontal position.

The TD-1020 is a solid-state, four-track, three-speed recorder. Two pairs of phono jacks in the rear of the base provide all the necessary interconnection facilities, normally going to the "Tape Output" and "Tape Input" jacks of a stereo amplifier or receiver. A pair of microphone jacks is located on the front panel of the recorder. Plugging in a microphone automatically disconnects the corresponding rear input.

The tape transport is a single-motor type, with speed selection (7½, 3¾, and 1⅞ in/s) by means of a lever on the side of the head housing. The tape motion is controlled by a single lever moving in a "T-slot". Its left and right positions correspond to rewind and fast-forward operation, and pushing the lever along the other arm of the "T" puts the tape into normal motion. A separate "Record" interlock lever must be operated to make recordings and is released automatically when the tape motion lever is returned to its "Stop" position. There is a three-digit index counter with a knurled wheel for zero reset.

The preamp electronics are simple



and basic in their design. Each channel has a single amplifier, used for recording and playback. The combined record/playback head is switched to the input or output of the amplifier, as required, by means of the "Record" switch. A playback "Equalizer" switch selects the correct equalization for the selected tape speed and is out of the circuit when recording.

The bias/erase oscillator operates at 57 kHz. The recorder has separate left- and right-channel erase heads, selected by a recording "Mode" switch. In "Stereo", both channels are erased; in "Mono Left" or "Mono Right", only one is erased. The same switch shorts out the record head of the opposite channel so that either stereo or four-track mono recordings can be made.

The single level meter (called a "vu meter" but not a true vu meter in its ballistic properties) has a three-position selector switch which connects it to read either channel or the sum of both channels. It functions in both record and playback modes. The two level controls are concentric, coupled by a very effective clutch. Pressing the top knob down slightly disengages them and allows the two controls to be adjusted independently; releasing the knob couples them rigidly.

The record/playback frequency response was measured at ±3.5 dB from 80 to 14,000 Hz, at 7½ in/s. There was a shelf-like drop of about 5 dB below 200 Hz and a 12 dB/octave drop-off below 80 Hz. At 3¾ in/s, the response was down 6 dB at about 100 Hz and 7000 Hz. At 1⅞ in/s, the highs rolled off steadily above a few hundred hertz to −12 dB at 4300 Hz. The 7½-in/s playback response, with the *Ampex* 31321-04 test tape, was ±5 dB from 50 to 15,000 Hz.

The mechanical operation of the deck was excellent. Wow and flutter were low, measuring 0.02% and 0.07% at 7½ in/s and 0.04% and 0.10% at 3¾ in/s. These compare favorably with our measurements on the most expensive home tape recorders and are well below the manufacturer's specified limits. The signal-to-noise ratio was 40 to 42 dB at all tape speeds, referred to "0-vu" recording level. An input of 85 millivolts (0.8 mV at the microphone inputs) was sufficient to produce a 0-vu recording level. The level meter calibration was accurate, with 0 vu on playback corresponding to an output of 0.78 volt, or 0 dBm into 600 ohms.

The T-slot control was very easy to use. It allowed rapid changes of direction and, when locating a specific portion of a taped program, at no time broke or spilled the tape. The tape playback speeds were exact, but the fast speeds were disappointingly slow. Handling 1200 feet of tape required 200 seconds in fast-forward and 165 in rewind.

The sound quality of the machine at 7½ in/s was good, both in record/playback operation and when playing commercially recorded tapes. The loss of the lowest frequencies could sometimes be heard, but fortunately most program material has surprisingly little content below 80 Hz. At 3¾ in/s, the quality was adequate for non-critical recording, such as popular music. The slowest speed was suitable only for voice.

In the price range of the *BSR* TD-1020, one obviously can't expect the features and performance of machines costing several times as much. It does a highly creditable job and can be a useful adjunct to many medium- and low-priced music systems. The *BSR* TD-1020 sells for just under $100. ▲

"I have it going now, but it just plays in one position."

NEW PRODUCTS & LITERATURE

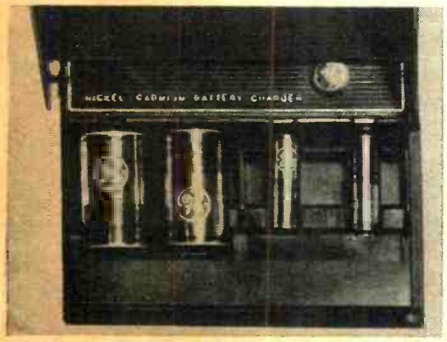
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupon on the Reader Service Card.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

RECHARGEABLE BATTERIES

A new line of "Perma-Cell" batteries which can be recharged 1000 times or more has just been introduced in three popular sizes: Type D, Type C, and Type AA.

The battery system, which consists of the nickel-cadmium battery and a simple, automatic



charger, is the company's answer to the problem of keeping a supply of batteries on hand. A major part of the battery system is the flip-top automatic charger. The charger operates off 117-volt a.c. and can charge any two or four of the batteries or any combination simultaneously. The charger accommodates the different sizes of batteries automatically and there are no dials to set or switches to move. Placement of the batteries starts the charging cycle. A red indicator light glows when the batteries are in the charger. Batteries may be removed after 14 hours or left in the charger indefinitely.

The nickel-cadmium batteries leave the factory uncharged and are activated with the charger. The batteries must be charged in the Model BC1 charger. It measures 7⅛" long x 5½" wide x 2½" high. General Electric

Circle No. 1 on Reader Service Card

MINIATURE INDICATOR LIGHTS

A full line of miniature, subminiature, or ultra-miniature indicator lights with incandescent or neon bulbs is now available from a single source.

Engineered for long service, several models are actually rated for 100,000 hours of life, according to the manufacturer. The lights are made from high-impact material in a wide range of transparent and translucent colors. They are available in round, square, or flat shapes which apply optical lens designs for brightness and clarity, in addition to 180° visibility on all models.

Ultra-miniature sizes mount in 3/16" panel holes, the subminiature in 5/16" holes, and the miniature in ⅜" holes. A catalogue describing the line in full is available on request. General Illumination

Circle No. 126 on Reader Service Card

MATV ANTENNAS

A line of rugged LPV antennas designed for master antenna applications has been introduced as the "Rough Rider" series.

According to the company, these antennas provide the high gain, clean lobes, flatness, and excellent front-to-back ratio typical of log-periodic designs. They are made of heavy gold anodized aircraft aluminum. The heavy-duty elements and double boom construction add to their ability to withstand the most severe weather conditions.

Output of these antennas is matched to 75-ohm coaxial cable, eliminating the need for a matching transformer. All units come complete with an F59 coax connector and weather boot. The line consists of four basic types of antennas and full details on the individual units will be supplied on request. JFD

Circle No. 2 on Reader Service Card

SNAP-IN PILOT LIGHT

A new rear-assembly, snap-in pilot light which, according to its maker, offers significant operational and production advantages in electrical applications is now available.

The light snaps in from the rear and locks into position firmly to provide simpler, swifter product assembly. It saves valuable production time consumed threading wire leads in conventional front-of-panel lights. No additional hardware is needed. Removal from the rear of the panel is effected by compressing a release mechanism on the unit.

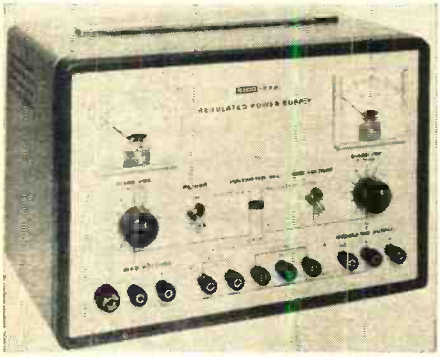
The new light is available in both neon and incandescent models over a full voltage range. It can be inserted in panels 1/32" to 1/16". Other thickness can be adapted. The unit is available with wire leads or ¾" male tab terminals. Leecraft

Circle No. 127 on Reader Service Card

REGULATED POWER SUPPLY

A regulated power supply which is available in both kit and wired versions is now on the market as the Model 1030. Regulated "B+" is continuously variable from 0 to 400 volts d.c. while the regulated bias supply can be varied continuously from 0 to —150 volts d.c. Ripple is less than 3 mV r.m.s.

Two double-jeweled d'Arsonval meters are



provided: the voltmeter with switched ranges of 0-400 volts d.c. and 0-200 volts d.c.; the milliammeter with 0-200 mA scale for monitoring the regulated "B+" supply. Power requirements are 160 watts at 120 V a.c., 50/60 Hz.

The supply measures 8½" high x 12½" wide x 9" deep and weighs 21 pounds. Eico

Circle No. 3 on Reader Service Card

INTRUSION ALARM SYSTEM

A new, low-cost intrusion-detection system for fenced areas has been introduced as the "Perim-Alert".

The low-voltage unit is a closed-circuit system with electronic sensors, installed at intervals on a fence, connected by wiring along the entire perimeter to be protected. Almost any receiver unit capable of picking up a closed-circuit signal will respond to Perim-Alert, including bells, buzzers, sirens, cameras, closed-circuit TV, telephone dialer units, central-station receivers, and intercoms. Each sensor can be adjusted for the sensitivity required in its specific location. This prevents over-alarm and false triggering of the system.

The system may be powered by a choice of 6 to 24 volts d.c. or a 110-115 volt power-pack with standby battery power. The system is weatherproof. Air Space Devices

Circle No. 4 on Reader Service Card

TONE-BURST GENERATOR

An outstanding feature of the new Model TG-210 1-MHz tone-burst generator is its ability to produce an output waveform which is phase coherent where input frequency content is consistent and controllable.

Consistency and controllability of the output

waveform are accomplished by selecting the desired input waveform and by setting the gate-open and gate-closed cycle ratio. According to the company, the TG-210 will gate a wide range of waveform inputs: sinusoidal, periodic, asynchronous, even noise. The unit is of integrated circuit design.

Frequency range is d.c. to 1-MHz input, dynamic range is greater than 30 dB, input impedance is greater than 10,000 ohms, tone burst and dwell times are independently variable from 1 to 1024 cycles in 20 steps, and switching transients are more than 50 dB below maximum signal input.

A technical bulletin with complete specifications will be forwarded on request. Aritech

Circle No. 128 on Reader Service Card

FLASHING INDICATOR LIGHT

A subminiature indicator light that mounts in ½" clearance hole and provides a choice of red or amber lens caps with refractive inner surfaces for warning/caution signal indications is now available.

Intermittent light-flashing operation is obtained without use of thermal elements or any moving contacts. The flashing action is made possible by a special high-brightness neon lamp plus solid-state circuitry. Operation is obtained on ordinary 110-125 volt a.c. circuits.

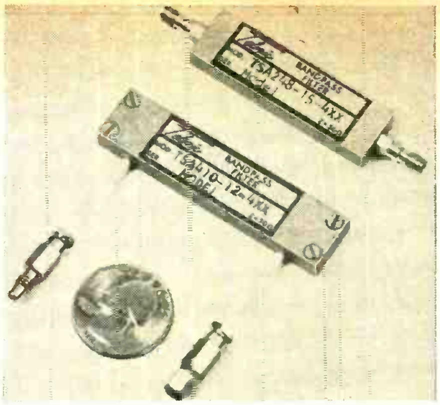
The driving-circuit components are soldered to a PC card which is enclosed within the body of the indicator light. An extending edge of the board exposes the terminations which are eyeletted openings adapted for soldering connections. Dialight

Circle No. 129 on Reader Service Card

CHEBYSCHEV FILTER

A new subminiature filter of 0.01-dB Chebyschev design, with center frequencies from 200 to 600 MHz, is now available as the Model TSA. The new filter is of magnetically coupled resonator design and may be specified with two to eight sections depending on bandwidth and other characteristics desired.

In cross-section, the filter measures only ¼" x 9/16" and is 2" to 3½" long, length being a



function of the number of sections and pass bandwidth. Input and output connectors may be specified as Sealectro or OSM, or any combination, and may be located at ends or sides.

Performance includes minimum 3-dB bandwidths from 1.0 to 15%, depending on the number of sections; v.s.w.r. at center frequency of less than 1.5:1; and insertion loss on the order of 2.45 dB for a typical 4-section unit with a 10% bandwidth. The average power input is 0.2 to 5 watts with peak power ratings of 1 to 30 watts. Telonic

Circle No. 130 on Reader Service Card

CATHODE-CURRENT INDICATOR

A compact, easy-to-use service aid, which indicates minimum cathode current and permits the replacement or adjustment of horizontal output tubes for minimum cathode current, is now available as the MCC-1.

The new tool has universal application and can be used with all novar, compactron, octal, and noval tubes now in use as horizontal outputs. Catalogue No. 11568 containing complete information on the device will be forwarded on request. Eby Sales

Circle No. 5 on Reader Service Card

BENCH POWER SUPPLY

A variable-voltage bench power supply which will provide continuously variable voltage from 0 to 34 volts at currents up to 1.5 amps is now on the market.

The solid-state circuit has built-in protection against overload or accidental shorts. Other features include regulation of 0.005% and ripple of just 250 microvolts. The supply incorporates the UNI-88 variable voltage module and a metered control module.

Complete information and full specifications will be supplied on request. Power/Mate

Circle No. 6 on Reader Service Card

HIGH-VOLTAGE TEST PROBE

A new 40,000-volt d.c. high-voltage portable test probe that is designed to operate with the company's Model 600 11-megohm input impedance, battery-operated transistorized v.o.m. is available as the Model 72-265.

The probe permits the user to perform accurate and safe high-voltage checks on all color as well as black-and-white TV receivers prior to making color alignment adjustments on the picture tube. It can also be used for checking power supplies of radio and TV transmitters.

Three ranges can be checked with the probe:

40 kV d.c., 16 kV d.c., and 4 kV d.c. To obtain proper readout, the Model 600's selector range switch is set to 40 V, 16 V, or 4 V d.c. ranges and the readings multiplied by a factor of 1000.

The probe weighs approximately 7½ ounces and measures 12½" long x ⅞" in diameter. Triplett

Circle No. 7 on Reader Service Card

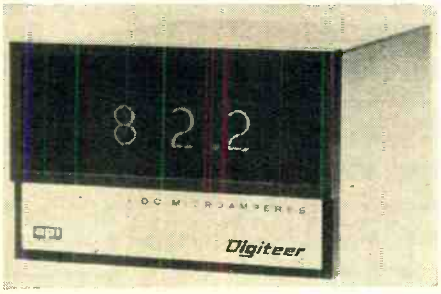
ILLUMINATED SWITCH

A new line of illuminated switches which comes in a wide variety of options is now available. Both slide and rocker versions can be had with illumination either neon or incandescent. Standard colors are red, white, clear, blue, green, and yellow. Light source voltages are 6.3, 14, and 28 volts for incandescent bulbs and 125 volts for neons. Rated life is 25,000 hours or more at rated voltages. The switches are UL listed. UID Electronics

Circle No. 131 on Reader Service Card

DIGITAL PANEL METER

A new digital panel meter which features exceptional long-term accuracy, small size, and no flicker—according to its maker—is now being marketed as the "Digiteer". The new unit is designed for either OEM meters, when it re-



quires a panel area only 3 inches high and 4½ inches wide, or for independent operation with table mounting. Since it measures the most popular standard ranges of either d.c. current or d.c. voltage, the meter may be used with any suitable sensors.

With dual slope integration, the long-term accuracy of voltage-reading models is ±0.1% of reading, ±1 digit. Accuracy of current-reading models is ±0.25% of full scale. Standard current ranges include 0 to 2, 20, and 200 microamperes and 0 to 2, 20, and 200 milliamperes. Standard voltage ranges are 0 to 200 millivolts and 0 to 2, 20, 200, and 1000 volts. Flashing lamps indicate when input voltage is overrange or when the signal is the wrong polarity. BCD output is available as an option. API Instruments

Circle No. 132 on Reader Service Card

TV MATCHING TRANSFORMER

A completely new 75-300 ohm matching transformer featuring maximum shielding for strong signal areas, improved return loss and linearity to 300 MHz, and dual capacitive blocking has just been introduced as the Model T-16.

Housed in a durable metal case with the twin-lead securely attached to a circuit board and sealed in plastic to prevent pull out, the transformer has a special C-F-61A fitting which accepts all popular cables used in CATV, MATV, and home TV installations.

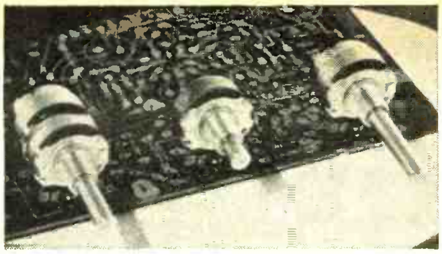
The unit measures 4½" long x ⅞" diameter. Craftsman

Circle No. 8 on Reader Service Card

LOW-PROFILE POTS

A line of low-profile potentiometers for printed-circuit board installation in compact entertainment equipment is now available. Maximum height above the PC board is 1.15 inches (0.681 inch to potentiometer center line).

The ½-watt, 15⁄16" diameter carbon composition pots have design parameters including shaft and bushing options similar to the firm's conventional Model 2 line with terminal configurations adaptable to compact TV, stereo, AM and FM, and tape recorder styling. Resistance range



is 100 ohms to 10 megohms in a variety of tapers. S.p.s.t. snap-action switches are available, rated 3 amperes at 125 V a.c. or 1 amp at 250 V a.c. Centralab

Circle No. 133 on Reader Service Card

RECHARGEABLE POWER PACK

The new CD-33 rechargeable nickel-cadmium power pack is designed to provide 6-volt power for lighting or ignition use. It has its own built-in recharger, can be plugged into any 117-volt a.c. electrical outlet for recharging, and can be left on charge indefinitely without harm. Burgess

Circle No. 9 on Reader Service Card

HI-FI—AUDIO PRODUCTS

HOME CASSETTE SYSTEM

The Model 200-S is a three-piece system that includes two matched speakers in decorator-styled walnut enclosures, plus a separate cabinet which holds a cassette deck with preamps and amplifiers. Inputs and outputs have been provided for the two dynamic microphones (included), a stereo headphone, and two line inputs and outputs.

The system also features separate tone and volume controls for each channel, two vu meters, a.c. pilot light, three-digit counter with push-button reset, as well as a pop-up compartment for loading or unloading the stereo cassettes. Concertone

Circle No. 10 on Reader Service Card

AUTOMATIC TURNTABLE

The "Module SLx" automatic turntable comes complete with base and magnetic cartridge and features the firm's "Synchro-Lab" motor which maintains constant speed under all conditions.

The turntable incorporates a new tonearm which is unusually light and thin. This permits a counterbalance of small size and light weight and keeps tracking force down to a minimum.

The unit comes prewired with audio and a.c. lead-ins, ready for installation. The turntable operates at all three speeds with a single lever controlling all speeds and sizes of records. The base measures 15" wide x 13¼" deep. Over-all height is 7¾". Garrard

Circle No. 11 on Reader Service Card

30-WATT STEREO RECEIVER

The SX-700T AM-FM-stereo receiver is rated at 30 watts per channel and is designed to meet the needs of those seeking a budget unit.

The receiver incorporates a sensitive wide-band FM tuner and an automatic switching multiplex section. The multiplex section uses a two-step discriminating circuit with a Schmitt trigger circuit for reliable performance. Stereo separation is 34 dB. The AM tuner section is a high-gain unit with built-in ferrite antenna.

The stereo amplifier is rated at 30 watts (IHF) dynamic power per channel with an r.m.s. rated output of 22 watts per channel. Distortion is 1% THD at 25 watts (IHF). Over-all frequency response is 25-50,000 Hz ±1 dB.

The front panel is brushed white gold with contrasting dark panel on which are lighted slide-rule markings. A tuning meter indicates maximum signal strength and an automatic stereo indicator shows when stereo broadcasts are being received. The receiver measures 16" x $5\frac{7}{16}$" x $13\frac{13}{16}$". Pioneer

Circle No. 12 on Reader Service Card

DYNAMIC BALL MICROPHONES

A series of omnidirectional, dynamic ball microphones has just been added to the company's line. Designed for all types of on-stage performances—singing groups, combos, professional artists, as well as taping, the new units feature an acoustical lined "ball" at the head of the microphone. The ball lets the user work as close to the microphone as he wishes without popping or wind noises.

Currently available in three models, the series offers the Model DM70-150-B, a high-impedance unit with "on-off" switch and a frequency response of 50-15,000 Hz; the Model DM70-250-B, a 10,000-ohm model with "on-off" switch and a 50-16,000 Hz response; and the DM70-550-B, a low-impedance model with "on-off" switch and a response of 40-18,000 Hz.

Complete specifications on all three models are included in a data sheet which will be supplied on request. Sonotone

Circle No. 13 on Reader Service Card

SOLID-STATE STEREO AMP

The compact KA-2000 stereo amplifier delivers 40 watts (IHF Standard 4 ohms) and 35 watts (IHF Standard 8 ohms) with 13 watts continuous power per channel at a THD of 0.5%. IM distortion is 0.5% (—3 dB of rated power). Frequency response is 20-50,000 Hz ±1 dB with a damping factor of 40 at 16 ohms and 20 at 8 ohms. The bass control is ± 11 dB at 100 Hz and the treble control is ±11 dB at 10,000 Hz, while speaker impedance is 4 to 16 ohms.

Built-in circuits include a tape monitor switch, loudness control, bass and treble controls, plus

a stereo headphone jack. There are terminals for Mag. Phono, Tuner, Aux. 1, and Tape. The amplifier measures 10¼" wide x 4⅛" high x 9⅜" deep. It weighs 10 pounds. Kenwood

Circle No. 14 on Reader Service Card

STEREO CASSETTE DECKS

Two stereo cassette decks, both for use with existing hi-fi equipment, have been introduced as the "2500" and the "Continental 450A".

The "2500" is a stereo cassette playback-only unit, while the "Continental 450A" is a stereo cassette recorder/player. Heart of the new decks is a special synchronous motor which is compact yet provides increased reliability and speed control. The "2400" comes in a highly styled walnut and brushed aluminum cabinet, measures 8" x 4½" x 2¼", and weighs just 2¾ pounds. It has a single selector control switch for play, stop, fast-forward, and rewind as well as cassette ejector and "on-off" push-buttons. The "Continental 450A" is housed in a teak cabinet and has volume, tone, balance, and record level controls and keyboard push-buttons for play, stop, fast-forward, rewind, record, and cassette eject functions. It also has a digital counter with automatic zero reset and a vu meter. Norelco

Circle No. 15 on Reader Service Card

MATCHING TUNER/AMP

For those wishing to have separate tuners and amplifiers in their hi-fi systems, the KG-865 50-watt stereo amplifier and the KG-795 FM-stereo tuner are now available.

The amplifier provides a power bandwidth of 20-20,000 Hz and frequency response within 1 dB from 18 to 30,000 Hz. The tuner features two tuned r.f. stages for best image rejection, drift-free tuning, FM-stereo reception, precision tuning indicator, automatic stereo switching, and a stereo indicator light.

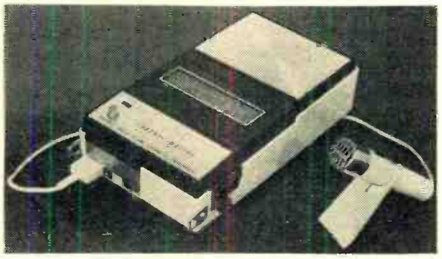
Each unit measures $3\frac{5}{16}$" x 13" x 10" deep. Optional oiled-walnut wood cabinets are available. These companion units are being offered in easy-to-assemble kit form. Allied Radio

Circle No. 16 on Reader Service Card

COMPACT CASSETTE RECORDER

The Model 6303 lightweight cassette recorder will operate on four "C" cells or from a.c. power with an optional adapter-charger.

The recorder comes with a remote-control



pencil-type microphone and stand, accessory case, earphone, carrying strap, and a prerecorded demonstration tape cassette. Optional accessories, other than the adapter-charger, include a remote-control footswitch, and a direct recording patch cord kit. Channel Master

Circle No. 17 on Reader Service Card

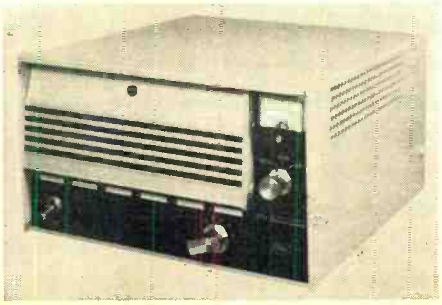
CB-HAM-COMMUNICATIONS

SOLID-STATE SSB TRANSMITTER

The Model PH17M is a transistorized SSB radiotelephone transmitter which will operate on up to six channels anywhere within the 1.6 to 12.5 MHz range. It may be used as a mobile unit in motor vehicles, aircraft, or ships, or at fixed locations.

Power output is 70-100 watts p.e.p., depending on channel and antenna used. Audio frequency response extends from 250 to 3000 Hz and is down only 2.5 dB at 500 and 2400 Hz with respect to 1000 to 2100 Hz. The transmitter can be operated in the A3J mode with carrier suppressed 46 dB or more, or in the A3H mode with carrier transmitted (compatible AM).

Frequency tolerance is ± one part per million per week. At room temperature, frequency stability is better than ±5 Hz when operating at 12.5 MHz. Within an ambient temperature range



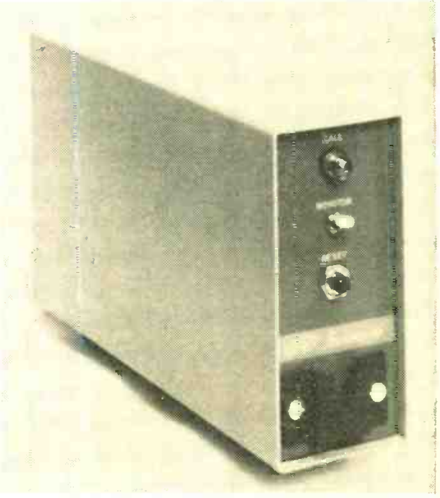
of −30° to +60° C, frequency stability is better than ±40 Hz.

The transmitter is available with power supplies for operation from 115 or 230 volts, 50 or 60 Hz or from a nominal 12-, 24-, or 32-volt d.c. source. Kaar

Circle No. 18 on Reader Service Card

SELECTIVE CALLING UNIT

A new selective calling unit monitors all telephone numbers dialed on the channel being received and signals the user when his own



telephone number is dialed by the marine operator. The device eliminates the need for constant monitoring of the channel: the speaker can be switched off until a phone call is received, unless audio monitoring is desired.

The new unit, called a "ringer" selector/decoder, is designed to operate with any marine radio on any frequency—AM, FM, or SSB. In effect, it makes any marine radio into a radiotelephone. When the user's number is dialed by the marine operator, the device generates both audio and visual signals—triggering a lamp and buzzer to notify the boat operator that he has been called.

The Model 1313 is all-solid-state and is compatible with the telephone company dialing system. Up to five digits are accommodated in the decoder unit. Detailed literature and specifications are available from the manufacturer. Scantlin Electronics

Circle No. 19 on Reader Service Card

BASE-STATION CB ANTENNA

The new "Astro Plane" base-station antenna is an all-direction type with radiation concentrated at the very tip, thus providing a power gain of 4 dB. Weighing only 3½ pounds, the clean-line design permits easy and economical installation on a simple pipe mast, thus eliminating radials. It is rated at 120 mi/h wind survival. The short, sturdy radials at the tip of the antenna provide full signal power on top and also direct an extremely low angle signal take-off for maximum distance.

Designed to operate in a frequency band of 27 to 29.7 MHz, the unit is omnidirectional, vertically polarized, and has a v.s.w.r. of less than 1.4:1 on all 23 CB channels. Avanti Research

Circle No. 20 on Reader Service Card

MARINE RADIOTELEPHONE

A new, popularly priced marine radiotelephone has been introduced as the "Cruise/Aider". It has five crystal-controlled channels to make it effective for either ship-to-shore or ship-to-ship use.

The radio has 60 watts of power to facilitate communications when boats are well offshore or to give the extra margin of readability to local conversations to raise them over the threshold of distant static on the most actively used marine channels.

The unit is shipped from the factory with three pairs of crystals installed. Two additional pairs can be installed locally to give the boat owner full coverage in his particular area of operation. The radio can also be used as a loud hailer simply by adding an external speaker as an accessory. An external socket on the radio makes it a simple, add-it-yourself accessory.

Measuring approximately 12½" square by 4" thick, the unit is supplied with a trunnion mounting bracket for attachment to shelves, overheads, or bulkheads. The mount permits easy removal for off-season storage. Raytheon

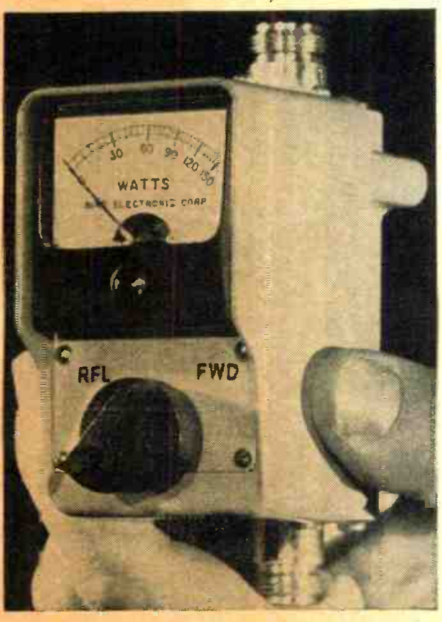
Circle No. 21 on Reader Service Card

R.F. DIRECTIONAL WATTMETER

The new 4110 series "Thruline" r.f. directional wattmeters are palm-sized power meters for servicing communications equipment in the 2-175 MHz range. They weigh just one pound. Built with 1%-2% components, the new units match the ±5% accuracy that is available in the company's Model 43.

The wattmeters, only 2" x 3" x 4½", can be switched from forward to reflected power on the blow-protected front panel. The 50-ohm instruments are completely self-contained—without batteries, line power, charts, or plug-ins.

Three models are currently available: Model



4113—1000/100 W, 2-30 MHz; Model 4112—200/20 W, 2-30 MHz; and Model 4111—150/15 W, 25-175 MHz. Bird Electronic

Circle No. 134 on Reader Service Card

HAM ANTENNA IN KIT FORM

The new Model DIV-80 kit permits maximum legal power on each band, 10 through 80 meters, from an antenna cut and designed by the user. Calculations can be made by means of technical information supplied with the kit.

The antenna features elements made with durable Copperweld wire for greater strength. The company's Model DPC-1 dipole connectors make it easy to build the antenna. The DPC-1 fits RG-8/U or RG-58/U coax. Weatherproof construction with corrosion-proof hardware is featured throughout.

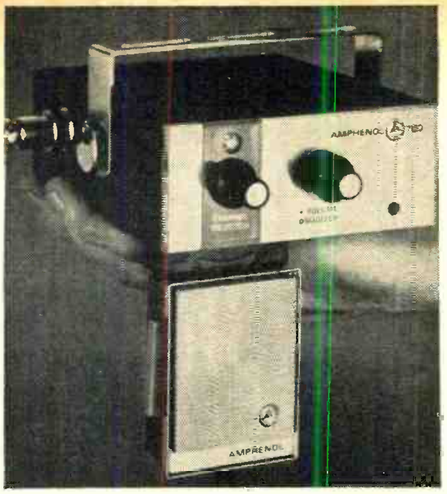
The kit includes 140 feet of Copperweld wire, the DPC-1 dipole connector, ceramic end insulators with anti-arc serrations, and all necessary hardware. Moseley

Circle No. 22 on Reader Service Card

LOW-COST CB UNIT

The Model 750 is a ruggedly constructed, solid-state CB transceiver which provides the full 5 watts of r.f. allowed under FCC regulations for effective HELP program communications.

In spite of its compact size (4¾" x 2" x 5¼"), sensitivity rating is 0.5 μV for 10 dB S/N ratio. Features of the new unit include an adjustable squelch control for noise-free monitoring, an effective automatic noise limiter to minimize ignition whine and hash, and a superhet receiver



which provides good sensitivity, selectivity, and image rejection over the entire 27-MHz band, according to the maker. The unit's microphone doubles as a speaker when the unit is set in the "receive" position.

The unit is supplied with a channel-9 crystal and sockets for five more transmit and receive channels. Amphenol

Circle No. 23 on Reader Service Card

MANUFACTURERS' LITERATURE

PICTURE-TUBE DATA

A 12-page illustrated brochure, ID-1304, showing the latest technological advances in the company's "Hi-Lite" line of color picture tubes is now available on request.

The booklet explains the brightness improvement that has been obtained with the new red phosphor and the servicing advantages of such features as Perma-Chrome and unity current ratios for technicians using these replacement types. RCA Electronic Components.

Circle No. 24 on Reader Service Card

D.C. VOLTAGE REGULATORS

A four-page data sheet describing the new miniature, self-contained Series 805 d.c. voltage regulators has just been released as No. 68485.

The publication provides complete specifications for fixed-output, +3- to +9-volt hybrid series, presented in an easy-to-read "minimum-typical-maximum" performance chart. Significant construction, performance, and environmental characteristics are also discussed.

The data sheet provides full details on circuit design and includes a circuit schematic. Helipot

Circle No. 135 on Reader Service Card

POWER SUPPLIES

A new 8-page, full-color catalogue covering a line of modular power supplies for commercial, industrial, and military applications has just been issued.

The publication describes all units made by the firm, including the new CS 7-3, CS 18-2, and CS 30-1 card supplies. Price and delivery information is also given. Valor

Circle No. 136 on Reader Service Card

PRECISION POTS

A 6-page condensed catalogue of precision potentiometers is now available for distribution. The publication outlines the company's capabilities in custom-designed conductive plastic and wirewound pots and elements, and provides specific data on the firm's standardized "Waterpot" and "Econopot" lines. Included throughout the catalogue are rotary and linear motion models and linear and nonlinear functions. New England Instrument

Circle No. 137 on Reader Service Card

MODULAR D.C. POWER SUPPLIES

A 20-page catalogue covering modular d.c. power supplies and voltage references is now available as #168.

Offering a choice of four regulations from 0.05% to 0.0005% to allow the engineer to specify just as close a regulation as his instrument or system requires, the publication outlines all supplies in the line.

A unique ordering system that allows selections in almost unlimited cross combination of center voltage, regulation, and additional options is explained in detail in the catalogue. CEA

Circle No. 138 on Reader Service Card

COLOR-TV COIL GUIDE

A four-page cross reference guide (NR #29) for twelve new color-TV coils is now available. The twelve coils provide exact replacements for 550 video and chroma coils for sets produced by virtually all manufacturers. J.W. Miller

Circle No. 25 on Reader Service Card

BOOKLET ON CCTV

A new 8-page booklet which tells in detail how a 16-channel closed-circuit instructional television system has revolutionized observation of classroom methods by student teachers at Appalachian State Teachers College is now available.

The booklet tells how two sets of microphones and TV cameras are located in each of eight classrooms at the high school. One set picks up the high school teacher's presentation; the other picks up the student responses. The video and audio signals are transmitted simultaneously by cable to observation rooms at the college, more than 1½ miles away.

A two-page technical section of the booklet gives details on how the electronic equipment is used and contains a schematic diagram of the cable system. Copies of Form No. ECSD-C-8020 will be supplied on request. Jerrold

Circle No. 26 on Reader Service Card

D.C. POWER-SUPPLY DATA

An 88-page catalogue and handbook has just been issued which combines a text-like discussion on d.c. power supplies with a complete listing of the firm's line of power supplies.

In addition to full descriptions and specifications, a selection guide and condensed listing makes it easy for the prospective purchaser to select the supply which best meets his own particular needs.

The handbook section includes discussions of circuit principles, operating features, performance measurements, and special applications of regulated d.c. power supplies. Harrison Division

Circle No. 139 on Reader Service Card

DIFFERENTIAL VOLTMETERS

An 8-page brochure describing differential voltmeters made by the firm is now available as publication D-3043.

Included are the company's new solid-state models for measuring e.m.f. up to 1100 volts in four ranges with ±0.0025 percent accuracy. Operating features and related operations of other voltmeter models, both a.c. and d.c., are also presented in the illustrated booklet. Honeywell

Circle No. 140 on Reader Service Card

INVERTERS/FREQUENCY CHANGERS

Catalogue #138a is a four-page condensed description of the company's line of solid-state inverters and frequency changers. Models described include unregulated, regulated, and sinusoidal types converting d.c. input to 60 or 400 Hz a.c. with power ratings from 15 VA up to 500 VA. Electronic Research Assoc.

Circle No. 141 on Reader Service Card

DIGITAL READOUTS

A new 12-page booklet covering some state-of-the-art advances in illuminated digital displays has just been published.

Entitled "The Second Generation Optimum Contrast Digital Displays", the booklet discusses three major developments which have significantly improved the total performance of illuminated bar readouts. The booklet also contains a description of the system characteristics of the firm's readouts along with a discussion of pertinent reliability considerations.

There is a detailed presentation of the wide selection of heat sink and mounting arrangements in which the readouts may be employed. Complete physical and electrical specifications are included. Tung-Sol

Circle No. 142 on Reader Service Card

CALCULATORS AND TECH BOOKS

An all-new, 1968 catalogue has been issued containing full descriptions of slide and circular calculators, drafting templates, handbooks, manuals, technical books, curves, slide rules, converters, and other time-saving devices and reference works for electronic, mechanical, and manufacturing designers and engineers.

Copies of this 16-page, illustrated catalogue will be supplied on request. TAD Products

Circle No. 27 on Reader Service Card

STRIP-CHART RECORDERS

A four-page folder, No. L-1001, gives complete details on the Model 2750 precision low-speed strip-chart recorders. The recorders described have an accuracy of $\pm 1.5\%$ of the full-scale value and also provide continuous visual readout.

In addition to full technical data, the illustrated folder lists accessories and operating ranges for a large number of a.c. and d.c. instruments. Simpson Electric

Circle No. 143 on Reader Service Card

H.F. POWER TRANSISTORS

An 8-page engineering data sheet has been issued which provides detailed descriptive information on both B-14800 and B-15500 series high-frequency silicon transistors.

SOAR (Safe Operating ARea) charts and comprehensive specifications charts and graphs are a special feature. SOAR is defined for d.c. and pulsed operation, resistive, unclamped inductive, and unclamped switching operation. Bendix Semiconductor

Circle No. 144 on Reader Service Card

ELECTRICAL SWITCHES

Three new catalogues covering its lines of electrical switches have been published. Catalogue 100, an 84-page publication, describes basic switches; actuator brackets and terminal enclosures; metal enclosed switches and door interlock and appliance switches. In addition, there is a section on replacement parts and an equivalent guide.

Catalogue 200 covers subminiature, miniature, series 1 and 4 Tyni, rotary, and open-blade switches. There is also an equivalent guide in this 48-page publication.

Catalogue 300, 20 pages, describes panel mount and modular push-button switches and includes an equivalent guide. Robertshaw Controls

Circle No. 145 on Reader Service Card

TECHNICAL DATA ON RESISTORS

A brochure which features a number of technical articles published by its Engineering and R&D staffs is now available.

Among the articles reprinted in this 12-page booklet are: "Faster Risetimes in Wirewounds", "How to Measure Resistor Self-Heating Effects", "How to Specify Temperature-Compensated Wirewound Resistors", and "How to Measure Performance of Wirewound Resistors". RCL Electronics

Circle No. 146 on Reader Service Card

DATA SHEET ON VERNIER CONTROLS

A two-page, two-color data sheet, No. 1150, illustrates and technically describes two carbon and one wirewound vernier variable resistors. Included are dimensional drawings and complete electrical and mechanical specifications for carbon types VA-45 and 5VA-45 and wirewound type VA-AW. CTS Corp.

Circle No. 147 on Reader Service Card

SERVICE INSTRUMENT DATA

A two-page data sheet, Bulletin SP-11, which details the company's line of Snap-Around volt-ammeters and volt-ohm-ammeters, has just been published. The units are pictured and their features and operation described in some detail. A. W. Sperry

Circle No. 28 on Reader Service Card

SOLID-STATE REGULATORS

A complete new line of pre-engineering solid-state VSR regulators for process control and drive speed control is covered in Bulletin D-2523-1 which is now available. The 4-page booklet is illustrated. Reliance Electronic

Circle No. 148 on Reader Service Card

MINIATURE CHART RECORDERS

A 20-page catalogue which gives details on 50 different models of miniature strip chart recorders, all of which feature a unique dry writing process, has just been issued. It includes detailed information on chart paper, drive motor specifications, accessories, optional features, dimensions, weights, and complete ordering information. Rustrak

Circle No. 149 on Reader Service Card

QUARTZ CRYSTAL UNITS

A six-page, letterhead-size, three-color brochure describing a line of quartz crystal units that are available in solderseal or coldweld holders is now available.

Frequency range of each quartz crystal element is charted and solderseal and coldweld holders are illustrated in actual sizes. Technical information includes frequency tolerances over various temperature ranges and details of crystal manufacture. Tabular information is also given on crystal filters and crystal oscillators. Reeves-Hoffman

Circle No. 29 on Reader Service Card

DIODES AND SCR'S

A 48-page catalogue, C-67/68, contains descriptions, ratings, and specifications for zener voltage-regulator diodes, voltage-reference diodes, and low-power silicon rectifiers.

The catalogue lists 66 different series of zeners, ranging from 150 mW to 50 W in nine package designs. In addition, there are 11 different series of voltage-reference diodes listed with nominal temperature coefficient ratings to five parts per million, as well as 34 different series of low-power silicon rectifiers in current ranges from 0.4 ampere to 16 amperes and voltage ratings (maximum peak reverse) from 50 to 100 volts. International Rectifier

Circle No. 150 on Reader Service Card

BROCHURES ON MATERIALS

The American Society for Testing and Materials (ASTM) is now making available a 34-page "List of Publications". Issued in September, 1967, the book contains a listing of more than 500 ASTM publications dealing with materials, materials evaluation, and the standardization of methods for testing and specifying materials.

Single copies are available free of charge on letterhead request from American Society for Testing and Materials, Dept. HHH, 1916 Race Street, Philadelphia, Pa. 19103. ▲

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COMMERCIAL RATE: For firms or individuals offering commercial products or services. 70¢ per word (including name and address). Minimum order $7.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 40¢ per word (including name and address). No Minimum! Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issue closes January 1st). **Send order and remittance to:** Hal Cymes, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 6556 W. Higgins Rd., Chicago, Ill. 60656.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

METERS—Surplus, new, used, panel and portable. Send for list. Hanchett, Box 5577, Riverside, Calif. 92507.

INVESTIGATORS, FREE BROCHURE, LATEST SUBMINIATURE ELECTRONIC SURVEILLANCE EQUIPMENT. ACE ELECTRONICS, 11500-J NW 7TH AVE., MIAMI, FLA. 33168.

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A22, Box 10563, Houston, Texas 77018.

R.F. CONVERTERS World's largest selection. Also CCTV cameras, etc. Lowest factory prices. Catalog 10¢. Vanguard, 196-23 Jamaica Ave., Hollis, N.Y. 11423.

MUSIC LOVERS, CONTINUOUS, UNINTERRUPTED BACKGROUND MUSIC FROM YOUR FM RADIO, USING NEW INEXPENSIVE ADAPTER. FREE LITERATURE. ELECTRONICS, 11500-Z NW 7th AVE., MIAMI, FLORIDA 33168.

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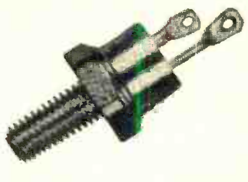

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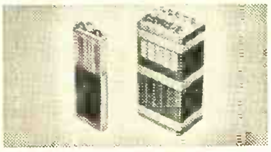

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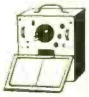

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BECKMAN #6126 & #607: COUNT DC to 1000 mc. Solid state, only 5¼" high, 16¾" wd. 8 Electroluminescent digits in basic 25 mc Universal Counter, w/basic plugin, rack-handle adapters, 2 PC extender boards, books, & Feb. 1968 NBS-traceable Certificate of Calib. 5 parts/100 million, long term 5 parts/billion. Plus #607 plugin 25-1000 mc; has tuning meter, easy to use, eliminate all ambiguity. Today's price is $3245.00! From us, like brand new, with books and Certificates of Calib **$1950.00**

OTHER COUNTERS: 0.1, 1.2, 220 & 510 mc **ASK!**

HIGH-FREQ. DUAL-TRACE OSCILLOSCOPES: Hewlett-Packard said: ". . . is the scope to use anywhere from DC to 1000 mc. It offers the same simplicity of operation, the same big bright steady trace as conventional low-freq. scopes, yet . . . is swift and easy to use all the way to 1000 mc." The scopes sold for $2000.00. The plugins were $1000.00 extra. The 120 nsec Delay Line was $200.00 extra. **Now see our prices:** All with the Delay Line, with the dual-trace plugin, 2 probes for the plugin, books, and NBS-traceable Certif. of Calib. **SLEEPERS!**

#185A accepts triggers 50 cy to 50 mc. With **#187A** plugin which is useful to greater than 500 mc **$750.00**

#185A with **#187B** plugin which is useful to 1000 mc **$850.00**

H01-184A Synchronizing Trigger Unit is a countdown to view up to 800 mc with the 185A; generates sq-waves locked to the input freq. Regular $215.00 **$150.00**

OTHER SCOPES .... **ASK!**

STODDART NM-20B Noise & Field Strength Meter 150 kc to 25 mc $550.00
OTHER STODDARTS 14 kc to 1000 mc .... **ASK!**
POLARAD TSAW Spect. Analyz 10-1000 mc $750.00
OTHER heads to 44,000 mc .... **ASK!**
Hewl-Pack. 608A signal generator 10 to 500 Mc **$475.00**
Other Hewl-Pack., Boonton, Meas. Corp., General Radio, & other **SIGNAL GENERATORS** .... **ASK!**
Brush, Est-Ang, Sanborn & other **RECORDERS ASK!**

Aer. Radioshop, Amplifiers, Attenuators, Audio Test, Bridges, Potentiometers, Galvos, Voltage Dividers, Decade Boxes, Communications, Freq. Meters, Freq. Standards, Calibrators, DVM's, Meggers, Mod. Meters, Phase Meters, Precision Meters, VTVM's, Power Supplies, Freq. Converters, Pulse Generators, Line Voltage Regulators, Etc. Etc . . . **NAME IT BY CATEGORY & ASK!**

Above is a small sampling of our terrific inventory. **We ALSO BUY!** We want Tektronix scopes, Hewlett-Packard equpt., Aeronaut, radio-shop equpt., etc. . . . AND Military Communications of all kinds.

DO NOT ASK FOR CATALOG! ASK FOR SPECIFIC ITEMS OR KINDS OF ITEMS YOU NEED!

R. E. GOODHEART CO. INC.
Box 1220-A, Beverly Hills, Calif. 90213
Phones: Area 213, office 272-5707, messages 275-5342

FREE "HAM SHACK PAK" $25 WORTH OF TRANSISTORS, RECTIFIERS, RESISTORS, CONDENSERS, DIODES, ETC. Add 25¢ for handling

PLUS ANY $1.00 * ITEM FREE (* or items totalling $1.00.)

BOTH FREE WITH ANY $10 ORDER

EPOXY TRANSISTORS & IC's

Fairchild, Motorola, Texas, Bendix

- ☐ 3—2N3683 1000 MC 200MW TRANSISTORS $1
- ☐ 4—2N3563 NPN, 600MC, 200MW Fairchild $1
- ☐ 4—2N3643 NPN, 250MC, 350MW Fairchild $1
- ☐ 3—B-5000 5W. 3Amp, NPN, Bendix transistors ... $1
- ☐ 4—2N4313 PNP 600MC, 200MW Fairchild $1
- ☐ 3—2N3565, 500HFE, NPN, 200MC by Fairchild $1
- ☐ 3—2N4265, 400HFE, NPN, 350MC by Motorola $1
- ☐ 1—DUAL 4 IN. GATE, EXPANDER by Fairchild $1
- ☐ 1—QUAD 2 IN. NAND/NOR GATE $1
- ☐ 1—703 LINEAR RF AMP. Fairchild $2.49

STEREO PREAMP 4.95 ☐
- ★ 8 TRANSISTORS by Fairchild
- ★ Ready to Play thru tape Amplifier, radio, TV
- ★ Volume, Tone, Controls sw

4 Transistor Amplifier

☐ tuners, mikes, phono- SOLID STATE **3.95**

1 AMP TOP HAT AND EPOXIES

PIV		Sale	PIV		Sale	PIV		Sale
50	☐	5¢	800	☐	19¢	1800	☐	82¢
100	☐	7¢	1000	☐	29¢	2000	☐	1.25
200	☐	8¢	1200	☐	42¢	3000	☐	1.50
400	☐	10¢	1400	☐	55¢	4000	☐	1.95
600	☐	15¢	1600	☐	69¢			

Actual Size →

1 AMP MICROMINIATURE SILICON RECTIFIERS

PIV		Sale	PIV		Sale
50	☐	7¢	600	☐	20¢
100	☐	9¢	800	☐	25¢
200	☐	12¢	1000	☐	39¢
400	☐	17¢			

2 AMP SILICON RECTIFIERS

PIV		Sale	PIV		Sale
200	☐	12c	1000	☐	45¢
400	☐	16c	1200	☐	59¢
600	☐	19¢	1400	☐	69¢
800	☐	29¢	1600	☐	89¢

1.5 AMP 2000 PIV SILICON RECTIFIERS $1 ☐

TRIACS * SCRS **

PRV		3A** AMPS		6* AMPS
50	☐	.35	☐	—
100	☐	.50	☐	.85
200	☐	.75	☐	1.35
400	☐	1.25	☐	1.95
600	☐	1.80	☐	2.60

SILICON POWER STUD RECTIFIERS

PIV		3A		6A		12A		55A
50	☐	.06	☐	.16	☐	.20	☐	.50
100	☐	.07	☐	.22	☐	.25	☐	.75
200	☐	.09	☐	.30	☐	.39	☐	1.25
400	☐	.16	☐	.40	☐	.50	☐	1.50
600	☐	.20	☐	.55	☐	.75	☐	1.80
800	☐	.30	☐	.75	☐	.90	☐	2.30
1000	☐	.40	☐	.90	☐	1.15	☐	2.70

SOLITRON DEVICES, 5 AMP Epoxy Rectifiers

PIV		Sale	PIV		Sale
50	☐	19¢	600	☐	59¢
100	☐	25¢	800	☐	69¢
200	☐	39¢	1000	☐	89¢
400	☐	45¢			

'GLASS AMP' ONE AMP SILICON RECTIFIERS

PRV may be exceeded without the rectifier breaking down.

PIV		Sale	PIV		Sale
50	☐	5¢	600	☐	19¢
100	☐	7¢	800	☐	21¢
200	☐	9¢	1000	☐	32¢
400	☐	12¢	1200	☐	45¢

10¢ FOR OUR "SUMMER" BARGAIN CATALOG ON: ☐ Semiconductors ☐ Poly Paks ☐ Parts

POLY PAKS

TERMS: send check, money order, include postage—avg. wt. per pak 1 lb. Rated net 30 days. CODs 25%

P.O. BOX 942W
SO. LYNNFIELD, MASS. 01940
"PAK-KING" of the World

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INVESTIGATE ACCIDENTS: Earn to $1000 monthly. Men urgently needed. Car furnished. Business expenses paid. No selling. No college education necessary. Pick own job location. Investigate full time or earn to $8 hour spare time. Write for FREE information. No obligation. Universal Schools, CZ-5, 6801 Hillcrest, Dallas, Texas 75205.

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I MADE $40,000.00 YEAR by mailorder! Helped others make money! Start with $10.00—Free proof. Torrey, Box 318-N, Ypsilanti, Mich. 48197.

FREE BOOK "990 Successful, Little-Known Businesses." Work home! Plymouth-245Y, Brooklyn, New York 11218.

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$200.00 DAILY In Your Mailbox! Your Opportunity To Do What Mailorder Experts Do. Free Details. Associates, Box 136-K, Holland, Michigan 49423.

REBUILD Color/B.W. TV Picture tubes. Kit cost $950.00. 80 hours assembling time. Send $2.00 for additional information. ELECTRONICS WORLD, Classified, Box 587, 1 Park Avenue, New York, N.Y. 10016.

REPAIRS AND SERVICES

SPEAKER REPAIR. Hi-Fi, guitar, organ speakers reconed good as new at fraction of new speaker price. For details and Reconing Center in your area write: Waldom Electronics, Inc., Dept. EW, 4625 W. 53rd St., Chicago, Ill. 60632.

MISCELLANEOUS

WINEMAKERS: Free illustrated catalog of yeasts, equipment. Semplex, Box 7208, Minneapolis. Minn. 55412.

WATCHES AND CHRONOGRAPHS—Import from Switzerland, save 50%. Color catalog. DFI, West Dennis, Massachusetts 02670.

ELECTRONICS WORLD MAY 1968
ADVERTISERS INDEX

Printed in U.S.A.

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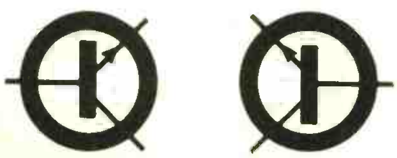

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176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

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WORLD'S LARGEST SELLING AND WORLD'S NEWEST Hand Size V·O·M's

TRIPLETT

MODEL 310-C
World's Newest
Volt-Ohm-Milliammeter

MODEL 310
World's Largest Selling
Volt-Ohm-Milliammeter

BOTH TESTERS SHOWN ACTUAL SIZE

1 HAND SIZE V-O-M WITH PROVISION FOR ATTACHING AC CLAMP-ON AMMETER.

2 20,000 OHMS PER VOLT DC SENSITIVITY; 5,000 AC.

3 ONE SELECTOR SWITCH MINIMIZES CHANCE OF INCORRECT SETTINGS AND BURNOUTS.

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields. FITTING INTERCHANGEABLE test prod tip into top of tester makes it the common probe, thereby freeing one hand. UNBREAKABLE plastic meter window. BANANA-TYPE JACKS—positive connection and long life.

Model 310—$44.00 Model 310-C— $56.00 Model 369 Leather Case— $4.20

ALL PRICES ARE SUGGESTED U.S.A. USER NET, SUBJECT TO CHANGE

310-C PLUS FEATURES

1. Hand size V-O-M with provision for attaching AC Clamp-on Ammeter.
2. 15,000 OHMS per volt AC sensitivity; (20,000 DC same as 310).
3. Single fully enclosed Lever Range Switch, plus DC Polarity Reversing.

MODELS 100 AND 100-C

Comprehensive test sets. Model 100 includes: Model 310 V-O-M, Model 10 Clamp-on Ammeter Adapter; Model 101 Line Separator; Model 379 Leather Case; Model 311 leads. ($83.20 Value Separate Unit Purchase Price.)
MODEL 100—U.S.A. User Net.. $78.00

MODEL 100-C—Same as above, but with Model 310-C, Net........... $88.00

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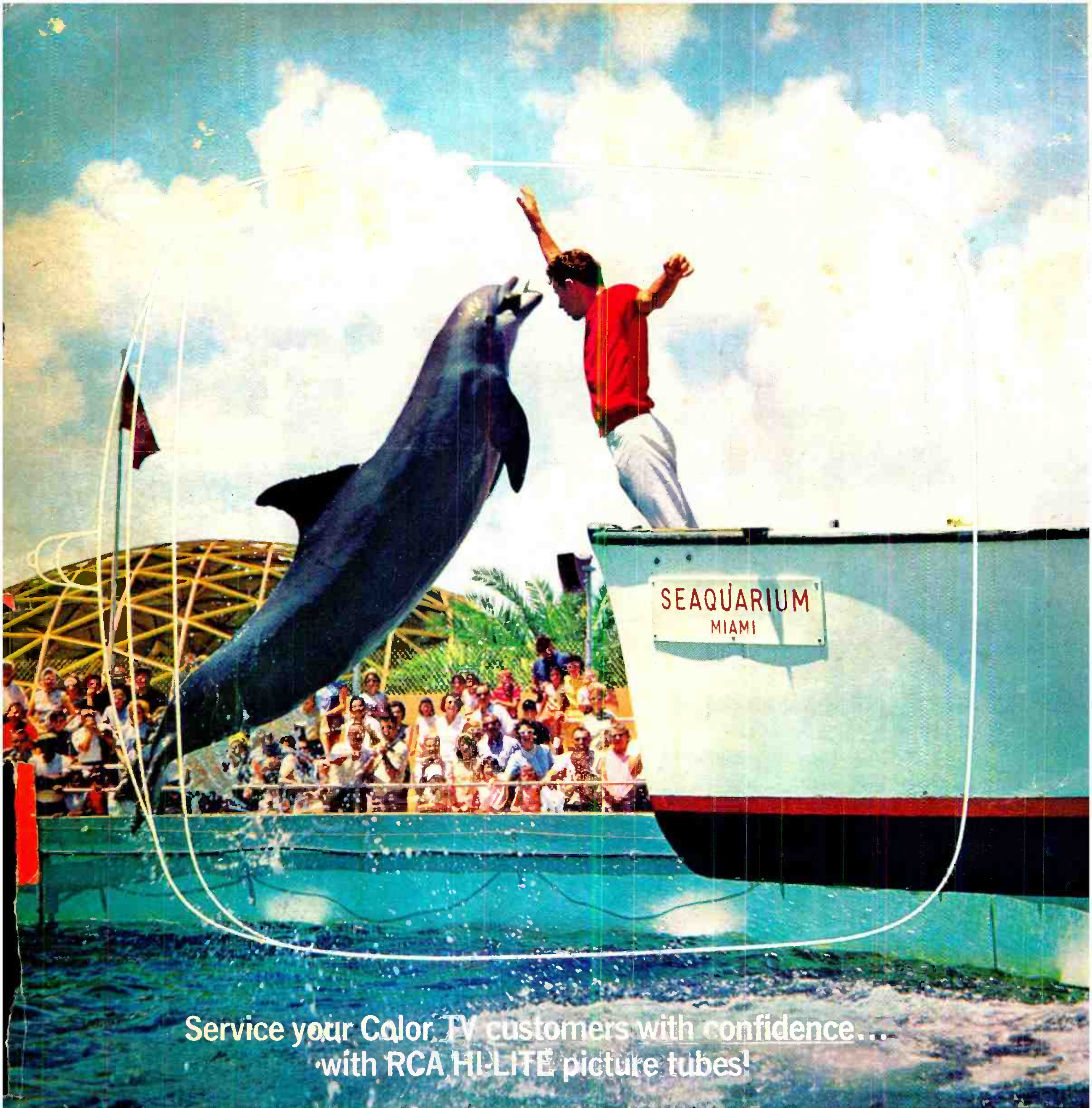

Customer satisfaction . . . and consequently your service reputation . . . can very often depend on the quality of the replacement parts you use. When it comes to replacement picture tubes, you can depend on an RCA HI-LITE for picture brightness and color fidelity at its finest. Install them and you literally "up-date" your customer's set with the same quality . . . the same tubes . . . that go into today's original equipment sets.

Enjoy the confidence of offering the finest. Rely on RCA picture tubes to protect your service reputation. They are designed to protect the biggest reputation in the Color TV industry

RCA