Electronics World

NOVEMBER, 1964
50 CENTS

TRANSISTORS VS TUBES FOR TWO-WAY RADIO

COMMUNICATING IN A HIGH-NOISE ENVIRONMENT

VIBRATION INSTRUMENTATION

SCR AUTOMOTIVE IGNITION SYSTEM

SEMICONDUCTORS FOR POWER SUPPLIES

HiFi/Stereo Review
June, 1964

"...the designers of the E-V TWO were aiming for a smooth, uncolored sound, and they have succeeded very well. Overall the E-V TWO is a very smooth and musical reproducer."

Radio-Electronics
February, 1964

"In brief, the E-V TWO's produce a quite spectacular sound with a big, low-down bass...that is the best, to my ears, that Electro-Voice has yet produced."

POPULAR SCIENCE
June, 1964

"They effortlessly fill my large listening room with clean, well-balanced sound."
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AUDIO
April, 1964

"...the Electro-Voice Model SIX is as close in sound to a Patrician as one can come without being a Patrician. You listen."

high fidelity
April, 1964

"Reproducing test tones, the Model SIX was found to have a remarkably smooth, clean and uniform response across the audio range!... But whatever one's personal listening tastes are, it would seem there is an E-V model to suit them."

The American Record Guide
December, 1963

"(I) have found them to be smooth and easy-to-listen-to...I found the top end very smooth and silky, not overbright, and also it extended well beyond the 15-kc. claim of the manufacturer."

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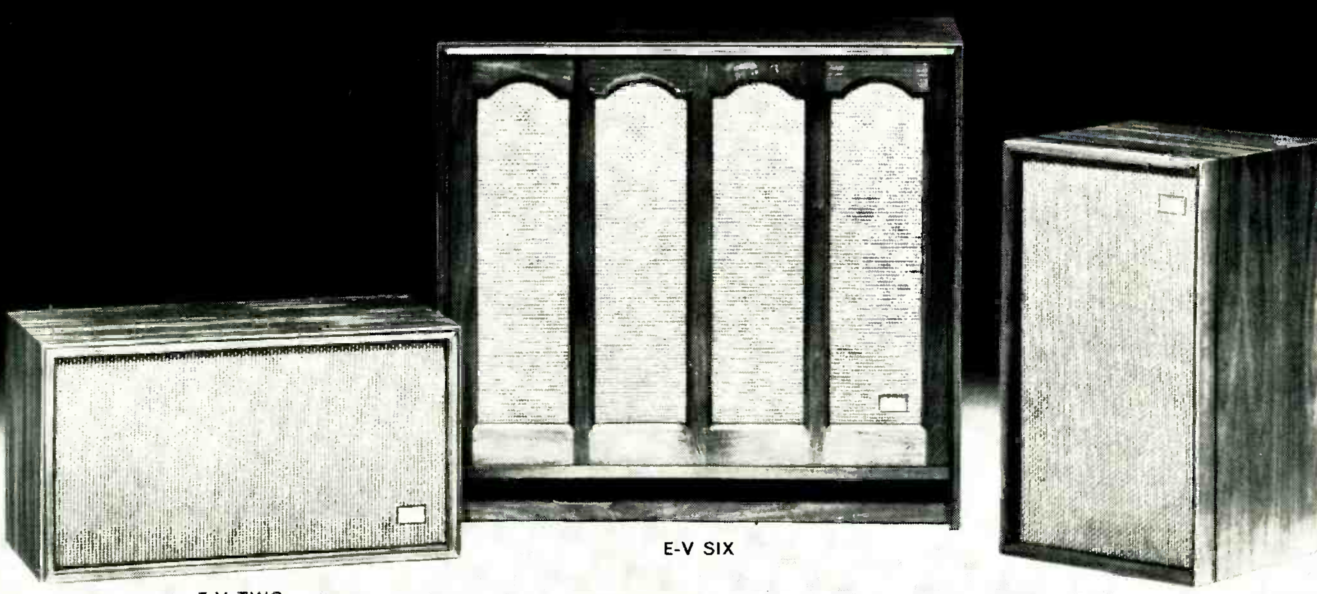

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Read what the critics say about the new E-V TWO, E-V FOUR and E-V SIX acoustic suspension speaker systems. Then conduct your own impartial listening test. For a complete set of review reprints, plus the name of your nearest franchised E-V hi-fi showroom, write us today.

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ELECTRO-VOICE, INC., Dept. 944H, Buchanan, Michigan 49107

CIRCLE NO. 180 ON READER SERVICE PAGE

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SETTING NEW STANDARDS IN SOUND

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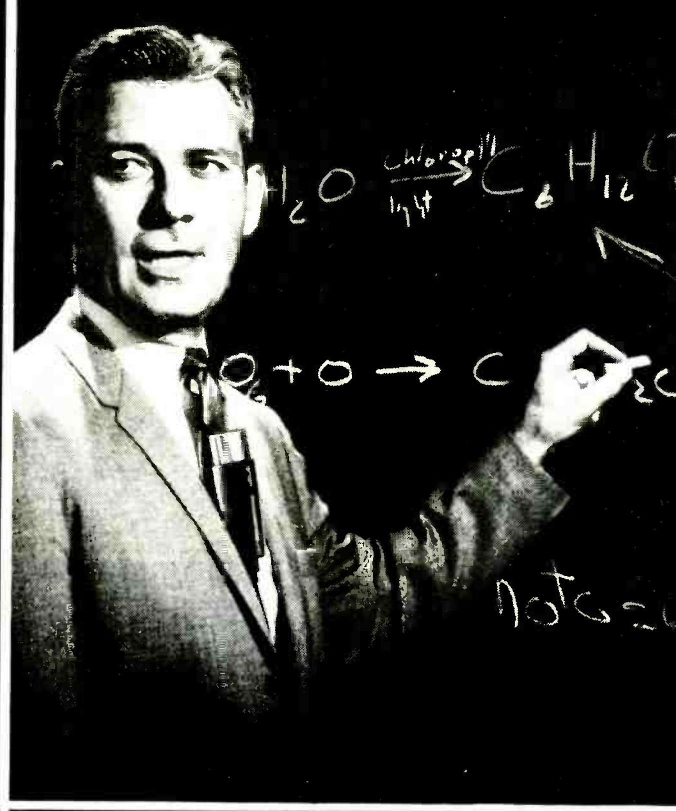
You really need 2 types of microphones



BUY THIS FIXED-POSITION MICROPHONE **...GET THIS LAVALIER FOR ONLY $5.00**

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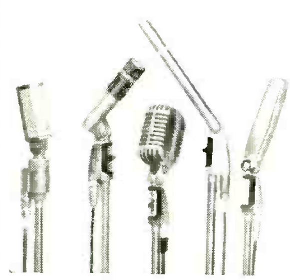
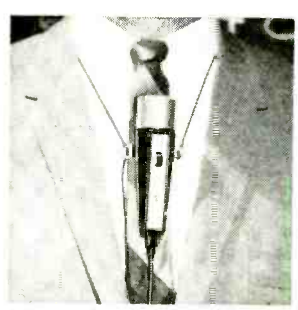
This special limited-time offer applies to the famous Unidyne II and III series and other fine Shure microphones listed below.* Unidyne III is the only cardioid microphone with pick-up pattern symmetrical about axis and uniform at all frequencies. Outstanding for voice or instruments.

*Models 300, 315, 330, 333, 555W, 55S, 545, 545S, 546, 556S, 576, 578, 578S. A Shure Lavalier for only $5.00 with each, when you send in your guarantee registration card. Offer expires December 31, 1964.





For lecturers, teachers, ministers, managers, public speaking requires the freedom and flexibility of a second microphone. The ability to move around while talking frees the speaker for writing on a blackboard or handling visuals, makes any speaker more interesting, more effective. Prove it to yourself for only $5.00 when you buy a Shure Microphone for fixed-location use.

Steps to obtain your Lavalier Microphone:

Purchase any of the microphones listed above thru your distributor or sound installer.

Remove guarantee registration card from microphone package. Specify whether you wish high impedance or low impedance lavalier microphone in the comment section of guarantee registration card.

Mail to Shure Brothers, Inc. with your check or money order for $5.00. If sending cash please send by registered mail.

That's all there is to do. Your microphone will be sent to you post paid. Sorry, no C.O.D.s.

SHURE

Shure Brothers, Inc., 222 Hartrey Avenue, Evanston, Illinois

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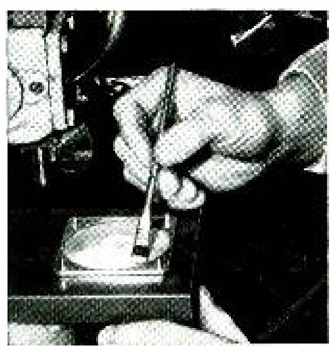
Silicone Rubber Adhesive/Sealant solves 1000 electronic problems ...permanently

New General Electric silicone rubber adhesive sealants are ready-to-use, permanent and waterproof. Available in a variety of colors (white, black, red, aluminum and translucent), RTV sealants set up in minutes and cure in air to form a tough, flexible bond. They won't shrink, crack, harden or peel, even at temperatures from $-75°F$ to $+500°F$. Like all silicones, RTV's resist moisture, weathering and ozone.

In either the non-sagging form or the free flowing form, RTV makes an excellent caulk, gasket, encapsulant, electrical insulator, sealer, laminate and general stick-um. Here are eight ways this unique do-it-yourself rubber solves production and maintenance problems or reduces manufacturing time. Look around in your plant. You'll think of many more.

1. RTV-108 provides instant, "see-through" insulation as well as vibration resistance and environmental protection. RTV needs no pre-mixing; is applied directly from the tube.



2. RTV seals filament condenser plates in dielectric heaters. Reasons: RTV resists high temperature, insulates electrically, locks out conductive contamination.

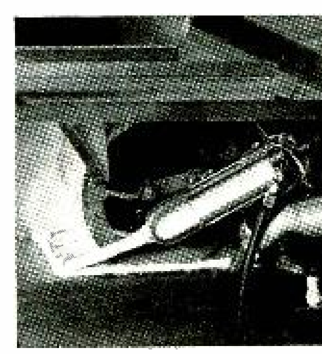
3. RTV seals AN connectors, terminals and wire harness joints and other flexible parts. It will absorb shock and vibration, eliminating the fatigue failure of connections.

4. RTV bonds sheeting into desired configuration in low volume production of cylindrical air ducts for dielectric heaters. Results: production costs cut more than 300%.

5. RTV laminates layers of mica sheeting and plates in production of plate condensers. Results: improved operational reliability, assembly time cut from 24 hours to 20 minutes.

6. RTV eliminates need for screws and drilling when used to affix name plates and decorative emblems on any surface. Results: no unsightly rust drainage; plates stay put indefinitely, but can be cut loose when desired.

7. RTV seals out moisture and dust, making cases, cabinets and chassis completely and quickly weatherproof. An excellent material for vibration dampening in electronic equipment.



8. RTV bonds vent units and ducts in new Hotpoint range, seals areas of metal-to-metal contact to prevent escape of cooking vapors. RTV is damping medium for vent motor, reducing sound and vibration.

RTV comes in 3 oz. and 12 oz. tubes and in polyethylene cartridges for use with automatic pressure guns. For more information or a trial 3-oz. tube, use this coupon.

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Section BR11124R **Waterford, New York 12188**

Send me (quantity) _____RTV-102 white, _____RTV-103 black, _____RTV-106 red, _____RTV-108 clear, _____RTV-109 aluminum, at $2.00 per tube. I've enclosed a check for $_____made out to "General Electric." No C.O.D.'s, please.

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Electronics World

CONTENTS

NOVEMBER 1964
VOL. 72, No. 5

MONTHLY FEATURES

THIS MONTH'S COVER shows a collection of various types of semiconductor diodes that are employed in power supplies. At the upper right-hand corner is a pair of selenium diodes, the larger one is used as a rectifier and the smaller one is used as a transient protector. The unit at the top left is a medium-current (25 a.) silicon-rectifier stack. At the bottom right is a 250-a. silicon diode. The group of diodes at the lower left are medium- and low-current silicon diodes, with the exception of the second unit from the bottom, which is a low-current, fairly high voltage selenium unit....... (Photo: General Electric)

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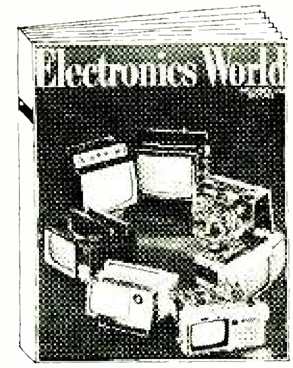
COMING NEXT MONTH



PORTABLE TV SETS
Freed from reliance on the a.c. power line, these sets can go anywhere. This article covers sets made by Delmonico, General Electric, Panasonic, Philco, Realtone, Sharp, and Sony. The picture screen sizes range from 4½" to 9".

TRANSISTORIZED FM-STEREO DEMODULATOR
Three engineers from RCA discuss the design of a multiplex adapter, using inexpensive transistors and featuring noise-immunity and automatic mode switching. Readily available components and coils make this circuit especially interesting to design engineers as well as audiophiles.

HIGH-SPEED ELECTRONIC PRINTER
Use of a special CRT and fiber-optic techniques make possible an all-electronic, completely noiseless printer. A. W. Edwards of Century Electronics & Instruments, Inc. describes this commercially available computer adjunct.

TRIGGERED SWEEP FOR IMPROVING SCOPES
One of the major differences between low- and high-priced scopes is the very accurate sweep and calibration circuits found in the latter. The article describes a transistorized sweep unit which can be added to kit-type and other relatively inexpensive models to improve the stability of their sync circuits.

EARLY VACUUM TUBES
Historic photographs from Marconi Co., Ltd. and the Science Museum in London highlight this description of some of the early Edison-effect lamps and oscillation valves developed by Fleming at the beginning of this century.

NEW SCR DEVELOPMENTS
Some of the recent four-layer, gate-controlled semiconductor switches are low in cost, self-protecting, and transient-immune. For these reasons, as Donald Lancaster points out, they are adaptable to a wide variety of industrial and consumer electronics equipment.

ANNUAL INDEX
A complete listing of all of the major feature articles which have appeared in Electronics World during 1964. The Index covers Volumes 71 and 72 (January through December 1964).

*All these and many more interesting and informative articles will be yours in the DECEMBER issue of ELECTRONICS WORLD . . . **on sale November 19th.***

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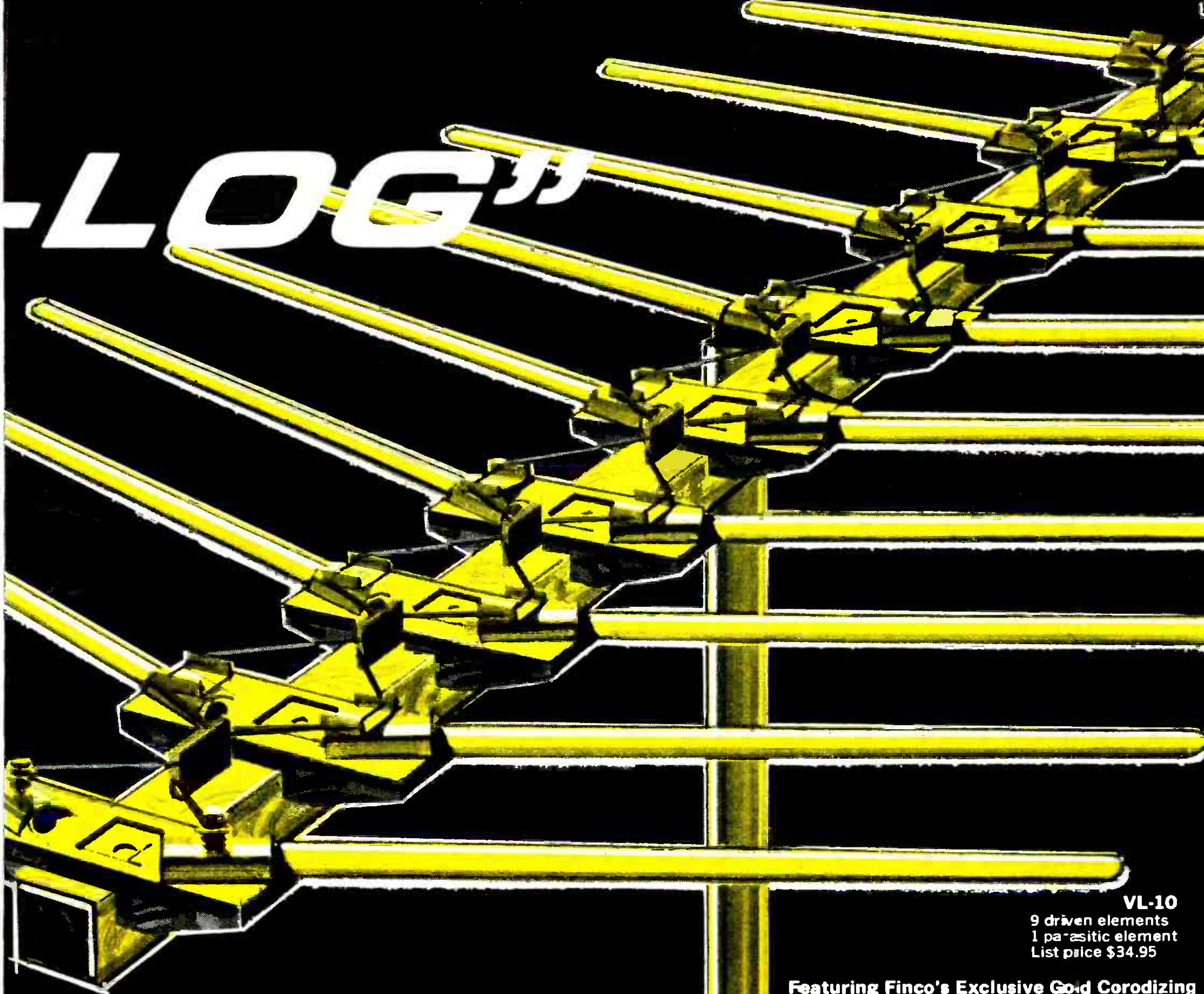
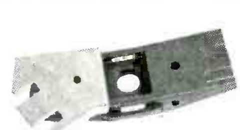


Finco's boom-mast bracket, rust-proofed by zinc plate-gold di-chromate dip process, is the finest available. It has positioned cleats to assure sag-free positive direction of the antenna. Locks tight. Can't tilt. Antenna stays in proper position at all times.



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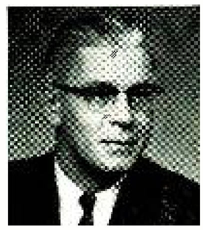

For the record

WM. A. STOCKLIN, EDITOR

PARTS SHOW MOVES TO N. Y.

IMPORTANT changes have just been announced regarding the 1965 Electronic Parts Distributors Show. For the first time since 1937, the show will be held away from Chicago, and not in the month of May.

Charles G. Fouts, national distributor sales manager for *ITT Cannon Electric Company*, and the newly elected president of the Electronic Industry Show Corporation, announced that plans are to rotate this annual show among New York, California, and Chicago. The 1965 show will be held between March 31 and April 4 in New York City at the New York Hilton and Americana Hotels.

In 1966, the show will be held in San Francisco, returning to Chicago in 1967.

Along with this announcement, many new policies will be in effect. Instead of the customary 3-day run, the show will be extended to 5 days, opening with two days of educational forums. The exhibit halls will then open on a Friday and remain open through Sunday.

Exhibit privileges will be extended to any manufacturer who sells his products through parts distributors, even though he may not belong to one of the sponsoring associations.

Admittance to the show will be extended to all companies which buy directly from exhibitors. A vigorous effort will be made to attract attendance from original-equipment manufacturers as well as from all companies re-selling high-fidelity and commercial sound products.

Important changes—without a doubt—but they had to come. As pointed out in our August editorial, the Electronic Parts Shows in the past have had declining attendance. Moving the shows to the East and West Coasts will give many of those involved in the electronics industry a chance to attend this important event. Parts are the basic building blocks of all electronics equipment, and engineers and technicians alike should make every effort to keep abreast of the new developments by attending the show.

Allowing two extra days for educational forums will contribute materially to the interest of those attending. On the other hand, though, if these forums are not well-planned, they could be a drawback rather than an asset to the show. It is our hope that the show committee exerts every possible effort to present educational programs of worthwhile content to reward those in attendance.

This coming March will be a busy month. In addition to this new Parts Show, we cannot overlook the IEEE Convention which will be held March 22-25 and, especially for those of us in the New York area, there is a lot of industry activity for us to look forward to. ▲

RAYMOND V. PEPE (1912-1964)

Raymond V. Pepe, vice-president of James B. Lansing Sound, Inc. and Chairman of the Board of Directors of the Institute of High Fidelity, Inc., died suddenly in Los Angeles on August 15 after what had been considered a mild heart attack.

Only 52 at the time of his death, he was born in New York City and graduated from Columbia University. He served in the office of the Comptroller of New York City during Mayor LaGuardia's administration.

Ray received his greatest recognition as a leader in the component hi-fi industry. His everlasting efforts to bring an air of professionalism to the industry will never be forgotten. Whenever any problems arose, either in the States or abroad, Ray was available at a moment's notice.

His most outstanding achievement was as a spokesman and his unique ability in diplomacy enabled him to resolve many challenging problems within the industry.

With the entire hi-fi components industry, we mourn his passing. —30—

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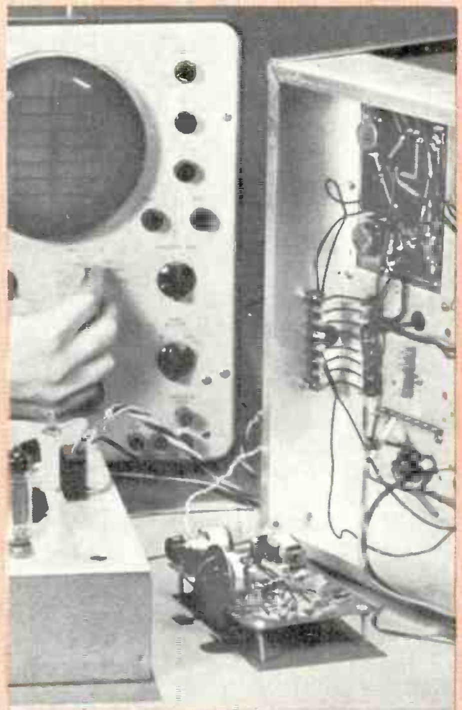

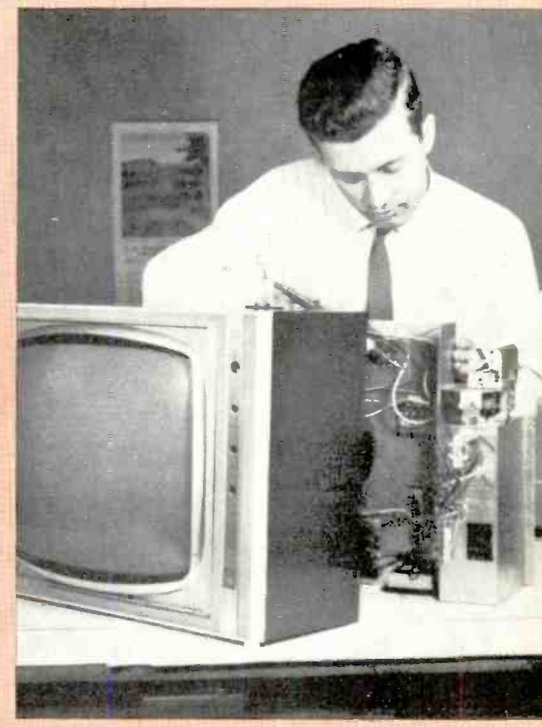

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Here is one of seven training kits you get in the NRI Complete Communications Course. With it, you get *actual practice* in building a crystal-controlled phone/code transmitter and putting it on the air, actual practice in many aspects of commercial transmitter operation (modulation, "clamping" circuits, key filters, etc.). This kit—as with all NRI kits—features the most modern circuits and parts. It complies with FCC regulations and can be put on the air simply by attaching to an antenna. Be a part of the "life line" of the Space Age. Enroll for NRI's Complete Communications Training.

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Industry, business offices, the government and military all need trained Electronics Technicians. In NRI's Complete Industrial Electronics Course you progress through 10 custom-designed training kits, topping off your studies by building this analog computer with which you solve simple mathematical problems, experiment with feedback control systems and digital logic elements. This kind of practical experience as you train prepares you to step into a good paying position ready to do your knowledgeable best. Prepare now the NRI way for Industrial Electronics.

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Want to make $3 to $5 an hour in your spare time? Want your own full-time or part-time business? NRI's complete course in Radio-TV Servicing offers these money-making opportunities. NRI starts you with the ABC's of Electronics. You learn how to install, maintain and service stereo hi-fi, radios, PA systems and TV sets (including color). Included in your training are eight NRI-designed training kits; the final one is this complete, custom-designed table model TV receiver you build yourself. You learn servicing procedures you will use on the job—and earn *extra money* as you train. Enroll now.

SEE OTHER SIDE ▶

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Whatever your interest in Electronics . . . whatever your education . . . whatever your need . . . before you decide on any school you'll want to investigate NRI's extensive list of training plans and practical, thorough, absorbing training methods. NRI training equipment and "bite-size" programmed texts are the finest money can buy, the finest highly skilled instructors and engineers can design and perfect for you. Mail the postage-free card for your copy of the NRI catalog. NATIONAL RADIO INSTITUTE, Electronics Div., Washington, D.C. 20016.

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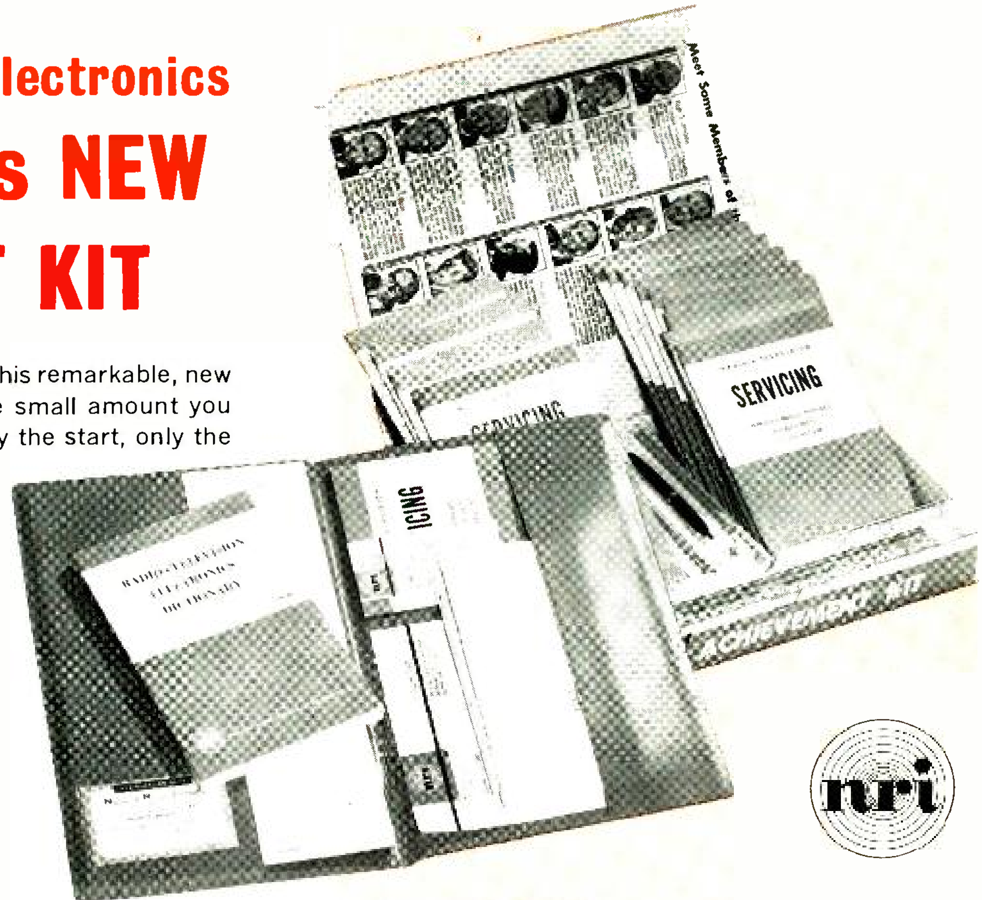

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Join the thousands who gained success with NRI

"I want to thank NRI for making it all possible," says Robert L. L'Heureux of Needham, Mass., who sought our job consultant's advice in making job applications and is now an Assistant Field Engineer in the DATAmatic Div. of Minneapolis-Honeywell, working on data processing systems.

His own full-time Radio-TV Servicing Shop has brought steadily rising income to Harlin C. Robertson of Oroville, Calif. In addition to employing a full-time technician, two NRI men work for him part-time. He remarks about NRI training, "I think it's tops."

Even before finishing his NRI training, Thomas F. Favaloro, Shelborne, N.Y., obtained a position with Technical Appliance Corp. Now he is foreman in charge of government and communications division. He writes, "As far as I am concerned, NRI training is responsible for my whole future."

"I can recommend the NRI course to anyone who has a desire to get ahead," says Gerald L. Roberts, of Champaign, Ill., whose Communications training helped him become an Electronic Technician at the Coordinated Science Laboratory, U. of Illinois, working on Naval research projects.

◀ SEE OTHER SIDE

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NOTE: You *must* pass FCC exams on completion of any NRI communications course or your tuition payments are refunded in full.

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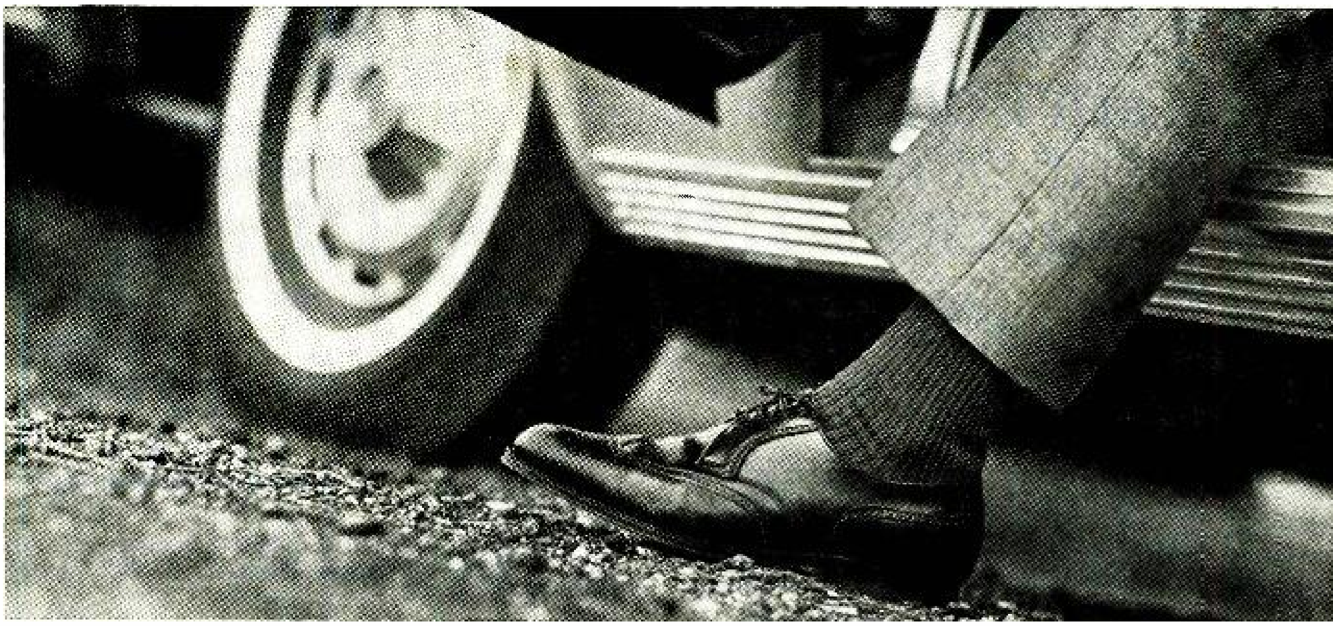

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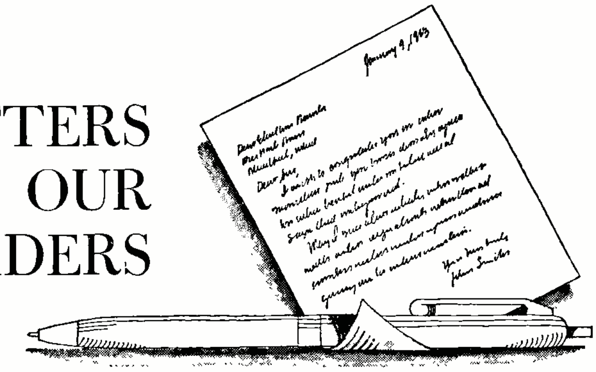
LETTERS FROM OUR READERS



RADIO TELESCOPES

To the Editors:

We read with interest your excellent summary on radio telescopes which appeared in the July issue. It might interest you to know that our radio telescope here at the University of Texas (your cover illustration) is now being operated at 94 gc. with over 70-db gain. Future plans call for reception of signals in the 140-220 gc. range using highly sensitive germanium bolometer detectors operated at −268.8°C.

D. GRAHAM GALLOWAY
Electrical Engineering Research Lab.
The University of Texas
Austin, Tex.

* * *

MAGNETORESISTANCE TRANSDUCERS

To the Editors:

Ray Shiver does a good job in your July issue of introducing a wide range of industrial transducers. Your readers might like to learn about some less-known transducers based on the magnetoresistance principle.

Magnetoresistance is the effect found in bismuth, germanium, lead sulfide, indium antimonide and other materials, whereby electrical resistance increases with applied magnetic field strength. A particular advantage of magnetoresistance transducers is that the magnetic field can be supplied by a permanent magnet—no supply source is needed. Resistance values are then altered by simply moving the magnet.

All of the major U.S. engine manufacturers are looking into the possibilities of using the magnetoresistance method as a source of trigger pulses for electronic ignition. The magnetoresistance transducer depends for its output on the *amount* of applied magnetic field, not on the rate at which this field changes. Inductive pickups, of course, deliver outputs proportional to the rate of change of field, hence don't deliver much output at low speeds. The magnetoresistance device delivers the same output for stationary crankshafts as it does for high speed ones.

Other applications include machine-tool positioning in numerical-control systems; elevator control, where the car is homed to the correct floor height; and automatic weighing machines, where a motor adjusts the balance weight until the transducer that is employed reads zero for proper balance conditions.

By contrast with the linear differential transformer, the magnetoresistance transducer operates from a d.c. supply rather than 20 kc. a.c. Moreover, the magnetoresistance device delivers d.c. output, whereas the differential transformer needs an expensive demodulator to convert its a.c. output into phase-sensitive d.c.

The usefulness of magnetoresistance devices is not confined to electromechanical transducers. By using an electrically controlled magnetic field rather than a permanent magnet, many types of analog control devices can also be developed.

ROBERT M. GITLIN
Vice President and General Mgr.
American Aerospace Controls, Inc.
123 Milbar Blvd.
Farmingdale, N.Y.

* * *

"MUSICOLORTRON"

To the Editors:

I have been contacted by Mr. Morris Wetzel, *Musicolor, Inc.*, Chicago, in reference to my article "Transistor-Photocell Color Organ" in the July, 1964 issue of ELECTRONICS WORLD. Mr. Wetzel took severe objection to the word "Musicolortron" which appears in the photo of the unit, and to the use of the term "dancing lights" in the text. He claims that the name "Musicolor" is registered or copyrighted, and that the term "dancing lights" in relation to colored music is his.

I would like to emphasize that my use of the name "Musicolortron" on my prototype was entirely coincidental, and any infringement on his rights was entirely inadvertent. I had no prior knowledge of Mr. Wetzel, his products, his patents, or his rights to the terms referred to.

FRED BLECHMAN
Canoga Park, Calif.

The color organ that was built by our author and which he labeled "Musicolortron" was not a commercial product intended for sale but was built for his own use. Also, we have employed the description "dancing lights" for many of the color organ displays that we have run in years past. In any case, no infringement was intended. We also understand that Mr. Wetzel's particular

color organ is not similar in any way to the device described in the article by Author Blechman.—Editors.

° ° °

PARTS SUBSTITUTION

To the Editors:

I read with the greatest interest your first letter in the "Letters" column of your August issue.

This was from James Young of Rochester, N.Y. He was having trouble with the transistor power supply article in your May issue, which I sent in to you. He claimed his only change was to use a different transistor in the circuit described.

The parts list with this article showed the *Dao Corporation* of this city as a source of both the toroid cores and the completed transformers. The transformer is a special item only available from *Dao*—the core is an *Arnold* product but difficult to locate unless you want several dozen.

You will be interested to know that *Dao* has sold 162 cores and 43 transformers. This seems to be a rather high level of interest and it's a satisfaction to know that *Dao* hasn't received a single complaint.

James Young of Rochester, however, has not been a *Dao* customer and this is the reason for my interest. It would be interesting to know if the transistor substitution is the only one he's made.

R. L. WINKLEPLECK
Terre Haute, Ind.

We did not publish Reader Young's letter to disparage Author Winklepleck's power supply in any way. The letter was published as an example of a common type we receive wanting to know why some of our circuits will not operate properly when parts substitutions or circuit changes are made. We are sorry that we cannot specify substitute parts or circuit changes unless these are suggested by our authors who have actually tried out these particular modifications. —Editors.

° ° °

TRIAD FILAMENT TRANSFORMER

To the Editors:

Recently you ran a brief article by Rufus Turner entitled "Filament Transformer as Audio Substitute" on p. 75 of your August issue. This article refers to the *Triad* F-14X as "*Stancor* F-14X." It happens that *Stancor* has an equivalent, the P-6134, which will be substituted by distributors when the customer calls for the "*Stancor* F-14X."

We appreciated Mr. Turner making the measurements on our unit and mentioning it by number, but a correction would be a great help to your readers in getting the right transformer, which is the *Triad* F-14X.

NEWTON COOK, Sales Mgr.
Triad Distributor Div.
Huntington, Ind. ▲

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To get more information, promptly, about products and services mentioned in this issue, simply circle the number corresponding to the ad or editorial mention and send the proper coupon to us. Your request will be sent to the manufacturer immediately.

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NEW PRODUCTS & LITERATURE

2	3	4	5	6	8	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
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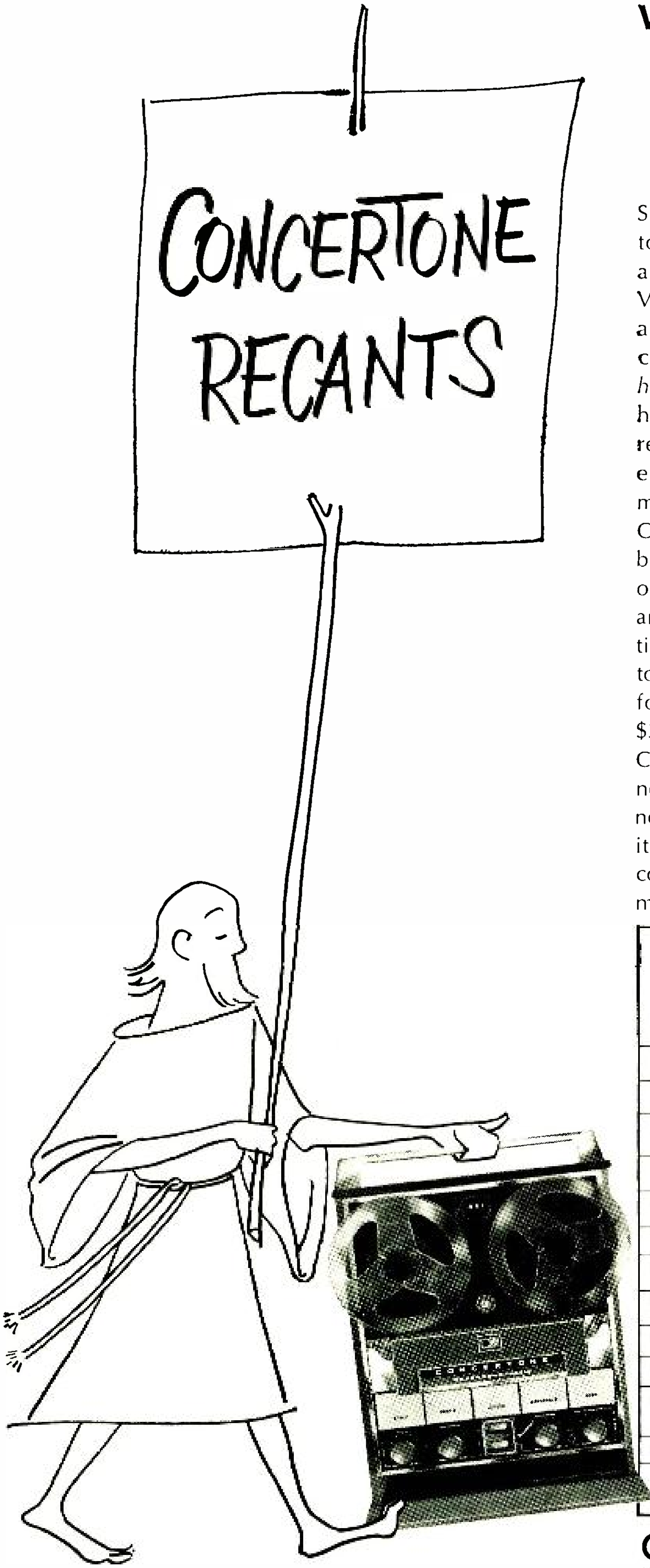


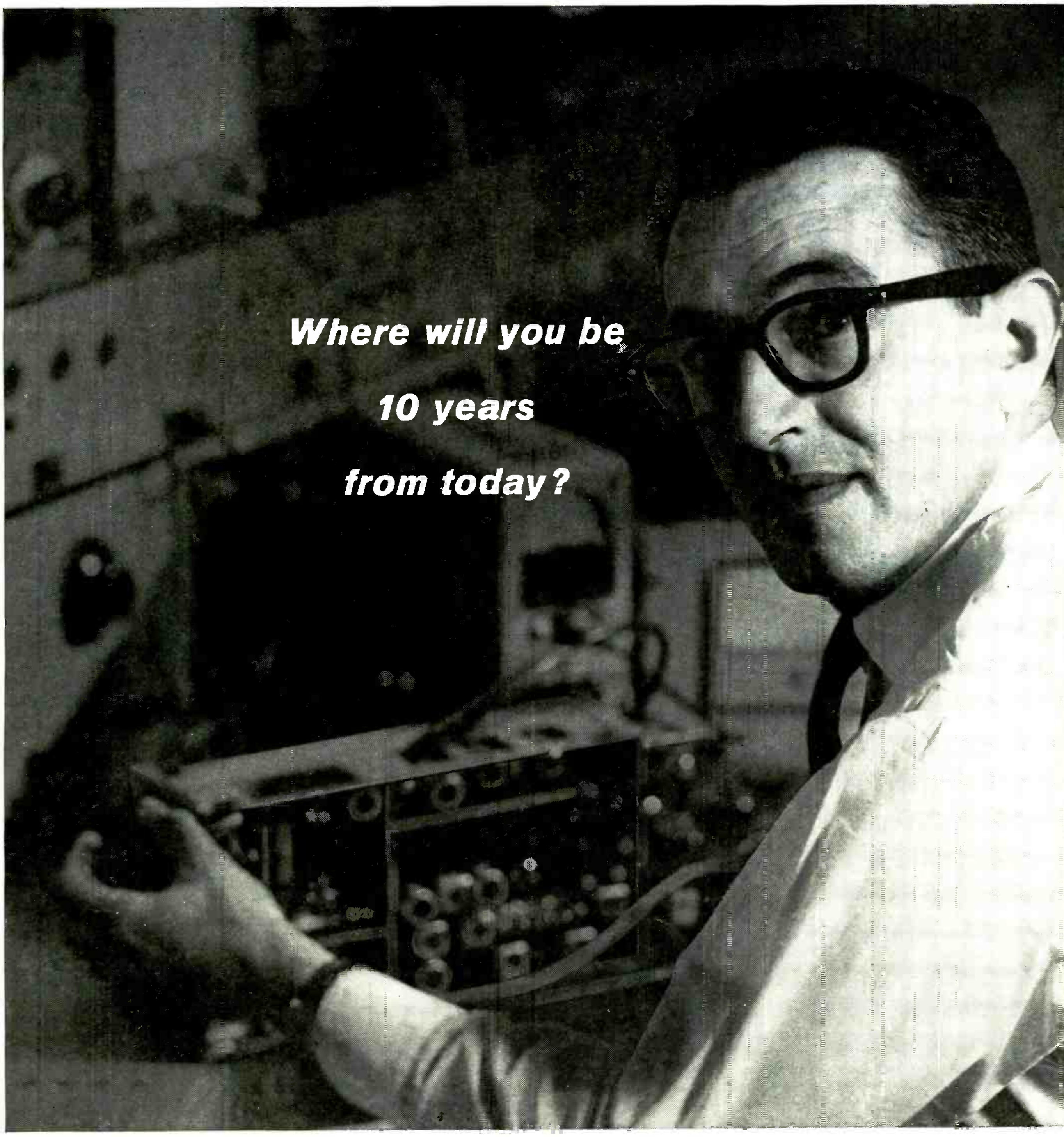
WE DARED TO COMPARE THE CONCERTONE 800

and heard from our competitors

Since "an honest tale speeds best being plainly told," we would like to make a public apology about our first Feature Comparison Chart. The Viking 220 tape recorder *does have* tape lifters and transistors. The Freeman 200 *does have* center capstan drive. And, the Tandberg 64 *does have* remote control and tape lifters. Hence, we have amended our Chart accordingly and have reproduced it again. While contrite, because we erred originally, we feel that even with these minor adjustments you will still see that the Concertone 800 (portable or tape deck) is your best value in stereo tape recorders! Furthermore, only the Series 800 has double Reverse-o-matic® and six heads that combine to give you continuous music playback and recording with the touch of a button, without reel turnover. Prices for this incomparable device start as low as $379.95. If you're really interested, send for a Concertone brochure and the name of your nearest dealer. The brochure is flawless, with no accidentally erroneous comparisons. Besides, it's free and has a neat drawing of a bird on the cover. Write to Concertone, Repentance Department, Box 3866, South El Monte, California.

FEATURES:	AMPEX 2010	CONCERTONE 800	CONCORD 884	EICO RP-100 WIRED	FREEMAN 200	NORELCO 401	REVERE M-2	ROBERTS 990	SONY 300	TANDBERG 64	V M 740	WEBCOR [illegible]	VIKING 220
6 HEADS	No	Yes	No	No	No	No	No	No	No	No	No	No	No
3 MOTORS	No	Yes	Yes	No	Yes	No	No	Yes	No	No	No	No	Yes
AUTOMATIC REVERSING FOR RECORD & PLAY	No	Yes	No	No	No	No	No	No	No	No	No	No	No
PUSH BUTTON CONTROLS	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
REMOTE CONTROLLABLE	No	Yes	No	No	No	Yes	No	Yes	No	Yes	No	No	Yes
SOUND ON SOUND	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BUILT-IN ECHO CONTROL	No	Yes	No	No	No	No	No	Yes	No	Yes	No	No	No
CENTER CAPSTAN DRIVE	No	Yes	No	No	Yes	No	No	No	No	No	No	No	No
TRANSISTORS	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	Yes
TAPE LIFTERS	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes
OPERATES BOTH HORIZONTAL & VERTICAL	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes
COSTS UNDER $400	No	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	No

CONCERTONE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TV Serviceman, Electronic Tester, Junior Technician	Electronics and Television Receivers (V-3)	2 yrs. High School with Algebra, and Physics or Science or RCA Preparatory Course.
Transistor Circuits Specialist	Transistors	Radio background
Color TV Service Technician	Color Television	Television background
Industrial Electronic Technician	Automation Electronics (V-14)	Radio and Transistor Background
Computer Service Technician	Digital Computer Electronics (V-15)	Radio and Transistor Background
Console Operator, Junior Programmer,. Programmer (RCA-301, RCA-501, IBM-1401)	Computer Programming (CP-1), (CP-2), (CP-3), (CP-4)	College Grad. or equivalent or Industry sponsored
Preparatory (for above courses)	Preparatory ath Course (P-1)	1 yr. High School
Preparatory (for above courses)	Preparatory Mathematics And Physics (PO-A)	1 yr. High School

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Color TV Service Technician	Color Television	Black and white Television Training or Experience
Automation Technician	Automation Electronics	Radio and Electronic Fundamentals
Transistor Circuits Specialist	Transistors	Radio and Electronic Fundamentals
Transmitter Technician, Communications Specialist	Communications Electronics	Radio and Electronic Fundamentals
Communications, 1st Class FCC Licensee	FCC License Preparation	Radio and Electronic Fundamentals
Communications Specialist	Mobile Communications	FCC License Preparation or equiv. study or experience
Nuclear Instrumentation Specialist	Electronics for Nuclear instrumentation	Radio and Electronic Fundamentals
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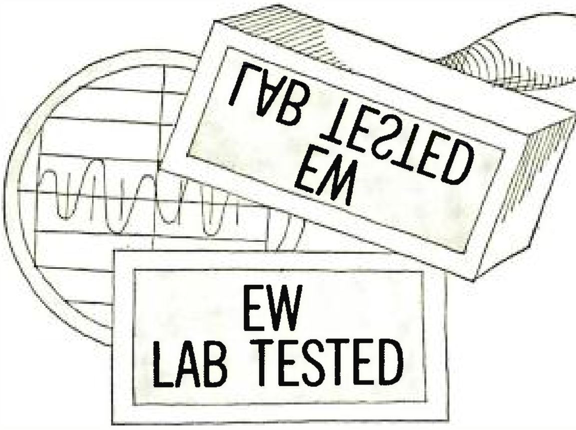


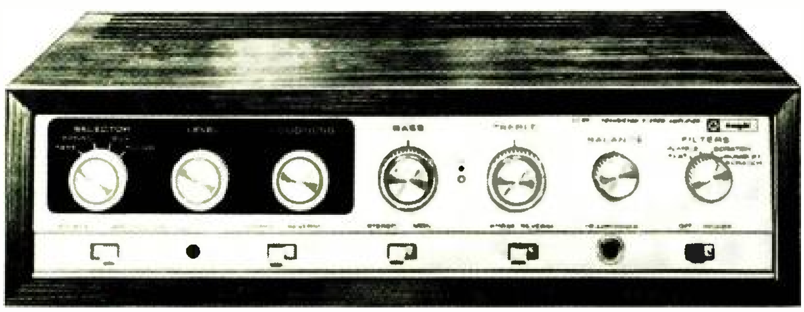
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

"Knight-Kit" KG-870 Amplifier
Eico Model 2200 FM-Stereo Tuner

"Knight-Kit" KG-870 Amplifier

For copy of manufacturer's brochure, circle No. 60 on coupon (page 15).



THE "Knight-Kit" KG-870 70-watt transistor amplifier is sold either as a kit or factory-wired by *Allied Radio Corp*. It is the firm's most advanced solid-state stereo amplifier and has several interesting and novel design features.

The amplifier uses a total of 22 transistors and 4 diodes. Four of the transistors are silicon types for maximum stability in low-level stages. The output transistors are mounted on the bottom of the metal chassis which acts as a heat sink. They are protected against thermal runaway by 6-volt automobile-type incandescent lamps in the emitter circuits. These self-protecting features and other design details on this amplifier were described in the June 1964 issue ("Self-Protecting Transistor Hi-Fi Amplifier").

This is the first transistor amplifier we have seen with a direct-coupled output stage. No blocking capacitor or transformer separates the output transistors from the speaker voice coils. This maintains a high damping factor down to the lowest audio frequencies.

Much of the circuitry is assembled on printed boards. The main amplifier board is hinged for accessibility. The transistors plug into sockets, preventing damage to them while soldering components to the board and making transistor replacement a simple matter should it become necessary.

The KG-870 is rated at a total of 70 watts IHF music power output or 28 watts per channel sine wave (one channel driven). It will drive either 8- or 16-ohm speakers. The use of 4-ohm speakers is not recommended. The amplifier has inputs for tape head, magnetic phono cartridge, tuner, and two high-level auxiliary. It has separate level and loudness controls, which is the only correct method of obtaining loudness compensation for low-level listening. The "Level" control is uncompensated. The "Loudness" control affects the volume over a limited range (about 30 db), but introduces both bass and treble boost as its level is reduced. The "Level" control is adjusted to give the loudest desired volume with the "Loudness" control at its maximum setting; reducing the "Loudness" setting then provides an excellent tonal balance down to the softest background listening levels.

The bass tone controls for the two channels are concentrically mounted, as are the treble tone controls. A balance control can cut off either channel without materially affecting the other. A single 4-position "Filter" switch has positions for "Flat," "Rumble," "Scratch," and "Rumble + Scratch."

Along the bottom of the front panel is a row of slide switches, for tape monitor operation with a three-head machine, stereo channel reversal, stereo/mono mode selection, speaker phase reversal, and power. A headphone jack completes the front-panel control lineup.

This rather completely equipped amplifier measures only 2¾" x 13" x 11" and weighs about 20 pounds. It runs very cool and has the well known solid-state virtues of low current drain and freedom from microphonics.

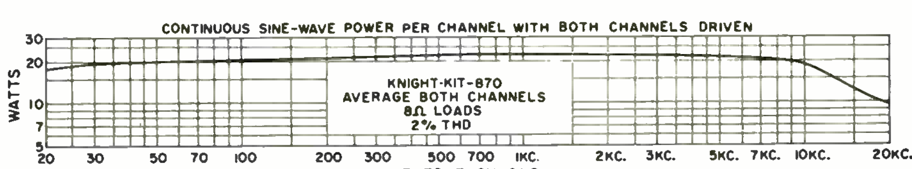
Driving both channels together, with 8-ohm loads, we measured 22.5 watts per channel at mid-frequencies, and more than 20 watts per channel from 50 to 10,000 cps at 2% distortion. The low-frequency power response was excellent with 18 watts available at 20 cps with 2% distortion. The high-frequency power output fell off somewhat, to 10 watts at 20,000 cps.

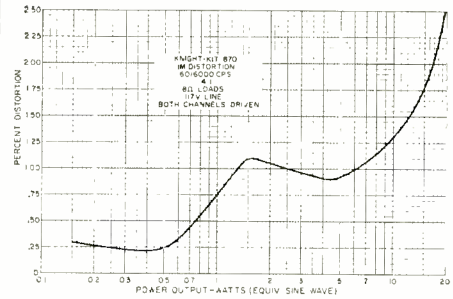
Like most transistor amplifiers, this unit had a moderate amount of IM distortion at low power levels. It averaged about 1% between 1 watt and 10 watts output, falling to 0.25% at outputs of less than 1 watt.

Its frequency response was flat from a few hundred cycles to 20,000 cps, rising about 2 db below 100 cps. The phono equalization was accurate to within ±1 db of the RIAA curve from 30 to 15,000 cps. The NAB tape equalization was within ±2.5 db from 45 to 15,000 cps. The rumble and scratch filters were rather strong in their action, with the latter removing a good deal of the high-frequency program material. The tone controls had a moderate range, about 8 to 10 db of boost or cut at 50 and 10,000 cps. This is adequate for any normal listening situation.

The amplifier was stable with moderate capacitive loads, but oscillated with a 0.65-μf. load. Such a condition would only be encountered when driving an electrostatic speaker. Its hum and noise were −75 db on high-level inputs and −50 db on phono inputs (referred to 10 watts output). This consisted mostly of hiss and was not audible in ordinary listening.

The KG-870 is a prime example of what has come to be known as "transistor" sound. With good, but not ex-



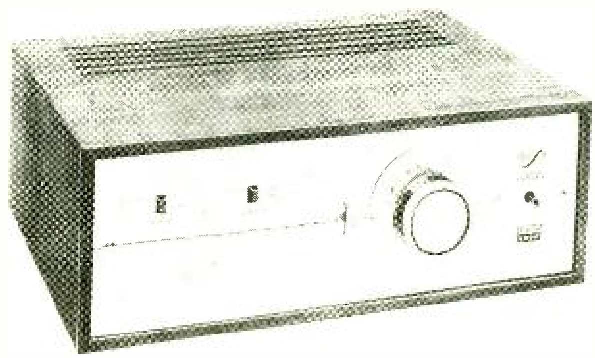


ceptional measured performance, it nevertheless has a superbly transparent and well-defined listening quality. This may be due in some measure to the direct-coupled output stages, but whatever the reason, this low-priced amplifier sounds remarkably like some selling for twice its price. It is convincing evidence that low-priced, high-quality transistor amplifiers can be designed.

The "Knight-Kit" KG-870 sells for $99.50 in kit form and $149.50 factory wired. An oiled walnut case is available for $12.95 additional. ▲

Eico Model 2200 FM-Stereo Tuner

For copy of manufacturer's brochure, circle No. 61 on coupon (page 15).



THE new *Eico* Model 2200 FM-stereo tuner is one of the firm's "Classic" series of high-fidelity components. Although it resembles, both in style and performance, some of the more expensive factory-made tuners, it is actually a very moderately priced, easy-to-build kit (also available factory-wired).

The front-end is a pre-assembled and pre-aligned unit, using an ECC85 dual triode as a neutralized r.f. amplifier and self-oscillating mixer. It is thoroughly temperature-compensated and needs no a.f.c.

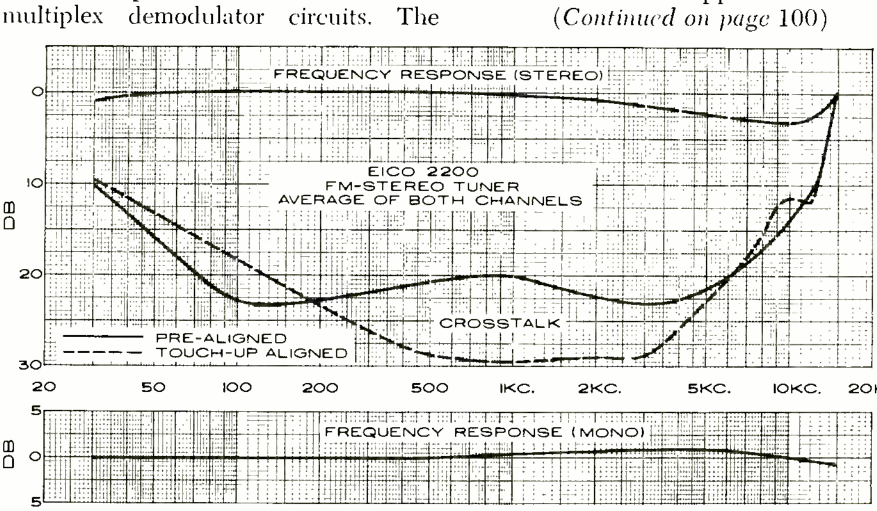
The i.f. portion of the tuner is a printed-board assembly, with three 6AU6 i.f. amplifiers, a 6AU6 limiter, and a 6AL5 ratio detector. For mono reception, the de-emphasized detector output goes directly to the two triode output stages (each is ½ 12AU7).

Another printed board contains the multiplex demodulator circuits. The composite detected signal is amplified by ½ 12DW7, whose output is separated into the 19-kc. pilot carrier and the composite stereo signal. The pilot carrier is amplified and doubled by a 6AU6 and synchronizes a ½ 12DW7 38-kc. subcarrier oscillator. This oscillator gates a two-diode switch, which separates the composite signal into left- and right-channel components. Encapsulated networks de-emphasize the two stereo outputs individually and filter out any 38-kc. carrier which may be present.

An EM84 bar-type eye tube is used as a tuning aid. A spring-return "Stereo Check" switch on the front panel of the tuner disables the stereo circuits and connects the grid of the eye tube to the output of the 19-kc. amplifier/doubler. If a stereo broadcast is being received, the eye closes.

The tuner kit is supplied with all cir-

(*Continued on page* 100)



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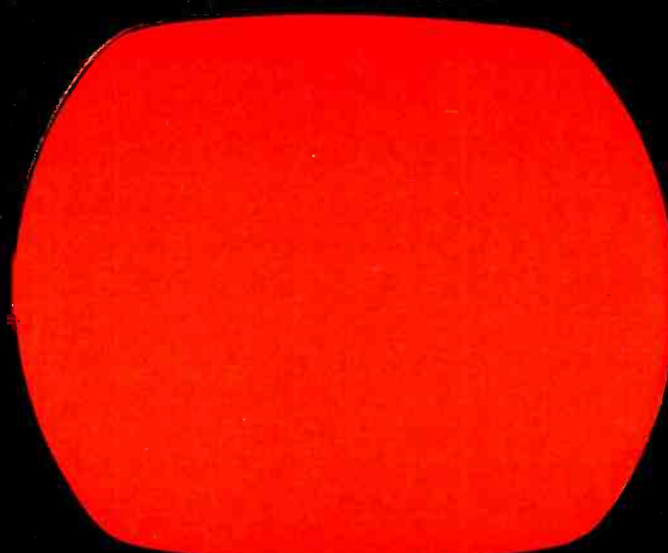

Sylvania's new **EUROPIUM RED.**

New COLOR BRIGHT 85 picture tube brings more natural color to television and increases monochrome brightness 43%.*

The startling news in the television industry is Sylvania's new picture tube, and its new, truer red phosphor.

EUROPIUM RED, developed at GT&E Laboratories, is the brightest red known to the industry. And, to match it, now the full brightness of blue and green is used. The result is a color picture tube that gives the entire television industry a boost.

Because the COLOR BRIGHT 85 tube is *really* bright, dealers can demonstrate color TV effectively in normally lighted showrooms. As the set's brightness is adjusted, the colors remain true—not shifting to unnatural tones in the highlights of the picture.

Another thing, black and white performance is far better than you've ever seen before in a color tube. Besides the increased brightness, there's improved contrast in a sharp, vivid picture.

The new, exciting COLOR BRIGHT 85 picture tube is a product plus from Sylvania for the entire color television industry, and particularly for dealers. In color, as in black and white, you know it's good business to handle the Sylvania line.

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*Tests show the COLOR BRIGHT 85 tube is 43% brighter, on the average, than standard color picture tubes.

No other solid state stereo tuner/amplifier kit has EICO's $500-$600 quality...

and looks it. (for only $229.95)

Introducing the new 3566 all transistor F.M. MPX Stereo Tuner/Amplifier. Designed throughout to the quality level of the costliest Tuner/Amplifiers on the market.

SUPERIOR TRANSISTOR SOUND: Perfect deep bass fidelity, the clarity and detail of exactly reproduced transients . . . the sweet, airy quality achieved with extremely low distortion and extended frequency response. Plus plentiful reserve power for orchestral crescendos (even with inefficient speaker systems)—all against a velvet quiet background: This is the new **transistor sound** that is taking over in high fidelity . . . This is the sound of the superior new EICO 3566.

UNSURPASSED FM STEREO TUNER PERFORMANCE: Entirely new FM "Front End" and 4-Stage IF Strip with wideband ratio detector, developed only after the practical requirements of optimum FM Stereo performance were established by experience with earlier transistor designs in the field . . . Achieves **Minimum Bandwidth Variation with signal level** for consistently high quality reception regardless of signal strength . . . . **Handles even abnormally strong signals without overloading** (a strong local signal won't "blanket" the dial) . . . **Unsurpassed usable sensitivity** with only slightly more signal required for full 40db quieting. **Time-switching** transistor multiplex circuitry, incorporating separation and balance adjusts, achieves outstanding 38db channel separation . . . completely effective filtering of all types of interference. Noiseless, purely electronic **Automatic Switching** between FM Stereo and FM Mono (controlled by the pilot frequency in stereo broadcast signal), with defeat. **Stereo Indicator Light** gives instantly visible indication of stereo broadcasts . . . **D'Arsonval tuning meter** gives exact center-of-channel tuning indication . . . **Adjustable-threshold inter-station noise muting** gives you silence between stations while tuning, and infallible stereo program indication. Convenient Muting-Off Switch for weak station reception . . . **Exactly right AFC pull-in range** permits you to tune in stereo stations accurately with ease. Convenient AFC-Off switch for tuning in weak stations.

UNSURPASSED STEREO AMPLIFIER/PREAMPLIFIER PERFORMANCE: Entirely new amplifier/preamplifier circuitry, designed with the highest performance objectives. **Phenomenally low noise, low distortion RIAA phono preamplifiers** with maximum overload resistance. **Low distortion, variable inflection feedback tone controls** permit boost or cut at the extremes of the range without affecting mid-range response or the volume level. Isolated from power amplifier by buffer stages to eliminate loading distortion. **Unique, very low distortion drive of power amplifier output stages,** plus 36db of overall feedback to reduce distortion to an inaudible level. **No output transformers**—giving unrestricted bass response and eliminating transient distortions normally occurring due to output transformer characteristics.

SIMPLIFIED KIT ASSEMBLY: You wire only non-critical audio and power supply circuits, mostly on military-style terminal boards for easy checkout . . . **FM "Front End," 4-stage FM IF strip, and entire multiplex circuit pre-wired and pre-aligned . . . Transistor Sockets** eliminate risk of transistor heat damage . . . **This kit can be recommended to beginners!**

CONTROLS: Input Selector, Mode (incorporates FM stereo defeat), Volume, Balance, Bass, Treble, Loudness Compensation, Muting-off, AFC-off, Power on-off. INPUTS: Mag. Phono, tape, auxiliary, 300 Ω antenna. OUTPUTS: left and right speakers, tape, headphones. INDICATORS: Illuminated tuning dial, tuning meter, stereo program indicator light. FUSES: Line, Left Speaker, Right Speaker, SIZE (HWD): 5 x 16½ x 13¼ inches.

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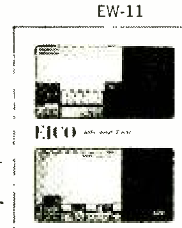

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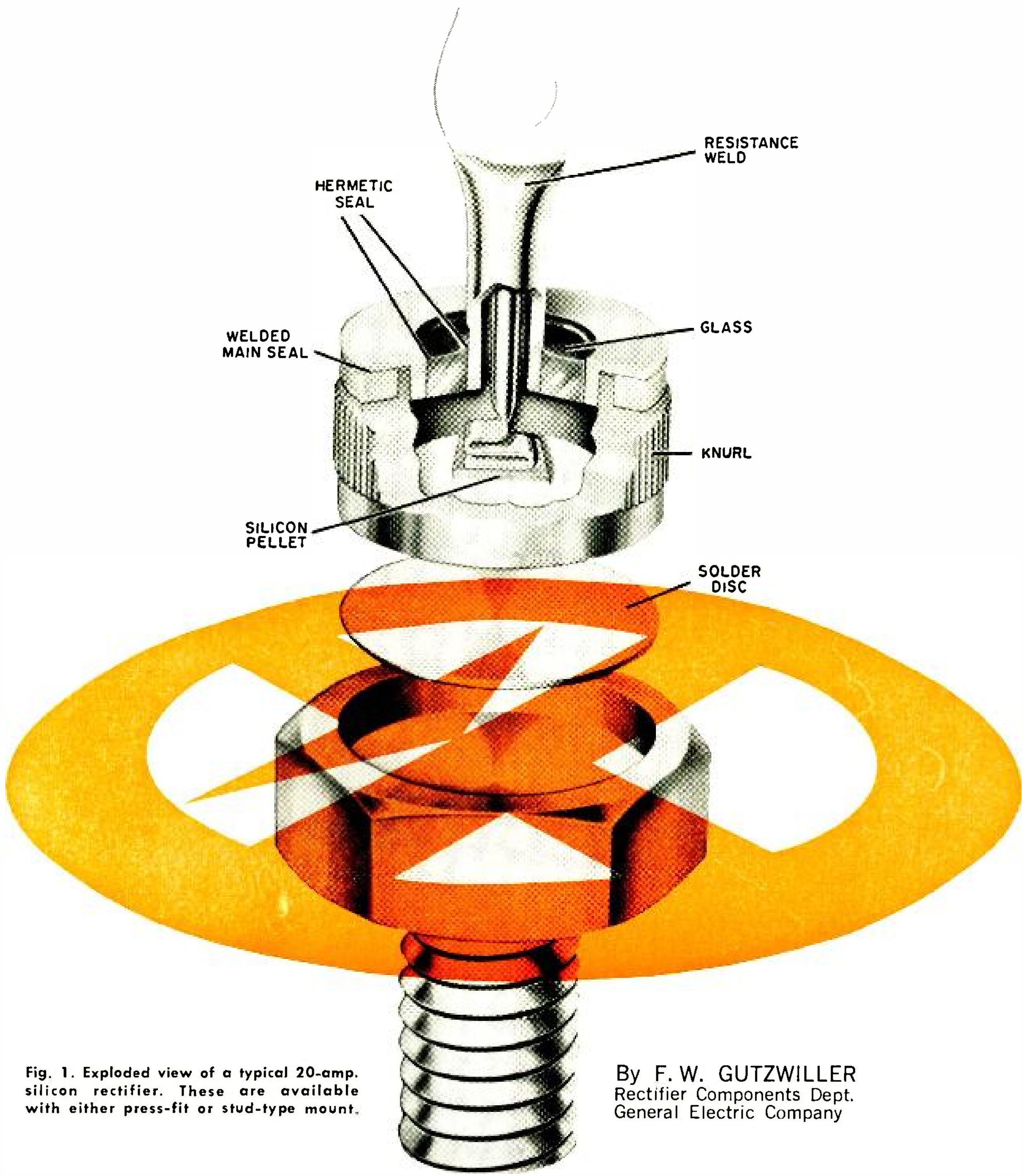


Fig. 1. Exploded view of a typical 20-amp. silicon rectifier. These are available with either press-fit or stud-type mount.

By F. W. GUTZWILLER
Rectifier Components Dept.
General Electric Company

SEMICONDUCTORS FOR POWER SUPPLIES

Solid-state rectifiers are fabricated from copper oxide, selenium, germanium, and silicon. Here is a comparison of various types and applications of each.

WHILE transistor circuits and highly regulated and sophisticated power supplies have monopolized the semiconductor spotlight in recent years, the workhorse of the electrical and electronics industries has continued to be the unregulated d.c. rectifier power supply. Often termed the "brute-force" type of power supply, its function arises from the simple fact that most electrical power is generated and distributed as alternating current, but that many uses for electrical power require direct current for proper operation. Typical d.c. uses include "B+" for TV and radio sets, computers, laboratory experiments and measurements, electroplating, motor controls, and battery charging. While motor-generator sets have been used in the past, today the static rectifier power supply usually acts as the vital conversion link between a.c. and d.c. systems.

Rectifier power supplies rely on a one-way "valve" of some kind for their power-conversion action. The ideal rectifying "valve" conducts electrical current in its forward direction with zero resistance and hence no voltage drop across it. In the opposite, or reverse, direction the ideal rectifier presents an infinite resistance to the flow of current, and hence no current flows when the voltage in the rectifier circuit is reversed. With this combination of characteristics, the ideal rectifier device operates without internal power losses and is therefore 100% efficient.

Vacuum and gas rectifier tubes furnish rectifying action by the unilateral conduction characteristics of an electron-emitting cathode and an electron-collecting anode. This action depends, however, on a precisely controlled environment (gas or vacuum) as well as a heater of some kind to "boil" electrons off the cathode. The tube cathode has inherent limitations as a source of electrons and, as a result, eventual replacement is almost inevitable in any long-term application. While tubes are excellent in their reverse-blocking characteristics, their forward resistance causes at least 15 to 20 volts drop when conducting.

Because of the obvious limitations of motor-generator sets and tube-type rectifiers, the solid-state or semiconductor rectifier with no moving parts or filaments has assumed a major role among rectifying devices in recent years. Semiconductor rectifiers in common use today are made from four different types of materials: selenium, copper oxide, silicon, and germanium. These materials receive the general classification of "semiconductors" because they exhibit alternately the characteristics of both insulating and conducting materials depending on their impurity content and temperature. While silicon's characteristics have led it to the forefront of semiconductor rectifiers for most applications, certain traits of selenium, copper oxide, and germanium have earned these types their own unique application areas.

Copper Oxide and Selenium

The first semiconductor power rectifiers used in any significant number were made of copper oxide. Developed in the early 1920's they are used today only in very specialized low-voltage applications. However, from this beginning sprang the development of selenium rectifiers in the 1930's.

While several methods are employed today for manufacture of selenium rectifiers, the following is representative of the general method used. Selenium material is evaporated in a controlled vacuum atmosphere and is deposited on an aluminum back-plate. On this layer of selenium is deposited a layer of cadmium sulfide, thus forming the rectifying junction. A counter-electrode (see Fig. 2) made of cadmium is then deposited by evaporation or spraying. To improve (form) the rectifying characteristics of the broad area junction between the selenium and the cadmium sulfide, a voltage is applied in the blocking direction of the cell for a period of time under controlled conditions. Certain types of selenium cells can then conduct up to 300 or 400 ma. per square inch of active junction area on a continuous basis under low ambient temperature conditions. At 130°C ambient, some designs are still capable of handling 160 ma./in.². The size of plate as well as the ambient temperature determine the total current rating of a cell. Plates as large as ten inches by twelve inches are commonly used, and these can handle 30 amperes on a continuous basis, and substantially more on an intermittent basis.

The ability of the "formed" cell or plate to block reverse voltage in a rectifier circuit depends on the particular process used to make it and the life expectancy desired. Maximum ratings of 45 volts r.m.s. (63 volts peak) are typical. For higher voltages, plates are stacked in series on studs, in cartridges, or in clip-type packages as shown in Fig. 3.

With rated current flowing, a voltage drop of about 1.2 volts is developed across a selenium junction. Under rated load conditions, this voltage drop slowly increases with time. The rate of this increase is a function of the manufacturing process and the current, voltage, and temperature at which the cell is operated. In time the rectifier heating due to the increasing voltage drop and the loss in d.c. voltage across the load may require the rectifier to be replaced. Under normal conditions of operation, a well-fabricated, conservatively used selenium rectifier will have a useful life expectancy of at least 80,000 hours of operation.

Silicon

The past ten years have seen silicon move into the forefront of all rectifying devices. While it is one of the most common materials in the earth's crust, silicon must be refined to an extremely high degree before it is suitable for rectifying junctions. For high-performance rectifier units made from silicon, impurity levels less than one part in 10,000,000,000 must be attained. A small wafer of refined silicon, typically 0.01-inch thick, acts as the parent material. Into this wafer is carefully alloyed (melted) or diffused (gaseous penetration) another material such as aluminum or boron. The interface or junction between the parent silicon and the added material exhibits the rectifying characteristics. When mounted to a suitable cooling medium such as an air-cooled fin, a silicon rectifying junction can operate at current densities of 1000 amperes per square inch without overheating and with less than one volt developed across the wafer. A small chip of silicon less than 0.2 inch on a side is sufficient for the heart of a 30-amp device.

Fig. 2. Cutaway of selenium-rectifier cell.

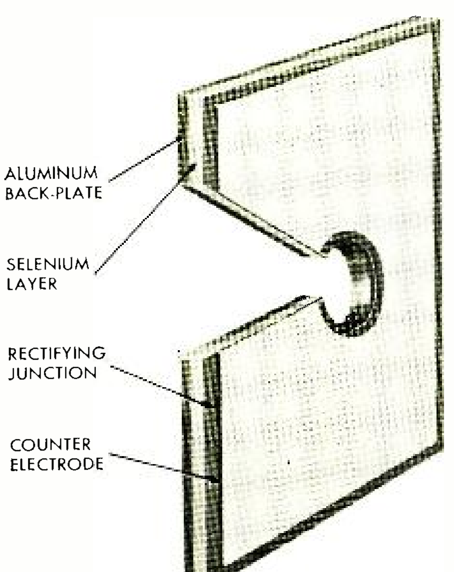


Fig. 3. Selenium rectifiers come in a variety of sizes and shapes as shown.

In its reverse or current-blocking direction, well-built silicon rectifiers can block as high as several thousand volts with a leakage current of only a few microamperes although typical commercial-grade silicon devices are usually designed and fabricated for operation at considerably lower voltages, such as 200 or 400 volts peak.

Because the full circuit voltage must be blocked across only a few thousandths of an inch of creepage distance on the surface of the rectifying junction, this surface must be protected against contamination by moisture and other foreign substances. Hence the basic rectifying junction is sealed in an impervious housing of some type. While plastic encapsulations are used for some types made today, maximum reliability and life expectancy is attained only by true hermetically sealed housings. One such type is shown in cross-section in Fig. 1 for a typical 20-ampere silicon rectifier.

Properly designed and fabricated silicon rectifiers can operate indefinitely without measurable change in their characteristics provided the hottest spots at their rectifying junctions do not exceed 175 to 200° C. In spite of their extremely good efficiency (less than 1% losses in typical applications), the heat developed at the small junction must be carried away efficiently if the junction is not to overheat and thus fail. For this reason some types of silicon rectifiers are furnished with a stud or knurled housing for bolting or pressing into a cooling fin. Other types come from the semiconductor manufacturer already attached to cooling fins with several fins on a common mounting base and connected for the particular circuit requirements. Silicon rectifiers with current ratings below approximately 1½ amperes require no cooling fin. Fig. 4 shows examples of several silicon rectifier types. Individual silicon rectifier diodes with current ratings up to approximately 500 amperes are available.

Generally the heat sink or housing of the rectifier is common with the cathode connection of the rectifier, although reverse-polarity types are also available from some makers.

Germanium

Germanium rectifiers, like silicon, use single-crystal metal for their basic junction material, unlike selenium and copper-oxide rectifiers which use polycrystalline material. The development of the germanium type actually preceded the silicon by about five years and was stimulated by the development of the transistor. Both externally and internally, germanium rectifiers look much like silicon devices. The rectifying junction is formed by alloying a dab of indium metal into the surface of a germanium chip. Chemical or electrolytic etching is usually necessary to optimize the reverse blocking characteristics of the device.

In its reverse blocking ability, the germanium rectifier is inferior to silicon, being capable of about 400 volts maximum. However, in its forward or conducting direction, germanium rectifiers develop only about one-half of the voltage drop of silicon. Maximum operating junction temperature of germanium rectifiers is limited to about 125°C since the indium alloy melts at 155°C. Today individual germanium rectifier diodes are available with ratings up to 2 amperes.

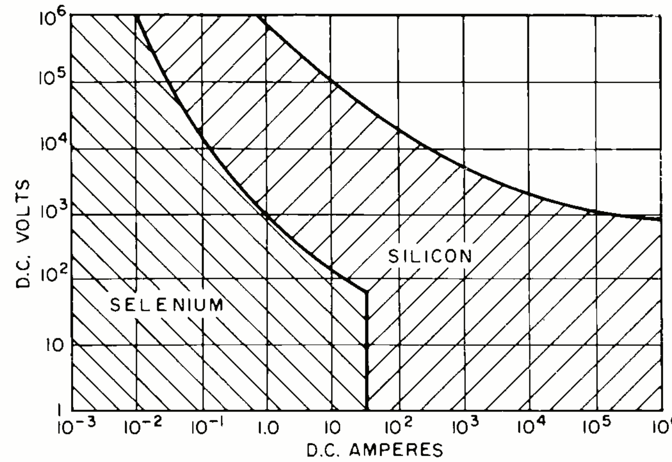


Fig. 5. Areas of application for selenium and silicon rectifiers.

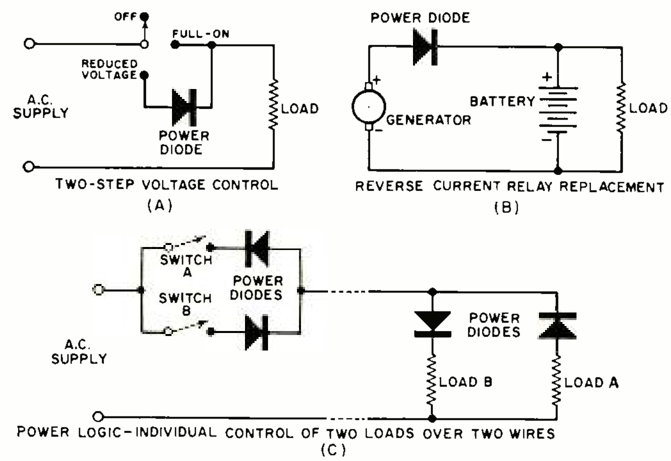


Fig. 6. Some non-rectifier uses for semiconductor power diodes.

Fig. 4. Various types of silicon rectifiers.

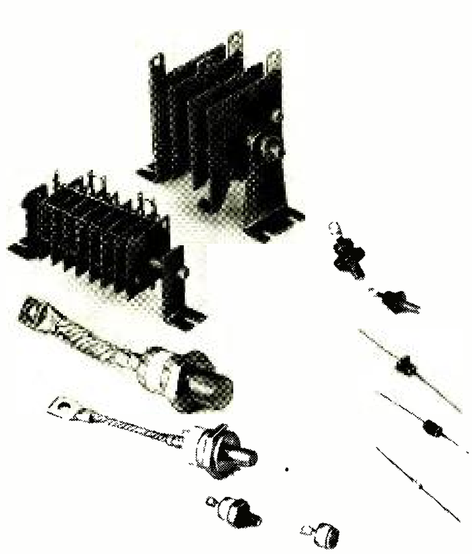


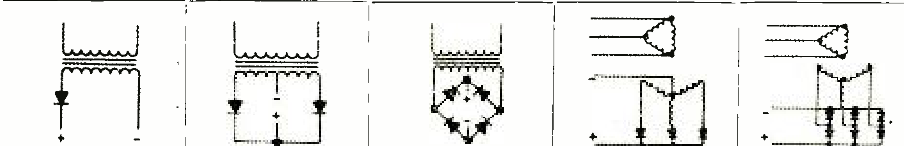
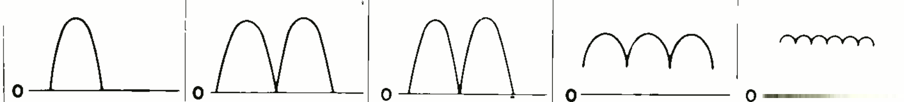
Table 1. Comparison of characteristics of typical semiconductor rectifiers.

	COPPER OXIDE	SELENIUM	SILICON	GERMANIUM
Average Current Density (amps/sq. in.)	0.1	0.2	1000	200
Peak Reverse Voltage (volts)	25	63	1200	300
Forward Voltage Drop at Rated Current (volts) New	0.5	1.2	0.9	0.5
Aged	0.55	2.4	0.9	0.5
Max. Junction Temperature (°C)	65	130	200	105
Size	Large	Large	Very small	Small
Ability to Recover from Voltage Transients	Excellent	Excellent	Poor	Quite poor
Unforming (loss of rectifier characteristics on shelf)	None	Some	None	None
Overload, Fault Capacity	Excellent	Good	Poor	Poor
Frequency Response	Poor	Poor	Good	Good
Life	Very long	60,000 to 100,000 hrs. normal	Very long	Very long

Table 1 lists a comparison of the main characteristics and application considerations of the four types of semiconductor rectifiers. While the features of silicon and its attractive component cost, which is as low as 30 to 40 cents per kilowatt of rectified energy in medium-current applications, make it the best choice for most applications, the other three types have maintained their superiority in a good many areas in electronics where applications are more highly specialized.

Compared to silicon, selenium is much less subject to damage from overloads and overvoltage transients. Its large junction area can absorb the additional heating of momentary surge currents. Also, a selenium junction can heal itself after an otherwise damaging voltage transient has occurred, unlike typical silicon and germanium cells which can develop a short circuit across the junction under the influence of a momentary transient. For this reason, selenium continues to be used often in such applications as relay and transformer switching circuits where severe transient voltages are commonly developed, and in garage-type battery chargers where common practice is to short circuit the d.c. terminals of the charger to determine if the charger is operating. Because large numbers of small-diameter selenium punchings from a larger plate can be economically stacked in series, selenium is also the most economical method of rectification for very high voltage at low currents (*Continued on page* 114)

Table 2. A listing of the major rectifier circuits in common use along with their most important operating characteristics.

TYPE OF CIRCUIT		SINGLE-PHASE HALF-WAVE	SINGLE-PHASE CNTR-TAP	SINGLE-PHASE BRIDGE	THREE-PHASE STAR (WYE)	THREE-PHASE BRIDGE		ASSUMES ZERO FORWARD DROP AND ZERO REVERSE CURRENT IN RECTIFIERS AND NO A.C. LINE OR SOURCE REACTANCE
PRIMARY / SECONDARY								
ONE CYCLE WAVE OF RECTIFIER OUTPUT VOLTAGE (NO OVERLAP)								TO DETERMINE ACTUAL VALUE OF PARAMETER IN FIRST COLUMN, MULTIPLY FACTOR SHOWN BY VALUE OF
NUMBER OF RECTIFIER ELEMENTS IN CIRCUIT		1	2	4	3	6		
AVERAGE D.C. VOLTS OUTPUT	=	1.00	1.00	1.00	1.00	1.00	×	AVERAGE D.C. VOLTAGE OUTPUT
R.M.S. D.C. VOLTS OUTPUT	=	1.57	1.11	1.11	1.02	1.00	×	AVERAGE D.C. VOLTAGE OUTPUT
PEAK D.C. VOLTS OUTPUT	=	3.14	1.57	1.57	1.21	1.05	×	AVERAGE D.C. VOLTAGE OUTPUT
PEAK REVERSE VOLTS PER RECTIFIER ELEMENT	=	3.14	3.14	1.57	2.09	1.05	×	AVERAGE D.C. VOLTAGE OUTPUT
	=	1.41	2.82	1.41	2.45	2.45	×	R.M.S. SECONDARY VOLTS PER TRANSFORMER LEG
	=	1.41	1.41	1.41	1.41	1.41	×	R.M.S. SECONDARY VOLTS LINE-TO-LINE
AVERAGE D.C. OUTPUT CURRENT	=	1.00	1.00	1.00	1.00	1.00	×	AVERAGE D.C. OUTPUT CURRENT
AVERAGE D.C. OUTPUT CURRENT PER RECTIFIER ELEMENT	=	1.00	0.500	0.500	0.333	0.333	×	AVERAGE D.C. OUTPUT CURRENT
R.M.S. CURRENT PER RECTIFIER ELEMENT (RESISTIVE LOAD)	=	1.57	0.785	0.785	0.587	0.579	×	AVERAGE D.C. OUTPUT CURRENT
R.M.S. CURRENT PER RECTIFIER ELEMENT (INDUCTIVE LOAD)	=	—	0.707	0.707	0.578	0.578	×	AVERAGE D.C. OUTPUT CURRENT
PEAK CURRENT PER RECTIFIER ELEMENT (RESISTIVE LOAD)	=	3.14	1.57	1.57	1.21	1.05	×	AVERAGE D.C. OUTPUT CURRENT
PEAK CURRENT PER RECTIFIER ELEMENT (INDUCTIVE LOAD)	=	—	1.00	1.00	1.00	1.00	×	AVERAGE D.C. OUTPUT CURRENT
RATIO PEAK TO AVERAGE CURRENT PER ELEMENT (RESISTIVE LOAD)		3.14	3.14	3.14	3.63	3.15		
RATIO PEAK TO AVERAGE CURRENT PER ELEMENT (INDUCTIVE LOAD)		—	2.00	2.00	3.00	3.00		
% RIPPLE (R.M.S. OF RIPPLE/AVERAGE OUTPUT VOLTAGE)		121%	48%	48%	18.3%	4.2%		
		RESISTIVE LOAD		INDUCTIVE LOAD OR LARGE CHOKE INPUT FILTER				
TRANSFORMER SECONDARY R.M.S. VOLTS PER LEG	=	2.22	1.11 (TO C.T.)	1.11 (TOTAL)	0.855 (TO NEUTRAL)	0.428 (TO NEUTRAL)	×	AVERAGE D.C. VOLTAGE OUTPUT
TRANSFORMER SECONDARY R.M.S. VOLTS LINE-TO-LINE	=	2.22	2.22	1.11	1.48	0.740	×	AVERAGE D.C. VOLTAGE OUTPUT
SECONDARY LINE CURRENT	=	1.57	0.707	1.00	0.578	0.816	×	AVERAGE D.C. CURRENT OUTPUT
TRANSFORMER SECONDARY VOLT-AMPERES PER LEG	=	3.49	1.57	1.11	1.43	1.05	×	D.C. WATTS OUTPUT
TRANSFORMER PRIMARY R.M.S. AMPERES PER LEG	=	1.57	1.00	1.00	0.471	0.816	×	AVERAGE D.C. CURRENT OUTPUT
TRANSFORMER PRIMARY VOLT-AMPERES PER LEG	=	3.49	1.11	1.11	1.21	1.05	×	D.C. WATTS OUTPUT
AVERAGE OF PRIMARY AND SECONDARY VOLT-AMPERES	=	3.49	1.34	1.11	1.35	1.05	×	D.C. WATTS OUTPUT
PRIMARY LINE CURRENT	=	1.57	1.00	1.00	0.817	1.41	×	AVG. LOAD I × SEC. LEG E ÷ PRI. LINE E
LINE POWER FACTOR		—	0.900	0.900	0.826	0.955		

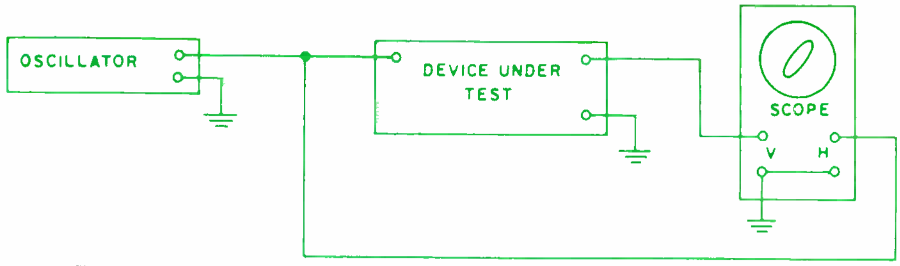


Fig. 1. Equipment setup employed for the measurement of phase shift on scope.

phase-shift Nomogram

By LARRY W. BRINDLEY

Graphical method of determining phase shift by measuring 1:1 Lissajous pattern on oscilloscope.

PHASE shift is usually measured by using the cathode-ray oscilloscope method. In this method, a reference-phase alternating voltage is one input and the unknown-phase alternating voltage is the other input. The combination of these two alternating voltages results in a pattern produced on the screen of the scope. The pattern produced is a straight line, circle, or ellipse depending upon the phase difference. The phase shift is calculated by using the formula: $\sin\theta = B/A$, where the ratio B/A is the ratio of the intercept B to the maximum A, as shown in Fig. 2.

To use this method, adjust the undeflected beam to the center of the CRT as shown by the midlines of the grid. Apply the unknown voltage to the vertical input and adjust the gain for any convenient deflection. Disconnect this input and apply the reference voltage to the horizontal input. Adjust the gain so that the amplitude is the same as for the vertical input. Reconnect the unknown voltage without changing the amplification. See Fig. 1. Measure A and B in any equal units. The angle whose sine is the B-to-A ratio is the desired angle of the unknown phase shift.

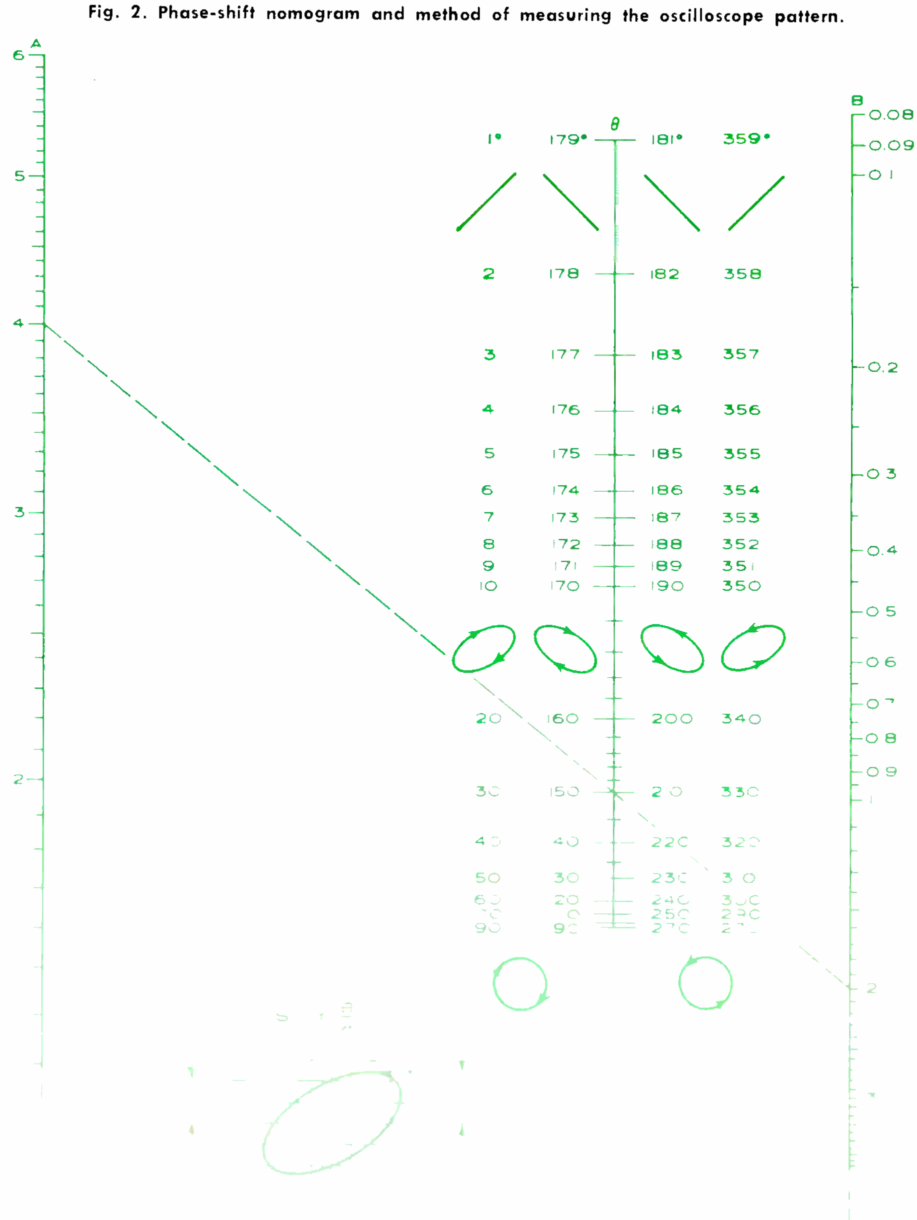
The nomogram of Fig. 2 facilitates this calculation. A solution can be obtained by using the scales A, B and θ. Place a straightedge between the pattern height value on the A scale and the intercept value on the B scale. Read the unknown angle on the θ scale.

The nomogram shows that two answers may be obtained for each pattern. Several methods have been developed to determine if the angle is "leading" or "lagging."

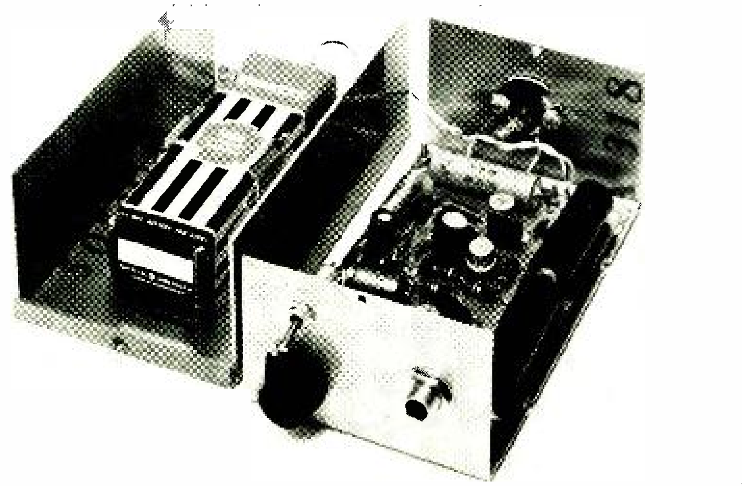
The simplest way to resolve this problem is to delay the unknown phase by a small amount. This can be done by means of a phase-shifting network connected in series between the source and the scope. The small additional delay will change the pattern. This change will be toward different limiting patterns depending on the beam rotation. For example, a 40-degree ellipse will become rounded and tend toward a circle when delayed, where on the other hand a 320-degree pattern that looks similar will shift toward a straight line when the delay is added.

As an example of the use of the nomogram, assume that the maximum deflection is 4 units and the intercept is 2 units, the ellipse major axis tilt is to the right and the beam rotation is clockwise. Construct a straight line from 4 on the A scale to 2 on the B scale. This line intercepts the θ scale at the 30, 150, 210, and 330-degree points. By the tilt of the ellipse the choice is reduced to either 30 or 330 degrees. For clockwise rotation of the beam select 30 degrees. Thus there is a 30-degree phase difference between the applied voltages. ▲

Fig. 2. Phase-shift nomogram and method of measuring the oscilloscope pattern.



audio-compression preamplifier



The circuit was constructed on a 3" x 4" piece of fiber board which was mounted with the battery in a small utility box.

By JESS C. WRIGHT/ Cubic Corp.

Circuit using negative feedback to produce 20 db of compression with low distortion and wide frequency response. Can be used with low-level mikes in p.a., recording, or modulator applications.

THIS article will cover the theory and design of a negative-feedback audio-compression preamplifier. The circuit is designed as a modular microphone preamplifier with wide frequency response and 20 db of audio compression. The circuit is relatively simple, using only three transistors and three diodes as active elements.

The limiting of audio dynamic range is usually accomplished by one of two basic methods. Fig. 1 illustrates the waveform produced by these two methods and compares it to the waveform of the audio-compression preamplifier. Let Fig. 1A be the input signal. Fig. 1B shows the output of a conventional audio limiter. The peaks of the output are clipped, thus creating gross harmonic distortion. This type of limiting can be achieved by a shunt pair of diodes. The circuit is very simple but for most uses the distortion is undesirable.

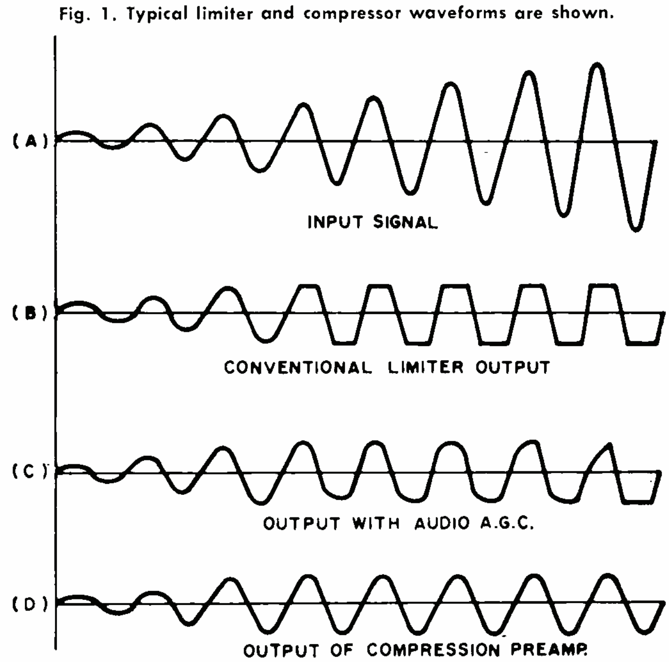
Fig. 1C is the output waveform caused by varying the bias to a transistor amplifier stage (audio a.g.c.). The harmonic distortion in this case need not be as severe as the limiter. However, the distortion is still too high for good quality audio signals. Various complex circuits and *LC* filters have been used to reduce this distortion to acceptable levels. Fig. 1D illustrates the output of the compression preamplifier to be described below; note the absence of gross distortion that is obtained without resorting to any filters.

Theory of Operation

The theory of operation is very simple. It has been shown that for a transistor voltage amplifier, gain is: G=(approx.) $R_L/(R_e+R_b)$, where R_L is the load resistance, R_e is the unbypassed emitter resistor, and R_b is the emitter-base diode resistance. If R_e is much larger than R_b, the gain reduces to G=(approx.) R_L/R_e. Stage gain can clearly be controlled by controlling R_e, but changing R_e also changes the circuit operating point. If a circuit is designed with $R_L=R_e$ then the gain is unity (this is a split-load phase inverter). However, if R_e is bypassed by a large capacitor, the gain is R_L/R_b, a very much higher value.

Fig. 2 is the basic feedback circuit. In this circuit $R_e=2R_L$, therefore with no emitter bypassing the amplifier, gain is ½. If

Fig. 1. Typical limiter and compressor waveforms are shown.



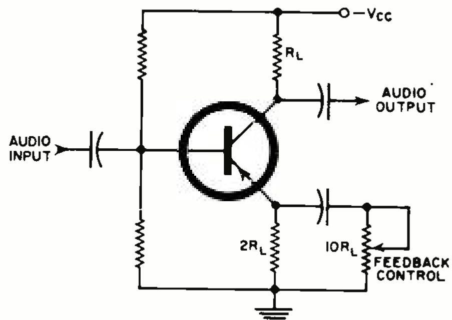


Fig. 2. Basic circuit arrangement employed in audio compression preamp.

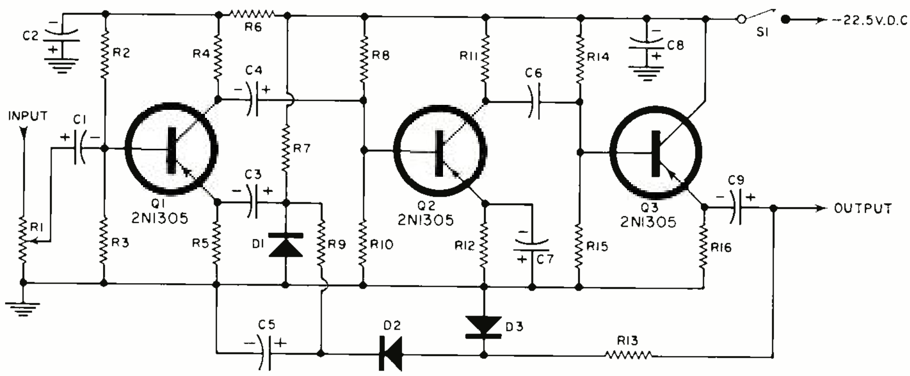


Fig. 3. Three inexpensive transistors are used in the circuit. Output voltage is rectified by D2 and D3; resultant d.c. changes resistance of the diode D1.

R1—5000 ohm pot	R8—100,000 ohm, ½ w. res.	C4—1 μf., 15 v. elec. capacitor
R2,R14,R15,—18,000 ohm, ½ w. res.	R9—3300 ohm, ½ w. res.	C5—25 μf., 6 v. elec. capacitor
R3—22,000 ohm, ½ w. res.	R11—4700 ohm, ½ w. res.	C6—.1 μf. capacitor
R4,R10,R16—2700 ohm, ½ w. res.	R12—210 ohm, ½ w. res.	C7—100 μf., 6 v. elec. capacitor
R5—6800 ohm, ½ w. res.	C1—10 μf., 15 v. electrolytic capacitor	S1—S.p.s.t. toggle sw.
R6,R13—680 ohm, ½ w. res.	C2,C8—100μf., 25 v. elec. capacitor	D1,D2,D3—1N270 diode
R7—47,000 ohm, ½ w. res.	C3,C9——15 μf., 15 v. elec. capacitor	Q1,Q2,Q3—2N1305 transistor

a large variable resistor is placed in series with the bypass capacitor, the effective value of R_e can vary from 0 to nearly $2R_L$ and the gain can, in theory, be changed from R_L/R_L to ½. In the derivation of this formula, the assumption was made that h_{fe} of the transistor was large compared to the gain, therefore in practice a maximum circuit gain in the order of approximately 10 to 30 is practical.

Practical Circuit

The circuit of Fig. 3 is one built by the author to prove the theory of operation and to provide a microphone preamplifier for an AM modulator. The variable resistor of Fig. 2 has been replaced by a diode (*D*1). The resistance of the diode is controlled by a d.c. voltage of an amplitude proportional to the output level.

The first amplifier stage is used as the control stage. With no input signal, the diode *D*1 is biased to saturation by the 47,000-ohm resistor (*R*7). In this condition *Q*1 is fully bypassed and has maximum gain. For small input signals then, *Q*1 has full gain, *Q*2 further amplifies the signal to a useful level, and *Q*3 provides a low-impedance emitter-follower output.

As the input signal increases, diodes *D*2 and *D*3 rectify a portion of the emitter-follower output and apply a positive potential to diode *D*1. This voltage brings *D*1 out of saturation and increases its resistance. This reduces the gain of *Q*1 and holds the output level constant. The output level is thus held constant until the gain of *Q*1 is reduced to its minimum value. At this point the output of the amplifier again linearly follows the input, but at a reduced gain slope. Fig. 4 is the output characteristic of the amplifier shown in Fig. 3. Note that signals up to 1.5 mv. have a gain of approximately 1200 times.

The output is then relatively constant until an input of about 27 mv. At this point *Q*1 has reached minimum gain and the amplifier takes on the gain slope of 120. Thus the reduced gain at large signal levels prevents early overloading of the amplifier and adds a further amount of compression of large signals.

The control voltage is really negative feedback. Care must be taken to assure that the amplifier does not "motorboat." For this reason the interstage coupling capacitors are small to limit low-frequency response. The dotted line in Fig. 5 shows the frequency response with the control loop open. Notice that gain drops to unity at about 42 cps. The filter time constant of the feedback loop (*R*9 and *C*5) is $T=RC=3.3\text{ k}\times 25$ μf. = 82.5 milliseconds, or the feedback loop bandwidth is $f=1/T=12$ cps. A criterion for a stable feedback amplifier is: if the amplifier gain is unity at a frequency above the feedback loop bandwidth, the amplifier will be stable. Since 42 cps is almost two octaves above the loop bandwidth, the amplifier is unconditionally stable.

The solid line of Fig. 5 shows the closed-loop frequency response. Note how the feedback has improved the bass response. The 3-db point has gone from 190 cps to 58 cps. While this is not high fidelity, this unit is designed for communications where the bandpass is more than adequate. It is assumed that for voice communications where a 300 to 3000 cps bandpass is desired, the band limiting would occur in the modulator or driven amplifier. (*Continued on page* 79)

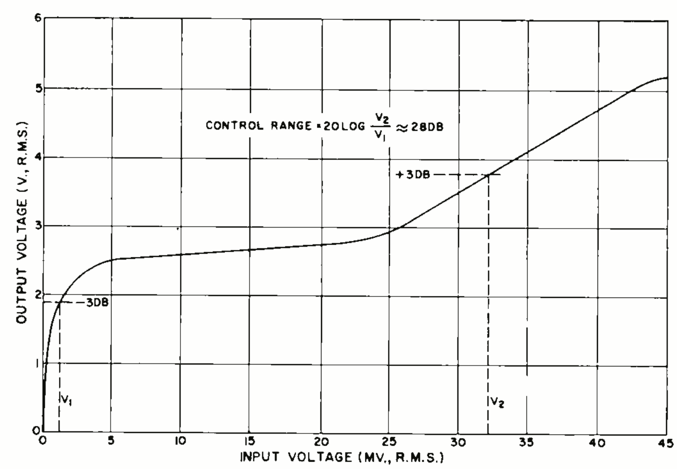
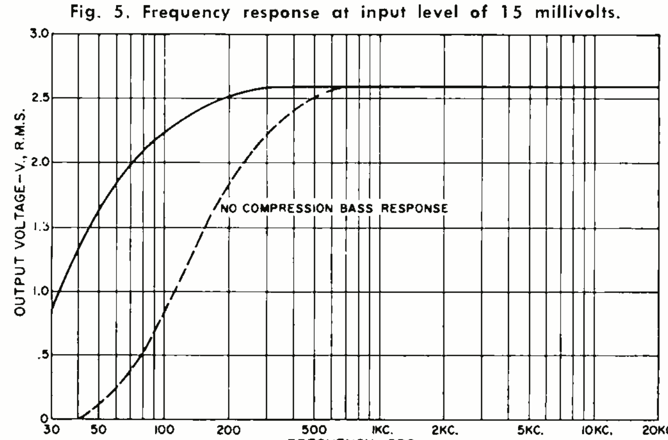
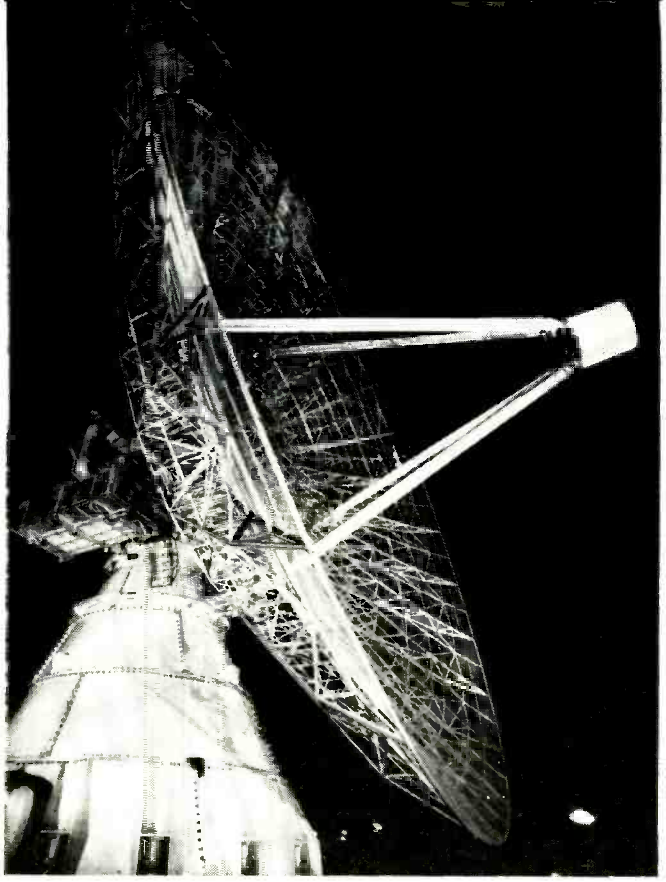


Fig. 4. Output voltage versus input voltage for the preamp.

Fig. 5. Frequency response at input level of 15 millivolts.



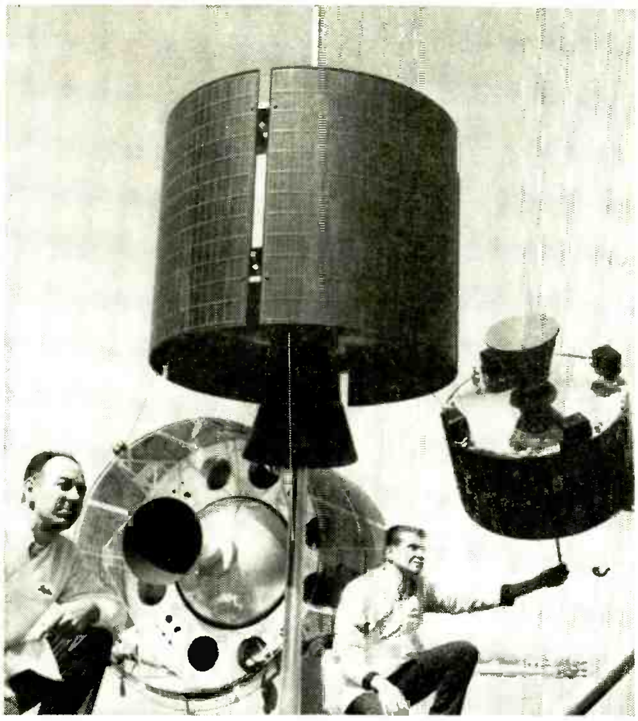
RECENT DEVELOPMENTS in ELECTRONICS



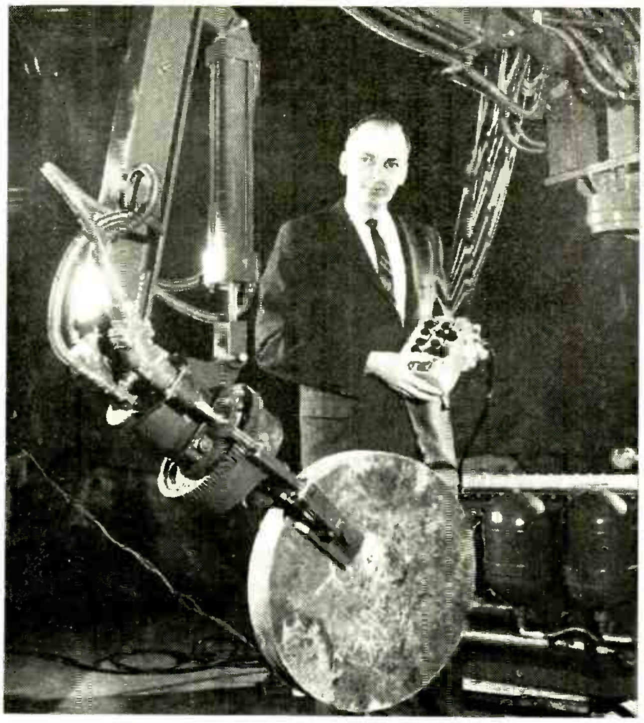
Round-the-clock Space Tracker. (Above) This 84-foot radar antenna, housed within a giant white radome at Moorestown, N.J., is the only installation in the U.S. performing round-the-clock space-tracking service. All data on satellites and satellite debris, both the Western Allies' and the Russians', is fed into the USAF Air Defense Command headquarters at Colorado Springs. Utilizing data in a computer at the headquarters, the giant antenna locates and tracks the satellite and transmits its information back to the computer. Should a satellite's orbit change or should an unrecorded object be detected, this information is flashed to Colorado Springs for checking. Inside the facility, an operations director and eight technicians—all RCA employees—are on duty at all times under the direction of USAF personnel.

Powerful X-ray Tube. (Above) A new x-ray system, so powerful it can "watch" the shifting patterns of atoms during the making of man-made diamonds, has been developed at the Westinghouse Research Laboratories. Scientists will use the system to study the structural changes that occur in crystalline materials under very high temperatures and pressures. Heart of the new system is a special high-intensity x-ray tube which produces extremely intense beams of x-rays. The tube's high power comes from a water-cooled, rotating anode, or target, where the x-ray beam originates. The beam passes through the crystal sample and strikes a photo film or electronic x-ray detector. A slight diffraction of the beam as it passes through the sample gives a visual pattern that shows the crystal structure. The tube has developed a beam of 140 milliamperes at a voltage of 50 kv.

Automated Cardiac Survey. (Left) Five hundred Alexandria, Va. people, some with known heart ailments, are participating in a project described as the first automated at-home cardiac survey on a community-wide basis. Electrocardiograms are being made with a 7-lb., battery-operated Honeywell "Cardioview" carried into homes by public-health nurses. The heart impulses are transmitted by telephone directly to an instrumentation and data-processing center in the nation's capital across the Potomac river. Through similar and larger surveys, the incidence in a city or region of various types of heart disease for different age groups can be learned and thus lead to preventive measures. The EKG's are stored on magnetic tape and monitored with an oscilloscope. The photo shows a 13-year-old rheumatic-fever victim having his electrocardiogram taken.

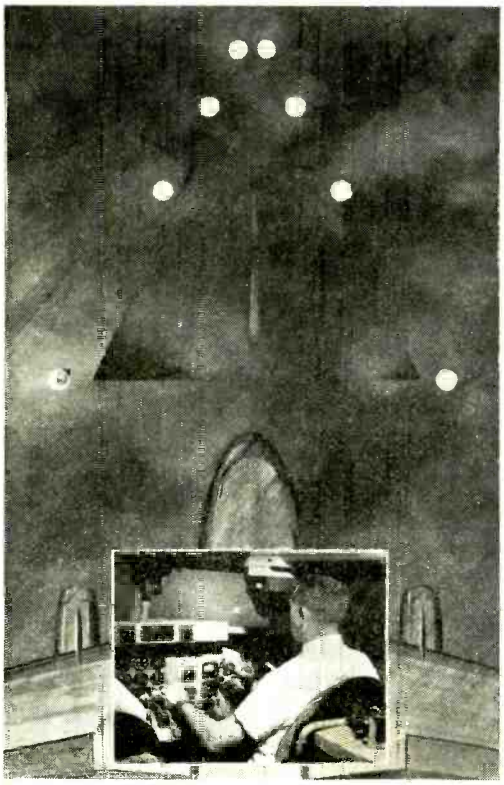


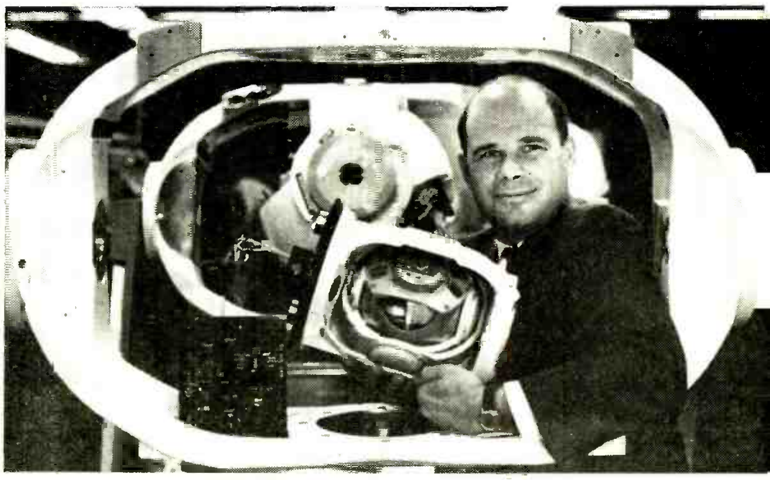
Simple Communications Satellites. (Above) The simplicity of design for communications satellites is observed by Hughes technicians on the first "birthday" of Syncom II, still in its 22,300-mile-high orbit—well above harmful radiation. Company scientists predicted a 10-yr. life for future such satellites, including the Advanced Technological Satellite (ATS) at lower left, Comsat's "Early Bird" (center), and Syncom III (right).



Underwater Mechanical Arm. (Above) This rugged underwater mechanical arm designed to recover objects from the ocean's depths is shown being tested prior to delivery to the Navy. The arm consists of a 10-foot-long hydraulic structure whose operation is electronically controlled by means of an ACF Industries control system. The arm is now attached to the underside of the bathyscaphe Trieste, and can be used to pick up from the ocean floor objects weighing in excess of 500 lbs.

All-weather Landing Aid. (Below) Those white dots outline an airport runway as a pilot "sees" it with "Microvision," a new all-weather landing aid demonstrated by Bendix. Electronic beacons placed parallel to the runway emit microwave signals received by the plane and appear on a viewing window in the cockpit just as normal runway lights show up in clear-weather night landing.





Commercial Inertial. (Above) Framed by the gimbals of a submarine inertial navigation system, Sperry engineer is shown holding similar equipment to be used in commercial airlines' first inertial navigation system. The compact airborne system is to be installed beginning next summer in Pan American's entire fleet of 707 jet aircraft. Design of both the gyroscope and the microcircuit computer in the system resulted in a major reduction in the initial price and the cost of maintenance. Even so, the entire purchase contract amounts to $12.5 million. In the beginning, maintenance will be done by Sperry but it is expected that the airline's maintenance technicians will be trained to take over the maintenance function after a certain period of time.

By WALTER H. BUCHSBAUM

SHIELDED CABLES

These interconnecting cables are the nervous system of most electronic hookups. There are many types of cables and the choice should be made with a full understanding of their particular characteristics.

WHENEVER we consider electronics systems—be it a home stereo system, space telemetry equipment, or a business computer—little attention is usually paid to the cables which interconnect the various parts of the system. We tend to take these interconnecting devices for granted, never realizing that they are the nerves, the vital signal paths, without which the entire system could not function. Yet, rocket and satellite launchings have failed because of a faulty cable, and anyone working with home electronics knows that broken or frayed cables account for a surprising number of defects. In this article we want to focus attention on the many types of cables available and the vital role they play in over-all equipment operation.

Single-conductor wires are usually used only within a cabinet or chassis. Whenever signals are brought from one unit to another, shielded cable is frequently required. Depending on the signals and their frequency, this may be a coaxial cable, or simply one or more wires surrounded by a metal shield. The type of cable usually determines the type of connector used with it, but because of space limitations, this article will consider only the actual cables that are used.

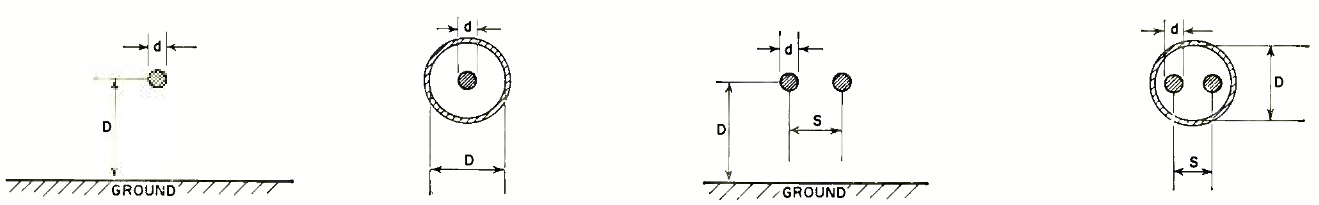
Since World War II, the number of different cable types has increased just as rapidly as the rest of the electronics industry so that today we have a choice of over 100 military standard cables, identified by the familiar RG. . . ./U nomenclature, and at least as many different types of cables for civilian and special-purpose applications. One interesting fact is that some of the basic characteristics have remained at the standard values. Impedances of r.f. coaxial cables, for example, are limited to a nominal 50, 75, or 93 ohms. Cables differ greatly in size, frequency and attenuation characteristics, environmental capability, and in the effectiveness of the shield. This latter factor has particular importance in applications such as audio and industrial instrumentation where low-level, noise-free signals must be transmitted.

In the following paragraphs, the reader will find the basic factors which must be known to select the right type of cable, and a description of coaxial and other shielded cables with emphasis on special performance characteristics of the latest cable types. While this article cannot claim to make the reader an expert on shielded cables, it contains the fundamental concepts necessary for choosing a cable for either new equipment or for replacing existing cables.

Why Shielded Cable?

The problem of connecting two electronic circuits or two different equipments together is as fundamental and also as important as Ohm's Law. In many instances, Ohm's Law determines the method of interconnection. But at radio frequencies, it may be Maxwell's equations that define the interconnecting device. In every case, however, the correct method of interconnection is a vital part of the over-all electronic operation. If the connection between the phono pickup arm and the preamplifier were simply a pair of separate wires, excessive hum and noise could ruin the signal. If the connection between the antenna and a short-wave receiver were made of even the best grade of audio cable, little r.f. signal might reach the receiver.

Many factors, in addition to frequency, will determine the type of connecting cable which will give the best performance. Signal losses may not be important in the audio cables which drive the speakers of a stereo system, but in a community-TV system, the losses due to the cable become critical if a high signal-to-noise ratio must be maintained.



(A) $$Z_0 = \frac{138}{\sqrt{e}} \log_{10} \frac{4D}{d}$$

(B) $$Z_0 = \frac{138}{\sqrt{e}} \log_{10} \frac{D}{d}$$

(C) $$Z_0 = \frac{276}{\sqrt{e}} \log_{10} \left[\frac{2S}{d\sqrt{1+\frac{S^2}{4D^2}}} \right]$$

(D) $$Z_0 = \frac{276}{\sqrt{e}} \log_{10} \left[\left(\frac{1-\frac{S^2}{D^2}}{1+\frac{S^2}{D^2}} \right) \left(\frac{2S}{d} \right) \right]$$

Fig. 1. Some basic transmission lines and their impedance equations. The symbol "e" is the insulator dielectric constant.

It may seem that any shielded cable would assure noise-free signals between the microphone and its amplifier, but measurements show that different types of shielded cables may vary as much as 20 db (a hundred times the power) in the amount of noise picked up.

Whether a new design or arrangement of different equipment is involved, or if a substitute cable is needed for replacement, the same considerations go into the selection of the proper cable. For the reader's convenience, we have listed eight basic factors which will determine the choice of a cable, or at least narrow the choice down to a few different types. These factors can be used as a check list in practically every type of electronic system in which shielded cable is used.

Frequency: The frequency band which must be transmitted is of prime importance. Frequency affects not only the attenuation due to the cable, but also the power rating, the amount of phase shift, reflections or ghosts, and the impedance.

Impedance: The characteristic impedance or surge impedance of cables is discussed in more detail in a later paragraph, but impedance matching between the output of one and the input of another device is a general requirement in all electronic work. Therefore the impedance of a cable is usually a very important factor.

Attenuation: We know that every conductor has some losses. Depending on the frequency, the length of the transmission path, power levels of the signals, and the construction of the cable itself, the attenuation or reduction in power due to the cable must be determined. We shall see that attenuation varies greatly with frequency and with different cable construction. Generally speaking, the attenuation consists of losses due to the resistance of the copper path, radiation losses, and dielectric losses in the insulator. The latter is especially dependent on signal frequency.

Power: Transmitted power will determine the dimensions of the cable, together with such considerations as permissible attenuation, frequency, and length of line. In the milliwatt range, small-dimensional cables are sufficient, but when watts or kilowatts of power are to be sent over the cable, the size of the conductors and, therefore, the over-all size of the cable will increase accordingly.

Noise and Radiation: The main reason for using shielded cable is to keep the transmitted signal in and undesirable signals out. The effectiveness of the shielding properties against noise are particularly important when dealing with low-level signals such as audio from the microphone, video from the camera, or r.f. from the receiving antenna. Radiation becomes a problem in applications where the signals from one cable must not interfere with other signals in the equipment. Even in telephone or other communications systems, crosstalk due to coupling between cables can be a serious problem and radiation has to be kept to a minimum. We shall cover special audio cables, such as the "Beldfoil" construction, which have extremely low radiation and noise levels, in a later paragraph.

Capacitance: A certain capacitance theoretically exists between any two conductors, and in shielded cables this can be quite substantial. When pulse signals with steep sides are transmitted, this capacitance has the effect of rounding off the corners. A square wave can be changed to look almost like a clipped sine wave. Careful consideration must be given to this effect and, if necessary, compensating circuits may be used with the cable.

Size and Weight: There are few instances where the size and weight of a cable are not important. Usually outdoor cables must be supported somehow, or the available space in the equipment is limited. Connectors, which depend on the type and size of the cable, are another important factor, but in this article, connectors will not be considered.

Environmental Conditions: These words usually make us think of such extreme environments as outer space or high-flying aircraft. Actually, the use of cables outdoors presents very severe environmental conditions, too. A community-TV cable exposed to average weather conditions can suffer quite a bit over the period of just one year. The effects of the sun's radiation, chemical air pollution in metropolitan or industrial areas, or the abrasion encountered in ice or due to storms all require careful cable selection.

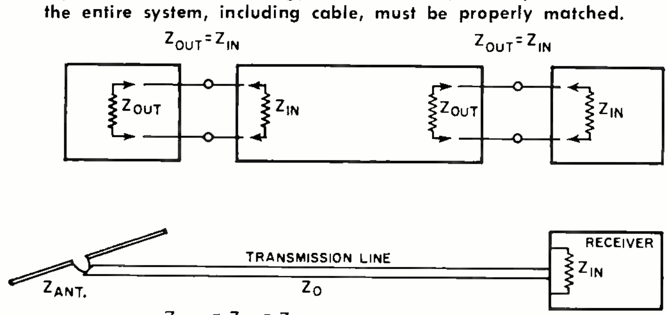
All of these factors combine to require an amazing variety of cables. To give an idea of the different sizes of available coaxial cable, they range from one having an outside diameter of 0.039 inch (smaller than #18 wire) to others having an outside diameter of 1.5 (or more) inches.

Coaxial Cables

This is probably the type of shielded cable that first comes to mind when we consider transmission of higher frequencies, or reduction of radiation and noise. Yet, coaxial cable is but one of the many types of transmission lines which are covered by classical transmission-line theory and for which precise equations have been derived. The basic transmission line is really a single wire spaced a fixed distance from an ideal ground, as illustrated in Fig. 1A. When the ground path was wrapped around the wire at a fixed distance, the coaxial cable was born. The equations for the basic coaxial cable shown in Fig. 1B include the dielectric constant e which would be 1 if free air were used between the center conductor and the shield. In some dielectrics, particularly when the construction

Fig. 2. This special Phelps-Dodge "Styroflex" coaxial cable has very low losses at ultra-high frequencies.

Fig. 3. For maximum energy transformation, the impedance of the entire system, including cable, must be properly matched.



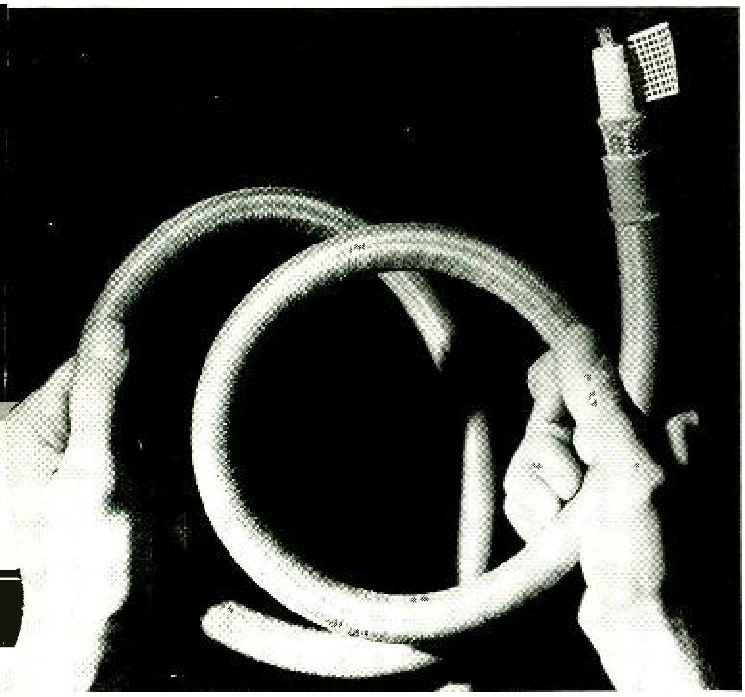


Fig. 4. Some special coaxial cables use a perforated insulator.

includes a lot of air space, this constant is very close to 1. In other cable types, as will be shown later, the constant can be 2, 3, or higher, allowing the outer diameter to be much closer to the inner conductor for the same impedance. Two wires balanced above ground and its shielded equivalent are shown in Figs. 1C and 1D.

At this point, the definition of the vital parameter "characteristic impedance," "surge impedance," or Z_o might be repeated to remind those of our readers who are somewhat removed from theory. To transfer maximum power from one circuit to another, the input and output impedance must be the same, as illustrated in Fig. 3. Every amplifier, transformer, loudspeaker, antenna, and transmission line has its own "characteristic" impedance. Impedance can be capacitive or inductive, but at resonance only the resistive component remains. For transmission lines this resistive component is called the characteristic impedance, or surge impedance, or Z_o, and it is essentially constant over the frequency range for which the cable is designed. We could simplify the definition by saying that a line "works best" when both ends are terminated by a circuit which has the same impedance as the "characteristic impedance" of the transmission line. As we have seen from Fig. 1, coaxial cable can be made for different characteristic impedances, based on the ratio of the inner and outer conductor sizes and the dielectric used.

A typical example of a large r.f. cable would be the RG-221/U cable which has an inner conductor of 0.26 inch and uses polyethylene, which has a dielectric constant of 2.29. The impedance is 50 ohms, which means that its shield must have an inner diameter of about 0.910 inch. It has a polyvinyl jacket, producing a total o.d. of 1.195".

One important characteristic in r.f. cable is its attenuation as a function of frequency. For the RG-221/U, taken as an example here, the losses range from 0.17 db per 100 feet at 10 mc. up to 7.7 db per 100 feet at 3000 mc. The primary reason for this is that polyethylene becomes more lossy at the higher frequencies. By reducing the amount of insulating material and introducing air spaces, the attenuation can be greatly reduced. Shown in Fig. 2 is a cut-away view of ⅞-inch diameter "Styroflex" cable which has a loss of only 0.2 db per 100 feet at 3000 mc. Its characteristic impedance is 50 ohms, its capacitance is 24 picofarads per foot, and its dielectric constant is 1.35.

The power which a cable can carry is limited by the size of the inner and outer conductors, just like the wire size in house wiring limits the safe current. In addition, the dissipation of r.f. power in the dielectric becomes an important factor. It is safe to say that larger diameter cable can carry greater power, but for exact values for a particular cable, the manufacturer's data must be checked.

Coaxial cables vary greatly in every aspect of their construction. Inner conductors are made of solid or stranded wire and occasionally of specially woven thin strands of copper wire. Outer conductors range from the familiar braided shield, armored or corrugated shields, or solid tubing to such novel arrangements as aluminum-coated Mylar tape. Aluminum foil is used in many lightweight cables, but this has the drawback that you cannot solder to the outer shield. To overcome this limitation, one or more copper wires are usually carried between the outer shield and the outer insulating jacket. These copper wires then serve as a solderable contact for the outer shield. Where flexibility with low r.f. attenuation is important, the dielectric may be made of perforated Teflon tape as in the cable shown in Fig. 4. Where extra shielding is required, a separate shielding braid may be used in addition to the outer portion of the coaxial structure. The type and thickness of the jacket which usually covers the outer shield will depend on the environmental conditions for which the cable has been designed.

For spacecraft installation, the cables must also be very light, more efficient, and able to withstand greater temperature variations. Teflon has a dielectric constant of about 2.1 and can withstand temperatures up to 200 degrees C. The

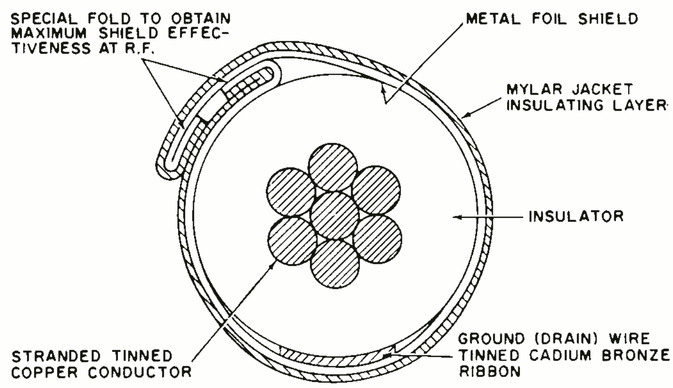


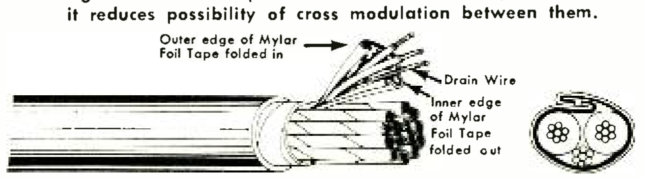
Fig. 5. Belden "Z" fold as used on a single coaxial cable.

miniature cable cited earlier for its outside diameter of 0.039 inch ("HiTemp" 50-29 CWXTC) has a 50-ohm impedance, an attenuation of about 10 db per 100 feet at 100 mc., and uses Teflon as dielectric. Its inner conductor is 0.011-inch diameter copper-covered, silver-plated steel, giving it the necessary strength as well as good electrical properties for r.f. use. The outer conductor is thin, flexible copper tubing rather than a braided shield used in larger cables.

Other Shielded Cables

Coaxial cables are essential in r.f. interconnections, but there are also a host of applications where shielding is required for signals which are much lower in frequency. Electromechanical transducers, photocells, thermostats, microphones, and other devices used (*Continued on page* 111)

Fig. 6. When each pair of wires is individually shielded, it reduces possibility of cross modulation between them.



By ROBERT P. DEVANEY
Systems Engineer, Roanwell Corp.

communicating in a HIGH-NOISE environment

What is noise, what are its effects on a human being and a communications system, and what are the relative merits of different types of circuits, earphones, and microphones for use in establishing reliable communications in a high-noise situation?

WHEN Alexander Graham Bell succeeded in communicating over a length of wire, he set off a sequence of developments that, taken together, rank as a wonder of the modern world. Almost as impressive is some of the misunderstanding that has grown with it.

For example, a "telephone system"—a limited, station-to-station affair—is considered distinctive from a "voice communications" system—a multi-station, multi-channel operation. Yet telephone hardware is liberally used in advanced communications systems. Such special situations, on the other hand, like those found in aircraft, ships, and armored vehicles, have evolved rather unique communications systems.

These special systems relate to another assumption: that system design is an academic problem, involving a series of black boxes that include the necessary switching, amplifying, and patching functions. Then one merely specifies standard headsets, handsets, or headset-microphones, and other items; the difference between one system and another being mostly in packaging.

One problem, always present but now difficult to ignore, is forcing reconsideration of such a simple approach. The problem is *noise*. Its effect on communications is easily overlooked because people have the inherent ability to adapt to noisy situations. In an extreme case, like that of a crew in an armored tank, voice is abandoned altogether in favor of foot or hand signals.

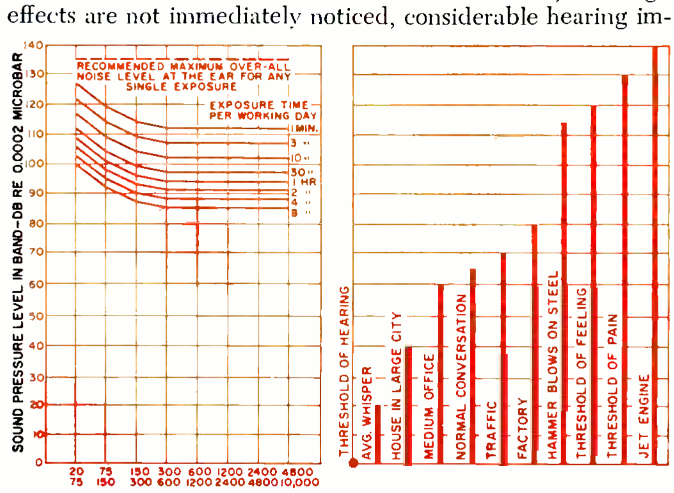
But noise has been guilty of more than mere interference with communications. Studies have shown that, although effects are not immediately noticed, considerable hearing impairment may result. As the ambient noise level increases, the problem becomes more critical. Consider, for example, the noise environments of modern weapon systems. Even brief exposures can result in severe and permanent hearing loss. Recommendations now considered standard on maximum exposure levels and time durations are indicated in Fig. 1, along with levels for some typical noise sources.

Ear Defenders

From the need to protect personnel against the extreme noise of jet engines and rockets, there evolved the "ear-defender" headset configuration. It consists of rigid-plastic, large-volume cups, resilient earcushions, and a headband. Such a rigid cup acoustically sealed to the head (by the cushion) will indeed reduce noise reaching the ear. The greater the volume enclosed by the cup, the greater the attenuation. Currently available earcups range from 110 cubic centimeters to over 350 cubic centimeters. Fig. 2 shows attenuation *vs* frequency.

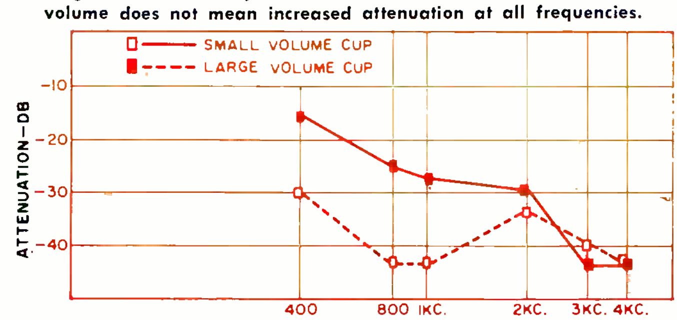
This grossly oversimplifies the rather complex design of ear defenders, which is not our main point. The point is that they were chiefly developed to *provide protection* rather than facilitate communications. As a secondary consideration, the direct mating of large-volume defenders with earphones and microphones has been used with varying success in extreme noise environments (over-all sound pressures from 125 to 145 db), to improve intelligibility.

In the area from 90 to 125 db, however, communications may seem adequate and hearing loss is cumulative rather than



◄Fig. 1. Conditions for noise exposure levels establish recommended practices where adequate ear protection must be applied.

Fig. 2. Differences in attenuation for a small volume and a large volume earcup show their characteristics. Increased volume does not mean increased attenuation at all frequencies.



Modern headset-microphone assembly for improved communications.

immediate. Ignoring the latter effect, system engineers proceed to black-box design techniques without considering ambient noise. We must first appraise the environment, then work back to the black boxes. The objectives, in order of importance, should be: (1) to protect personnel against hearing losses, immediate or cumulative; and (2) to provide maximum intelligiblity in speech communications.

The first goal requires that the noise environment be defined early. Is noise continuous or transient? Where in the audible spectrum is acoustic power concentrated? Are there any dominant, pure-tone components? What is the over-all sound pressure level? These are but four of the questions to be answered.

Such analysis establishes how much protection is needed. The need is, in turn, weighed against physical limitations imposed by operational requirements, such as wearing of protective head-gear or face masks. These are limitations that can complicate design for a noisy environment.

Intelligibility

The second aim is intelligibility. Can we measure it? It is generally accepted that high intelligibility in speech communications is associated with a low message repetition rate, *i.e.*, one in which information is received with few errors. The problem does not sound formidable, especially since the telephone industry has pursued this objective for years. Telephone conversations, however, are not usually received or transmitted in noise.

Although accepted tests for intelligibility do exist, they are rarely performed. It is common practice to breadboard a communications system and "talk it out." If it "sounds" good, incorporates necessary switching and other functions, and meets applicable environment-specification requirements, it is approved. See Fig. 3.

The accepted test procedure is similar to a "talk-out" test —but has important differences. First, both talkers and listeners are trained. Second, the test material consists of standized word, number, or nonsense lists. The phonetically balanced word lists in ASA Standard S3.2-1960 are the most common test material.

Trained talkers read the word lists. The answer sheets of trained listeners are scored, with the average being the intelligibility score for the system. The greater the number of subjects and test runs, the more reliable will be the results. However, even a dozen runs involving two or three subjects, done under actual or simulated noise conditions, will indicate whether the system meets the communication requirements.

With the environmental problem measured and the objectives clear, let us see how one attains them.

As for protection, this is strictly a function of the noise-attenuating headset. There has been experimental work with filter networks and circuits to sample environmental noise, then invert its phase. To date the results have been costly and unimpressive. The author knows of no practical electronic circuitry for reducing ambient noise at the human ear. The only remaining approach is the ear-defender cup.

As stated, cup volume, configuration, and cushion design depend on both the degree of desired protection and limitations imposed by operating conditions. The rule is to try for maximum possible suppression because it serves both goals: in addition to personnel protection, it enhances intelligibility by improving the signal-to-noise ratio.

When intelligibility is also considered, microphone and receiver elements come into the picture. Forsaking a detailed study, we will evaluate some common acoustical transducers in terms of this objective. As to microphones, a list of basic types, not necessarily complete, would include carbon, magnetic (balanced armature), dynamic (moving coil), crystal, ceramic, and ribbon. The first three types of microphones—carbon, magnetic, and dynamic—are the most widely used in telephone and communications systems.

Microphones

Until lately, the carbon microphone has been the type used exclusively in telephone circuits and most frequently in other communications systems. It is rugged, inexpensive, gives years of excellent service, and its power output level is usually very good. Frequency response of popular types tends to range from 300 to 3500 cps.

Drawbacks that can be overlooked in common telephone practice, however, become serious in conference-type systems, particularly when operated in noisy environments. Inherent to all carbon units is a relatively high, self-noise content. Also known as burning noise or thermal agitation, it is primarily due to random motion and arcing between carbon granules.

Because carbon microphones are non-linear devices, harmonic and intermodulation distortion is high, sometimes running up to 15%. When used in noisy environments, they are additionally susceptible to non-linear distortion due to granule agitation by the noise field.

In another aspect of non-linearity, equal and progressive drops in sound pressure applied to the microphone do not result in equal drops in electrical output. Also, if several carbon elements are to operate on one channel input simultaneously, their high combined current drain can create a problem. Finally, these types age over a period of time, with such marked effects on their characteristics as reduced output level while self-noise and distortion rise.

Magnetic or "sound-powered" microphones, widely used in shipboard intercom systems, do not need d.c. power to function. Nor, as a rule, do they need amplification between stations. This efficient type can deliver power levels in excess of 1 or even 2 mw. It achieves this by concentrating its power into a narrow bandwidth that limits intelligibility. Nevertheless, it makes an excellent emergency or maintenance microphone. If ambient noise is high, however, there are no presently available sound-powered microphones with noise-cancelling features.

Although dynamic or moving-coil microphones are not new, they have been applied to communications system design only within the last decade. An early application was the AIC-10 Aircraft Intercom System for the Air Force. Like the sound-powered type, the dynamic is a self-generator that does not need a power source. There is no self-noise content and distortion is negligible, usually below 1%. While frequency response varies with individual design, it is usually wider and more uniform than that of carbon and magnetic types.

The response of typical units will range from about 200 to over 5000 cps. Electrical power output, low enough to require system amplification, ranges from −50 dbm to −72 dbm (0 dbm = 1 mw.). These elements are quite linear over a wide range of sound-pressure input. The small size and mass of modern versions suit them ideally for mounting on headset booms, leaving the operator's hands free.

A final aspect of microphone design is the ability of certain types, popularly known as noise-cancelling microphones to discriminate against ambient acoustic noise. This ability is one of the two most important design considerations of a headset microphone assembly to be used in high-noise environments.

With differential noise-cancelling microphones, the effect is greatest at the low-frequency end of the spectrum. Fortunately, most military and industrial noise situations are strong in this area. Fig. 4 shows the discriminatory characteristic of one type of differential microphone.

Another noise-discriminating type finding wide application is the directional cardioid. Although no true noise cancellation occurs, it can be oriented to reject unwanted sound originating from the rear. Such types are frequently installed in gas and oxygen masks. They may also be used with noise-attenuating mouth cups, which are popularly known as "mush mouths."

As with microphones, there are many basic earphone types, but only two, the magnetic and the dynamic (moving coil) earphones, are used in telephone and communications systems.

The history of the magnetic earphone parallels that of the carbon microphone. Popular magnetic earphone elements are substantially uniform from 300 to 3500 cps. This is also true of most of the popularly used carbon microphones.

Frequency Response

Having touched on frequency response, let's digress to make a point. Restricting telephone transducers to about 3500 cps has not been a matter of accident. The limit was best suited to obtaining the maximum number of speech channels on wire and low-frequency radio carrier systems. Nevertheless, Air Force studies have established that response should extend to about 5500 cps for greatest intelligibility, with higher extensions adding little improvement. Although, most acoustic power in speech is concentrated in the lower frequencies (vowels), higher frequencies (consonants) contribute much to intelligibility.

Just as the carbon microphone and magnetic earphone are looked upon as mates, so is the dynamic microphone a mate for the dynamic receiver element. Distortion in the latter is very low. Its relatively wide frequency response may range from 200 to 5000 cps or better, depending on individual design. In addition, its acoustic impedance is quite low, as compared to the high-impedance magnetic receiver.

That is an important difference. In lieu of an involved discussion of acoustic impedance, its nature, and its effects, we will confine ourselves to stating this accepted principle: the higher the acoustic impedance of a receiving element, the more closely it should be coupled to the human ear; the lower the impedance, the better is the element's ability to work into large volumes. Thus the dynamic unit is a good choice for use in large-volume, ear-defender cups mentioned earlier.

We now approach a frequently overlooked problem. It is customary to specify the frequency response characteristics of the receiver element in accordance with certain standard practices, which were established many years ago in the telephone industry. The transducer is mounted on what is known as a 6 cm.^{3} coupler fixture. This volume approximates the cavity of the human ear as enclosed by the telephone handset receiver cap.

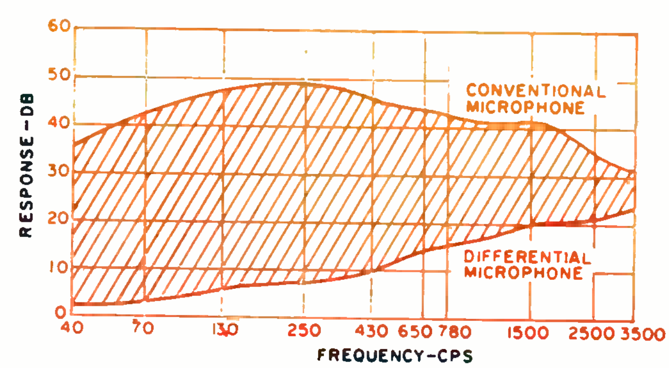
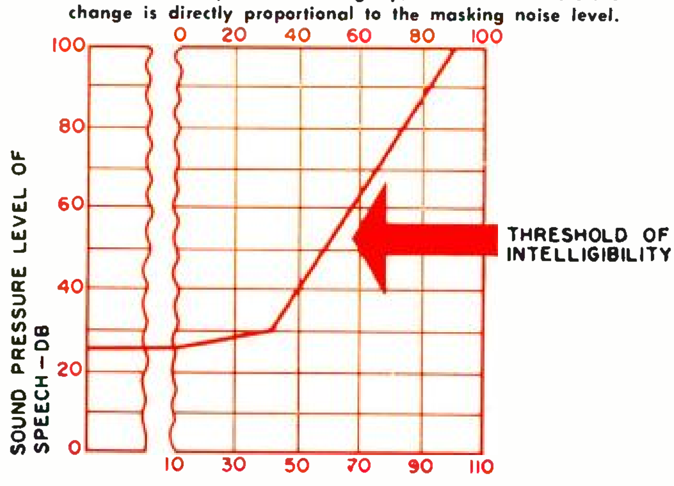


Fig. 4. Characteristics of a conventional and differential microphone, both located 4 ft. from a noise source. Shaded portion shows difference in the amount of noise transmitted.

Unfortunately, the frequency response of receiver elements tested in this way gives no indication of their characteristics when used in large-volume rigid earcups. Recent studies with various artificial ears and artificial heads have produced results markedly different from those obtained with the standard 6 cm.^{3} coupler. Yet engineers continue to use the present standard as a guide in specifying earphone elements for earcup mounting. The difference between the performance desired and that obtained can be substantial.

Equally important, engineers specify on the assumption that the output level they see on their data, taken with the standard fixture, is what will be presented to the subject's ear. So-called cavity loss, however, which increases with the size of the cavity in which the transducer is mounted, takes place. It is not unusual for a system design engineer to pick a receiver element that (*Continued on page* 80)

Fig. 3. Sound pressure must be increased in the presence of noise to maintain intelligibility. As noise level approaches 20-db threshold, curve rises slightly. For 40 db or more the change is directly proportional to the masking noise level.



COMMENTS ON
the new CB rules

SPLITTING off and restricting channels in the 27-mc. band is the most provocative change introduced by the recent tightening of the CB rules. Its impact is immediate, promising to affect more CB-ers than any other provision of the new rules. Yet, it is just one of a series of amendments devised by the FCC to recast the band into its original mold first set down in 1958; namely, the CB is a communications tool, not an end in itself. The overhaul of the regulations does not spell fundamental change. More properly, it serves to expand and clarify an FCC intent expressed some half-dozen years ago. But the very newness of the current amendments has precipitated mild confusion among some CB-ers. It can be traced to two sources: (1) the belief that the original FCC proposals, widely circulated for nearly two years, were adopted as today's law; and (2) that the new amendments are solely restrictive. Closer examination of the new Part 95 reveals that both are incorrect.

Band-Splitting Rule

Consider the band-splitting rule. The Commission initially proposed *five* channels for use by "different" stations (that is, units operating under different call signs, as opposed to "same" stations—a base and its mobile units, for example, operating under a single call). The five channels, in the final rule, were expanded to seven (9 through 14 and 23).

But the unwritten part of the new law is also significant. For one, it does not deny the use of those seven channels to same stations. Also, the lumping together of different stations in the band's mid-section distinctly favors communications among similar stations. If restricted frequencies were intermixed throughout the band (as petitioned by some CB interests), all stations would experience a given amount of adjacent-channel interference. The mid-channel grouping, however, effectively isolates the kind of activity which traditionally produced the greatest congestion; that of different stations. The hunter, plumber, or Boston's pizza-dispatching service may still freely utilize any channel for expediting its activities. It would appear, however, that channels 1-8 and 15-22 would be preferable for same-station use. Such decentralization has already tended to occur in the past. In many areas mid-channels are over-utilized.

Silent Periods

This favoring of same stations also appears in another one-sided provision of the recent law. Not readily apparent is the full ramification of the new "silent period." In the earlier rule, a station had to observe a two-minute radio silence after five minutes of transmission. The silent period is now extended to five minutes. But stations under the same license are not included in the tighter regulation. In fact, they may now communicate for as long as 15 minutes without even uttering a station identification. Clearly, this burdens different stations with frequent silent periods and station identification. (Such stations do have a minor escape clause during silent periods; they can transmit a brief acknowledgement of an incoming call to tell a calling station that a silent period is being observed at this time.)

Ground-Wave and Skip

Several other amendments, which apply to everyone, also temper certain operating excesses of the past. There was, for example, some ambiguity in the quasi-technical terms "ground-wave" and "skip." Parked atop a mountain, a mobile might work at distances upwards of 100 miles. On the other hand, a short path *via* sporadic-E propagation might cause skip distances of a mere few dozen miles. And to compound the problem of definitions, some would argue that practical ground-wave coverage is non-existent for CB. With v.h.f. characteristics the wave path is more correctly termed line-of-sight. Thus the vague "short-range" designation is now replaced by a precise figure; a maximum radius of 150 miles. Reference to ground-wave or skip was dropped entirely.

Abbreviations & Language

This definitive treatment has also been applied to several minor operating details. The Commission feels that no undue hardship is imposed by the new requirement which states that call signs must be said in English, although communications are conducted in some other language. The ubiquitous use of "10" and other non-official codes or abbreviations is still acceptable—provided that a copy of their plain-language definitions is a part of the station records. Transmissions do not have to be impeded during station identification with words like "this is" or "from."

One of the most widely known restrictions in CB radio—the one forbidding profanity, obscenity, and indecent language—has been formalized. Surprisingly, it had no specific reference in the earlier rules. (It is hidden in the fine print on the back of the license. The Commission depended on the Communications Act of 1934 to proscribe such activity.) Not only is this restriction written into the new CB law, but it tacks on an additional proviso. The *meaning* of such language is now prohibited. It appears to be aimed at the story-telling CB-er who can evoke "indecent" meanings without saying an indecent word directly.

Remote & Selective Calling

Now consider several changes which strike closer at the technical aspects of the CB radio. Again there is evidence of clarification, but also there appear subtle signs of relaxation. Take the matter of phone-patching. In its original proposals the Commission wished to outlaw such devices with a specific CB rule. The new rules contain no phone-patch reference. Nevertheless, the Commission points out that interconnecting CB with public telephone equipment may be in violation of other laws. (This would appear to follow the *de facto* recognition of phone patching in amateur radio.)

Remoting CB equipment is still prohibited, but a newly introduced definition of "remote control" permits such control between points on the same premises, craft, or vehicle. Thus, legal approval is now granted recent "control heads" which have appeared for CB, floor-to-floor remoting, or remote control between buildings of a single plant or construction site.

Direct connections into public-address equipment continues to be prohibited, but the Commission informally explains that CB can be used in conjunction with p.a. *Information heard* on a CB receiver (during a sports event, for example) can be utilized for p.a. announcements. Preventing direct connection, it was argued, avoids prolonged frequency tie-ups and the risk of something undesirable being said over a p.a. system.

Although the FCC has tightened up the rules, the CB-er who has been operating within the intended letter and spirit of the previous regulations will have little difficulty in complying with the newly adopted rules.

By LEN BUCKWALTER

Another new rule limits on-the-air testing to one minute out of five (not "brief" periods as before).

The term "selective call" enters CB regulations for the first time. The rule imposes a 15-second limit on the signaling period, but will not affect call systems now in use, even the 3-tone sequential devices which take several seconds to complete a calling cycle. Allowance is also made for sub-audible calling tones. Such calling tones are defined as any frequency that is below 150 cycles per second.

Maximum Power

A new FCC position on r.f. power is introduced. According to the old law, the 5-watt maximum was measured indirectly; a product of final plate voltage and current. Today, a second limit appears alongside the 5-watt figure. It is a 4-watt maximum r.f. *output*. The output rating, in itself, is not startling. Transmitters in other services are frequently rated in this fashion and, in fact, Canada's "CB" (the General Radio Service) places the output figure at 3 watts.

The FCC's reason for an output rating is to accommodate its field personnel. It is more convenient to connect a power output meter to a suspicious transmitter, than to cope with the diverse connections and systems for reading input power. But the outstanding feature of the new rule is 4 watts. A quick calculation indicates that a 5-watt final must operate at 80 percent efficiency to deliver 4 watts output. Since 80 percent is highly optimistic even for a class C amplifier, the Commission originally based its output figures on 70% efficiency (or 3.5 watts).

Several CB manufacturers balked at the low figure. They claimed their units could achieve efficiencies up to 80%. Responsive to these comments, the Commission ultimately adopted the 4-watt figure. No existing equipment should be affected by the new rating.

Also under the heading of power comes the first formal rule making which provides official approval of CB sideband. Is is worded this way: "Class D stations in this service are authorized to use amplitude voice modulation, including single sideband and/or suppressed carrier. . . . ." But of greater technical interest is how the old power rating chart was revised and footnoted to accommodate sideband. Just below the earlier "Power Input" heading we now find the crucial, qualifying entry "Average Watts." This provides for large *peak* powers of single sideband transmission, much in excess of the customary 5-watt maximum.

A newly added footnote on the power chart specifies the type of meter to be used for measuring average power (2% accuracy, maximum time constant of 0.25 second). No set limit, however, is given for peak power. The Commission, in a comment apart from the actual rules, states: "For single sideband operation, peak envelope power will exceed the average power by an amount which is dependent upon the peak-to-average characteristics *of each station operator's voice*." (The italics in the preceding quotation are ours.)

Antennas

On antennas, the Commission made several comments, but its final ruling little affects the *status quo*. Nearly all the amendments in this section are aimed at misinterpretation of what is meant by a man-made or natural formation (which still may not be exceeded by 20 feet). Most important is a new definition which is phrased somewhat negatively: that a man-made structure is *other than* a tower, pole, or mast. This precludes utilizing it exclusively as a CB antenna mount. There is also a new rule aimed at defeating the practice of mounting a CB antenna atop a tower already bearing a TV or other receiving antenna. Although a receiving tower may be used for a CB mount, the tower then would also have to comply with the fundamental rule: it may not rise higher than 20 feet over a man-made or natural formation.

Another feature of the new antenna rules narrows down the limits for mounting a CB antenna on an existing transmitting tower (one that is already under FCC jurisdiction). Here the CB antenna may not exceed the height of the existing antenna.

The rationale behind the 20-foot rule and the other height restrictions originated not with the FCC but with the FAA. The aeronautical agency advises that 20 feet over a natural or man-made formation poses no potential hazard to aircraft. There are, of course, countless exceptions where heights exceeding 20 feet would not endanger aircraft. Nevertheless, the Commission feels that case-by-case consideration (done in many other services) is impractical for CB. The number of licensees, now approaching one million, is simply too great to handle with existing resources. So, the blanket FAA-recommended rule remains in force.

A number of comments filed with the FCC when the antenna proposals were under consideration pressed for some relaxation in limits. Some suggested a 30- or 40-foot height restriction to permit antenna types of lower radiation angles —for better ground-wave, less skip. It was rejected as offering too little advantage in the face of the recognized 20-foot rule. One recommendation, however, was given significant consideration by the Commission. The comment suggested that the present rule is inequitable; some CB antennas are at a disadvantage due to the shielding effects of nearby obstacles. It recommended that CB antennas be permitted a mounting height at least as high as trees, natural formations, power lines, etc. within a *specified radius*. This does not appear in the new rules. What is important, however, is that the Commission expressed its awareness of the problem and decided to continue studying it. There is a good possibility that it may be treated in future rule making.

What could be a precedent and possible solution to the antenna problem has already been promulgated by Canada in its handling of CB's equivalent, the General Radio Service. Canadian rules permit an antenna to be mounted as high as 30 feet above a natural or man-made formation which lies within a radius of 1000 feet. This would allow, for example, a tower to be erected for clearing a nearby obstacle of comparable height. To protect low-flying aircraft, the Canadian rules go on to say that the antenna may be as high as 75 feet off the ground provided that the station in question is more than six miles from an "aerodrome."

Thus the revised edition of Part 95, as we have seen, attacks certain abuses in CB, singles out specific areas for correction, and generally ties loose ends which have tended to cause misunderstanding among some CB operators in the past. Yet, the single most important feature of the new rules is clear: if a CB-er had been operating his station within the intended spirit of the old law, he should experience little difficulty in complying with the new one. ▲

By BRICE WARD

A high-performance capacitive-discharge type system employing the original ignition coil. High-speed switching of current is done with a silicon controlled rectifier.

SCR AUTOMOTIVE IGNITION SYSTEM

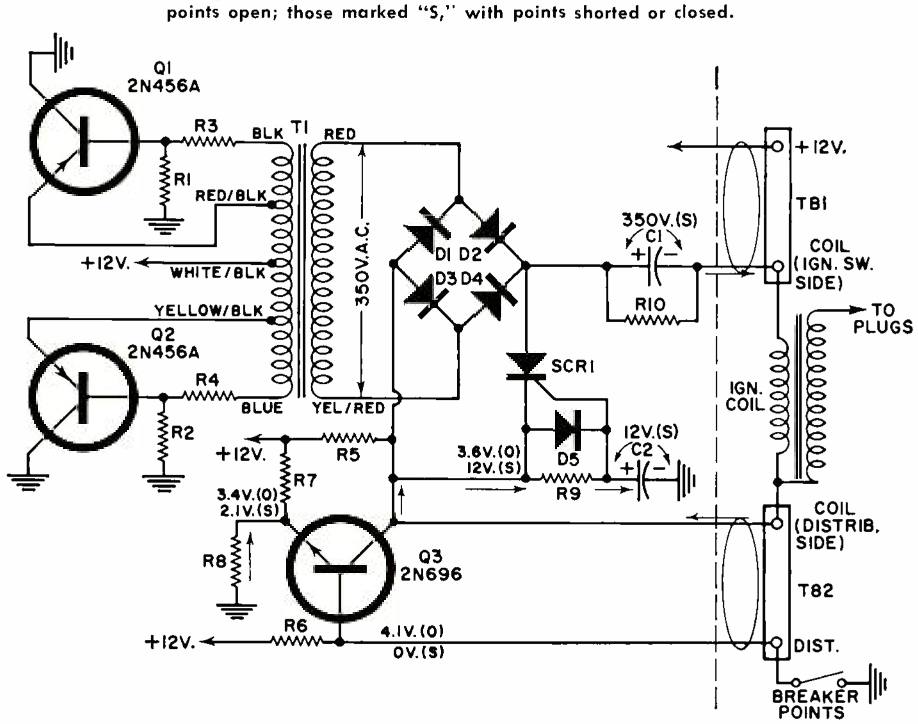
THIS ignition system is unique in that it uses the very desirable capacitive-discharge system along with semiconductor devices. It achieves the goal many have been working toward for several years, and it achieves it with a minimum of parts. What is more, this system will operate with the car's ballast resistor in the circuit. Also, it is not necessary to replace the original ignition coil with a special type, as this circuit uses the coil presently installed in the car.

The entire circuit can be built inside a 3″ x 3″ x 5″ heat-sink housing. Only four connections are required from the circuit and the total installation time is only about 10 minutes. The original ignition system can be restored for testing in just 1 minute.

A rise time on the order of 2 microseconds greatly enhances the ability of the unit to fire fouled plugs, and the total pulse energy is retained at a high level to eliminate the "lean-mixture surge" and other problems that sometimes occur in other capacitive-discharge systems.

The circuit (Fig. 1) can be divided into three major sections: the inverter section (transistors Q1 and Q2), the con-

Fig. 1. Arrows in this schematic show the direction of current flow in the circuit with the breaker points open. The voltages designated "O" are those obtained with the breaker points open; those marked "S," with points shorted or closed.



R1, R2—220 ohm, 1 w. res. ± 10%
R3, R4—39 ohm, 1 w. res. ± 10%
R5, R6—1000 ohm, ½ w. res. ± 10%
R7—470 ohm, ½ w. res. ± 10%
R8—100 ohm, ½ w. res. ± 10%
R9—330 ohm, ½ w. res. ± 10%
R10—330,000 ohm, ½ w. res. ± 10%
C1—1 μf., 400 v. capacitor (Good-All 663UW*)
C2—.47 μf., 100 v. capacitor (Mallory PVC 1047*)
D1, D2, D3, D4, D5—750 ma., 400 v. silicon rectifier (Sarkes Tarzian F-4*)
T1—Special inverter trans. (Delta Products, available separately)
TB1, TB2—Terminal board
SCR1—5 amp., 400 p.i.v. silicon control rectifier (Sarkes Tarzian 5TCRH*. Approx. price $18.00)
Q1, Q2—2N456A power transistor
Q3—2N696 transistor (Texas Instruments*)

*Printed circuit board is designed for parts listed. Other manufacturers' parts may be used if mechanically and electrically equivalent.

Note: A complete kit of parts to build the ignition system is available from Micro-Kits, Co., P.O. Box 494, Paramount, Calif. 90724 at $34.95 complete. This company will also supply separately the special transformer ($6), the chassis, heat sink, end and bottom plates ($2.50), and the printed-circuit board ($1.70).
Factory-assembled units are available as the "Thunderbolt Mark 10" from Delta Products, Inc., P.O. Box 974, Grand Junction, Colo., 81502 at $49.50.

trol section ($SCR1$), and a trigger section (transistor $Q3$). The inverter is a transistor power oscillator which changes the 12 volts d.c. from the car's battery into alternating current. This a.c. is rectified by a full-wave bridge which delivers about 350 v. d.c. to the SCR and storage capacitor $C1$. Every time the breaker points open, trigger transistor $Q3$ conducts and applies a positive pulse to the SCR gate electrode. The SCR then fires rapidly and discharges the storage capacitor through the ignition coil, thus producing the high voltage for the spark plugs. When the capacitor voltage is reduced to zero or swings negative (during the oscillatory discharge), the SCR cuts off and the high-voltage pulse terminates. When the points close, neither $Q3$ nor the SCR is conducting and the storage capacitor recharges.

The Inverter Circuit

Simplicity has been achieved in the inverter portion of the circuit by making it a common-collector circuit with resistive starting, which means that in an automobile circuit the collectors can be mounted directly on the heat sink without insulating washers. Elimination of the insulating washers and the safety factor designed into the transistors allow the transistors to operate at case temperatures very near maximum junction temperature ratings.

In addition to this major advantage, the transistors stop oscillating if a short is accidentally applied across the inverter output. As well as inverter transistor protection, this self-protecting factor leads to still another not-so-obvious advantage. With no filtering in the output of the rectifier circuit, the SCR shorts the inverter each time it fires and stops the oscillator.

This serves a two-fold purpose: 1. It removes "B+" which, in turn, assures that the SCR will be *reliably* turned off each time it fires. 2. It allows the inverter frequency to be modified upward as the number of pulses from the distributor increases with rpm.

The nominal operating frequency of the inverter is 55 cps. This means that more output pulses than distributor pulses will be obtained up to approximately 1100 rpm. At and above this frequency, the load reflected to the primary of $T1$ modifies the oscillator frequency upward. At 6000 rpm in an eight-cylinder engine this frequency will be 400 cps.

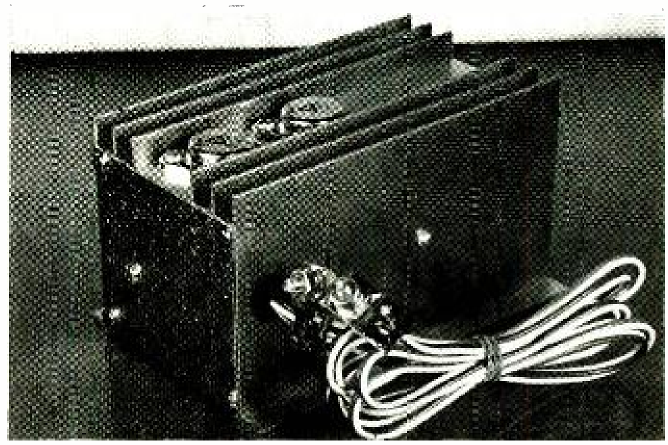
Capacitive-Discharge Feature

$C1$ is the energy-storage capacitor. In a standard ignition system, energy is stored in the inductive (magnetic) field of the coil. In an inductive circuit, voltage could rise to an extremely large value with an open load circuit. The arc at the spark plug reflects a low impedance to the primary of the ignition coil to limit the voltage rise to something less than 400 volts, and a capacitor is used in the distributor to act as a buffer as the points open, thus preventing arcing. Should an open occur in the secondary circuit, the voltage can rise sufficiently to damage or destroy the coil, points, or capacitor.

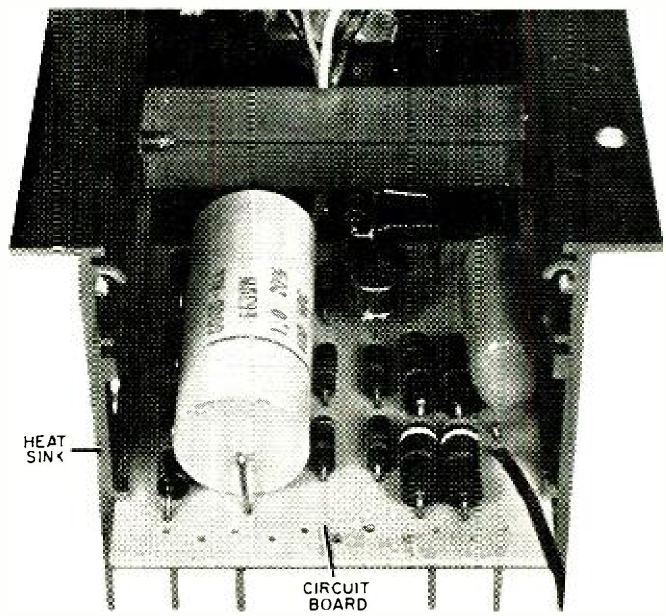
On the other hand, with a capacitive-discharge system and a conventional 90:1 turns-ratio ignition coil, the voltage can only rise in this case to 350 v. × 90 or 31.5 kv. This voltage is well within the design ratings of the high-voltage components in modern ignition systems.

This is one of the reasons for recommending that a conventional coil be used rather than a high turns-ratio coil. Another reason is that the standard coil is already installed in the car; hence it is not necessary to purchase and install a special coil.

It has been pretty well established that a minimum of 30 milliwatt-seconds of energy is required at the spark plug in modern ignition systems. $C1$ has been chosen to give 80 milliwatt-seconds, allowing ample reserve energy. The purpose of resistor $R10$ shunting the storage capacitor is to serve as a bleeder resistor to (*Continued on page* 82)

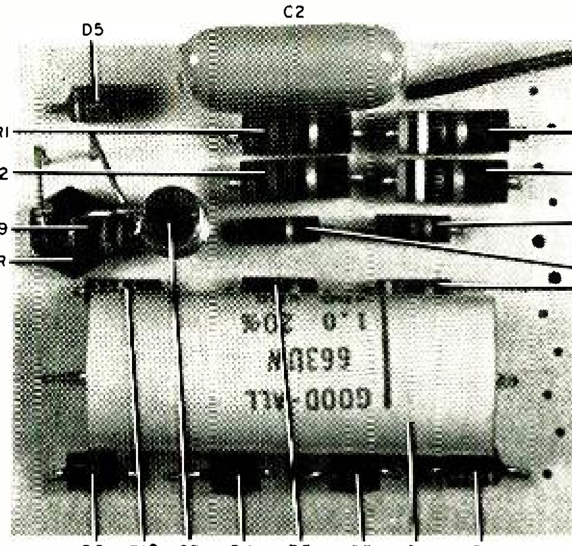


The entire SCR ignition system is built within a heat sink to which the two inverter transistors are bolted. The inverter transformer and printed-circuit board with all its components fit under the heat sink. Two 3" x 3" metal plates cover the ends. Four connections from circuit are tied to two terminals pads or boards which are bolted to coil primary terminals.



Bottom view of the heat sink showing how the printed board slides into ribs of the heat sink and showing the location of inverter transformer (top). Connections between the transformer and the board and between the board and the external leads will be made later using the eyelets at end of board.

The component side of the printed circuit board used is shown.



Liquid Temperature Controller

This solid-state controller can maintain a liquid bath to within a few hundredths of a degree for a 24-hour period.

By WILLIAM D. SCOTT / University of Washington

THE economical, sensitive, solid-state, proportional temperature controller to be described has a stability of ±0.1°C per month. With reasonable consideration in the placement of heater and thermistor sensor and adequate stirring, the temperature of a water or oil bath can be controlled to within a few hundredths of a degree for a 24-hour period. Control can be varied from a nearly proportional type of control to ordinary on-off control by changes in the sensitivity of the control circuit. The circuit shown works quite well between 60°C and 200°C with some loss in sensitivity at the higher temperatures. With proper choice of thermistor and other bridge components, almost any temperature range can be obtained. With appropriate circuit modifications, other devices such as positive temperature coefficient thermistors, tungsten wire elements, light-sensitive resistors, and even solar cells could probably be used to control an unlimited number of variables.

The schematic is shown in Fig. 1. Temperature preset pot *R3* has its dial marked in temperature in degrees after the controller is calibrated against an accurate thermometer.

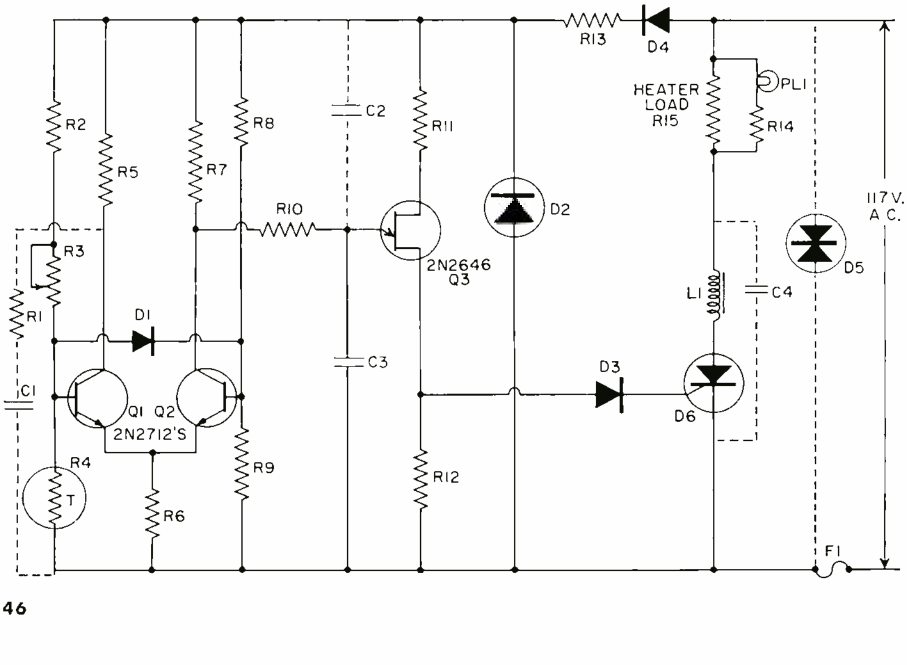
As the temperature of the bath rises, the resistance of thermistor sensor *R4* decreases and current through the thermistor increases, drawing off some of the base current from Q1. This drastically reduces the emitter current of Q1, and to maintain a constant common emitter voltage, this necessitates an equivalent increase in the emitter current of Q2, resulting in an increase in current through *R7*. This increase in current results in a decrease in the charging voltage of capacitor *C3*, thus the firing voltage of unijunction transistor Q3 is delayed, silicon controlled rectifier *D6* fires later in the positive half cycle, and a smaller r.m.s. voltage reaches the heater load. The temperature of the bath therefore decreases and the resistance of the thermistor increases. This increases the power being supplied to the heater therefore the bath temperature goes up. The system will then cycle about the preset (by *R3*) operating temperature.

The heater rating is a function of the SCR conducting current.

The value of *R6* is quite critical and depends upon the absolute magnitude of the zener voltage, the exact value of *R5*, *R7*, *R8*, *R9*, *R11*, and the properties of Q1, Q2, and Q3. Resistances *R5* and *R7* should be matched to within 1%. All other resistors are 10% tolerance, ½-watt except where noted. Wirewound resistors could be used in the bridge although they are not necessary. *R11* is the temperature compensating resistor for unijunction transistor Q3. Theoretically,

Fig. 1. The schematic and parts list for the proportional temperature controller.

R1—2200 ohm, ½ w. res. (approx., see text)
R2—500 ohm, 1 w. res.
R3—100,000 ohm, 10-turn pot
R4—100,000 ohm thermistor (Fenwall GA55P8)
R5, R7—10,000 ohm ½ w. res. (matched ±1%)
R6—3000-10,000 ohm, ½ w. res. (see text)
R8—15,000 ohm, ½ w. res.
R9—5000 ohm, ½ w. res.
R10—2200 ohm, ½ w. res.
R11—470 ohm, ½ w. res.
R12—20 ohm, ½ w. res.
R13—2000 ohm, 5 w. res.
R14—100,000 ohm, ½ w. res.
C1—Approx. 0.1 μf. (see text)
C2—See text
C3—0.1 μf., 600 v. paper capacitor
C4—.005 μf., 600 v. paper capacitor
L1—See text F1—See text
PL1—NE-51 neon pilot light
D1—1N536 silicon diode
D2—18 v., 1-watt zener diode (1N1526)
D3—1N91 diode
D4—200 p.i.v., 0.1 amp diode (1N1695)
D5—Thyrector voltage suppressor (G-E 6RS 20SP4B4)
D6—Silicon controlled rectifier (G-E C22B)
Q1, Q2—2N2712 transistor
Q3—2N2646 unijunction transistor



*R*11 could be adjusted to compensate the circuit perfectly for thermal fluctuations in the temperature of the room. However, the unijunction transistor introduces little thermal drift in comparison to *Q*1 and *Q*2. *R*2 limits the current flow through the thermistor *R*4, and *D*1 limits the inverse voltage to *Q*2 should *R*3 (the temperature control preset pot) be set at a low value.

Ordinary paper capacitors are used. The diodes need not be the equivalent of the diodes listed as long as they have the proper voltage and current ratings. Diode *D*1 should be silicon but inexpensive diodes, a zener diode, and even an inexpensive SCR will suffice.

The value of *R*6 is found as follows: After the circuit components are in place, a carbon resistor of about 5000 ohms is substituted for thermistor *R*4 and a 10,000-ohm rheostat is substituted for *R*6. The heater, or a substitute for it, must be in its place or the SCR will not fire owing to lack of current —a 100-watt light bulb makes a good substitute. The rheostat is set at 10,000 ohms and the circuit is connected to the a.c. supply. Temperature preset control *R*3 is adjusted until the base voltages of the two transistors are nearly equal. (The heater should now be on.) The value of *R*6 is then lowered until the heater just turns completely off. One of the leads to *R*10 is unsoldered (with the a.c. supply disconnected) and the collector voltage of *Q*2 is measured using a vacuum-tube voltmeter. This is the required r.m.s. firing voltage of *Q*3. *R*6 and *R*3 are now adjusted until the collector voltages of both transistors are equal to the required firing voltage. *R*3 should not require much adjustment. If it does, it may be necessary to replace one of the transistors (*Q*1 or *Q*2) to obtain a better match. *R*3 adjusts the relative magnitude of the two collector voltages and *R*6 adjusts the absolute magnitude of the two collector voltages. Finally, *R*6 is replaced by a fixed resistor (or resistors) equivalent to the value of the rheostat, and *R*10 is reconnected.

Capacitor *C*3 is listed as 0.1 μf. However, it can have any value from 0.02 μf. up to nearly 1 μf. In the former case, the control is nearly on-off; in the latter, the heater voltage varies over a large range. With larger value capacitors, the charging current is so great that it is an appreciable part of the collector current of *Q*2. Thus, some method of compensation is necessary. This is the purpose of *R*1 and *C*1. This network compensates by drawing an appropriate charging current from the collector of *Q*1 during the first cycle of unijunction *Q*3. Once *Q*3 has fired, there is no need for compensation. With the smaller value of *C*3, the charging current is so small that it is greatly influenced by transients in the a.c. supply. These effects can be partially eliminated by bypassing the a.c. portion of the wave by capacitor *C*2 which should have approximately twice the capacitance of *C*3.

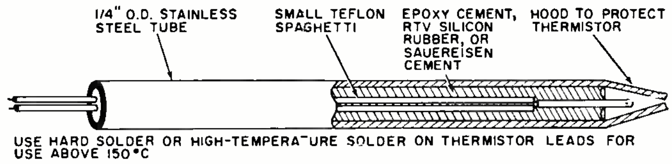
Inductor *L*1 in series with the SCR consists of roughly 65 turns of #16 enameled wire wrapped on a ¼" ferrite rod. In conjunction with *C*4 it helps to cut down the radio-frequency noise generated by the SCR. *L*1 also should help to delay the surge of current created if the heater leads should be shorted out. It could delay the current long enough for the fuse to blow and save the SCR. For this reason, the fuse should have as low a current and voltage rating as possible. If the load has appreciable inductance, a diode should be installed in parallel with it to eliminate high-voltage surges. Thyrector diode *D*5 should also be used to eliminate voltage transients.

The thermistor specified is a 100,000-ohm nominal resistance, glass-coated type. Ordinary disc, washer, and rod thermistors can be used but with decreased stability. In selecting a thermistor, care should be taken that the operating point is well below the maximum safe r.m.s. voltage of the thermistor.

Positive temperature-coefficient thermistors (such as the *Westinghouse* Type 83401) can also be used to increase the sensitivity of this unit.

However, PTC thermistors have a rather narrow temperature range and require inversion of the *Q*1-*Q*2 bridge.

Care should be taken in modifying the bridge that the reverse voltage rating (5 v.) of the base-emitter junctions is not exceeded.



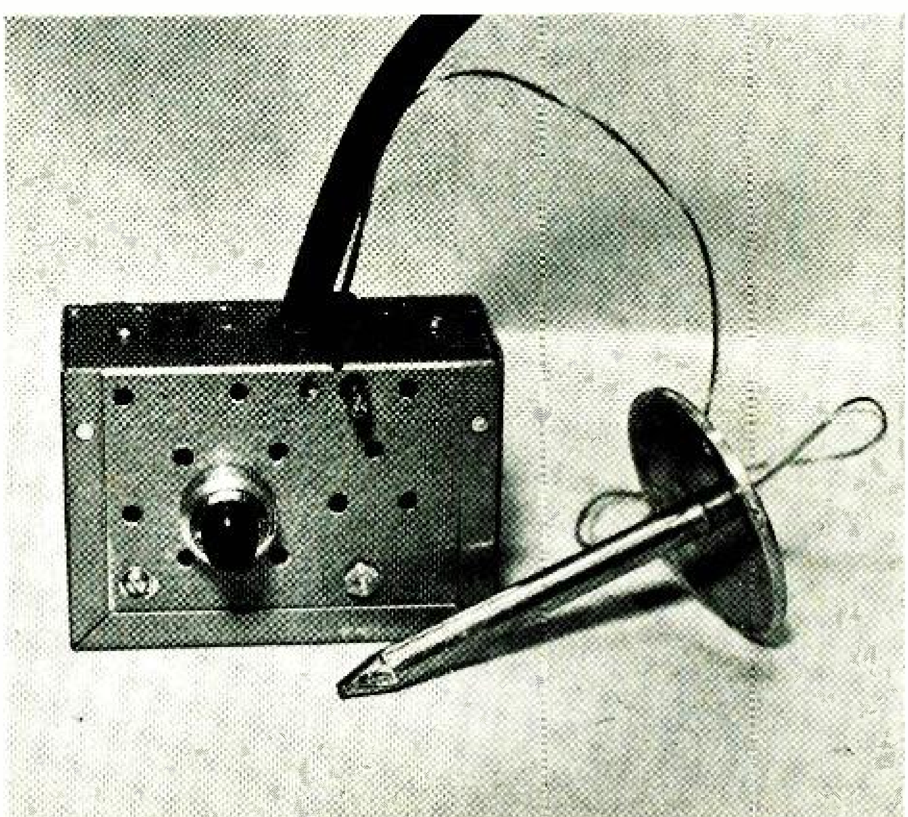
Method of mounting the thermistor in a protecting metal probe.

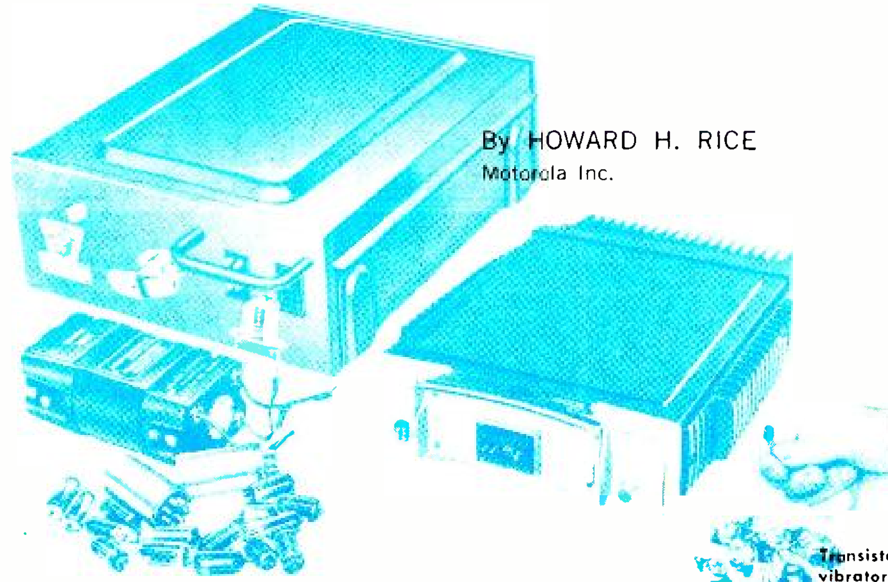
Another silicon shunting diode in parallel with *D*1 but with opposite polarity provides one way of limiting the reverse voltages.

If full-wave control is desired, the "RC Diode Slaving Circuit" (page 61 of the *G-E* 'SCR Manual") is ideal. This circuit has the advantages of half-wave control over full-wave power.

An easier method of increasing the power control is to use a larger capacity SCR. ▲

This version of the temperature controller was built in a small metal box having several ventilation holes drilled in it. The temperature controlling potentiometer has its dial calibrated in degrees C. The thermistor probe is ready to be affixed to tank of liquid.





By HOWARD H. RICE
Motorola Inc.

TRANSISTORS VERSUS TUBES FOR TWO-WAY RADIO

Transistors, in unit at right, replace the dynamotor, vibrators, and tubes in radio on left. Both radios offer comparable operating specifications, but transistorization has provided quite a few real advantages.

Tubes still play an important role in mobile radio systems, but transistors are providing greatly reduced size and current drain as well as lower maintenance costs and higher over-all reliability.

A GREAT deal has been said lately about the relative advantages of the transistor over the vacuum tube. Not too long ago the transistor was looked upon, in some circles at least, as little more than a novelty. But today, solid-state electronics is allowing us to communicate with artificial satellites while high-fidelity enthusiasts are praising (or damning) "transistor sound." In general, the transistor appears to be well on its way toward challenging the very existence of the vacuum tube.

The tube, however, is far from dead. For this reason, a single sweeping statement to the effect that the transistor (or the tube) is superior makes as little sense as saying that Scotch is better than Bourbon. The individual application (or taste) is the most important consideration. And if both devices are capable of providing essentially the same result in a particular circuit, the question boils down to which—the transistor or the tube—will do the better job at a reasonable cost.

In two-way radio applications there are some very special factors which are vital to the economic, efficient operation of a radio communications network, and these requirements are what determine how well either device is suited for this type of equipment. As it turns out, transistors are doing some two-way radio jobs which could never have been handled by tubes while, at the present state of the art, the vacuum tube is still doing a better-than-adequate job in applications which cannot be considered for a solid-state device.

Base-Station & Mobile Equipment

An example of this use of tubes can be found in present-day high-powered base-station equipment. Two-way radio base station vacuum-tube final r.f. amplifiers are providing as much as 300 watts and more into the antenna; it will be some time before we can do this at a reasonable cost with transistors. The station is either placed indoors, or outdoors in some type of weatherproof cabinet; space is usually not a limitation. The station has what can be considered a virtually limitless source of power (117- or 230-volt a.c. line). The receiver, transmitter, and power supply are built around time-proven, highly reliable circuitry. Most "bugs" have been ironed out years ago and new, improved industrial tube types provide longer life at a considerably reduced per-hour-of-operation replacement cost.

But the communications radio installed in an automobile—the mobile unit—is a different story. The very fact that a radio set is to be put into a vehicle and isolated, so to speak, from the rest of the world creates all kinds of problems. To understand how these problems must be met, either by tubes or transistors, we should consider how a mobile unit operates as part of the communications network.

The need for some kind of communication between a central point and the driver of the vehicle is probably the basic reason for installing a two-way radio system; this communication may be for closer control of drivers on the road, or merely for the exchange of information. Nevertheless, the need to contact a driver at a moment's notice demands that the mobile receiver be energized at virtually all times. The message must reach the driver; otherwise the effectiveness of the radio system is destroyed. And behind this requirement lies several rather serious implications.

In tube-type equipment, the requirement that the receiver be fully operative means that tube filaments are being heated, crystal heaters are intermittently drawing additional current, and high voltage is being applied to the plates of all receiver tubes. Furthermore, the transmitter tube filaments and crystal heater must also be energized so that the driver can respond to or initiate a radio message. Considering that all this power—to keep the radio in a "standby" condition—is derived from a 12-volt d.c. source (or perhaps even a 6-volt d.c. source), the total standby current drain can be rather heavy, while current drain during actual transmission is many times higher. And where does this current come from? the *battery* —the one component in an automotive electrical system which is already recognized as its weakest link.

Because of this excessive battery drain, the installation of a mobile two-way radio—particularly one with a transmitter

Table 1. Typical receiver specifications for tube, transistor models.

SPECIFICATIONS	TUBE MODEL	TRANSISTORIZED MODEL
Frequency band	25-50 mc.	25-50 mc.
Channel spacing	20 kc.	20 kc.
Sensitivity (EIA-SINAD)	0.25 μv.	0.25 μv.
Selectivity	-100 db @ ± 15 kc.	100 db @ ± 15 kc.
Spurious & Image Rejection	more than 100 db	more than 100 db
Audio output @ 10% dist.	2 watts	5 watts
Current drain @ 13.6 v.d.c.		
Standby	7.5 amps	0.35 amp
Receive	7.5 amps	2.2 amps

output rating on the order of 50 to 100 watts—often necessitates the additional expense of a heavy-duty battery as well as an alternator or a heavy-duty generator. Such a radio also entails some other costs to the operator, costs which are not as apparent as the new battery and generator. As an example, the fuel cost to idle the average passenger car 30 minutes a day, 22 days a month, just to keep the battery from discharging while the radio is in operation, can amount to approximately $16.50 per year. Cost of idling a truck for the same amount of time may run as high as $60.00 per year. Extensive idling is hard on the engine, too, which may be responsible for an engine overhaul at an average cost of about $75.00 or more.

If the battery ever goes dead because of the additional drain placed on it by the radio, towing charges added to the owner's increased blood pressure may provide the proverbial "last straw" as far as the radio system is concerned. These, of course, are the extremes of the situation; there are thousands of tube-type mobile units performing satisfactorily throughout the country. These extremes are not unrealistic, as your local police chief or police communications officer can readily testify from his own personal experience.

All-Transistor Receiver

In 1958, the introduction of an all-transistor mobile receiver contributed greatly toward overcoming the problems of battery drain. Transistors have no filaments to be heated so a major portion of the "standby" current drain was eliminated in the transistorized receiver. However, an important criterion for any transistor equipment is that it offer performance specifications which are comparable to its older tube-type counterpart. Table 1 is such a comparison which shows how this criterion has been met.

The two receivers are both "top-of-the-line" units. Notice, particularly, the difference in current-drain figures; the drains are actually not for the receiver itself, but for the entire radio set. This means that transmitter tube filaments are also responsible for part of the drain in both cases. Of course, the vacuum tube draws no more current in the "receive" mode than it does during standby, whereas the current drain of a transistorized receiver is increased when a message is actually being received. The bulk of this increased power drain in the transistorized unit during "receive" operation can be attributed to the audio power amplifier. Notice that the tube-type unit provides only 2 watts of audio output power against 5 watts of output power in the transistorized unit.

More Reliability

Among two-way radio users, transistorization has come to mean added reliability. When applied to a police or fire-department communications system, this reliability could be equated with the preservation of life or property. In business applications, added reliability means being able to depend on communications when they are needed most, perhaps to fill a need which could affect a large sum of money or expensive equipment.

At first glance, the claim of "added reliability" may seem a bit nebulous. As we have seen, transistors do contribute to a reduction in battery drain. But what about the over-all dependability of the radio unit; will it stand up under the kind of punishment inherent in industrial and public-safety use?

Heat has always been a problem in all types of electronic equipment, but especially in two-way radio applications. Many mobile units are mounted in the trunk of a car with only the control head and the loudspeaker installed under the dash. It gets hot in the trunk of a car; 140°F is not at all unusual In such cases, heat dissipation can be a real challenge and the more heat the radio generates, the more the radio contributes to its own destruction. Transistors, because they have no heater filaments and because they have higher efficiency ratings (*i.e.*, less power is lost in the form of heat), generate less internal heat and thus keep the inside of the radio set some 25 to 40 degrees cooler than comparable tube-type equipment.

Heat can work against transistors, too, and we should not overlook this fact. Transistors are very temperature-sensitive. Unlike the vacuum tube, the transistor's characteristic operating curves are a function of temperature. Therefore, if a transistorized unit is designed to operate at 25°C (room temperature), the transistors may be operating on a different portion of their characteristic curves when the radio is inside a hot automobile trunk. This is not really a problem, however, as well-designed equipment and commercial transistorized mobile radios will operate within EIA and FCC tolerances over the ambient temperature range of −30°C to +60°C.

Transistors, by nature, are a "permanent" type of component, just as resistors, capacitors, coils, and so forth. Certainly transistors fail, as do a certain percentage of any component used in electronic equipment. Generally speaking, though, transistors do not fail in or of themselves. They will fail, as an example, because of a current which exceeds their rated value, but such a failing is not due to inherent properties of the transistor itself; it is due to some other circuit malfunction *outside* the transistor. On the other hand, tubes fail because of their very makeup. They lose emission, filaments burn out, elements are susceptible to vibration and may become short-circuited.

In this new solid-state two-way radio, not only are all tubes replaced by transistors, but switching and crystal temperature compensation functions are performed by solid-state devices.

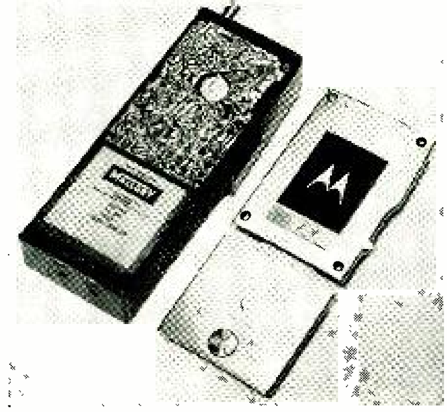
Older type tube portable is contrasted with equivalent all-transistor unit. The smaller unit weighs 6 pounds as against 19 for tube model and provides 75-80% reduction in battery replacement costs.

Statistics gathered from service stations throughout the country have shown conclusively that transistorized radio units require less maintenance and service than do equivalent tube-type units. The cost of maintaining transistorized equipment has averaged better than 10% less than the cost of keeping a similar tube-type radio operating properly. And the cost of "down time," to a user who is really depending on his radio, is an intangible but significant factor in judging the value of reliability.

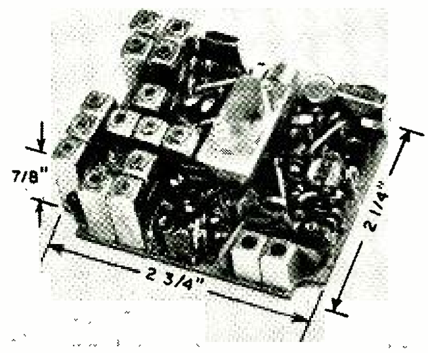
Additional Features

A newly developed *Motorola* all-solid-state mobile radio provides some additional interesting features contributed by transistor circuitry. All mechanical switching in this unit has been replaced by solid-state switching devices. The functions of the "push-to-talk" relay and its slave, the antenna relay, are both handled by solid-state electronics. Thus, what used to be done by mechanical switching is now done without the need for moving parts. Contact corrosion and pitting are eliminated. Mechanical fatigue is gone.

Solid-state electronics has, in this new radio, provided extreme stability. The oscillator voltages are regulated by zener diodes to compensate for varying primary power voltages. Solid-state compensating circuitry keeps the crystal oscillators within $\pm 0.0005\%$ of the operating frequency, and this is accomplished without crystal ovens or heaters, despite an ambient temperature variation between $-30°C$ and $+60°C$. Furthermore, frequency drift due to crystal warm-up cycling has been eliminated. With this particular radio, the user can transmit—on his exact frequency—the moment the radio is turned on.



Completely transistorized hand-held two-way radio. Radio circuitry occupies little more than half of total volume, while battery accounts for rest of the 8" case.



Receiver module for hand-held radio. Specifications include .035 μv. sensitivity for 20 db quieting and $\pm 0.0025\%$ stability, unusual for such a small sized receiver.

The solid-state transmitter (50 watts in the 25-50-mc. region and 30 watts at 150 mc.) has eliminated power slump problems often associated with vacuum-tube final r.f. amplifiers. And this consistent power output is a long-term affair; the final r.f. transistors can be considered a much more permanent component than even the best industrial-rated vacuum-tube r.f. amplifier.

Transistors have also made some refinement in mobile radio design. Because of the extremely compact size of solid-state circuitry, a transistorized preamplifier can be fitted right into the microphone housing. Such a preamp allows the low-level signal from a dynamic microphone element to be boosted to the level of the signal from a carbon mike. Not only does this allow the user to take advantage of the superior signal quality of the dynamic mike, it also gives the audio signal a "head start" over any hum or noise which could be picked up by the mike cable. Thus, if the transmitter is installed in the trunk of a car, a clean, high-level audio signal is introduced into the modulator stage.

The Power Supply

Another refinement contributed by the transistor is in the mobile radio power supply. Replacing the vibrator and dynamotor supplies, a solid-state multivibrator circuit (using power transistors to handle high currents) changes the low-voltage d.c. from the vehicular electrical system to a high-voltage square wave. The square wave is stepped up further by a saturable core transformer and the waveform is rectified and filtered to provide the necessary high voltages. Rectification, incidentally, is performed by silicon diodes, thus eliminating vacuum-tube rectifier heater current and the associated radiation of heat within the radio, while providing improved rectifier efficiency.

The transistorized power supply was actually the first application of transistors in mobile radio design, predating the transistorized receiver by a year. The most important benefit is, once again, the elimination of moving parts. If you will remember some of the vibrator troubles you have experienced with your car broadcast-band receiver, you can appreciate the contribution transistorized power supplies makes toward over-all reliability. Vibrators also cause a certain amount of "hash" interference which has been eliminated by the transistorized multivibrator circuit. Dynamotors, on the other hand, represent their own brand of trouble; they are expensive, heavy, and require a good deal of maintenance. This, too, has all been eliminated by the simple, straightforward transistor circuitry. And such a power supply is able to provide sufficient power to units that are rated as high as 100 watts of transmitter output.

In portable communications equipment, transistors have made a dramatic difference. A good deal of the size and weight of a portable communications radio is due to the battery complement alone.

With the reduced primary power requirements of transistorized circuitry, the physical size of the battery has allowed a distinct reduction in the size and weight of the radio. Also, transistors themselves are far smaller than subminiature vacuum tubes and allow a further reduction in radio size. We are quickly approaching the goal of Dick Tracy's famous wrist-watch two-way radio.

Equipment Cost

Which brings us around to the final consideration—cost. How do the benefits of transistorization affect the user's pocketbook? The initial cost of transistorized gear is, admittedly, somewhat higher than the price of a comparable tube-type unit. But over-all cost must be integrated over three factors: initial price, operating costs, and maintenance cost. Furthermore, most industrial and business users are also interested in the equipment trade-in value at the end of a 5-year (or whatever length of time) write-off interval of time.

We have already shown many areas in which transistorized mobile and portable communications equipment offer significant reductions in both operating and maintenance costs. And it might be well to reiterate the idea that the cost of "down time," although it is not as easily measured, is a factor to be considered very carefully in evaluating the merits of transistorized equipment. On the used-equipment market, transistor communications radios can be expected to bring a much higher percentage of trade-in return, simply because they will be that much less obsolescent at the time the equipment is traded than will vacuum-tube gear. This trend is already quite noticeable and the gap will undoubtedly widen considerably over the next few years as more and more transistorized equipment comes into use.

Tube-type equipment is still being purchased by many owners of new two-way radio systems. But in equipment which offers a choice between tubes and transistors, the prospective user should give serious consideration to all the factors involved before making his final selection. Tubes aren't dead—not by a long shot—but transistors are here to stay in radio communications equipment, and they are providing tangible benefits. The most important of these include greatly reduced equipment size and battery-current drain, less maintenance, and more reliability. ▲

QUIETING AUDIO SWITCHING TRANSIENTS

By RONALD L. IVES

Some simple methods of eliminating switching noises that may occur during audio transfers.

FREQUENTLY when switching in an audio circuit, there is a loud and unwanted "plop" in the speaker. Elimination of this annoyance has been found quite difficult, so that many audio circuits are transferred by fading, rather than by switching. Happily, as a switch is very much cheaper than a fader, audio switching, in most instances, can be quieted so that the transfer "plop" is almost or entirely inaudible.

Most of the transfer noise in audio circuits is due to a small difference in d.c. potential across the switch. Conditions leading to this difference of potential are shown in Fig. 1. Here when the switch is open, the output side of the plate capacitor acquires a positive charge approximately equal to that on the plate of the tube. This charge will be greatest with a high-grade well-insulated capacitor, and least with one which leaks to ground. Leakage across the capacitor will then complicate this picture still further.

The grid of the following tube will be slightly negative with respect to ground, due to "contact potential." Depending on the tube characteristics and the grid resistance, this can be anything from a few millivolts up to perhaps two volts, the higher value being attained only when the grid circuit resistance is extremely high.

When the switch is closed, the charge on the output side of the plate capacitor is applied to the grid of the following tube, driving it positive for a few microseconds, and producing the unwanted "plop" in the system output.

The annoying switching transient can be greatly attenuated, usually by more than 20 db, by use of a variety of potential equalizing circuits. The circuit shown in Fig. 2 is one of the simplest of its type. Here, the interstage coupling capacitor is replaced by two capacitors in series, each of double the original capacitance. The switch is placed between them. The switch side of each half of the coupling capacitor is grounded through a relatively high resistance, such as 4.7 megohms. As both sides of the switch are at substantially the same potential, both before and after switch closure, no transient due to d.c. potential differences can occur as a result of switching.

Values of the grounding resistors are not very critical. In very general terms, resistance must be low enough to drain off charges plus leakage (*all* capacitors leak, but good ones may have a leakage resistance considerably in excess of 100 megohms). Resistance must also be high enough so that the grounding resistors do not load the audio circuit appreciably and "bleed off" the signal. Values from 1 to 10 megohms are usually suitable for low-level audio systems; from 0.1 to 1 megohm for high-level systems; and as low as 1000 ohms for low-impedance circuits, such as cathode-follower outputs.

(Editor's Note: A simple technique that is often successful is to shunt the switch with a large resistor, on the order of 10 megohms. In order to prevent excessive signal leak-through, however, this can be done only if the following grid resistor is one-tenth or less of this resistance value.)

An alternative circuit, which is usually equally effective and which uses about the same number of components, is shown in Fig. 3. Here, the load side of the plate blocking capacitor is held to the potential of the grid of the following tube by the two resistors shunted across the switch. Signal "sneak through" is greatly attenuated by the large capacitor from the junction of the two resistors to ground. Resistor values should be in about the same range as the previous circuit. The "signal dumping" capacitor should be as large as convenient, preferably several microfarads, although a value as low as 0.1 μf., used in conjunction with 4.7 megohm resistors, is quite effective.

A number of other circuits are about equally effective and almost any rational arrangement that keeps the two sides of the switch at the same d.c. potential while not loading the circuits excessively and bleeding off the signal will be effective in reducing transients to a low, negligible, or undetectable value. ▲

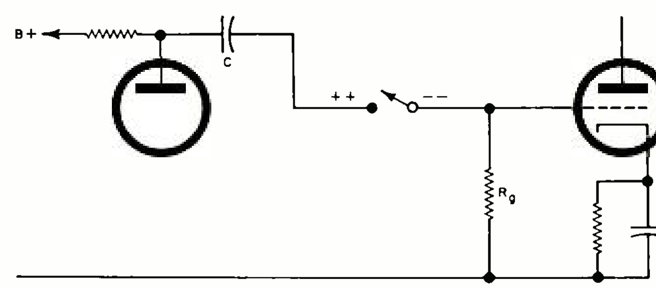


Fig. 1. Potential differences that exist across the switch.

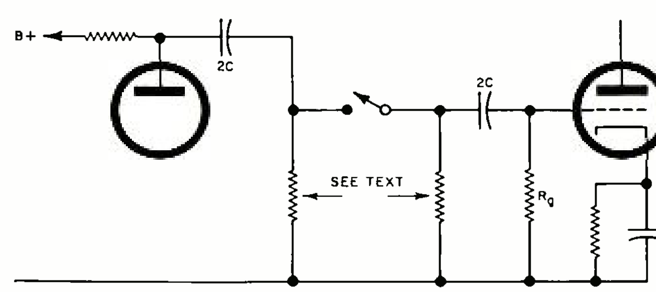
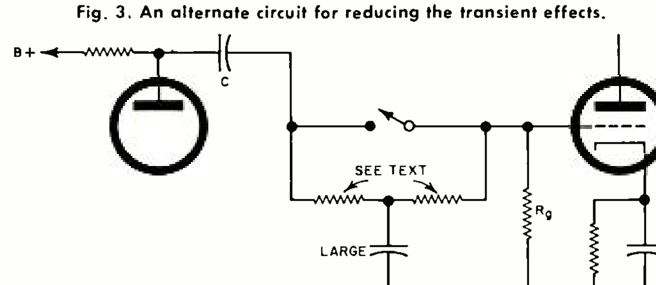


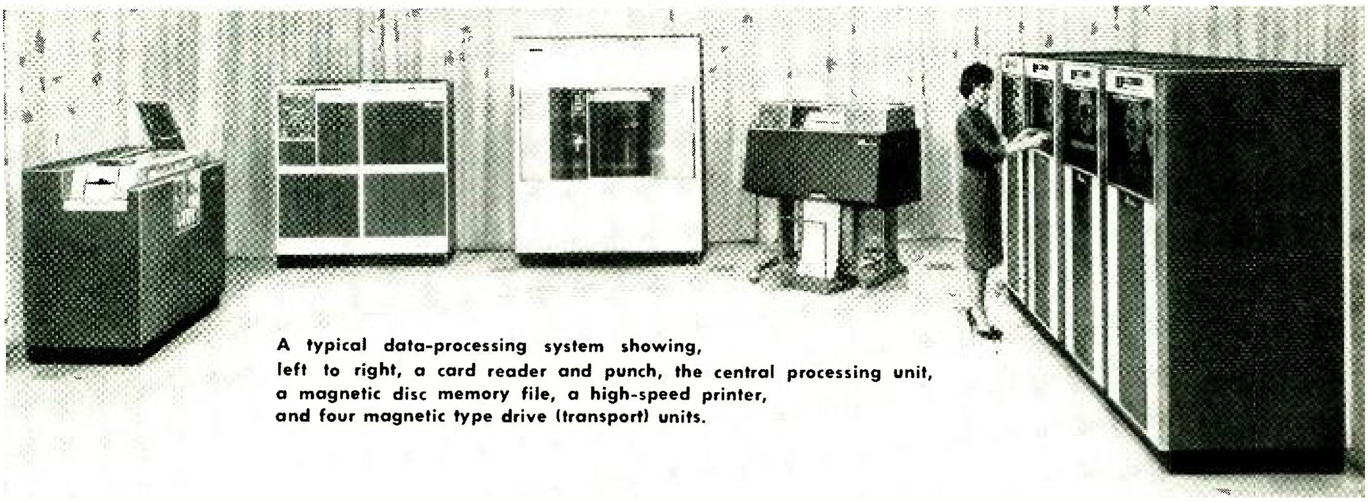
Fig. 2. Potential-equalizing circuit for switching transients.

Fig. 3. An alternate circuit for reducing the transient effects.



COMPUTER INPUT-OUTPUT EQUIPMENT

By ED BUKSTEIN



A typical data-processing system showing, left to right, a card reader and punch, the central processing unit, a magnetic disc memory file, a high-speed printer, and four magnetic type drive (transport) units.

The central computer communicates with its human user by means of punched cards, magnetic tape, and various high-speed printers.

MUCH of the "hardware" of a computer installation is input/output equipment. It is through this I/O equipment that the central computer receives data and instructions, and communicates the results of its data processing. A complete computer system therefore consists of (1) the *central computer*, also known as the processor or central processing unit, which contains the memory, arithmetic, logic, and control circuitry; and (2) the *peripheral* devices, serving as I/O units for the central computer. Typical installations are shown in the photos and in block form in Fig. 1.

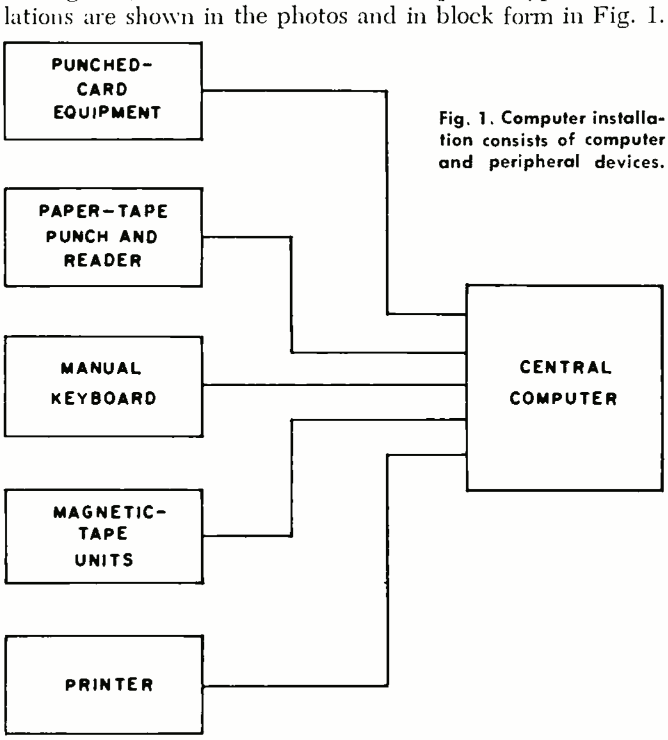


Fig. 1. Computer installation consists of computer and peripheral devices.

Peripheral devices may be used either *on-line* or *off-line*. Off-line devices are not electrically connected to the central computer and therefore are not under its direct control. These units prepare cards or tapes for later use by the computer. On-line devices are connected to and controlled by the central computer. This mode of operation permits the central computer to communicate directly with the peripheral devices and to call for such operations as card punching, magnetic tape search, and reading paper tape.

Punched-Card Machines

The punched card is a familiar medium for introducing data into a computer. In one of its popular forms, it is a 3¼" by 7⅜" piece of flexible cardboard with holes punched through it in various positions. It is the *positions* of these holes that represent the data. Fig. 2 shows a card punched to represent the digits and alphabetic characters. The standard *IBM* card has 80 columns and can, therefore, be punched to represent as many as 80 digits, alphabetic characters, punctuation marks, or special symbols. Numerical data is represented by a single punch per column, and alphabetic characters require two punches per column. Some special symbols are represented by three punches per column.

The card *reader* is a machine which examines the cards and interprets the data represented by the holes. The deck of cards to be read is placed in a hopper, and a card transport mechanism feeds them past the reading station one at a time. Reading can be accomplished either by means of wire brushes that contact a metal roller through the holes in the card, or by photocells illuminated through the holes. Reading speeds up to 2000 cards per minute are attained in some machines, but 250 to 1000 cards per minute is more typical.

The machine that produces the holes is known as a *punch*. In this machine a deck of blank (unpunched) cards is transported—one card at a time—to the punching station. Here, the punches are activated to produce the desired pattern of holes.

After each card is punched,, the card transport mechanism moves it to a stacking bin. Some machines have a manual keyboard to permit the operator to punch-in the desired data, others are designed to be controlled by electrical signals from the central computer. As might be expected, card punching is a slower operation than reading. A typical maximum speed for the punching operation is 250 cards per minute.

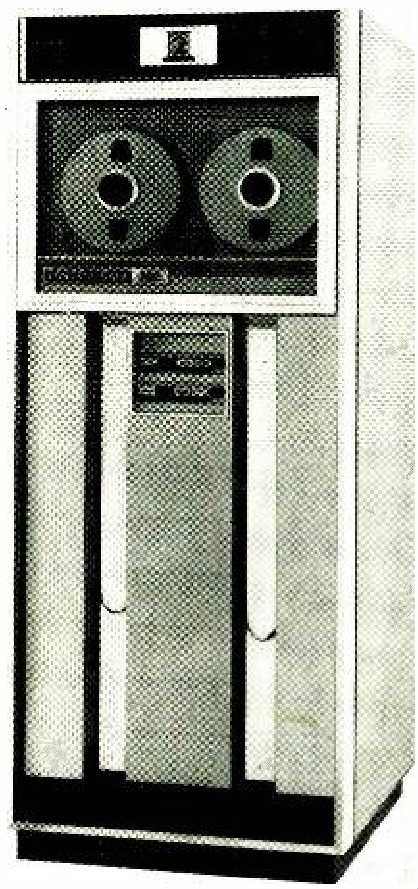
Another useful card-handling machine is the *sorter*. As implied by its name, the sorter can inspect a deck of cards and sort them in numerical sequence according to the digits in specified columns.

In business-data processing, for example, a card may be punched for each transaction. The card may show the date of sale, amount of purchase, and the customer's account number. Assume that each customer is assigned a six-digit account number, and that the first 6 columns of the card are punched accordingly. A group of columns punched to represent a specific item of information is known as a *field*. At some time during the data processing it may become desirable to sort a deck of cards into numerical sequence according to one of the fields.

Assume, for example, that the cards are to be sorted according to customer account number. The deck of sales cards is placed in the hopper of the sorter, and the brush or photocell sensing unit is set to read column six of each card. The sensing unit controls an electromagnet to "steer" each card into one of several bins. In this manner, the cards are stacked in separate bins according to the right-most digit (6th column) of the customer account number. All cards having a 0 in the 6th column are stacked in one bin, those having a 1 in the 6th column are stacked in the next bin, etc.

The operator now takes the cards from the bins and places them back in the hopper. This time the reading brush or photocell is set to read column 5. As a result, the cards are sorted again into separate bins, but this time on the basis of the digit in column 5. The process is then repeated for columns 4, 3, 2, and 1. The end result is a deck of cards in numerical sequence according to customer account number. Sorting can also be accomplished on the basis of alphabetic characters.

Another useful card-handling machine, the collator, can be used to merge two separate decks into a properly sequenced single deck which facilitates the processing.



Magnetic tape is widely used for data storage. This magnetic tape transport shows tape loops hanging in vacuum columns.

Perforated Tape

Punched paper tape is a popular item for storing programs and data and for introducing these into the computer. The punched tape, also known as perforated tape, is a long strip of paper with holes punched through it to represent digits, alphabetic characters, and special symbols. Several different paper tape codes are in use: two typical examples are shown in Fig. 3. One of these is a five-channel or five-level tape, and the other has seven levels.

The five-level code was originally developed for teletypewriter equipment. This code is ambiguous in the sense that a given configuration of holes can represent either of two characters depending on whether it has been preceded by an "upper-case" or a "lower-case" signal. The same hole configuration, for example, can represent either "B" or "$."

An interesting feature of the seven-level code shown in Fig. 3 is that each character is represented by an *odd* number of holes. This feature of the code is useful for error-detecting purposes—a configuration containing an even number of holes would be recognized in the machine as an error.

Reading of paper tape can be accomplished either mechanically or optically. Mechanical reading involves wire brushes or pins that contact a metal plate through the holes in the tape, and the optical type employs light sources and photocells for converting the hole configurations into corresponding elec-

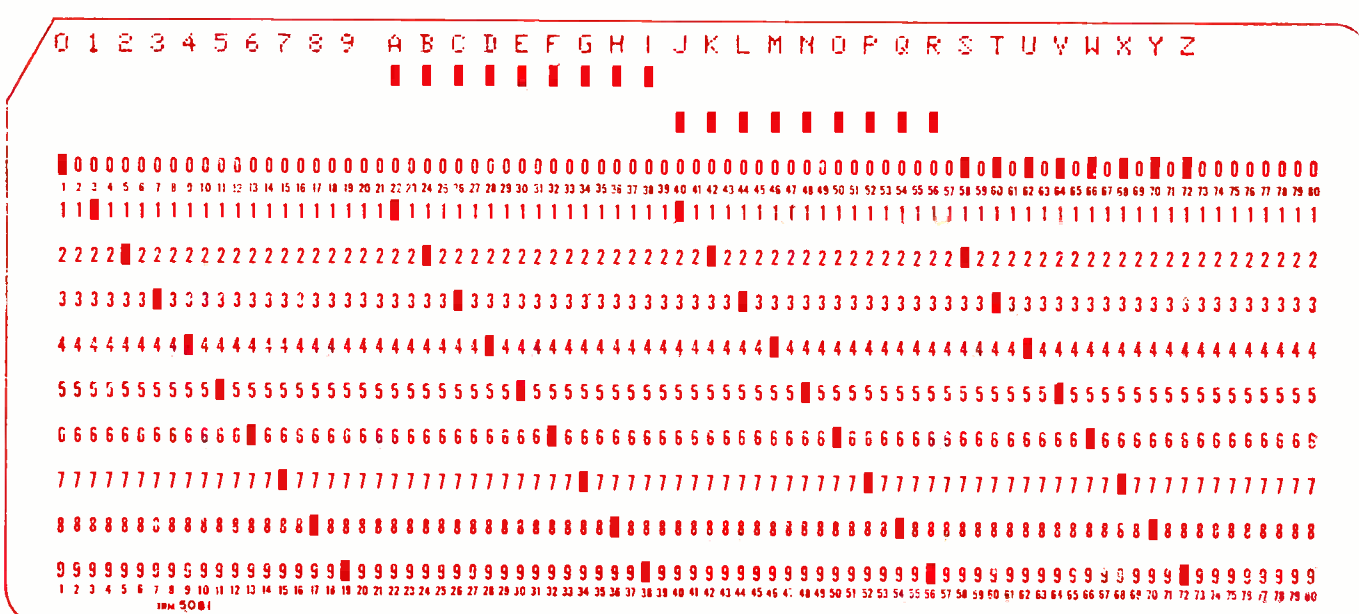


Fig. 2. Punched card showing hole configurations for digits and letters of alphabet. Every other column has been left unpunched for clarity, but could be used.

Another typical computer system. Operator's console is at center, punched-card machine at left, and tape machines at right. The "wall" in left background is central processor used with system.

trical impulses. The smaller, evenly spaced holes in the tape are used to control the movement of the tape through the machine. These are known either as *feed* or *sprocket* holes. Punching and reading functions are frequently combined in a single machine and controlled by a typewriter keyboard. A typewritten copy and the punched tape can therefore be produced simultaneously by the operator.

Tape-reading speeds vary greatly according to the design of the machine, and range all the way from as low as 10 to as high as 1000 characters per second.

Magnetic Tape

Magnetic tape is used extensively in computer installations. Because magnetic tape can be read much faster than either paper tape or cards, the paper tapes and cards are often converted "off-line" to magnetic tape. The data can then be read into the computer very rapidly. A further advantage of magnetic tape is that it can later be reused for other data. Except that it is of better quality and is manufactured to much closer tolerances, computer tape is essentially similar to the magnetic tape used for audio applications.

Instead of the hole or no-hole type of representation of perforated tape, data is represented on magnetic tape by magnetizing the tape in one direction or the other. The 0 and 1 of the binary system, for example, can be represented by opposite directions of magnetization. In another recording technique, the direction in which the tape is magnetized is reversed for each binary 1 and left unchanged for each binary 0. Information is recorded in many parallel tracks along the length of the tape. Typically, a tape one-half inch wide has seven parallel tracks—analogous to a seven-level perforated tape.

Computer tape is made up in reels of 1200, 2400, or 3600 feet, and between 200 and 800 characters can be recorded along each inch of tape. Literally millions of characters can therefore be stored on a reel of tape.

Information stored on magnetic tape is organized into groups known as *blocks* or *records*. Each block may contain one or more computer words, and the tape is left unmagnetized between successive blocks. These unmagnetized *gaps* are about ¾ inch in length. The block is the smallest separately addressable unit of information on the tape. A counter circuit keeps track of the passing blocks of information and activates the readout circuitry when the desired block has reached the reading station.

Because the relatively heavy reels of tape cannot be started, stopped, or reversed fast enough, the tape is allowed to hang loosely on each side of the read-write heads. Servo controls prevent the tape loops from becoming too long or too short. These loops constitute a low-inertia supply of tape that can be accelerated or decelerated very rapidly, and the motor-driven reels "catch up" a short time later. This arrangement permits starting and stopping times on the order of 2 to 5 milliseconds.

Tape-handling speed is generally in the range of 50 to 200 inches per second, but even (*Continued on page* 113)

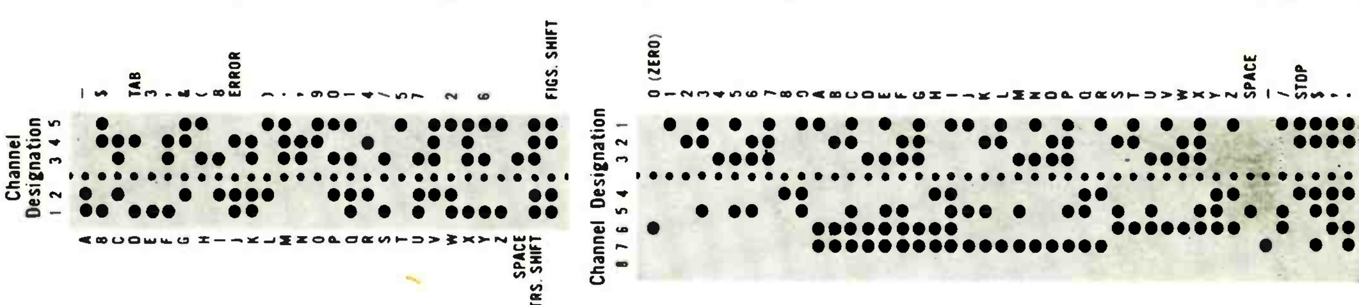
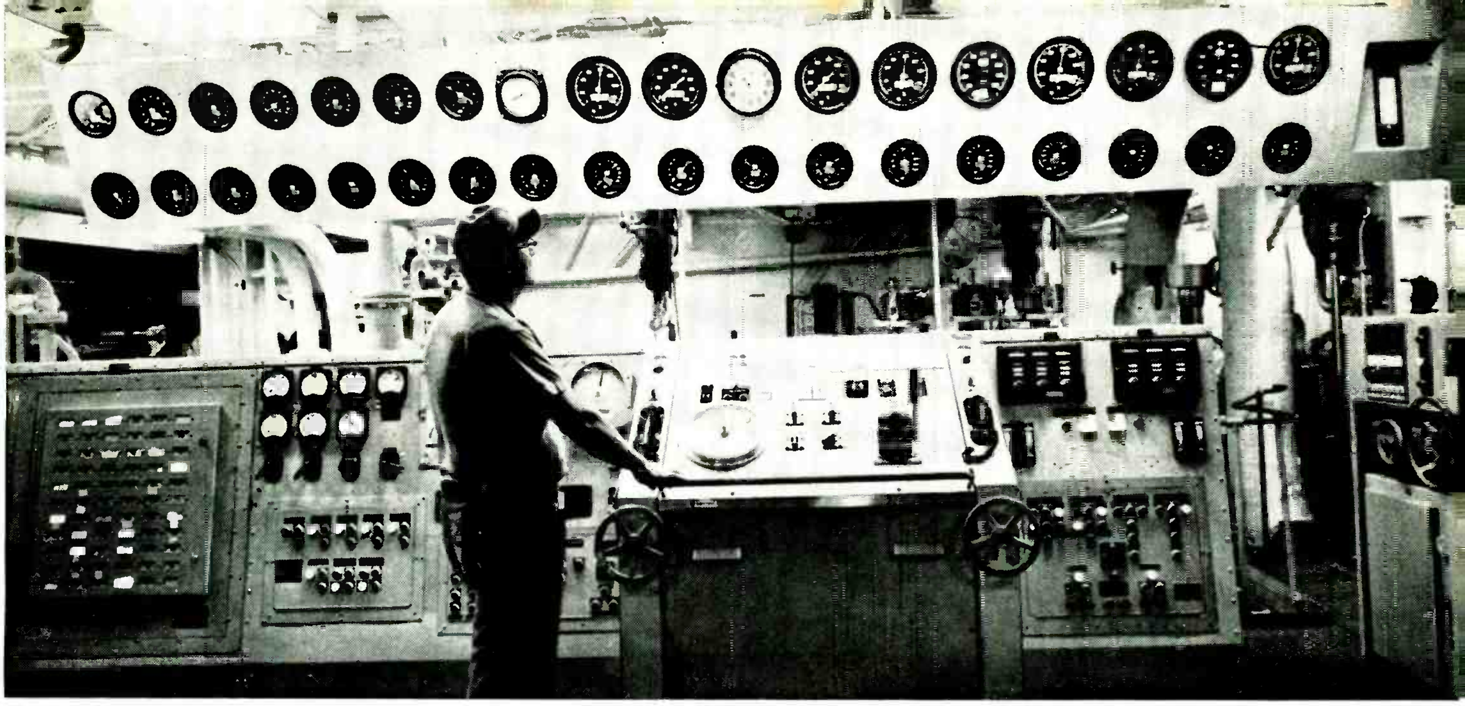


Fig. 3. Perforated tape is used to store programs and data for computers. Positions of holes represent digits, letters, punctuation.

This data-processing system employs an input-output typewriter shown at the right of console, perforated tape punch and reader, left.



The automated engine room shows how one man can observe and control the entire operation of the engine room of a modern ship. This vessel was built by Ingalls Shipbuilding Corp., a division of Litton Industries, for the Moore-McCormack Lines.

AUTOMATED SHIPS

By using electronic transducers and systems, it now becomes possible to have one man run the engine room of a modern cargo or passenger vessel.

THE SS *Mormacargo* (named for the constellation Argo) is the first vessel in U.S. maritime history to be centrally controlled by the use of electronics and represents a breakthrough in American vessel construction and operation. The vessel also carries the usual complement of conventional electronic radio and navigation gear.

For the first time, a ship's throttle (thus speed) can be controlled directly from the bridge; the main engine and boilers automatically respond to the movement of the bridge throttle lever, making it possible for the ship to go from zero to full speed in less than five minutes. The engine room can override the bridge at any time.

Transfer of throttle control cannot be accomplished in either direction unless the throttle levers are matched in command, otherwise there may be an engine-damaging "bump" during the transfer. Angle-measuring devices are coupled to each throttle with output displayed on a meter at each console. Besides the visual indication (meter) when the throttle positions are matched, an indicator lamp also comes on upon proper matching.

The engine room watch location (shown above) is the main control center. Here are located all the meters and gauges that formerly were scattered about the engine room and other sections of the vessel. Electronic transducers are used to sense the hundreds of points that formerly were monitored by the engineer on watch.

A tachometer on the propeller shaft senses shaft rpm and displays it both in the engine room and on the bridge consoles, while 108 separate points in the engine room are automatically scanned every five minutes for temperature, pressure, liquid levels, or motor failures. The results are read out on panel meters and on a system of print-out recorders. In the event of a dangerous condition, an alarm sounds and the console displays the source of the alarm condition.

Thermistors are scattered about the ship at various temperature-sensitive points, such as refrigerated holds, key lubrication points, and other temperature-sensitive areas. These points are scanned in sequence and an alarm indicates when one exceeds its predetermined level. Readout is by meter and print-out recorders.

An infrared-sensitive flame scanner is used to sense the condition of the flames heating the water in the boilers. If for some reason the flame changes color (due to changes in either fuel or air characteristics), the electronic circuit shuts down the boilers to avoid damage. A water-level detection circuit monitors water level within the boilers and shuts them down in the event of low level.

This centralized control console reduces engine-room personnel walking time by an estimated 85% and relieves the personnel of more than 150 former manual operations. ▲

The new look in ship's bridges. Using electronic circuits, the ship's throttle can now be controlled from the bridge.

VIBRATION INSTRUMENTATION

Excessive vibrations can destroy most machinery. Fortunately, there are several electronic methods of detecting and measuring their types and amplitudes before they become serious.

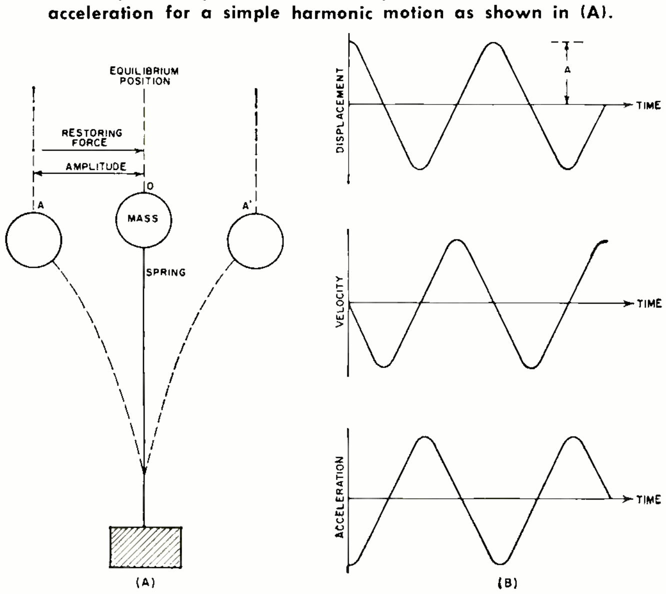
By SIDNEY L. SILVER

WITH the increasing use of high-precision instruments and electronic devices in automatic control processes, it is necessary to determine the existence of any dangerous modes of mechanical resonance which may be excited by the normal motion of industrial machinery. The mechanical vibration of component parts of the machinery may limit the accuracy of sensitive and delicate instruments and also result in the generation and transmission of undesirable acoustic noise. In addition, excessive vibration becomes a destructive force which can cause malfunction of equipment, or if the stress is sufficiently high, damage the equipment by structural fatigue.

To meet these problems, a suitable instrumentation system must be employed to continuously monitor the vibration patterns so that unwanted vibrations can be quickly detected and located under various operating conditions. The most common method of vibration measurement uses electronic techniques to convert the vibration component into an equivalent electrical signal. When the vibration exceeds a predetermined level, the signal may be used to trigger an alarm device or actuate a relay to shut down the equipment. To permit a detailed and precise study of the vibration modes, it may also be necessary to measure and analyze the directions of motion as well as the amplitudes of such vibration so that effective means may be devised for its elimination.

In military and commercial applications, shock and vibration measuring systems are often encountered in the dynamic testing of all modern vehicles to determine the magnitude of the forces acting on the vehicle under actual operating conditions. Such measurements are required, for example, to determine the riding qualities of railroad cars and automobiles. In the analysis of missile and aircraft data, vibration studies are frequently made in conjunction with airborne telemetry systems. From these investigations, the vibration characteristics can be evaluated and any modifications necessary to improve the structural design can be made.

Fig. 1. (A) Simple harmonic motion of a mass-spring system. (B) Graphical representation of displacement, velocity, and acceleration for a simple harmonic motion as shown in (A).



Vibration Characteristics

Vibration is a phenomenon that describes a continuing periodic motion, or oscillation, in a mechanical system. The periodic motion, usually unintentional and often undesirable, results in a change in the magnitude of a displacement of a solid structure from its position of equilibrium. It may be a simple sinusoidal motion having a single frequency component, or it may be of random frequency and magnitude where the vibration pattern is a combination of several sinusoidal quantities, each having a different frequency and amplitude.

The frequency range of solid-borne, or mechanical vibrations—such as those produced by unbalance of rotating machinery—commonly extends from one cps to 2000 cps (corresponding to rotational speeds of 60 to 120,000 rpm). Mechanical vibrations, such as those produced by powerful engines, may also involve the transfer of energy to the surrounding air in the form of sound waves in the audible frequency range (20 to 20,000 cps). These airborne vibrations create acoustic noise which is a source of annoyance and discomfort. If the intensity of the noise level is sufficiently high, equipment failure may occur due to damage to electrical or electronic components.

In general, vibration problems lie in six basic modes of motion which may occur linearly along the lateral, vertical, and longitudinal axes of a mechanical structure; or in a rotational motion along the corresponding axes. These modes may be excited by vibratory forces individually or in any combination.

In the simplest case, where the vibratory motion is a straight line (rectilinear), there is one particular mode of motion, referred to as simple harmonic motion, which forms the basis of studies of vibration. This motion is essentially a vibratory displacement with variable acceleration. As shown in Fig. 1A, the vibrating part may be represented by a spring securely clamped at its lower end, with a small mass or body attached to its free end. It is assumed that the spring is sufficiently long and the displacement is sufficiently small, so that the vibratory motion of the mass-spring system is essentially linear. A disturbing force displaces the spring to the left from the position of equilibrium to a maximum amplitude A. If the applied force is now removed, a restoring force is exerted by the spring which directs the mass toward the equilibrium position. The mass accelerates toward the origin, but since the rate of increase is not constant, the accelerating force decreases as the body approaches equilibrium. When the mass reaches the origin the restoring force has decreased to zero, but since the body now possesses some velocity it overshoots the position of equilibrium and moves toward the right. At the point of maximum amplitude A', the restoring force again comes into play but now is directed toward the left. Theoretically, if there were no loss of energy due to air resistance or internal friction of the spring, the vibratory motion would continue indefinitely. Since the motion is repeated in equal time intervals, it is described as a periodic motion, and since it traverses the same path over and over again, it is also an oscillatory motion.

To help visualize harmonic motion, the displacement, velocity, and acceleration may be represented graphically with the parameters plotted against time. As shown in Fig. 1B, these quantities are sinusiodal functions of the same frequency but displaced along the time axis. The time curves indicate that the magnitude of acceleration is proportional to the magnitude of displacement, but the direction of acceleration is always opposite to that of displacement. However, the velocity reaches a maximum value when the displacement is zero, *i.e.*, at the origin, and zero when the displacement is a maximum.

The magnitude of motion of the vibrating part or displacement, follows the sinusoidal function $d = A \sin \omega t$, where d is the displacement in inches, A is peak amplitude, ω is 2π times the frequency of vibration, and t is time in seconds.

The time rate-of-change of displacement, or velocity, is expressed by the formula $v = \omega A \cos \omega t$, where v is velocity measured in inches per second and A is peak amplitude.

Acceleration is the derivative, or time rate-of-change of velocity, and is given by $a = -\omega^2 A \sin \omega t$, where a is acceleration in inches/second/second.

The negative sign indicates that the vibrating part experiences a restoring force which is always opposite in direction to the displacement. To obtain r.m.s. values of displacement, velocity, or acceleration in the above equations, the peak amplitude A is multiplied by .707.

Transducer Systems

Transducing devices for translating mechanical vibrations to electrical signals may be divided into three classes according to whether displacement, velocity, or acceleration is the parameter to be measured. In the study of low-frequency vibrations, velocity and acceleration have very small values so that displacement is the most easily measured quantity. A measurement of displacement is desirable when the amplitude of motion is critical, such as in assemblies where parts must not contact each other. Where excessive motions are involved, for example, structural components may tend to stick together and cause serious damage due to rattling.

To measure the magnitude of motion of a vibrating body, it is common practice to employ a proximity pickup as the sensing element of the transducer. With such a device, no physical contact is made with the vibrating surface to be measured so that the transducer does not mechanically load the vibrating object.

Fig. 2 shows a proximity pickup based on the mutual inductance principle. In this configuration, a primary coil (L_p) and a secondary coil (L_s) are wound on a nonmetallic form in such a way that the length of an air gap between the coils and a vibrating surface is changed. To energize the transducer, the primary coil is excited by a regulated high-frequency oscillator (of the order of 2 mc.). The magnetic field produced by the primary coil opposes the eddy-current field induced in the vibrating surface, and the resultant magnetic field determines the voltage induced in the secondary coil. If the metallic surface to be measured is stationary with respect to the sensing probe, the output voltage is zero. If the surface is vibrating, however, the output contains an a. c. component which is directly proportional to the amplitude of vibration. As the vibrating part moves closer to the windings, for example, the opposing eddy-current field increases and the effective output voltage is reduced. The rectified output of the transducer, which is amplified and read on a v.t.v.m., thus provides a direct indication of the spacing between the sensing element and the vibrating surface.

When the vibrating surface is a magnetic metal or a nonconducting material, a strip of copper or aluminum foil may be cemented to the portion of the surface under the pickup.

In many vibration problems, a knowledge of velocity is essential when a vibrating part radiates sound energy in a manner similar to that of a loudspeaker. Velocity measurements are generally employed in acoustic and noise problems where the radiated surfaces are large compared with the wavelengths of the sound in air. Under these conditions, the vibrating part produces a sound pressure which is directly proportional to the velocity of vibration.

To measure the velocity of vibration, seismic devices are employed which are based on the mass-spring principle. In

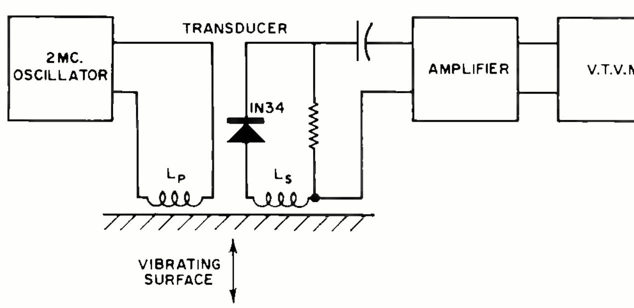
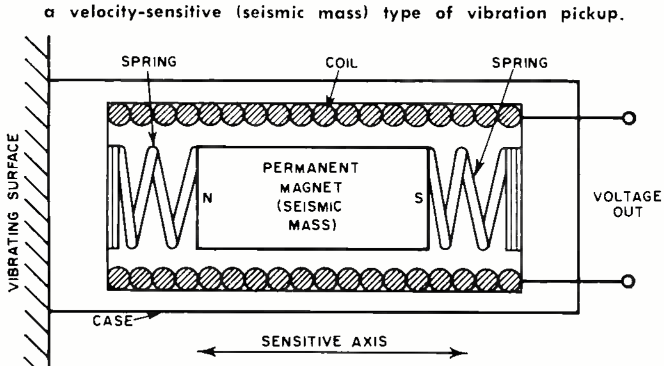


Fig. 2. The basic circuit of a vibration displacement measuring system based on mutual inductance operating principle.

Fig. 3. This cutaway view shows the internal construction of a velocity-sensitive (seismic mass) type of vibration pickup.



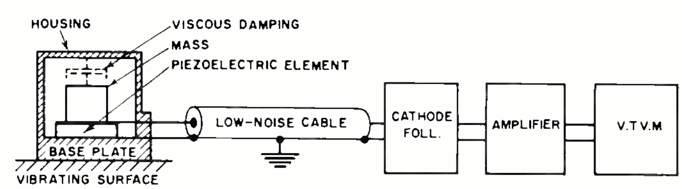


Fig. 4. Self-generating transducer system for measurement of acceleration-proportional vibrations uses a ceramic element.

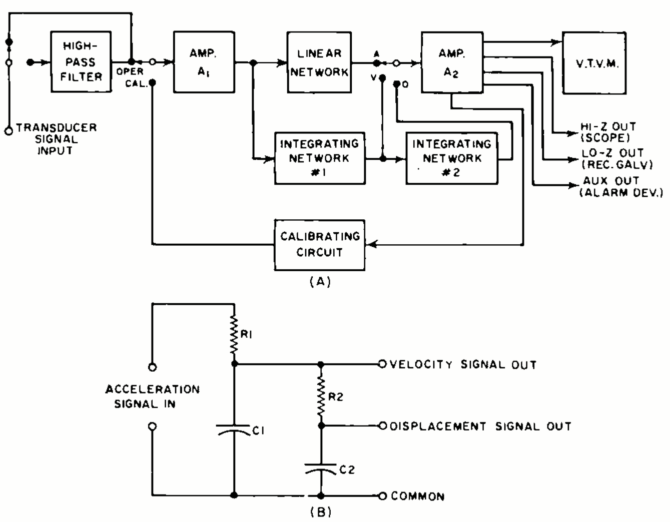


Fig. 5. (A) Functional block diagram of a typical vibration meter. (B) Simplified schematic of a two-section integrator.

these self-generating units, the two principal elements are a coil of wire and a permanent magnet. As shown in Fig. 3, the magnet is seismically coupled to the case of the instrument by means of springs, while the coil (integral to the case) is loosely wound on the seismic mass. The pickup is designed with a low resonant frequency characteristic (about 10 cps) so that the operating range of the instrument lies above the natural frequency of the seismic system.

If a vibratory motion is now applied along the sensitive axis of the transducer, a change in flux linkage is affected between the coil and the magnetic field produced by the magnet. Since the frequency of vibration is higher than the natural resonance of the mass-spring system, the suspended magnet remains essentially fixed in space. Thus, the relative motion between the magnet and the coil causes a voltage to be generated in the coil, the magnitude of which is directly proportional to the rate-of-change of displacement, or velocity.

Generally, seismic instruments are rigidly attached to the vibrating surface to be measured. Sometimes, however, the correct fastening point is not obvious and it may be necessary to explore the vibration pattern to determine the proper orientation of the pickup with respect to the direction of vibratory motion. For this purpose, a hand-held pickup may be employed in which the transducer may be rapidly positioned to measure vibration in any desired direction.

A typical commercially available hand-held pickup designed for vibration testing of components in applications where pickup weight is critical, adds only about one gram of mass to the vibrating structure so that undesirable shifts in mechanical resonance are avoided. To operate the device, a small metal rod or probe incorporated on the pickup is held in contact with the vibrating surface. The vibratory motion is transmitted along the probe to actuate a pivoted coil which is free to move in a magnetic field provided by a pair of permanent magnets. The voltage generated by the motion of the coil accurately reflects the amplitude and natural frequency of the structure under test. Since the unit is essentially a low-impedance device, a long cable may be used to run the output signal to a vibration meter for readout.

In many cases of vibration disturbances, small parts of machinery or equipment vibrate at relatively low frequencies so that the wavelength of the sound in air is larger than the front-to-back distance of the vibrating part. Since the vibrating surfaces are comparatively small, very little sound energy is radiated. In this situation, a knowledge of acceleration provides a better indication of emitted noise than does a velocity measurement.

Acceleration measurements are also useful in determining the forces and stresses produced by vibrating parts, especially when mechanical failure is a possibility. If a disturbing force continues to act at periodic intervals upon a body, the result is a forced vibration which is sustained indefinitely. When the frequency of the disturbing force coincides with the natural frequency of the vibrating part, a condition of resonance arises which results in vibrations of extremely large magnitude. Since the destructive force is equal to the product of the mass and the acceleration of the vibrating part, an acceleration measurement gives a direct indication of the magnitude of the force involved.

Fig. 4 illustrates a typical acceleration transducer or accelerometer based on the ability of a piezoelectric substance to generate an electrical charge when it is subjected to physical stress. The sensing element of the accelerometer is a small disc of piezoelectric ceramic material, such as barium titinate, which is bonded with a conductive cement between the mass and the frame of the instrument. In this type of transducer, the piezoelectric element serves as a stiff spring in a mass-spring system, which is designed with a high natural frequency as compared with the maximum vibration frequency of interest. Although viscous damping is sometimes incorporated between the mass and the frame of the device, many designs of piezoelectric transducers do not use damping so that no phase-shift error is introduced.

To operate the device, the transducer is rigidly attached to the surface of the vibrating object to be measured. If the vibrating part moves with a given acceleration, the mass is also subjected to this acceleration, and the accelerating force is thus transmitted through the ceramic element. The compressional and tensile forces exerted upon the sensing element are directly proportional to the acceleration of the frame of the instrument, and because of the piezoelectric property of the material, a corresponding electrical potential appears across the element.

To obtain high sensitivity and good response at low frequencies, it is desirable to feed the output signal (*via* low-noise coaxial cable) to a high-impedance device, such as a cathode follower. Since the accuracy of low-frequency measurements is a function of the time constant of the piezoelectric element and the input impedance of the cathode follower, sensing elements with large internal capacity (on the order of 50,000 pf.) are preferred. Thus, the input impedance requirements of the cathode follower are reduced and also the shunting effect of the cable capacity is kept to a minimum. The output of the cathode follower may then be amplified and fed to a v.t.v.m. calibrated in terms of G's.

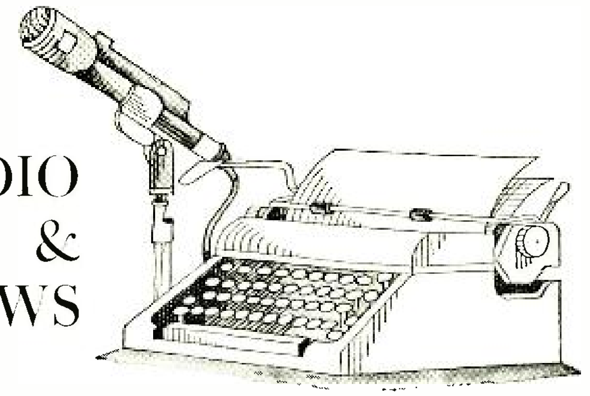
Meters and Analyzers

To provide a simple, accurate instrument for the quantitative measurement of vibration, it is convenient to employ a self-contained measuring system capable of being calibrated to read displacement, velocity, or acceleration amplitude. Such a system comprises a vibration pickup and a vibration meter which includes an adjustable attenuator, wide-band amplifier, suitable filter networks, internal calibration circuitry, and a direct-reading indicator.

Fig. 5A shows a block diagram of a typical vibration meter designed to accommodate a wide variety of input transducers. This instrument is capable of filtering out extraneous signal components which may obscure the desired vibration reading. For example, unwanted low-frequency vibrations are introduced by any motion of the hand when hand-held probes are employed. To attenuate these values, a high-pass filter is switched in to limit the response below 20 cps. The electrical signal from the vibration pickup is fed to a calibrated attenuator and then passed through a low-noise, adjustable-gain amplifier (A_1).

If the signal source is assumed to be an acceleration pickup, the output of the amplifier is fed to a linear network designed to produce a flat response at the output of the meter. To determine the velocity component (*Continued on page* 116)

RADIO & TV NEWS



WHEN we hear the word "laser," it usually conjures up an electronic research laboratory with several engineers gathered around a glowing glass tube. We tend to think of this new light source as a laboratory curiosity and as a feature in the Sunday supplements. However, that is not the case. The laser is coming into its own as an everyday working tool, and its use has made a number of changes in many commercial areas.

In the field of machine shop practice, the laser makes an excellent micro perforator, micro machining tool, and a microwelder, and is being presently used in these areas. The fine size of the output beam, coupled with the high beam energy, makes the laser an excellent tool for performing the type of machining heretofore considered impossible. The laser tools are provided with a magnifying viewing screen so that the operator can see the work being performed.

The laser is presently being tested in hospitals as an excellent welder of detached retinas.

The U.S. Army is presently field-testing laser rangefinders that can perform rapid, highly accurate range determination from a single location with a degree of security not obtainable with the more conventional radar devices. In this case, the laser uses a ruby rod as the lasering element, pulsed into operation by having a rotating mirror (part of the laser oscillation system) operate the rod. When the plane of the mirror is parallel to the longitudinal axis of the ruby rod, the laser fires. Like radar, the time that the light pulse requires to travel to the ranged-upon target back to the rangefinder is measured to obtain the range of the unknown.

Another use for the laser is in a miniature gas laser gyroscope being developed by *Sperry Rand*. In this new approach, three helium-neon gas lasers eight inches long are mounted around a square ring with one side open. The output of the lasers are mixed together, and as long as all the lasers are on the same frequency, there is no difference frequency generated. When the path lengths change, due to rapid rotation of the platform, an i.f. proportional to the rate of rotation is generated.

C.w. lasers, both gas and solid-state, have been successfully modulated with broadband video signals, thus opening up a new area in interference-free transmission mediums. They would be ideal for close-haul operation as the use of telescopes at both ends would reduce interference to a minimum. Because these radiations are not broadcast like radio waves, they make for a very secure communications system, and because of the tight beams involved, a tremendous number of them could be operated simultaneously in the same area without mutual interference.

It has been suggested that a relatively low-powered laser, coupled with a powerful optical system, would be ideal for communication over lunar distances.

Monotony Tester

One of the byproducts of this modern electronic age is that humans are being replaced by machines, mostly of the electronic variety. However, there is still the necessity of humans checking the outputs of some types of these devices.

Because there is sometimes a very long wait between the outputs, the human being tends to become lethargic and, in many cases, falls asleep.

Engineers at the NBS Institute for Applied Technology (U.S. Department of Commerce) have come up with a human testing machine called a Vigilometer that simulates a large variety of visual and auditory monitoring tasks and measures the response of the monitoring personnel under a variety of conditions.

The testing program is recorded on punched tape and includes the turning on of an indicator lamp, producing a 1-kc. tone, changing the display on an oscilloscope, deflecting a particular meter needle a couple of scale divisions, and changing the order of a five-digit, alphanumeric display. These changes do not occur with any period or in any particular order. Monitoring personnel respond by operating a switch. A built-in timer prints out the delay time between the stimulus and the response.

The test console can be placed at different locations to ascertain the effect of local distractions such as light, noise, and temperature, among others. ▲

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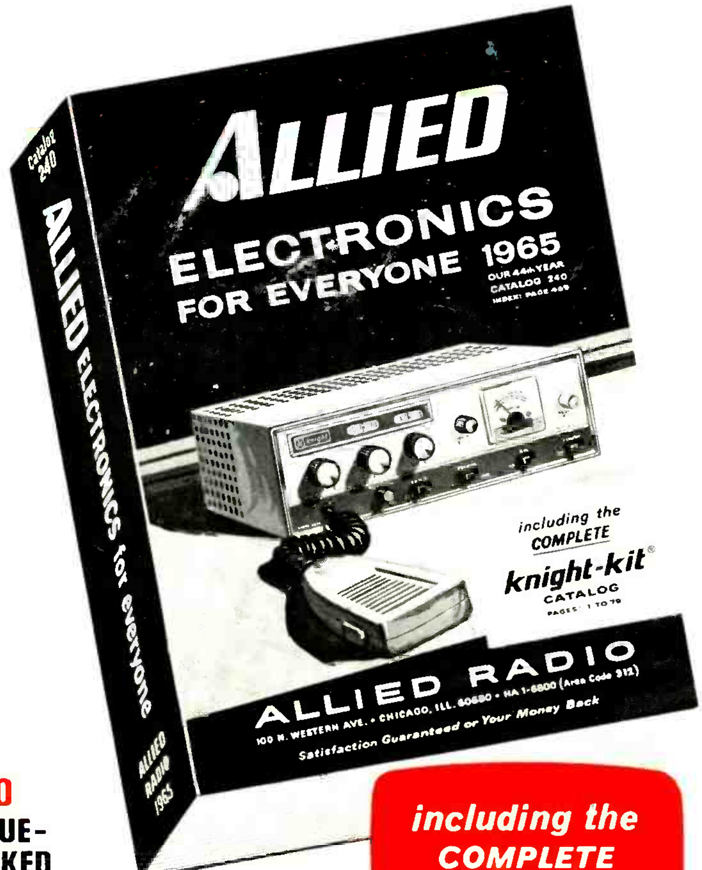

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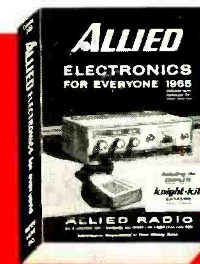

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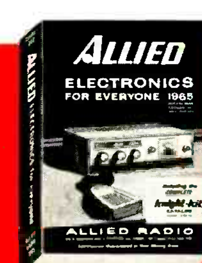

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JOHN FRYE

Experienced technicians must resist the tendency to work mechanically just because the job may seem to be routine.

"LATTER-DAY" ENEMIES

BARNEY whistled merrily as he snapped off the switch of the humming little radio, deftly removed the knobs and chassis bolts, and slid the chassis out of the cabinet and flipped it over on its back. Still whistling, he snipped loose the ends of the filter capacitor leads, being careful to leave enough colored insulation on the stubs to indicate the circuit connection points, and removed the capacitor and tossed it with a graceful basketball free-throw motion into the defective-parts barrel in a corner of the shop. He continued to whistle while he anchored a new capacitor in the chassis, snipped the leads to proper length, stripped the ends, and soldered them in place. But the happy whistle died abruptly when he turned on the switch and was greeted by an undiminished loud hum.

Mac, Barney's employer, watched out of the corner of his eye while the youth double-checked his soldered connections against the color-coded stubs of the old leads. Next Barney picked up a 40-μf. cartridge-type capacitor and successively bridged it across each unit of the filter capacitor. There was no change in the hum. Finally he turned the set over and removed the 50C5 output tube and tried a new one. That did it. There was no longer a trace of hum from the speaker. Barney glanced at the barrel with frowning indecision.

"Yes," Mac said softly; "fish the old capacitor out of the barrel and put it back in the set."

Barney's startled face flushed a brick red, but he obeyed. "I was just thinking maybe the filter capacitor was old enough to need replacing anyway," he muttered.

"That's not very good thinking," Mac said mercilessly. "Making a mistake in judgment is bad enough, but it becomes serious when you start trying to rationalize it as really no mistake at all. That radio is only a couple of years old, and we have both seen many sets in which original capacitors have gone four or five times that long. We can't take the fact that a few *do* fail in the first few months and blow it up into a sound argument for replacing a capacitor that shows no signs of failure simply to justify our removal of it as a result of a wrong diagnosis, now can we? Our customers deserve better than that from us. You know, I think you're about ready for my 'Latter-Day Enemies Lecture.' "

"Guess I've got a lecture coming," Barney admitted.

"It won't hurt too much," Mac promised, " and I probably need to hear it as much as you do. Actually, when I say you're ready for the lecture, I'm tacitly admitting you're an experienced technician. Only a fellow with considerable experience and training can appreciate the real truth of it."

"Okay, okay; let's get with it!" Barney interrupted. "Don't cat-and-mouse me."

"Try to think back to those days when you first started working for me as a green kid," Mac suggested. "Recall what you were afraid of. Can you remember?"

"I guess so," Barney said slowly. "I had no experience whatever and precious little theory. I was horribly afraid of failure. You'll never know how I knotted up inside when you turned a radio over to me. I didn't know how to begin. I had a terrible fear I wouldn't be able to find out what was wrong or be able to repair the trouble if I did blunder on it. And I was ashamed of how awkward I was in handling the tools and service instruments. You did things so easily and smoothly. I was all thumbs. I hated having you watch me work."

"Hey, that's good!" Mac applauded. There's hope for you when you can recall so vividly how you felt in the beginning. We agree, then, that the beginning technician's 'enemies'—the things that keep him from being a good technician—are: inexperience, lack of theory, lack of skill, and fear of failure; right?"

"Yeah, that's right," Barney answered. "Thanks to your patient, although prodding, tutoring, I've whipped all these enemies. When you turn a radio or TV set or tape recorder over to me now, I *know* I can fix it. Success with hundreds of other jobs tells me I can. I know how to recognize and diagnose symptoms. I know how to proceed in an orderly fashion to ferret out the trouble. Once I've found it, I know how to make repairs. Tools no longer feel awkward in my hands."

Barney stopped for breath and then went on, a little smuggly, "In fact, I've reached the place where I can do a lot of my work without really thinking, except in a superficial way. Experience has reduced much of my work to a cut-and-dried procedure. And then I've learned a lot of short-cuts that cut down on the time it takes me to reach a diagnosis or make a repair. I don't have to go from 'A' to 'C' by way of 'B.' I can jump right from 'A' to 'C.' "

"Boy, you need this lecture even more than I realized!" Mac exclaimed. "The whole point of the lecture is this: a technician defeats his early enemies, just as you have done; but he must be aware there are latter-day enemies lying in wait for him down the road that can prevent his ever becoming more than a mediocre technician."

"What enemies?" Barney demanded. "I don't see any."

"That's because the latter-day type are not nearly so easy to see and recognize as were the scary hobgoblins you met at the beginning of your technical career; but they're just as tough, and don't you forget it! The enemies of the experienced technician are such things as over-confidence, substitution of experience for thoroughness, unwillingness to admit and learn by mistakes, and a tendency to work mechanically and automatically instead of thoughtfully."

"Do you think I'm like that?" Barney asked in hurt tones.

"Well, let's look at what you just did. When turning down the volume control of that little radio had no effect on the hum, you immediately diagnosed open filter capacitors. You skimmed the surface of your experience and came up with the *most-likely* cause of the symptom, but you did not reach deep enough for *all possible* causes. I know that at least twenty-four out of twenty-five cases with that kind of hum *are* due to open filters, but that doesn't justify closing your mind to the twenty-fifth possibility: filament-to-other-element-leakage in either the audio amplifier or output tube.

That was your first mistake. A good technician keeps all possibilities in mind and eliminates them one by one.

"You could have done this, of course, by doing exactly what you did after you found you had guessed wrong. I mean bridging filter units with a good capacitor. That would have taken only seconds and would have revealed the capacitor was O.K., but you did not do it. That was your second error. Finally, you hesitated to admit to yourself you had made a complete boo-boo. You were tempted to leave in the new capacitor and charge the customer for it. That was your third, and most serious, mistake."

"Now let's not make a federal case out of a little slip," Barney protested.

"It's by a succession of unrepented 'little slips' that a technician descends into shoddiness," Mac retorted. "I want you to be especially wary of taking short-cuts. All too often taking these is not proof of your technical prowess, as you seem to think. Instead they are temptations to bypass thoroughness and to substitute educated guessing for adequate step-by-step procedure. The short-cutter is the guy who replaces a whole handful of capacitors to cure an intermittent instead of finding the single unit responsible. He 'touches up' i.f. transformers by ear or eye instead of taking time to use a signal generator and output meter or scope, and he bends capacitor plates of a radio in an attempt to make r.f. and oscillator stages track into a misaligned i.f. channel. He uses on-hand, make-do parts instead of correct replacements.

"But what really scares me is your boast you can do most of your work without thinking and that you have reduced much of it to a nearly automatic process. Did you ever stop to think that if you can do this—reduce your work to a set, inflexible procedure—you are no longer necessary? You have invited automation to take over your job. The degree to which *thinking* is necessary in your work is the margin by which your job is safe—at least for the time being—from the rising tide of automation."

"Now you've got *me* scared," Barney confessed. "How does a technician go about licking these latter-day enemies?"

"He considers each job a fresh challenge, and he doesn't permit his experience to get in the way of his powers of observation. All his faculties are kept keenly alert to spot obscure symptoms. He takes pride in doing the best possible job he knows how to do instead of merely satisfying an un-critical customer. He doesn't rely on what he already knows; he constantly strives to learn something new from each job, no matter how small or routine it may seem. He reaches a diagnosis; he proves or disproves it with checks; *then* he makes the repair. He is sure of himself every step of the way. He uses method as a tool, but he never allows it to become his master."

"It seems to me you're saying a good technician stays interested in his work," Barney said thoughtfully, "and that he never permits himself to become bored and careless simply because he does things easier than when he started. One way he does this is by constantly boosting his professional standards to keep them well above the level of his experience. He demands more and more of himself. He insists on doing his work more expertly and efficiently. He is increasingly ashamed of mistakes and strives to learn from them so they will not be repeated. All of his faculties are kept constantly alert to discover something new and significant in his work. If something seems 'funny,' he finds out why it's 'funny.' In short, the demands a good technician makes of himself are almost as exacting as those of a scientist."

"Precisely!" Mac applauded. "There's no caste-system in knowledge, and a top-flight technician *is* a scientist in his attitude toward his work, if not in education and formal training. I like your idea, and I hereby appropriate it for use in my lecture on 'Latter-Day Enemies.'"

"Okay, you can have it, but I'll tell you one thing."

"What's that?"

"You'll never again hear me say I can do service work without thinking or in my sleep," Barney promised. ▲

LOW-RIPPLE D.C. SUPPLY

By PAUL H. FUGE

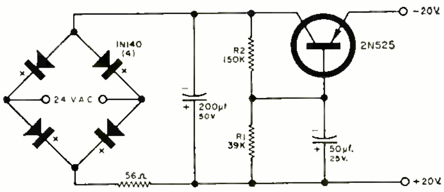
THIS low-ripple, low-voltage d.c. power supply provides filtered voltage that can be employed for transistor circuits.

In the circuit shown, the effective capacitance appearing across the 20-v. output terminals is approximately 50,000 μf. The values of the voltage divider R1 and R2 are not critical. However, the resistance ratio between them should be on the order of 4 to 1.

Using the component values shown in the diagram, the supply can deliver about 7 ma. at 20 volts. The ripple present at the output terminals is undetectable with a 25 mv.-per-inch sensitivity oscilloscope.

If more current is required, the capacitance values should be increased and the values of resistors R1 and R2 should be decreased. ▲

Circuit for transistor power supply.



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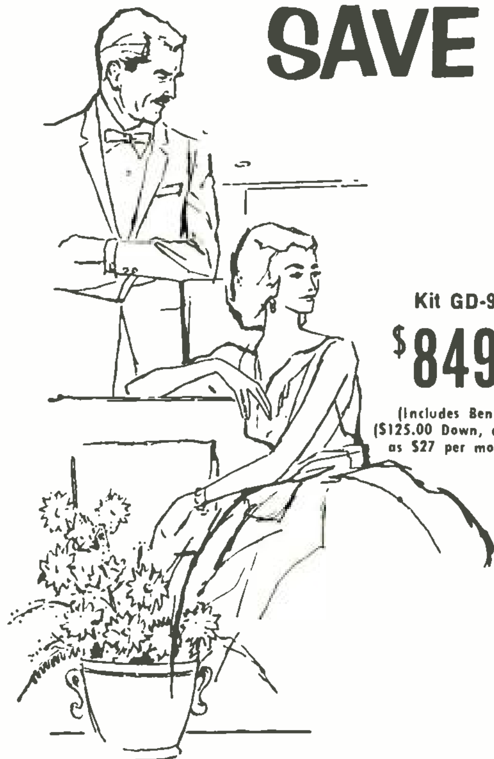

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You don't have to be an electronics wizard to build it, nor a professional organist to play it. Famous Heath "Engi-nuity" has reduced assembly of this magnificient instrument to simple-to-perform steps that require no special talents, knowledge or tools. Makes a fascinating, enjoyable project for the entire family! And the famous Thomas "Musical Fun Book" is included to start you easily playing many favorite tunes immediately. A special, recorded, 48-lesson course is also available at a $30 savings to provide you with a firm and lasting knowledge of music . . . lets you learn at your leisure! Before you know it, you'll be creating the sounds of an entire orchestra!

Each and every component in the GD-983 is a genuine Thomas factory-fabricated part. And its advanced all-transistor circuitry means less heat, better tone, longer life, and virtually trouble-free performance.

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Playing this luxurious Heathkit/Thomas "Coronado" is truly a rewarding activity that becomes more exciting, more fascinating each day! Just think of its many advantages!

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3. Parties Come Alive . . . you're a one-man band when friends gather for an evening of fun. And teens love the rhythm and bounce of its wealth of musical effects.

4. Provides A Wholesome Creative Outlet . . . helps you unwind, forget your problems, and ease tensions.

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Kit GD-983, Organ & matching walnut bench, 290 lbs. *$849.00*

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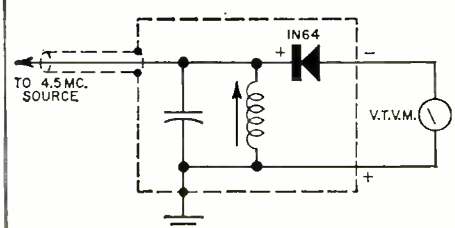
4.5-MC. DETECTOR ALIGNMENT PROBE

MANY TV sets use the quadrature method of FM detection in the audio section. As suggested by *Westinghouse*, the detector probe shown in the sketch can be used to align such circuits using an off-the-air signal. The probe itself consists of a small length of coaxial cable feeding a 4.5-mc. tuned circuit (can be a quadrature-coil assembly), whose output is rectified and read out on a v.t.v.m. The tuned circuit is set to exactly 4.5 mc. with either an accurate signal generator or by connecting the probe to the grid of a normally operating gated-beam sound detector through a 2-pf. capacitor. The slug is tuned for maximum meter deflection.

To align a quadrature detector from an off-the-air signal, connect the probe to the control grid of the detector; connect the ground side of the probe to chassis ground; and set the v.t.v.m. to a low-value negative d.c. scale.

Tune in the strongest available TV signal and set the "Quieting" control



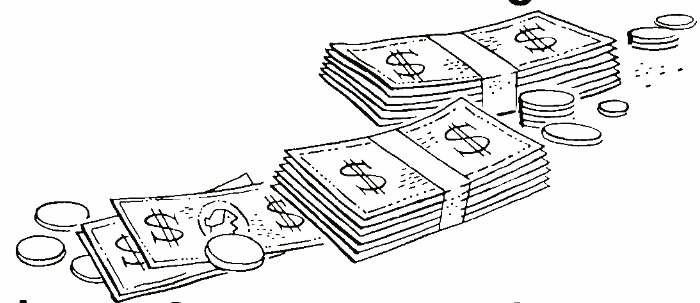
(usually a potentiometer located in the detector cathode circuit) to mid-range.

Set the volume control to a low volume level and adjust the set's quadrature coil for maximum speaker volume. Reduce the signal strength at the antenna by using either an attenuator pad or loose coupling, and tune the FM limiter input and output coils for maximum negative voltage indication on the v.t.v.m. Reduce the antenna input until the v.t.v.m. indicates −1 volt. Re-adjust the set's quadrature coil for maximum speaker volume.

With the strongest signal available, rotate the set's fine tuning control away from the best picture to the point where −2 volts is measured on the v.t.v.m. Reset the "Quieting" control for minimum noise or intercarrier buzz. If the manual fine-tuning range is inadequate, it may be necessary to set the tuner oscillator slug for the −2 v. reading. In this event, reset the oscillator slug after the "Quieting" control is properly adjusted.

The same circuit can be used to tune almost any other oscillator to a particular frequency if a tuned circuit for that frequency is substituted for the one shown in the sketch. ▲

Regardless Of What You Pay For Other Color TV



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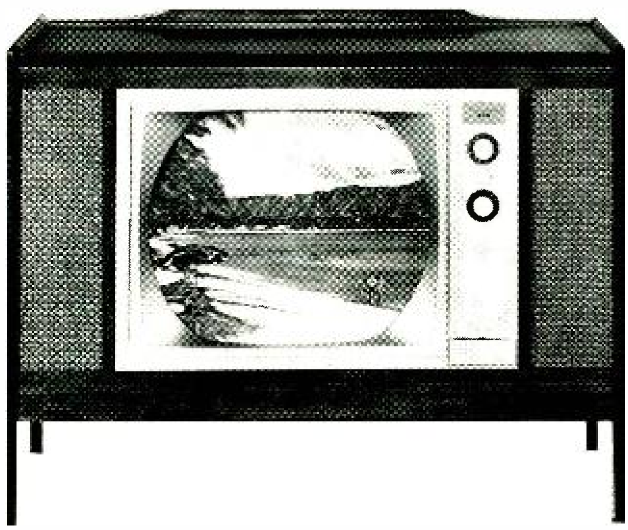

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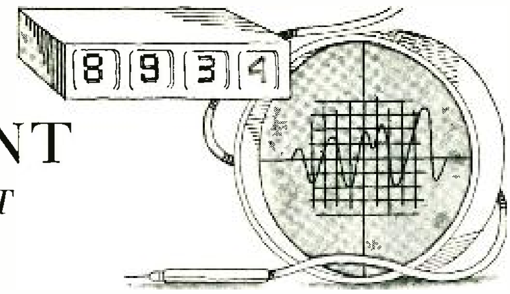


Seco Model 980 Color-Bar Generator

For copy of manufacturer's brochure, circle No. 62 on coupon (page 15).

THE Model 980, manufactured by *Seco Electronics, Inc.*, is a complete portable color generator. It produces the necessary test signals for modern color-TV installation and service.

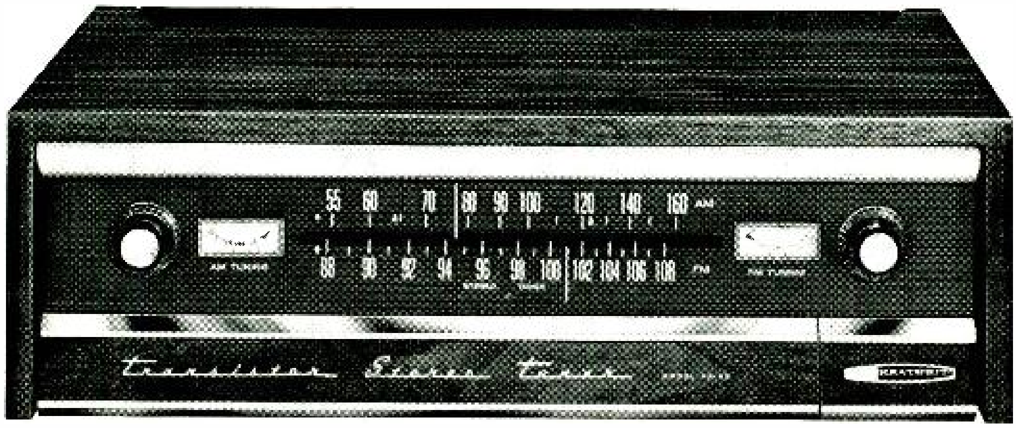
Color bars are produced by the keyed offset carrier method. This method gives ten distinct vertical color bars, beginning with a yellow-orange, continuing through the various shades of red and blue, and finally ending with a green stripe on the extreme right side of the screen. In addition to color bars, the Model 980 provides a dot pattern, a crosshatch pattern, a vertical-bar pattern, and a horizontal-bar pattern.

All signals are crystal-controlled. One section of a 12AZ7 (*V1*) is used as the master crystal-controlled oscillator using a 189-kc. crystal. The frequency of this oscillator is within .0001% so that crawl and shading are kept to a minimum. The oscillator feeds its signal to the second section of *V1*, then to a keyer (½*V5*), which controls the output of a 3.56-mc. oscillator. It also feeds a synchronizing driving pulse to the frequency dividers.

The Model 980 warms up to peak stability in 15 seconds and remains stable all day long. This stability is achieved by low-ratio frequency division which does not use any harmonic higher than the seventh (see diagram). All six frequency dividers are of the cathode-coupled type with their grid returns going through a high-value resistance to the positive side of the power supply. Variable supply and frequency control is provided by adjustable potentiometers for five of these multivibrators. The tightly coupled remaining multivibrator (*V6*) is driven by a pulse only two times its frequency and does not require potentiometer adjustment.

The ten color bars originate as a rainbow spectrum from a heterodyne between the generator burst signal and receiver crystal frequency. Color demodulators in the receiver sense the 360°-per-cycle phase shift on each horizontal scan. Then, keying information blanks out nine spaces in the spectrum so that the color appears on the screen in a pattern of vertical stripes with a

For The Stereophile With An Eye...



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This superb unit boasts a 26 transistor, 10 diode circuit that produces 70 watts continuous, 100 watts IHF music power at ± 1 db from 13 to 25,000 cps. And you enjoy complete freedom from microphonics, effortless transient response, and cool instant operation . . . characteristics unobtainable in tube-types.

In addition, there are complete controls, plus all inputs and outputs to handle any program source & most speaker impedances. Circuit safety is assured with 5 fast-acting, bi-metal circuit breakers . . . no fuses to replace ever! Transformerless output circuit and multiple feedback loops provide fine fidelity and low distortion levels.

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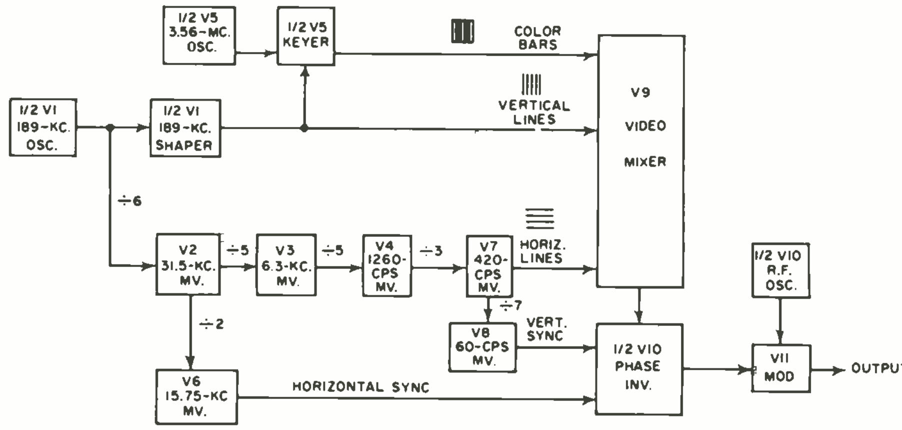


black bar between each. These stripes are used for alignment and troubleshooting.

Video information for dots, horizontal bars, and vertical bars is supplied by the 189-kc. crystal shaper and intermediate-frequency dividers. These produce: a pattern of 54 dots for d.c. or static convergence; a crosshatch pattern for dynamic convergence, overscan, and linearity adjustments (6 horizontal lines, 9 vertical lines); a vertical line pattern for adjusting dynamic horizontal convergence controls (9 vertical lines); and a horizontal line pattern for adjusting dynamic vertical convergence controls (6 horizontal lines).

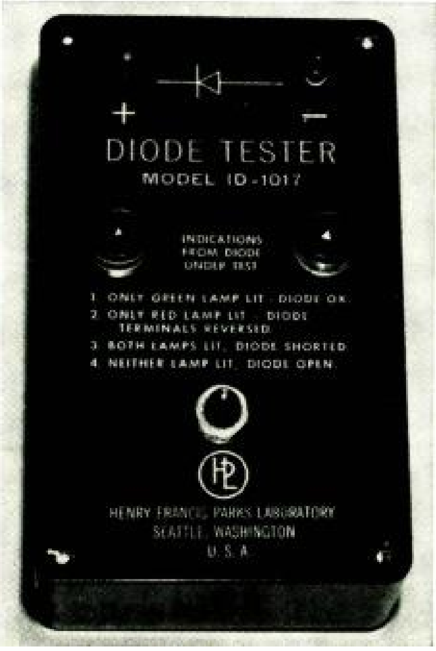
Because the Model 980 warms up quickly and remains stable, it is equally adaptable to intermittent or continuous duty for color-TV work in homes or at the bench. Foolproof crystal-controlled color bars and a sturdy steel case develop the stability and ruggedness needed for tough use in truck or shop.

Sync control is simple. Just two controls on the back of the instrument set vertical and horizontal hold. Two clip-on antenna leads hook the unit up to the TV set. Each unit is factory set to channel 3 and can be tuned to channels 2 or 4 if required.

The Model 980 color-signal generator is priced at $119.50. ▲

H. F. Parks Lab. ID-1017 Diode Tester

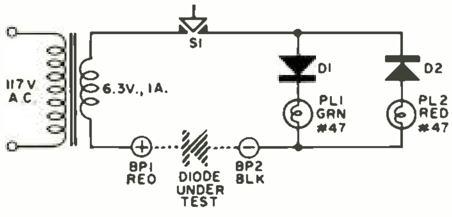
For copy of manufacturer's brochure, circle No. 63 on coupon (page 15).



ADVANTAGE is taken of the unilateral conductivity of diodes in the Model ID-1017 production-type diode tester manufactured by *H. F. Parks Laboratory*. This tester will check the printed polarity of the diode for correctness and will give a quantitative check that the diode is usable.

As shown in the circuit diagram, two oppositely wired diodes are employed in series with two colored lamp indicators. The diode under test is simply connected to the terminals with polarity as indicated, the push-button switch is depressed, and the indication is given. If the diode's marked polarity is correct and it is usable, the green lamp will be illuminated. If the polarity is reversed, the red lamp will light. If both lamps light, then the diode being tested is shorted so that current passes equally in both directions. On the other hand, if neither lamp lights, then the diode is open-circuited. In either of these last two cases, the diode should be rejected.

If a diode is already soldered into a circuit, it can, in many cases, be tested without unsoldering. The load placed on the diode being tested is that of the No. 47 indicator lamp, which is 150 ma. at 6.3 volts, or less than one watt. Hence, any diode rated at one watt or more can be safely tested with this unit. The tester checks silicon, germanium, or selenium rectifiers readily.



Which Stereo Receiver Is Your Best Value?

BRAND	IHF POWER	TUNER	CIRCUIT	PRICE
A	70 Watts	AM-FM FM Stereo	Transistor	$369.95
B	80 Watts	AM-FM FM Stereo	Tubes	$374.50
C	100 Watts	AM-FM FM Stereo	Transistor	$619.95
D	70 Watts	FM Stereo	Tubes	$429.90
E	66 Watts	AM-FM FM Stereo	Transistor	$195.00
F	60 Watts	FM Stereo	Tubes	$354.45
G	60 Watts	AM-FM FM Stereo	Tubes	$273.90
H	100 Watts	AM-FM FM Stereo	Transistor	$579.90
I	70 Watts	AM-FM FM Stereo	Tubes	$269.95

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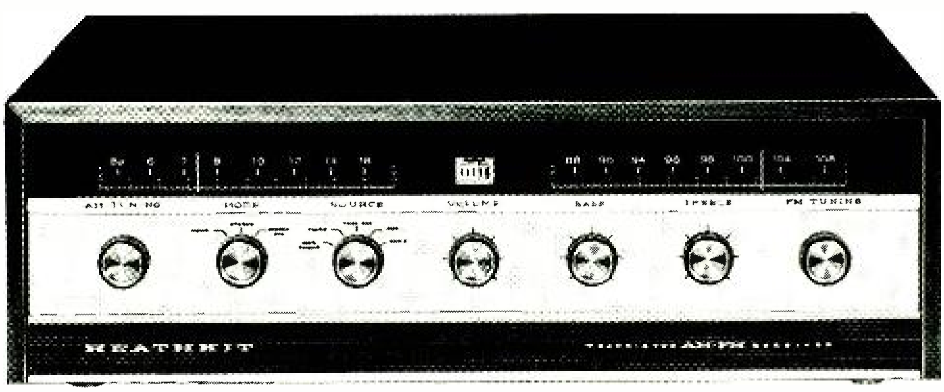

"E" is the Heathkit AR-13A All-Transistor, All-Mode Stereo Receiver. It's the first all-transistor stereo receiver kit. It costs from $75 to $425 less than the finest stereo receivers on the market today. This alone makes the AR-13 unique. But dollar savings are only one reason why it's your best value.

Even if you can afford to buy the costliest model, you can't buy better performance. Start with the AR-13A's 43-transistor, 18-diode circuit. It's your assurance of cool, instant, "hum-free" operation; long, trouble-free life; and the quick, clean, unmodified response of "transistor sound" . . . characteristics unobtainable in tube types.

Next, there's wide-band AM, FM, FM Stereo tuning for distortion-free reception to delight the most critical ear. It has two preamps. And its two power amplifiers provide 66 watts of IHF Music Power, 40 watts of continuous sine-wave power. And it's all housed inside one luxurious, compact walnut cabinet . . . just add two speakers for a complete stereo system.

There are plenty of operating conveniences, too. Like *automatic* switching to stereo; automatic stereo indicator; filtered tape recorder outputs for direct "beat-free" stereo recording; dual-tandem controls for simultaneous adjustment of volume, bass, and treble of both channels; 3 stereo inputs; and a separate control for balancing both channels. The AM tuner features a high-gain RF stage and a high Q rod antenna. The FM tuner has a built-in line cord antenna plus external antenna connectors.

In addition, there's a local-distance switch to prevent overloading in strong signal areas; a squelch control; AFC for drift-free reception; plus flywheel tuning, tuning meter, and lighted AM & FM slide-rule dials for fast, easy station selection. The secondary controls are concealed under the hinged lower front gold aluminum panel to prevent accidental system setting changes. Both of the AM and FM "front-ends" and the AM-FM I.F. strip are pre-assembled and prealigned to simplify construction.

Compare its impressive specifications. Then go direct to the coupon, and order the AR-13A. Now sit back and relax . . . you've just saved $75 to $425 without compromising!

Kit AR-13A, 34 lbs. $195.00

SPECIFICATIONS—AMPLIFIER: Power output per channel (Heath Rating): 20 watts /8 ohm load. (IHFM Music Power Output): 33 watts /8 ohm load. **Power response:** ±1 db from 15 cps to 30 kc @ rated output. **Harmonic distortion:** (at rated output) Less than 1% @ 20 cps; less than 0.3% @ 1 kc; less than 1% @ 20 kc. **Intermodulation distortion:** (at rated output) Less than 1%, 60 & 6,000 cps signal mixed 4:1. **Hum & noise:** Mag. phono, 50 db below rated output; Aux. inputs, 65 db below rated output. **Channel separation:** 40 db. **Input sensitivity:** Mag. phono, 6 MV. **Outputs:** 4, 8, & 16 ohm and low impedance tape recorder outputs. **Controls:** 5-position Selector, 3-position Mode; Dual Tandem Volume; Bass & Treble Controls, Balance Control; Phase Switch; Input Level Controls, Push-Pull ON/OFF Switch. **FM: Tuning range:** 88 mc to 108 mc. **IF frequency:** 10.7 mc. **Frequency response:** ±3 db, 20 to 15,000 cps. **Capture ratio:** 10 db. **Antenna:** 300 ohm balanced (internal for local reception). **Quieting sensitivity:** 3½ uv for 30 db of quieting. **Image rejection:** 30 db. **IF rejection:** 70 db. **Harmonic distortion:** Less than 1%. **STEREO MULTIPLEX: Channel separation:** (SCA Filter Off) 30 db, 50 to 2,000 cps. **19 KC & 38 KC suppression:** 45 db down. **SCA rejection:** 35 db down from rated output. **AM: Tuning range:** 535 to 1620 kc. **IF frequency:** 455 kc. **Sensitivity:** 30 uv @ 600 kc; 9 uv @ 1000 kc. **Image rejection:** 40 db. **IF rejection:** 55 db @ 1000 cps. **Harmonic distortion:** Less than 2% with 1000 uv input, 400 cps with 30% modulation. **Hum and noise:** 40 db. **Overall dimensions:** 17" L x 5½" H x 14¾" D.

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HF-173

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The Model ID-1017 is housed in a small Bakelite box, measuring about 6" x 4" x 2". It is available at a price of $19.95. ▲

Texas Crystals TC-3 Alignment Generator

For copy of manufacturer's brochure, circle No. 64 on coupon (page 15).

THE Model TC-3 crystal oscillator with its three fixed frequencies should find a convenient spot on the service bench. It is useful as a signal source for aligning i.f. stages, radio front ends, and as a marker generator. The *Texas Crystals* unit measures only 5" x 2" x 2". The transistor oscillator operates on a standard 9-volt battery, which should last a long time because of the low current drain.

Although the oscillator is not modulated, there should be no difficulty in using it for frequency spotting or alignment purposes. Three crystals are plugged into the receptacles at the left of the unit, and one of these is selected for use by the center switch. A quarter-megohm pot at the right serves as output attenuator. The r.f. output voltage is about 100 mv. on the high end of the frequency range (3000 kc.) and 500 mv. at the low end of the range (200 kc.). In order to keep equipment "B+" voltage from damaging the unit, a small blocking capacitor of about 50 pf. should be inserted in series with the output.

In addition to the three fundamental frequencies, harmonics of the oscillator can also be used. All output frequencies from the test oscillator are within ±.002% tolerance.

The Model TC-3 is supplied with a choice of three standard frequencies from the following: 255, 260, 265, 285, 290, 295, 450, 455, and 460 kc. Crystals for special frequencies, such as 1000 kc. (frequency standard), 1610 kc. (high-end calibration of broadcast band for car radios), and 2708 kc. (tenth harmonic for CB frequency spotters), are also available for plugging into the oscillator unit.

The oscillator is priced at $29.95, including battery and three standard crystals. ▲

SB-200 KW Linear Amplifier............$200!
• 1200 watts P.E.P. input SSB—1000 watts CW • 80 through 10 meter band coverage • Built-in SWR meter—Antenna relay—Solid-state power supply • Automatic Level Control (ALC) • Sheilded, fan-cooled amplifier compartment • Pre-tuned cathode input circuit for maximum efficiency & low distortion • Circuit-breaker power supply protection—no fuses • Designed for 120/240 volt operation.

Neat, compact and transportable (only 35 lbs.). The sturdy, yet lightweight construction of the SB-200 is achieved through the use of a heavy-gauge one-piece aluminum chassis that is partitioned for extra strength and isolation of circuits. Easy assembly is assured with clean, open circuit layout and high quality, well-rated components. The modern low-profile styling of the SB-200 makes it a neat, compact desk-top linear that is ideal for use anywhere!

Kit SB-200, 42 lbs...................$200.00
Note: Unit suitable for overseas operation.

SB-200 SPECIFICATIONS—Band coverage: 80, 40, 20, 15 & 10 meters. **Maximum power input:** 1200 watts P.E.P. SSB, 1000 watts CW. **Driving power required:** 100 watts. **Duty cycle:** SSB, continuous voice modulation; CW, 50% (key down time not to exceed 5 min.). **Third order distortion:** 30 db or better at 1000 watts P.E.P. **Output impedance:** 50 to 75 ohm unbalanced; variable pi-output circuit. SWR not to exceed 2:1. **Input impedance:** 52 ohm unbalanced; broad-band pre-tuned input circuit requires no tuning. **Meter functions:** 0-100 ma grid current, 0-1000 ma plate current, 0-1000 relative power, 1:1 to 3:1 SWR, 1500 to 3000 volts high voltage. **Front panel controls:** Load; Tune; Band; Relative Power Sensitivity; Meter Switch, Grid-Plate-Rel. Power-SWR-HV; and Power Switch, on/off. **Tube complement:** Two 5728/T-160-L (in parallel). **Power requirements:** 120 volts AC @ 16 amperes (max.), 240 volts AC @ 8 amperes (max.) **Cabinet size:** 14⅞" W x 6⅝" H x 13⅜" D. **Net weight:** 35 lbs.

SB-300 SSB Receiver..................$265!
• Complete coverage of 80 through 10 meter amateur bands • All crystals included, plus provision for VHF converters • Hermetically sealed 2.1 kc crystal bandpass filter • Built-in 100 kc crystal calibrator • Smooth, non-backlash venier dial mechanism • 100 cps stability after initial warmup • 1 kc dial calibrations—100 kc per dial revolution (provides bandspread equal to 10 feet per megacycle) • Provision for transceive operation with SB-400 Transmitter • Prebuilt linear master oscillator (LMO), wiring harness and two heavy-duty circuit boards for fast, easy assembly.

Kit SB-300, less speaker...22 lbs......$265.00
SBA-300-1 Optional AM Crystal Filter (3.75 kc) 1 lb..................................$19.95
SBA-300-2 Optional CW Crystal Filter (400 cps) 1 lb..................................$19.95
SBA-300-3 (6 meter converter), 2 lbs.....$19.95
SBA-300-4 (2 meter converter), 2 lbs.....$19.95
Export model available for 115/230 VAC, 50-60 cps; write for prices.

SB-300 SPECIFICATIONS—Frequency range (megacycles): 3.5 to 4.0, 7.0 to 7.5, 14.0 to 14.5, 21.0 to 21.5, 28.0 to 28.5, 28.5 to 29.0, 29.0 to 29.5, 29.5 to 30. **Intermediate frequency:** 3.395 megacycles. **Frequency stability:** 100 cps after warm-up. **Visual dial accuracy:** Within 200 cps on all bands. **Electrical dial accuracy:** Within 400 cps on all bands. **Backlash:** No more than 50 cps. **Sensitivity:** Less than 1 microvolt far 15 db signal plus noise-to-noise ratio for SSB operation. **Modes of operation:** Switch selected: LSB, USB, CW, AM. **Selectivity:** SSB: 2.1 kc at 6 db down, 5.0 kc at 60 db down (crystal filter supplied). AM: 3.75 kc at 6 db down, 10 kc at 60 db down (crystal filter available as accessory). CW: 400 cps at 6 db down, 2.5 kc at 60 db down (crystal filter available as accessory). **Spurious response:** Image and IF rejection better than 50 db. Internal spurious signals below equivalent antenna input of 1 microvolt. **Power requirements:** 120 volts AC, 50/60 cps, 50 watts. **Dimensions:** 14⅞"W x 6⅝"H x 13⅜"D.

SB-400 SSB Transmitter................$325!
• Built-in power supply • Complete transceive capability with SB-300 Receiver • Linear Master Oscillator frequency control • Built-in antenna change-over relay • All crystals supplied for complete 80-10 meter coverage • Automatic lever control for higher talk power, minimum distortion • 180 watts PEP SSB, 170 watts CW • Crystal filter type SSB generation • Operates SSB (upper or lower sideband) & CW • VOX & PTT control in SSB operation, VOX operated CW break-in • Crystal controlled heterodyne oscillators • 1 kc dial calibration—100 kc per dial revolution • Dial bandspread equal to 10 feet per megacycle • 500 kc coverage per band-switch position • Switched 120 V AC for external antenna relay • Sturdy, lightweight, heavy-gauge aluminum construction throughout • Neat, modern "Low-Boy" styling! • Variable loading!

Kit SB-400, 33 lbs...................$325.00
Export model available for 115/230 VAC, 50-60 cps; write for prices.

SB-400 SPECIFICATIONS—Emission: SSB (upper or lower sideband) and CW. **Power Input:** 170 watts CW, 180 watts P.E.P. SSB. **Power output:** 100 watts (80-15 meters), 80 watts (10 meters). **Output impedance:** 50 to 75 ohm—less than 2:1 SWR. **Frequency range:** (mc) 3.5-4.0; 7.0-7.5; 14.0-14.5; 21.0-21.5; 28.0-28.5; 28.5-29.0; 29.0-29.5; 29.5-30.0. **Frequency stability:** Less than 100 cps per hr. after 20 min. warmup. **Carrier suppression:** 50 db below peak output. **Unwanted sideband suppression:** 55 db @ 1 kc. **Intermadulation distortion:** 30 db below peak output (two-tone test). **Keying characteristics:** Break-in CW provided by operating VOX from a keyed tone (Grid block keying). **ALC characteristics:** 10 db nominal @ 0.2 ma final grid current. **Noise level:** 40 db down from single tone output. **Visual dial accuracy:** Within 200 cps (all bands). **Electrical dial accuracy:** Within 400 cps (all bands). **Audio input:** High impedance microphone or phone patch. **Audio frequency response:** 350 to 2450 CW at 6 db. **Power requirements:** 80 watts STBY, 260 watts key down @ 120 V AC line. **Dimensions:** 14⅞" W x 6⅝" H x 13⅜" D.

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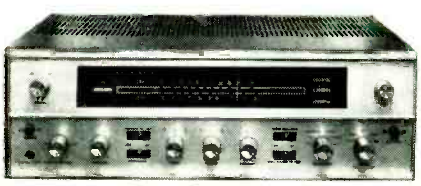

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New LR-800 70-Watt Complete AM-FM Stereo Multiplex Receiver features a tuned nuvistor "front-end" and an FM "Stereo-Search" multiplex indicator. Excellent sensitivity, frequency response, and low distortion specs. Imported, **99-0005WX.**

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New LT-325 AM/FM Multiplex Tuner combines simplicity, flexibility, and superb styling. 20-Tube performance provides a great variety of features, including a new audible tone "Stereo Search System." Imported, **99-0001WX.**

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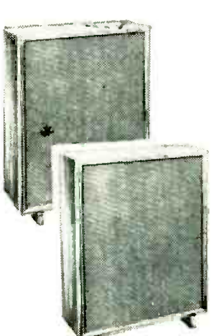

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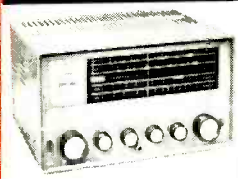

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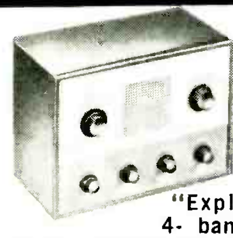
Deluxe Model HA-63 Shortwave Receiver is an excellent choice for the beginning shortwave listener or novice amateur. Covers 550 KC to 30mc in 4 bands and features electrical bandspread on all frequencies. 7 Tube circuitry gives outstanding selectivity and sensitivity. Imported, **99-2534WX**



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Model HA-50	**30-50Mc**	**99-2525WX**
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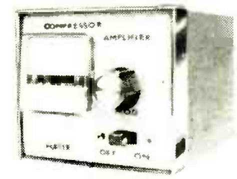

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The New Model HA-115 audio compressor amplifier instantly and automatically increases the "talking power" of your citizens band transceiver by increasing the average modulation of the transmitter section. Works with all popular CB units. **42-0117.**

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HE-29C 9-Transistor Walkie-Talkie provides two-way communications up to 1.5 miles. Powered by six penlight batteries with life expectancy of 55 hours. An AC power supply is also available. Specify channel. Imported, **99-3020CL.**

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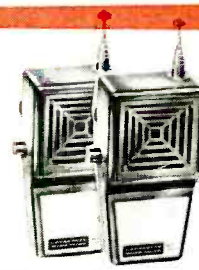
Model HA-85 6-Transistor "Walkie-Talkie" transmits and receives up to 1 mile. Ideal for sports, boating, construction and recreation. Complete with leather case, earphone, batteries, and crystals for the channel of your choice. Imported, **99-3013CL.**



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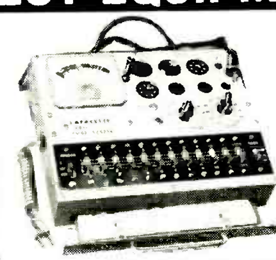

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Compression Preamp

(Continued from page 33)

Up to this point the amplifier response characteristics have referred to sine waves of various amplitudes. The reaction of a compression amplifier to voice is another matter. The amplifier does not keep all peaks the same amplitude but it does hold the *average* audio level constant. Thus when used in a p.a. system, for example, this circuit would give very close to the same average output volume over a 22-db range of input voice levels to the microphone.

Construction

The circuit layout is not critical, but due to the high gain and low signal levels involved, good audio practice should be followed. The author's unit was built on a 3"x 4" piece of fiber board and mounted in a utility box. The original unit operated on a 22½-volt battery. If an external power supply is to be used, care should be taken to reduce ripple to a minimum to eliminate any hum that might be present.

The amplifier is designed to be driven by a medium-impedance low-level microphone, about 500 to 2000 ohms. If it is desired to operate this unit with very high or very low impedance microphones, an impedance-matching transformer must be added to achieve optimum performance. Once the microphone is matched to the amplifier, the level control ($R1$) must be set for the best compression.

Adjustment

For best compression action, the average input to the amplifier should be about 15 mv. This can be set by talking into the microphone at an average level and setting the signal level on the base of Q1 to average 15 mv. If no test equipment is available, the level can be set by listening to the output and varying the level control. The control should be set in the middle of the range of settings that produce a constant volume level. Once the level is set, it should then remain fixed.

The output of the amplifier is about 2.5 volts. This signal is large enough to drive high-level inputs to tape recorders, p.a. amplifiers, and modulators. The output is low impedance, but to prevent excessive circuit loading, the input impedance of the driven amplifier should be in the order of approximately 2000 ohms or higher.

The first time this amplifier was put to use the results were outstanding. The average output remained essentially constant with the microphone held at arm's length or next to the lips. There was no noticeable distortion at either microphone position. ▲

High-Noise Environment

(*Continued from page* 41)

provides 100-db acoustic output for a given input, according to the data sheet, and to establish other parameters around this figure, while actually 85 to 90-db acoustic power reaches the ear with the stated electrical input in an earcup. This difference is not a matter of splitting hairs. Experience shows it to be a common pitfall.

Circuits

Microphones, earphones, and earcups have been discussed at considerable length. What about the proverbial black boxes? Are there any circuit tricks that can be used in them to complement what we are trying to do with acoustic apparatus?

Although recent years have seen many refinements in audio amplifier circuitry, there have been very few new concepts, particularly for our purposes. The first serious criterion involves the establishment of enough gain and enough power output to satisfy the headsets. Surprising as it may seem, this output in many existing systems is marginal at best. Since headsets generally require little power, it is easy to take for granted that any amplifier will satisfy the need. Inadequate understanding of the acoustic problem all too often results in power levels that are inadequate for proper operation.

The problem is not too critical in a quiet environment. In a noisy area, however, a respectable signal-to-noise ratio is important. Thus there should be at least 50 mw. of power available for each headset in the system. Remember that each listener can adjust his own listening level below this maximum. Making it necessary for him to do so is better practice than providing power so marginal that intelligibility is impaired by a poor signal-to-noise ratio.

Let's consider frequency response. One of the safest and most widely used approaches is to make the amplifier flat across its operating range. Something is to be said, however, for "tailoring." This takes into account the frequency response characteristic of the microphone and the receiver element mounted in its earcup. Any problems they present in some portion of the audio spectrum may possibly be remedied in the amplifier. This sloping or tailoring is not to be confused with narrow-band filtering.

There are only two electronic circuit concepts that may help over-all intelligibility: automatic gain control and peak clipping. Automatic gain control will hold amplifier output level relatively constant over a wide range of variation in input level—and the latter variation is considerable. It is easy to tell a man how to use a microphone, but there are too many factors influencing the speaking levels of different operating personnel.

Consider just one example. When a boom-mounted differential noise-cancelling microphone is used in a noisy area, the standard instruction calls for positioning the microphone in front of and approximately ¼" away from the lips for optimum results. Unfortunately, boom-mounted microphones are often positioned under the chin or at a distance ranging from ½" to 2" away from the mouth, which reduces electrical output drastically. If several people are working in one channel at the same time, and each has his own operating technique, input level will vary substantially from one to the other. Automatic gain control obviously permits listeners in the system to adjust once for the most suitable headset level without having to reset constantly.

There are some conditions in which a certain amount of peak clipping will also improve intelligibility. Removing transient peaks permits increasing the average power output of the remaining signal. However, clipping increases the distortion content. Tests indicate, however, that peak clipping as high as 10 to 12 db is tolerable. It is a matter of weighing the degree of clipping against the compensation of increased power. There is, of course, a point of diminishing returns.

There is one serious consideration here. For clipping to provide full advantage, input signal from the microphones must be clean. This means either transmission from a quiet area or the use of a differential noise-cancelling microphone. Peak speech components should be at least 15 db higher than peak noise components. Thus, even with 10 db of clipping, a 5-db S/N ratio is maintained.

The foregoing can be considered in designing new systems. Can anything be done about inadequate performance in existing ones? Within limits, there are remedies. Where the design has used carbon microphones, conversion to dynamic units can improve matters. A transistorized preamplifier can be incorporated in the headset microphone assembly, designed to work from the d.c. supply intended for the carbon elements. The preamplifier serves two functions. It isolates the dynamic element itself from d.c. and it raises the element's electrical output to match that of a carbon microphone. We have used this "retrofit" approach with great success many times.

The technique permits use of dynamic microphones in conditions otherwise considered inappropriate. In situations requiring considerable headset cordage length, the microphone output from a dynamic is ordinarily lost. The preamplifier removes restrictions on cordage length. Where personnel are mobile, this is a great advantage. ▲

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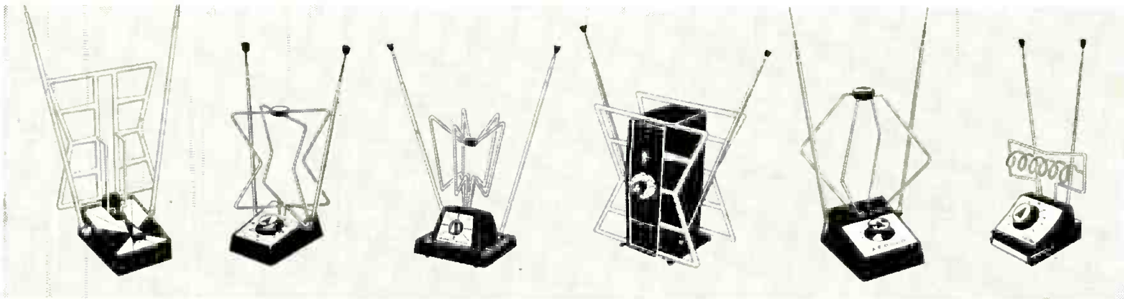

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SCR Ignition System

(*Continued from page* 45)

discharge the storage capacitor *C*1 when the system is turned off.

Lead Fouling

Lead fouling occurs in spark plugs in any normally operating automobile engine. Lead fouling deposits reduce resistance with temperature increase. At high rpm this resistance can drop low enough to cause misfire in an ordinary ignition system. Transistor systems improve the situation somewhat by slightly improving rise time, and holding energy levels at or near the 30 milliwatt-second requirements to very high engine rpm's.

A capacitive-discharge system with a rise time on the order of 2 μsec. will fire even badly fouled plugs under most operating conditions since the voltage builds up faster than the *RC* time constant of the secondary circuit can drain it away. The end result is that the faster the rise time, the more reliably fouled plugs will fire, and plugs that might normally be discarded at 10,000 to 25,000 miles may work satisfactorily to well past 50,000 miles.

As with all solid-state ignition systems, the low current through the breaker points results in extremely long life for these contacts as well.

Circuit Operation

Returning to circuit operation, the discharge of *C*1 through the coil primary is controlled by silicon controlled rectifier *SCR*1. *C*2 and *R*9 are a gate pulse-forming network which supplies a turn-on signal to the SCR gate each time *Q*3 conducts. *D*5 allows d.c. restoration of capacitor *C*2 and prevents reverse-polarity transients from being applied to the SCR gate.

*Q*3 and the associated circuitry is used as a trigger-forming circuit to invert the point signal and cause the SCR to turn on only when the points open. This section also serves to make the operation of the circuit reliable with various amounts of primary and ground-current resistance (including ballasts). *R*6 is a base-bias resistor used to turn on *Q*3 when the points open. *R*7 and *R*8 form a voltage divider to develop definite bias while the points are closed and *Q*3 is not conducting in order to prevent false triggering due to primary ripple or noise.

This system, designed around several unique circuit features involving several patents, represents a well-designed, reliable, and easily installed electronic ignition system.

Construction and Installation

Construction of a do-it-yourself unit will require locating suitable chassis and a 3" x 3" x 5" heat sink. A *Bud* "Minibox" or *LMB* box could probably be used with a strap mounting for the transformer which, because of the heat-sink mounting arrangement, is not equipped with mounting ears. The transformer is a special unit whose availability and price are shown in the parts list accompanying Fig. 1. The heat sink and printed board are also available as is a complete kit of parts or a factory-assembled unit.

Once the unit has been built, it can be mounted on the fire wall or on a fender ledge. Make sure that the heat sink and chassis are grounded properly. Disconnect the two primary leads from the ignition coil. It is not necessary to remove any ballast resistor or distributor capacitor. The 2-terminal insulated terminal boards are used for the coil, battery, and distributor connections. One of the terminal boards is bolted onto the ignition-coil terminal to which the ignition switch (battery) lead had been connected. This lead, previously disconnected from the coil, is now connected to the other terminal on the board to which the +12-volt leads in the circuit are tied. A lead from the negative side of *C*1 is tied to the terminal making contact with the coil-lead primary. (See *TB*1 in Fig. 1.)

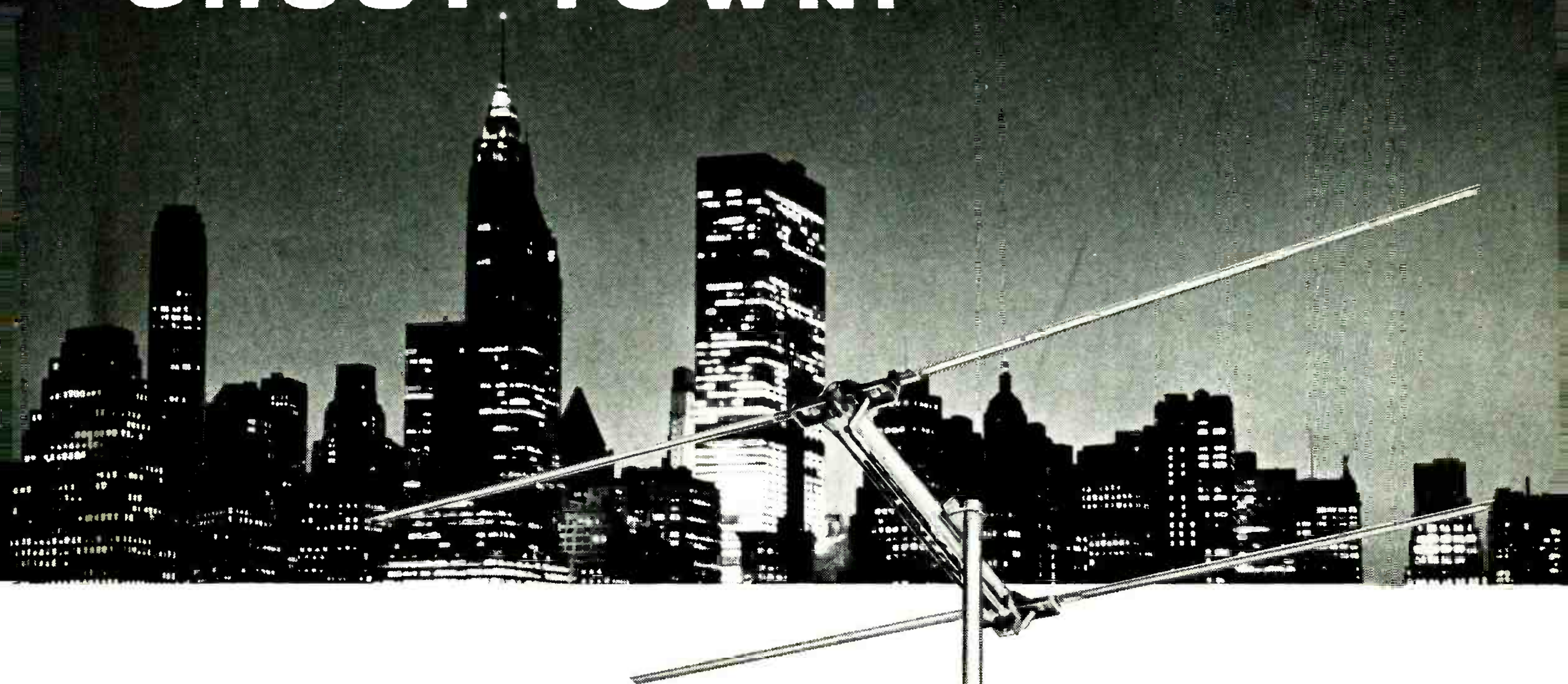
The second terminal board is bolted onto the ignition-coil terminal to which the distributor (breaker-point) lead had been connected. This lead, previously disconnected from the coil, is now connected to the other terminal on the board to which the base lead of *Q*3 in the circuit is tied. A lead from the negative side of the bridge rectifier (and *Q*3 collector) is connected to the terminal making contact with the other coil-lead primary. (See *TB*2 in Fig. 1.) This completes the installation and the unit is now ready for operation.

The circuit has been extensively used and tested for some time and its performance and reliability have been found to be outstanding. ▲

(Editor's Note: We would like to emphasize that the above SCR automotive ignition system, as described and shown, is intended for use only with cars which have the common 12-volt negative-ground electrical system.

The circuit is not suitable for use on cars that have a positive-ground system nor for cars which employ 6-volt electrical systems. We are sorry that we do not have any information on the circuit modifications that would be required for these cases. For 6-volt systems, an entirely different inverter transformer would be required in order to step up the lower voltage to 350 volts. With positive-ground cars, it would be necessary to use special insulated breaker points. These are not too readily available and, in the case of some cars, might not be available at all.)

GHOST TOWN!



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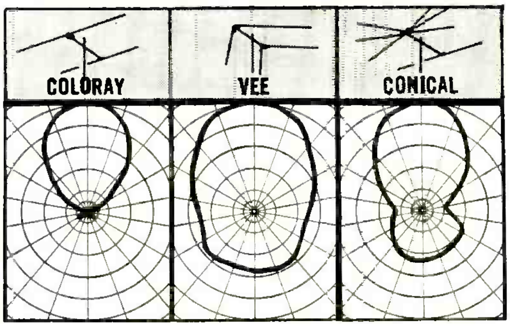
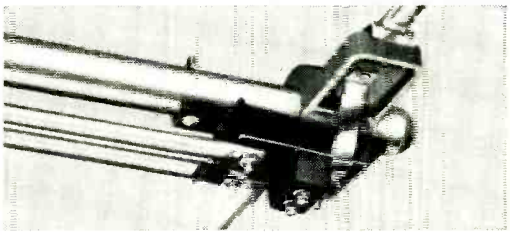


Compare polar pattern of Coloray with those of most commonly used city antennas.



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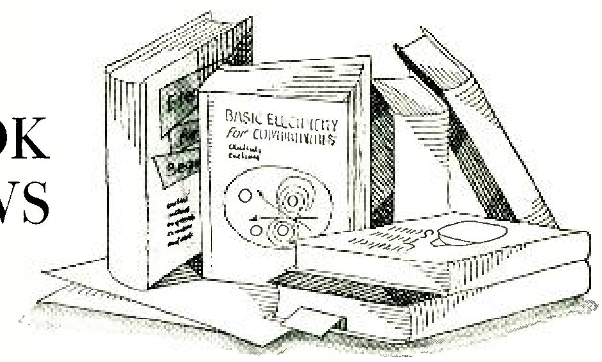
BOOK REVIEWS



"STANDARD ELECTRONICS QUESTIONS AND ANSWERS" by S. M. Elonka & J. L. Bernstein. Published by *McGraw-Hill Book Company*, New York. Two volumes. 232 and 452 pages respectively. $8.50 per volume, $15.95 per set.

These volumes can serve both as reference works and as textbooks for technicians interested in up-grading their job skills. The authors have managed to cover an amazing amount of ground in non-technical language and in question-and-answer format.

Volume 1 explains the basic principles of electronics without resorting to the mathematical approach. Individual chapters cover direct current, magnetism, inductance, capacitance, alternating current, vacuum tubes, semiconductors and transistors, voltage amplifiers, and power supplies.

The second volume, subtitled "Industrial Applications," covers many of the basic industrial circuits in their simplest form. Subject matter includes oscillators, special circuits, transducers and sensors, control systems, closed-circuit and color TV, industrial processes and devices, and test equipment.

Since the presentation is so clear, concise, and no-nonsense in its approach, these volumes could be studied with profit by beginners as well as more experienced electronics personnel.

* * *

"PRACTICAL OSCILLOSCOPE HANDBOOK" by Rufus P. Turner. Published by *John F. Rider Publisher, Inc.*, New York. 225 pages. Two volumes. $5.90 soft cover.

This is a handy how-to-do-it-and-why manual for anyone whose work or hobby involves the use of an oscilloscope. In three preliminary chapters, the author explains oscilloscope principles, controls and adjustments, and accessories. For those familiar with the scope, this material can be skipped. The rest of Volume 1 provides step-by-step instructions for tests and measurements of current, voltage, frequency, phase as well as amplifier, receiver, and transmitter testing. This material is of particular interest to lab technicians, service technicians, hams, and electronics hobbyists.

For the professional in industry and science, the second volume covers the features of a professional scope, recording, checking physical quantities, checking components, and performance checking on a wide range of equipment.

The selective applications covered in these volumes comprise a handy, practical reference work for those for whom the same publisher's "Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses" is more comprehensive and exhaustive than needed for their particular jobs.

* * *

"KLYSTRON PRINCIPLES" by Robert H. Kantor & Peter Pipe. Published by *Varian Associates*, Palo Alto, California. 226 pages. Price $6.95 plus 30 cents postage. Soft cover.

This is the first of a series of eight programmed texts for use at the professional and managerial level. The series will cover the theory of microwave tubes and devices.

The approach is what the company calls "criterion programming." The programs are all written for the non-specialist college graduate. It is assumed that the reader may already have some knowledge of the subject hence the emphasis is on material which is less familiar.

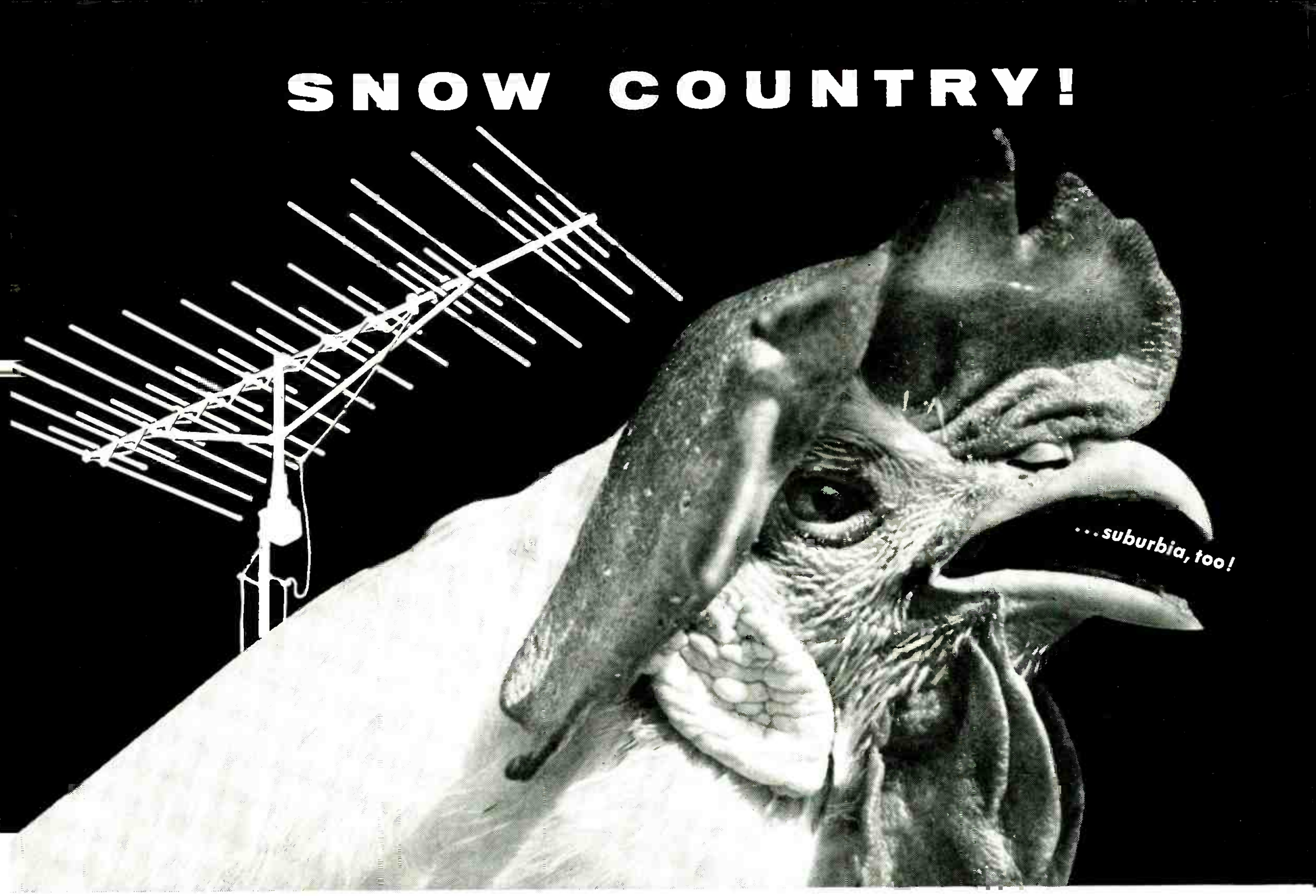
This volume includes an introduction to klystrons and covers both multi-cavity and reflex types. Each section begins with a list of the objectives of the instruction and ends with a self-quiz. A summary and index is also included. The discussion includes principles of operation, limitations, tuning methods, and typical values and efficiencies.

* * *

"DESIGN OF LOW-NOISE TRANSISTOR INPUT CIRCUITS" by William A. Rheinfelder. Published by *Hayden Book Company, Inc.*, New York. 151 pages. Price $3.95. Soft cover.

This volume is written for students as well as design engineers and provides a wealth of practical material to assist in designing transistor circuits with the lowest noise possible.

The first two chapters deal with noise factor and its measurement, while the third chapter is concerned with non-uniform noise. A summary of noise



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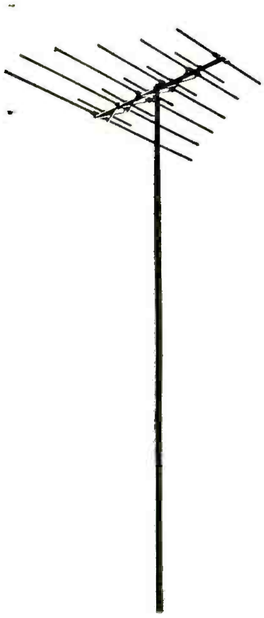

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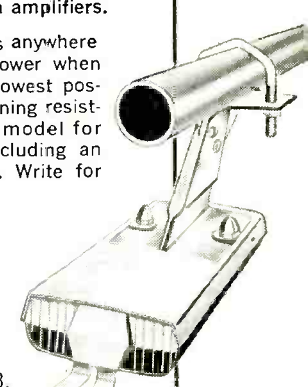

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sources in tubes and transistors is given in chapter 4.

The next three chapters cover the design for low noise in detail, according to the nature of signal and noise in the various regions of interest. The final chapter presents some of the latest low-noise designs as used by leading manufacturers in their commercial products.

The treatment is, of necessity, mathematical but the author has provided an appendix with pertinent gain formulas plus an extensive bibliography for those wishing supplementary information.

° ° °

"ELECTRONIC TRANSFORMERS" by Harold M. Nordenberg. Published by *Reinhold Publishing Corporation,* New York. 293 pages. Price $13.50.

This book has been prepared for the electronic equipment engineer, the transformer design engineer, and the electronic part application engineer and is a complete guide to the design, construction, and application of electronic transformers. The author has chosen military transformers in his examples since they represent the latest design and constructional techniques in the industry.

The text is divided into 11 chapters which deal with electronic part development; general information on transformers; electronic transformer materials; transformer tests; specification and selection; power, audio, and pulse transformers; specific types of transformer fabrication; power-transformer design; transformer faults; experimental types; and a look into the future of transformer development.

This is an engineering text and the treatment is mathematical. The author has assumed an engineering degree or its equivalent on the part of his readers.

° ° °

"BASIC TRANSISTORS" & "BASIC ELECTRONICS" prepared by the New York Institute of Technology. Published by *McGraw-Hill Book Company.* New York. $7.95 and $6.95 respectively. Soft cover.

These are two of the Institute's programmed courses in the electronics field. The "Basic Electronics" course, or its equivalent, is pre-requisite for the "Basic Transistors" course.

"Basic Electronics" assumes that the student has a background in electricity and devotes the entire book to basic electronic concepts. Mathematics are kept to a minimum and the text is well illustrated by means of simple, clear diagrams and graphs. The text is designed as a one-semester course but there is no reason why it couldn't be used in a home-study program. The material is self-checking.

"Basic Transistors" is in the same programmed format and covers semiconductor fundamentals; transistor fundamentals; parameters, equivalent

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circuits, and characteristic curves; parameter calculations; bias stabilization; using characteristics curves and charts; audio amplifiers; tuned amplifiers; wideband amplifiers; LC-type oscillators; transistor construction methods; reading transistor specifications; and transistor measurements.

* * *

"TRANSISTOR MANUAL" prepared and published by the Electronic Components & Devices Dept., *Radio Corporation of America,* Harrison, N.J. 377 pages. Price $1.50. Soft cover.

This is a second edition of the manual and covers technical data on more than 600 semiconductor devices and 45 "easy-to-build" circuits.

More than 80 pages of revised, descriptive text in the manual are devoted to bringing the reader up-to-date on the latest semiconductor-device technology and applications. The text is fully illustrated, written in an easy-to-understand style, and includes individual chapters on materials; junctions and devices; transistor design and circuit considerations; transistor characteristics and applications; silicon rectifiers; silicon controlled rectifiers; tunnel, varactor, and other diodes; and details on how to interpret data.

* * *

"THE RADIO AMATEUR'S HANDBOOK" by A. F. Collins, revised by Robert Hertzberg. Published by *Thomas Y. Crowell, Co.,* New York. 361 pages. Price $4.95.

This is the completely revised and updated 11th Edition of a useful ham publication. Written mainly for the Novice ham and would-be amateur operator, this volume covers radio fundamentals, basics of electricity, components, construction techniques, receiver and transmitter theory, FCC license requirements, antennas, mobile operation, test equipment, semiconductors, and the establishment and operation of a ham station.

The book is fully illustrated. ▲

USING ZENER DIODES

By IRWIN MATH

THE semiconductor equivalent of the gaseous regulator tube is the zener diode. The zener, unlike the gas-filled tube, is available in a wide range of voltages from about 2 to 30 volts. Multiple zeners, in the same enclosure, extend this range up to 200 volts and higher. Gas tubes, on the other hand, are usually limited to voltages in the 75 to 150 volt range. Zener diodes are also produced with much greater current-handling capabilities than gas-filled tubes.

The fundamental circuit for a zener diode regulator is shown in Fig. 1A. The zener is connected to the unregulated source (E_{IN}) through R_S, a series-limiting resistor. The value of R_S is given by the expression:

$$R_S = (E_{IN} - E_{OUT})/(I_{L\,max.} + I_{zener})$$

where I_{zener} is usually obtained from the manufacturer's specifications or, as a rule of thumb, chosen to be 10% of the maximum load current.

An example will clearly illustrate how easily a zener regulator can be designed. Suppose a 10-volt regulated supply at a maximum current of 100 ma. is desired for a piece of transistorized equipment, and a power supply of 15 volts is available. Fig. 1B shows this situation. We will assume that the input never goes below 15 volts and the output current never exceeds 100 ma. The zener current will be chosen as 10% of 100 ma. or 10 ma. R_S can now be determined.

$$R_S = (15 - 10)/(.1 + .01) = 5/.11$$

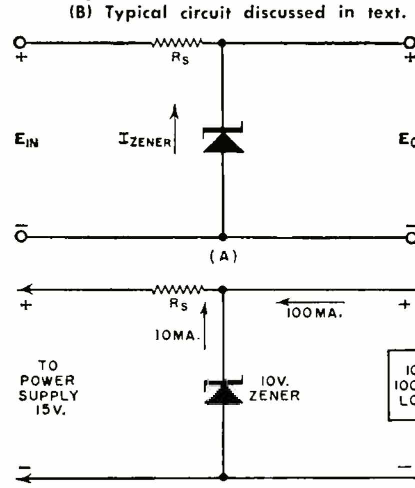
or 45.5 ohms.

By referring to Fig. 1B, it can be seen that the current flowing through R_S is the zener current and the load current. Therefore, the power dissipated in R_S is I^2R or about .55 watt. We can then choose a 47-ohm, 1-watt resistor and be sure of reliable operation. The power that is dissipated in the zener diode is as follows:

Power $= E_{OUT} \times I_{zener} = 10 \times .01$ or .1 watt.

Once this is known, a manufacturer's specification sheet collection can be consulted. Upon doing this we find that a 1N758A will give an output of 10 volts, and can dissipate .4 watt, thus it will easily handle the .1 watt. Any other zener can be used if it meets the requirements. ▲

Fig. 1. (A) Basic zener-diode circuit. (B) Typical circuit discussed in text.



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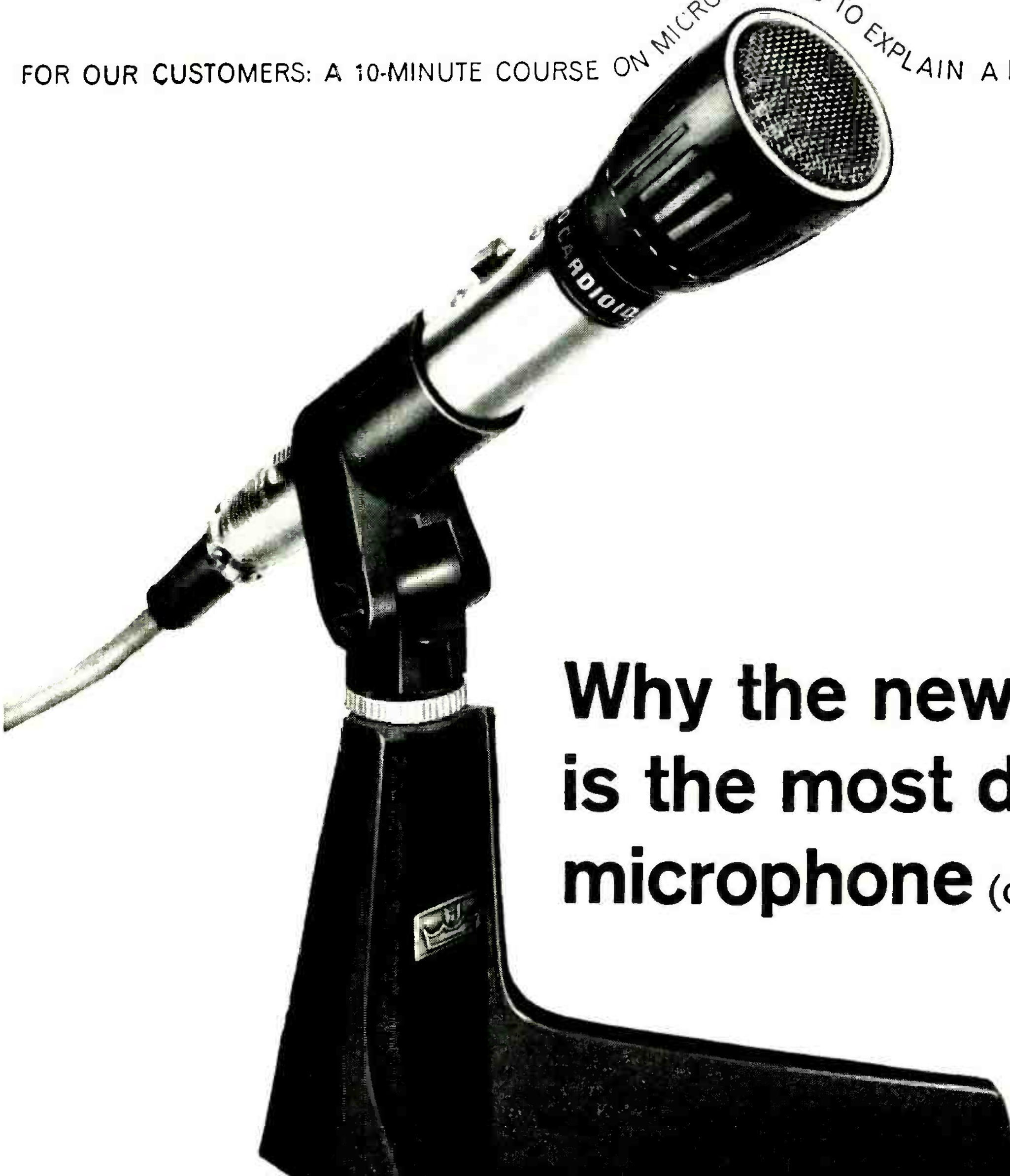

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It's a cardioid. It's dynamic. It's shock-mounted. It offers variable impedance and uniform wide-range response. It's designed and made by LTV/University and it's less than $50.00. Less than any other cardioid! *It's only $29.95.* And it's sold with the world's only five-year microphone warranty!

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For complete specifications on the fabulous 8000 series, write Desk S-11M.

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LOW "Q" RESONANCE

By JOSEPH TUSINSKI/Sr. Technical Instructor, The Technical Institute, Old Dominion College

Resonance may occur when X_L does not equal X_C. Some circuits are resonated by a variable R.

WHEN the question is asked, "What determines resonance in a circuit?" the answer invariably will be, "If the inductive reactance (X_L) equals the capacitive reactance (X_C) of the circuit, resonance occurs." This relationship will be true in most cases dealing with radio-frequency circuits for the "Q" of these circuits is high.

As to the question of what establishes the dividing line in deciding whether a circuit possesses a low "Q" or a high "Q," we will have to accept (for the time being) a simple statement that when the resistance of the circuit becomes a significant factor compared to the reactance of the circuit, the circuit may be said to have low "Q". In a low "Q" circuit the energy-storing ability of the circuit is low; that is, as much or more energy is being lost in the circuit as is stored. The energy is alternately stored in the magnetic field and then in the electric field.

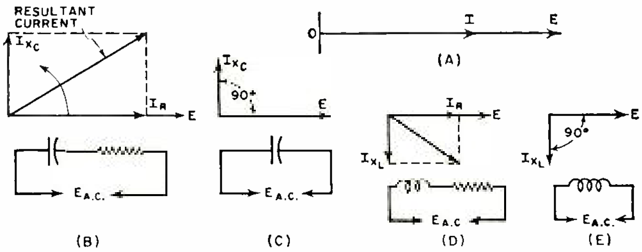


Fig. 1. Phase relations in resistive and reactive circuits.

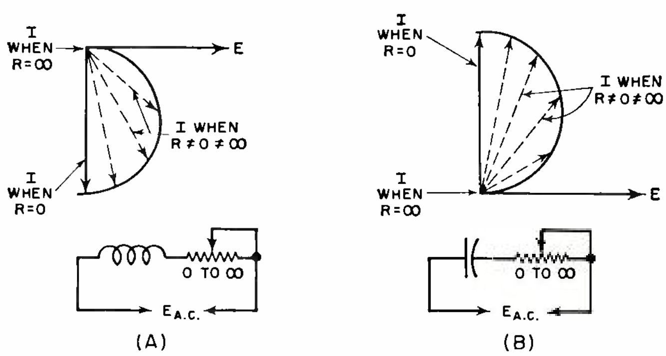


Fig. 2. Variation of current with changes in resistance.

Resonance is established in the circuit when the *power factor of the circuit is unity*. Unity power factor exists when the external current is in phase with the applied voltage of the circuit. In some circuits, resonance occurs when the inductive reactance *does not* equal the capacitive reactance and a variable resistance may resonate the circuit.

In a purely resistive circuit the voltage and current are in phase, and the magnitude of the current is determined by the value of resistance and the applied voltage. (Fig. 1A)

In a series a.c. circuit that is composed of a reactance and resistance, the current will lead or lag the applied voltage. If the resistance of the circuit is zero, current will be 90° out of phase with voltage (Figs. 1B-1E).

If we would draw a plot of the resultant current and applied voltage for conditions where the resistance was varied from zero ohms to infinity (open circuit), the resultant would be a circle diagram, as shown in Fig. 2.

If the resistance of the circuit is held to a constant value, and the reactance is made variable from zero to infinity, the circuit position is altered as is shown below in Fig. 3.

In all of the preceding illustrations it should be noted that as the reactive element approaches zero the phase angle (θ) between the current and voltage approaches zero. Also, as the reactance becomes much greater than the resistance the phase angle approaches 90 degrees.

Combining both inductance and capacitance in a series circuit will result in a phase pattern as shown in Fig. 4. Note that resonance occurs when the phase angle is zero and the power factor of this series circuit is unity.

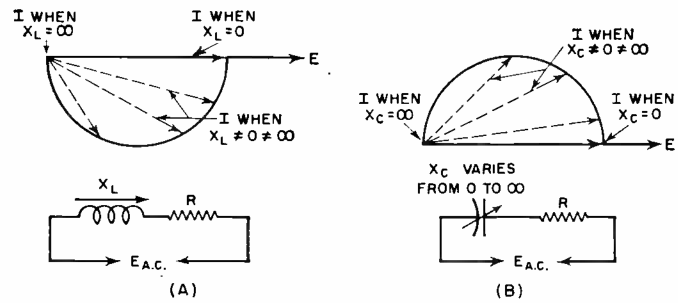


Fig. 3. Variation of current with changes in reactance.

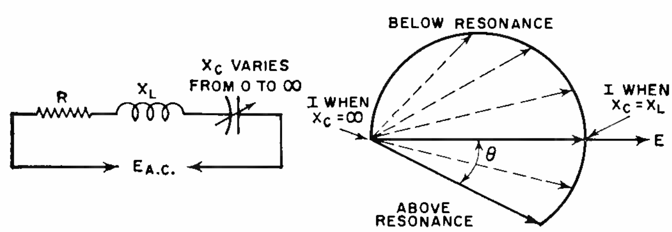


Fig. 4. Phase relations with both reactances and resistance.

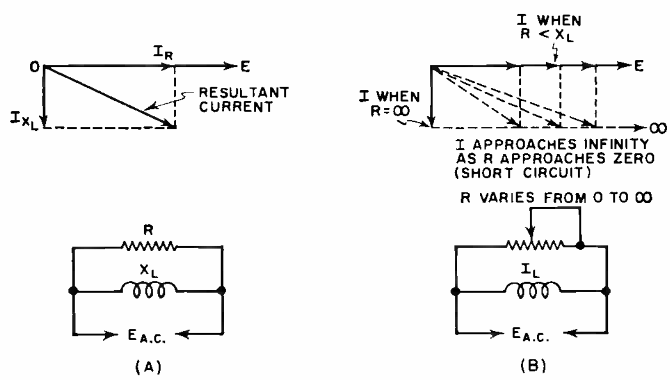
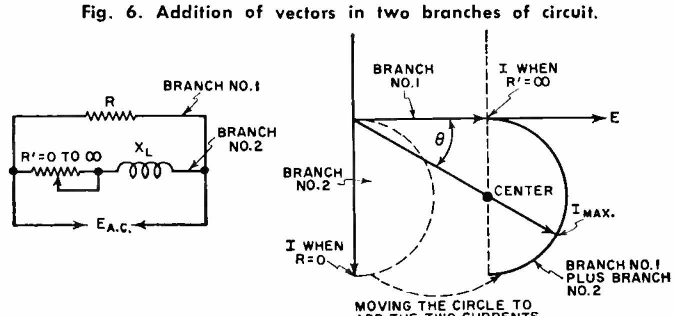


Fig. 5. Parallel circuits shown with resultant currents.

Fig. 6. Addition of vectors in two branches of circuit.



In a series circuit it seems obvious that nothing unusual is happening and it may be concluded that whether the circuit has high or low "Q," resonance occurs when $X_L = X_C$.

Fig. 5A shows a simple parallel circuit composed of an inductive reactance and a resistance. It can be seen that a circle is not formed by the current vector when a simple reactance and resistance are paralleled.

Let us now look at conditions when a resistance (R') is placed in series with the inductance of Fig. 5A and this added resistor is variable from zero ohms to infinity (Fig. 6).

Some very interesting relationships may be observed. It may be seen that the line current is minimum when branch No. 2 resistance is infinite in value (open circuit). Then by varying R' the current starts to lag and passes through the maximum value when the vector passes through the center of the circle. When R' is adjusted to zero resistance, the maximum phase angle (lagging) is formed and the current

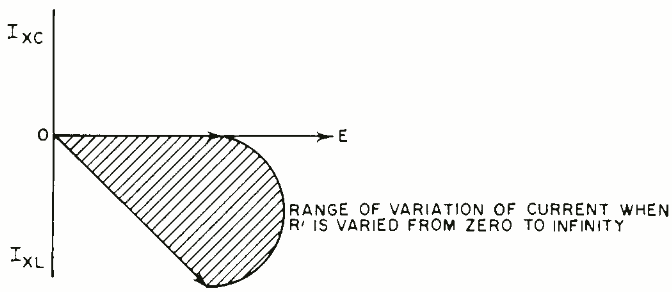


Fig. 7. Shaded area shows the range of current variation.

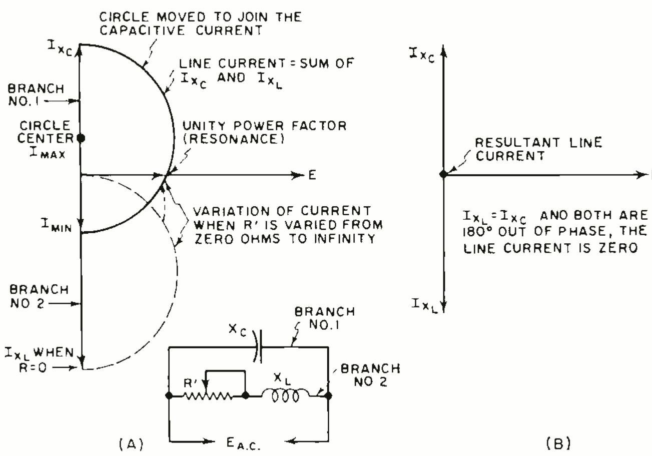


Fig. 8. Conditions that exist in parallel RLC circuit.

has decreased a slight amount. It should be kept in mind that when the current is maximum, the circuit impedance is minimum. Conversely, the current is minimum when the circuit impedance is maximum. Fig. 7 shows the range of current variation for the condition illustrated in Fig. 6.

Let us replace the resistor in branch No. 1 with a capacitive reactance and plot the results. In this case branch 2 will contain a variable resistance with a fixed inductance (Fig. 8A).

Note that in this case the maximum impedance (minimum current flow) does *not* occur at resonance, but when the circuit is purely inductive. Note also that resonance (unity power factor) can be produced even though the two reactances and their currents are *not* equal in value. It can be seen from the illustrations how the resistance R', which in this case is comparable to the circuit reactance, does have a tremendous influence on circuit performance. As a matter of fact, a change in resistance will alter the frequency at which unity power factor (hence, resonance) occurs.

If the circuit resistance were negligible and if $X_L = X_C$, the current would diminish to zero, indicating an infinite impedance at resonance. This would be the approximate condition for a high-"Q" r.f. tuned circuit. (Fig. 8B.) ▲

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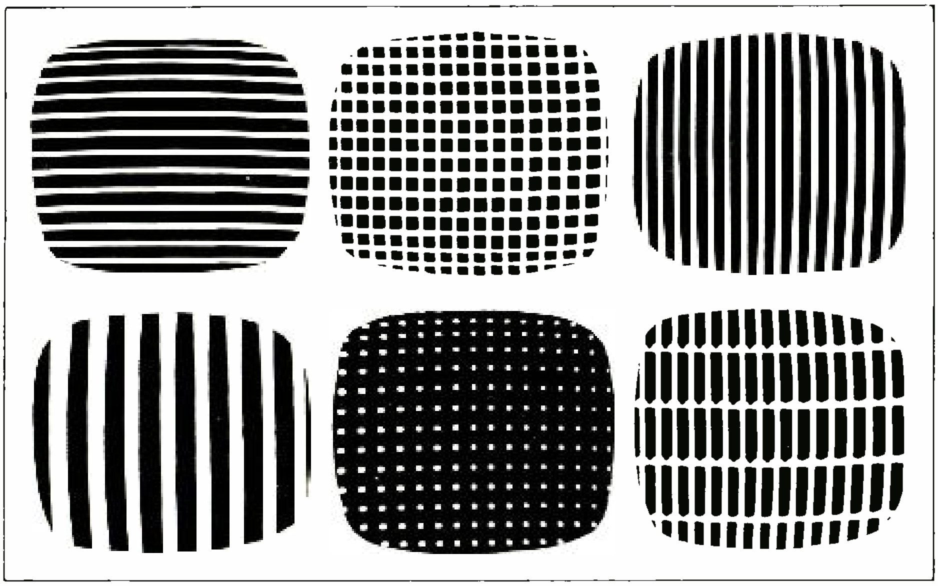


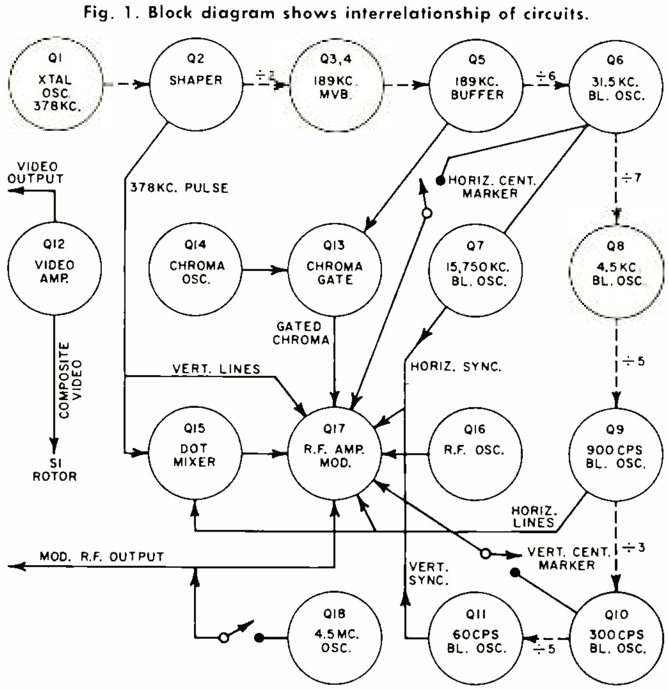
TRANSISTORIZED COLOR-TV PATTERN GENERATOR

This high-quality transistorized TV pattern generator can produce five varied alignment patterns, including color bars.

By JAMES K. STEWART

THIS battery-powered, transistorized TV-test-signal generator can produce vertical lines, horizontal lines, crosshatch or dot patterns, or color bars, besides producing a distinctive marker to identify the center horizontal or vertical line. All functions within the circuit are crystal-controlled either directly or through frequency division. A 4.5-mc. crystal-controlled oscillator is provided to check fine tuning and for adjustment of sound traps in the TV set. While r.f. output is crystal-controlled at channel 3, the unit also provides positive- or negative-going video for direct injection purposes.

Fig. 1. Block diagram shows interrelationship of circuits.



The color bar presentation is of the offset-subcarrier type, the chromatic oscillator being offset 1 horizontal line frequency from the color-burst frequency (*i.e.*, 3579.545 kc. color-burst frequency − 15.750 kc. line frequency = 3563.795 kc. offset-subcarrier frequency). This produces a phase difference of 0° to 360° across each line, and if the chromatic oscillator is gated at 30° intervals, the output will produce bars of color corresponding to the phase difference between the two signals at the gated intervals.

The unit can be battery-powered as power consumption is only 25 ma. at 9 v. Low-cost transistors and transformers are used throughout, making the generator cost less than a comparable commercial unit while at the same time offering many useful features.

The block diagram is shown in Fig. 1 while Fig. 2 and Fig. 4 show the complete schematic.

All line, dot, and sync pulses are timed from Q1, a 378-kc. crystal-controlled oscillator. The sine-wave output of Q1 is fed to Q2 where it is shaped by D1 and L2 for sharp vertical line and crosshatch presentation, and for synchronization of Q3 and Q4, a 189-kc. multivibrator. The pulse at Q2 emitter is coupled by D6 to dot mixer Q15.

The 189-kc. multivibrator produces square waves which are amplified by Q5 and used to key the chroma gate Q13 and to synchronize Q6, the 31.5-kc. blocking oscillator for a frequency division of 6. The chroma gate (Q13) is in a low-current state or cut off during the negative half cycles of the

189-kc. square wave but is suddenly turned on during the positive half cycle. This is accomplished when the positive-going pulse overcomes the reverse bias on *D4* which, in turn, throws a sudden forward biasing on the base of *Q13* through *D4* and *R16*. *Q13* can then amplify the chroma frequency from *Q14*. The chroma burst is then fed to *S1A* where it can be switched to the emitter of *Q17* to modulate the r.f. output. Since 189 kc. is the 12th harmonic of 15,750 cycles, 12 bursts are produced for each horizontal line. One burst is lost during horizontal retrace while another falls on the back porch of the horizontal sync pulse and acts as the sub-carrier burst, leaving 10 bursts to be presented as color bars.

The 31.5-kc. blocking oscillator (*Q6*) synchronizes the 15,750-cycle blocking oscillator (*Q7*) for horizontal sync, synchronizes the 4500-cycle blocking oscillator (*Q8*) for a further frequency division of 7, and provides a vertical marker at ½ horizontal frequency for horizontal centering and marking the 5th color bar in cases where picture width might be such that only 9 bars would be visible on the screen, making identification otherwise difficult.

The 4500-cycle blocking oscillator *Q8* is used only to sync the 900-cycle blocking oscillator (*Q9*) for a further frequency division of 5. The 900-cycle pulses are taken from the emitter of *Q9* and coupled to the dot mixer through *D5* and to *S1A* through *D8*.

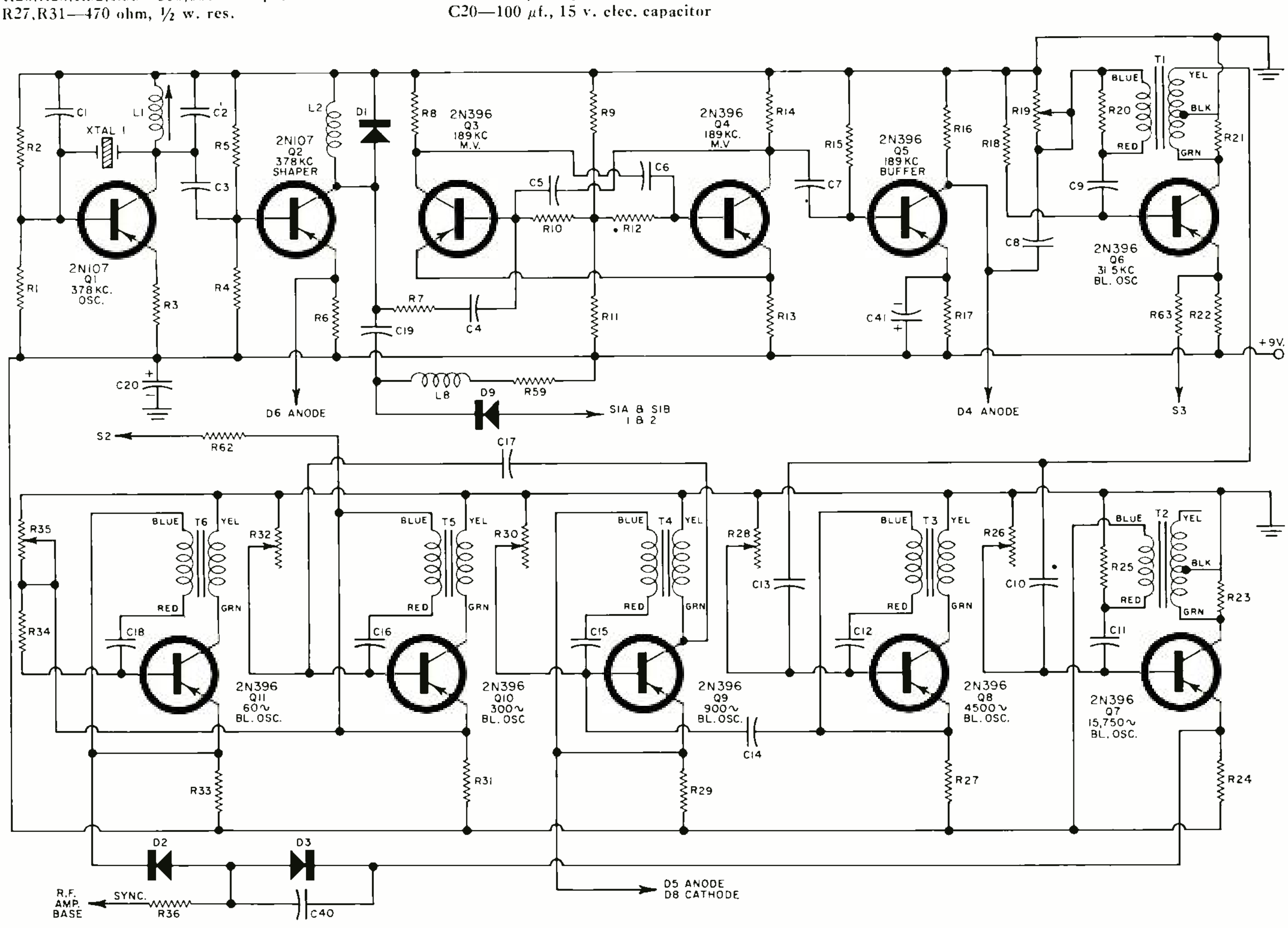
The 900-cycle pulses are also used to sync the 300-cycle blocking oscillator (*Q10*) for a further frequency division of 3. The pulse at the emitter is used as a vertical centering marker and is fed to the modulator (*Q17*) through *R62* and *S2*, and is also fed to the 60-cycle blocking oscillator (*Q11*) for a further frequency division of 5 to provide the vertical sync pulses. The vertical sync is taken from *Q11* emitter through *D2* and *R36* to the base of *Q17* modulator.

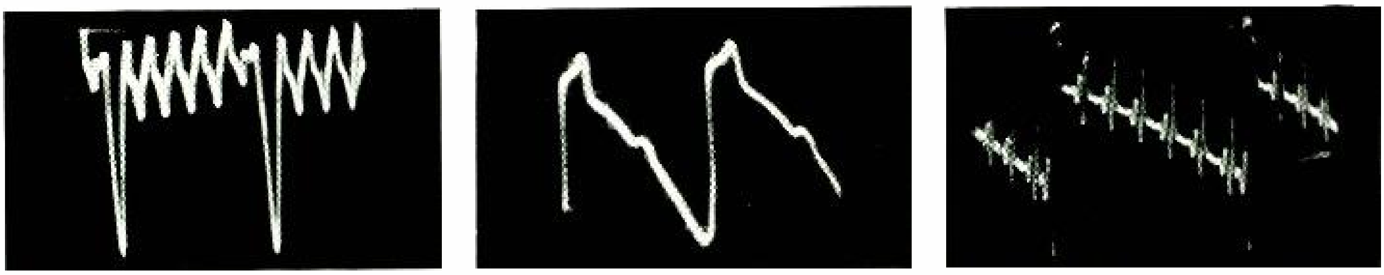
The positive d.c. voltage at *Q11* emitter back biases *D2* so that it is disconnected except during the negative pulse interval at the emitter. During this interval, the pulse forward biases *D2* and is transferred to the modulator base (*Q17*). This negative pulse is of the correct polarity to forward bias *Q17* for the pulse interval, thus producing modulation. Identical action takes place with *D3* from *Q7*, the horizontal sync blocking oscillator. Here it can be seen that *D2* and *D3* are connected back-to-back so that no interaction takes place between *Q7*, the 15.75 kc. blocking oscillator, and *Q11*.

The negative pulses at *Q2* collector are used to generate

Fig. 2. Schematic and parts list for the sync circuit. These circuits are kept in step by a crystal-controlled oscillator.

R1—82,000 ohm, ½ w. res.
R2,R18—150,000 ohm, ½ w. res.
R3—150 ohm, ½ w. res.
R4,R5,R7—39,000 ohm, ½ w. res.
R6,R17—1000 ohm, ½ w. res.
R8,R11,R14,R21—2700 ohm, ½ w. res.
R9—56,000 ohm, ½ w. res.
R10,R12,R20,R25—22,000 ohm, ½ w. res.
R13,R24,R29,R33—360 ohm, ½ w. res.
R15—270,000 ohm, ½ w. res.
R16,R23—4700 ohm, ½ w. res.
R19—5000 ohm pot
R22—100 ohm, ½ w. res.
R26,R28,R32,R35—500,000 ohm pot
R27,R31—470 ohm, ½ w. res.
R30—50,000 ohm pot
R34—220,000 ohm, ½ w. res.
R36—33,000 ohm, ½ w. res.
R59,R62—10,000 ohm, ½ w. res.
R63—8200 ohm, ½ w. res.
C1,C7,C13—120 pf. capacitor
C2,C3,C8,C9—82 pf. capacitor
C4,C5,C6,C10—39 pf. capacitor
C11—330 pf. capacitor
C12,C40—.001 µf. capacitor
C14,C17,C19—330 pf. capacitor
C15—.005 µf. capacitor
C16—.01 µf. capacitor
C18—.03 µf. capacitor
C20—100 µf., 15 v. elec. capacitor
C41—10 µf., 15 v. elec. capacitor
T1,T2—Driver trans. 10,000 ohms to 2000 ohms c.t. (Lafayette TR-98 or equiv.)
T3,T4,T5,T6—Input trans. 100,000 ohms to 1000 ohms (Lafayette TR-97 or equiv.)
Xtal.1—378 kc. (surplus FT-241 holder marked channel 4-20.4 mc. Available from Texas Crystals, Ft. Myers, Fla.)
D1,D2,D3,D9—1N34 crystal diode
L1—5 mhy. var. inductor (J. W. Miller 6322)
L2,L8—180 µhy. peaking coil (J. W. Miller 6180)
Q1,Q2—2N107 transistor
Q3,Q4,Q5,Q6,Q7,Q8,Q9,Q10,Q11—2N396 transistor





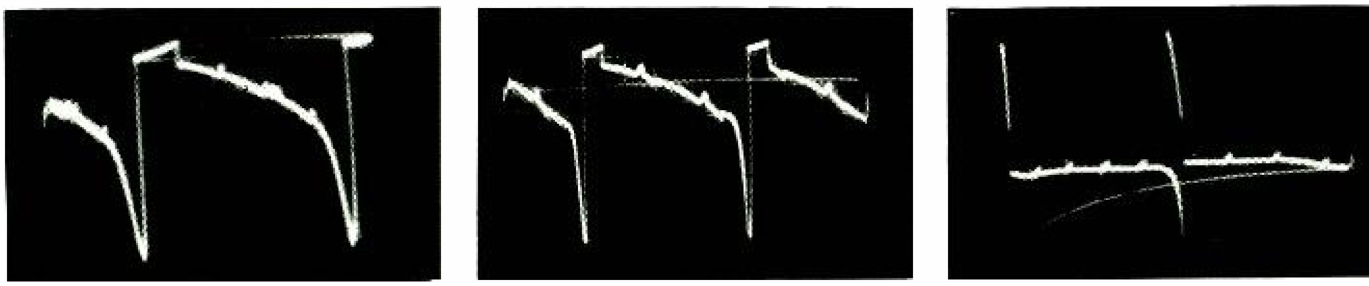


Fig. 3. (Above, left) 31.5 kc., (center) 15.75 kc., (right) 4.5 kc. (Below, left) 900 cps, (center) 300 cps, and (right) 60 cps.

the vertical lines; the network C19, L8, and R59 was added to eliminate overshoot of the pulse at Q17 emitter. D9 is used as a disconnect diode, being back biased except during the negative interval of the 378-kc. pulse at its cathode.

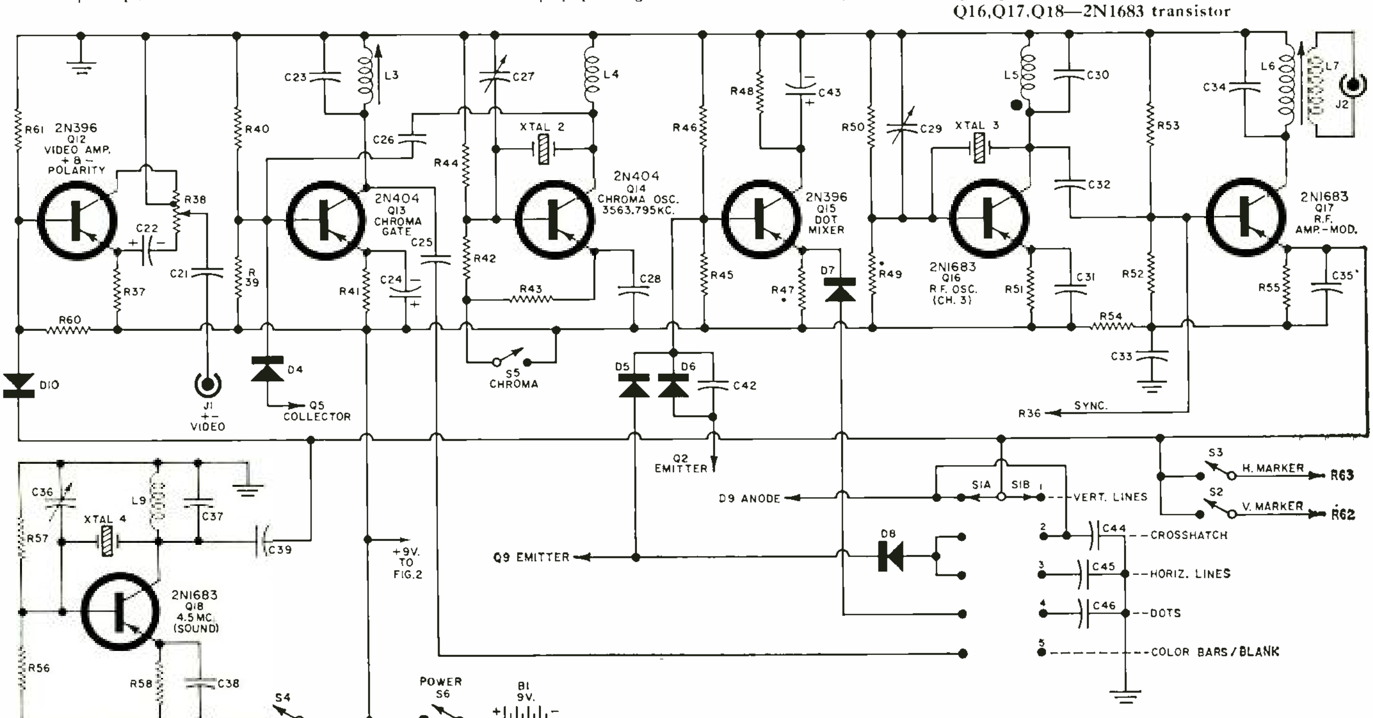
Alignment is not difficult if a reasonably good oscilloscope with a low-capacitance probe is at hand. This process is explained as follows on a step-by-step basis.

Step One—189-kc. multivibrator alignment. Place vertical input of scope to Q5 collector and horizontal input to Q2 collector. Adjust value of R9 (if necessary) to produce a stable figure-8 pattern on the scope.

Step Two—31.5-kc. blocking-oscillator alignment. Connect scope vertical input to junction of C8 and R19. Adjust R19 for 5 pulses (6 spaces) between major pulses, indicating a

Fig. 4. Schematic and parts list for the remainder of the circuit. Color bars, sound, and r.f. are crystal-controlled.

R37,R45—10,000 ohm, ½ w. res.
R38—15,000 ohm pot. tapped at 10,000 ohms (Mallory UT-153; with S6)
R39,R40,R61—330,000 ohm, ½ w. res.
R41—8200 ohm, ½ w. res.
R42—47,000 ohm, ½ w. res.
R43—270 ohm, ½ w. res.
R44—22,000 ohm, ½ w. res.
R46—220,000 ohm, ½ w. res.
R47, R48—4700 ohm, ½ w. res.
R49,R50,R52,R56,R60—39,000 ohm, ½ w. res.
R51—2700 ohm, ½ w. res.
R53,R57—270,000 ohm, ½ w. res.
R54—100 ohm, ½ w. res.
R55,R58—1000 ohm, ½ w. res.
C21—.25 μf. capacitor
C22,C24,C43—10 μf., 15 v. elec. capacitor
C23, C31, C37—82 pf. capacitor
C25—24 pf. capacitor
C26,C32,C39—3 pf. capacitor
C27,C29,C36—8-50 pf. var. capacitor
C28,C38—.001 μf. capacitor
C30—47 pf. capacitor
C33—.01 μf. capacitor
C34—10 pf. capacitor
C35—15 pf. capacitor
C42—33 pf. capacitor
C44,C45—500 pf. capacitor
C46—120 pf. capacitor
L3,L9—TV sound pick-off coil (J. W. Miller 1469)
L4—93 μhy. peaking coil (J. W. Miller 6177)
L5—9 t. #22, 3⁄16" dia.
L6—8 t. #28, 3⁄16" dia.
L7—3 t. #22, 3⁄16" dia.
Note: L6 and L7 made of modified TV i.f. coil; L7 added to coil form, ⅛" spacing from L6.
S1—D.p. 5-pos. min. switch
S2,S3,S4,S5—S.p.s.t. toggle switch.
S6—Part of R38 (Mallory US-26)
Xtal 2—3563.8 kc. crystal in HC-6/U holder
Xtal 3—61.25 mc. crystal in HC-6/U holder
Xtal 4—4.5 mc. crystal in HC-6/U holder
D4,D5,D6,D7,D8,D10—1N34 crystal diode
J1,J2—Chassis-mount mic. connector
B1—9 v. battery
Q12,Q15—2N396 transistor
Q13,Q14—2N404 transistor
Q16,Q17,Q18—2N1683 transistor



frequency division of 6. See Fig. 3 (top, left).

Step Three—15.75-kc. blocking oscillator alignment. Vertical input of scope to junction of *C*11 and *R*26. Adjust *R*26 for 1 pulse (2 spaces) midway on the discharge curve, indicating a frequency division of 2. See Fig. 3 (top, center).

Step Four—4.5-kc. blocking oscillator alignment. Vertical input of scope to junction of *C*12 and *R*28. Adjust *R*28 for 6 pulses (7 spaces) on the discharge curve, indicating a frequency division of 7. See Fig. 3 (top, right).

Step Five—900-cycle blocking oscillator alignment. Vertical input of scope to junction of *C*15 and *R*30. Adjust *R*30 for 4 pulses (5 spaces) on the discharge curve, indicating a frequency division of 5. See Fig. 3 (second row, left).

Step Six—300-cycle blocking oscillator alignment. Vertical input of scope to junction of *C*16 and *R*32. Adjust *R*32 for 2 pulses (3 spaces) on the discharge curve, indicating a frequency division of 3. See Fig. 3 (second row, center).

Step Seven—60-cycle blocking oscillator alignment. Vertical input of scope to junction of *C*18 and *R*34. Adjust *R*35 for 4 pulses (5 spaces) on the discharge curve, indicating a frequency division of 5. See Fig. 3 (second row, right).

Step Eight—Connect the r.f. output to a color television set known to be in correct operating condition, tune to channel 3, and adjust *L*6 and *L*7 core for the strongest pattern presentation. Adjust C29 if necessary to bring the output within range of the receiver fine tuning. C36 should be adjusted to zero-beat the sound oscillator r.f. output against a known 4.5-mc. signal.

Step Nine—Turn the color oscillator on and adjust *L*3 for maximum color intensity without shifting of the color shade from the leading to lagging edge of the color bars. With all receiver controls set for correct color presentation, C27 can be adjusted as necessary to make the color bar presentation correct. Re-adjust *L*3 for best results.

This completes the alignment of the unit. If any instability or failure to lock in occurs, recheck the alignment of the frequency division circuits. An incorrect count in any stage will naturally throw each succeeding count off.

Construction

Because the generator is completely transistorized, it lends itself very readily to etched circuit board construction. Two boards can be made, one for the r.f. circuits and the other for the sync circuits, by following the instructions given in an etched circuit kit.

These two boards can be mounted in a metal cabinet with the operating controls and output terminals mounted on the front panel. ▲

EW Lab Tested

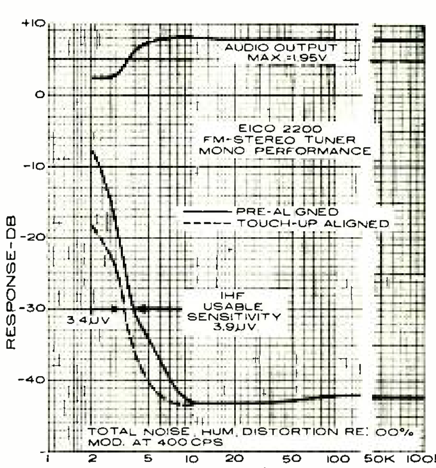
(*Continued from page 24*)

cuits – r.f., i.f., and multiplex – prealigned. The only adjustment recommended on the completed tuner kit is a slight touch-up of the first i.f. transformer, located on the front-end assembly.

We measured the IHF usable sensitivity on a kit tuner, with no further alignment, at 3.9 μv. Careful instrument alignment made only a slight improvement to 3.4 μv. Its rated sensitivity is 3 μv. Judging from this, we would suggest that anyone building the tuner follow the manufacturer's recommendations and not attempt any alignment. It is simply not needed.

In accordance with specifications, the tuner proved to be fully limited for any signals over 10 μv. We measured the total harmonic distortion at 100% modulation at 0.7% (rated 0.6%). The capture ratio was 3.9 db (rated 3 db). Channel separation averaged about 22 db before alignment, and almost 30 db after alignment. It is rated at 30 db at 1 kc. The frequency response was ±1.5 db from 30 to 15,000 cps on stereo, and ±1 db on mono. Drift was very slight and was complete within about 7 minutes after turn-on.

All in all, the Model 2200 tuner met its specifications handily, within the limits of normal measurement error. Its only weakness was a hum level of −51 db referred to 100% modulation. This could be heard during quiet periods, but did not intrude on program material. The tuner handled easily and was non-critical in tuning. We did find the "Stereo Check" system rather inconvenient since it only functions when the tuner is set to "Stereo" and the button is depressed, against a very stiff return spring. This, however, is a rather small sacrifice of convenience, when one considers that this easy-to-build and handsomely styled tuner sells for $92.50 in kit form or $119.95 factory wired. An oiled finished walnut cabinet is available for $19.95 and a metal cover for $7.50. ▲



MOTOR SPEED CONTROL

A simple control for 117/230 volt a.c. series-type motors.

THE simple circuit shown in the sketch provides motor speed control for series-type motors and makes use of the counter e.m.f. induced into the rotating armature by the residual magnetism during the half cycle that the SCR is blocking. Because counter e.m.f. is a function of motor speed, it can be used as an indication of speed changes for mechanical load variations.

The gate firing circuit consists of *R*1 and *R*2. During the positive half cycles, a fraction of the voltage developed at the rotor of *R*2 is compared with the counter e.m.f. developed in the rotating armature of the motor. When the SCR gate bias, set by *R*2, exceeds the counter e.m.f. of the motor, the SCR fires to apply power to the motor for the remaining portion of the positive half cycle.

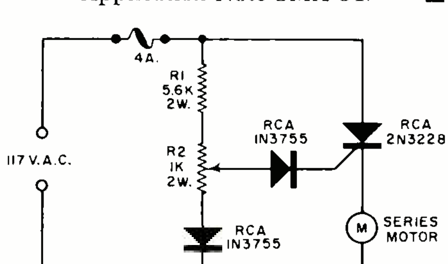
Speed control is accomplished by varying the setting of *R*2.

At no load and low speed, skip cycling occurs. This results in erratic motor speeds. Since no counter e.m.f. is induced in the armature when the motor is standing still, the SCR will fire at low bias (potentiometer) settings, causing the motor to accelerate to a point where the counter e.m.f. induced in the rotating armature exceeds the gate firing bias of the SCR and prevents it from firing.

The SCR is not able to fire again until the motor speed has reduced (due to friction losses) to a value where the induced voltage in the rotating armature is less than the gate bias. At this time, the SCR fires again. Because the motor deceleration occurs over a number of cycles, there is no voltage applied to the motor, hence, the term skip cycling.

When a load is applied to the motor, its speed decreases thus reducing the counter e.m.f. The SCR then fires earlier in the cycle providing increased motor torque to the load. The circuit shown was designed for 117-v. operation. For 230-v. lines, an *RCA* 40230 SCR would have to be used with a modified circuit.

This information was extracted from *RCA* "Application Note SMA-34." ▲



ELECTRONIC CROSSWORDS

By DONALD W. MOFFAT

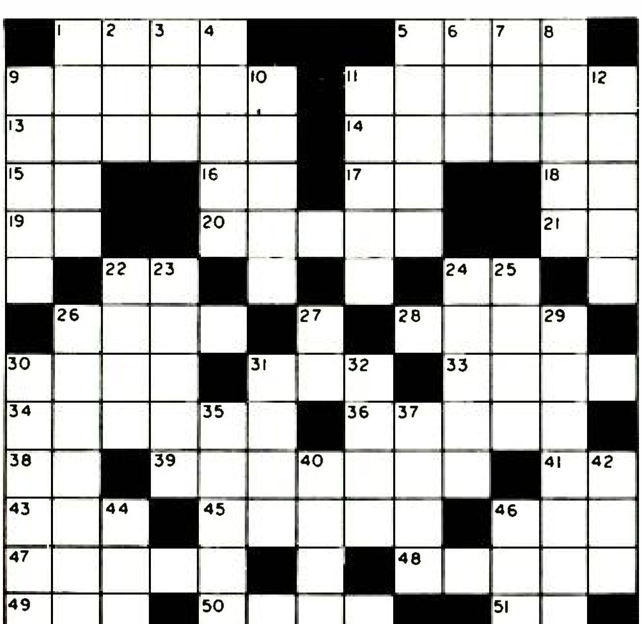
(Answer on page 125)

ACROSS

1. Greek letter used to designate feedback factor.
5. Unit of e.m.f.
9. Adjacent divided by hypotenuse.
11. One element in table salt.
13. Pentagon has five.
14. Toward the center.
15. Grid current (schematic notation).
16. Province in southeastern Canada (abbr.).
17. Paid public announcement (abbr.).
18. Universal pronoun.
19. Output resistance (schematic notation).
20. Called when flipping coins.
21. Engineer's license (abbr.).
22. Type of loudspeaker.
24. One of the broadcast bands (abbr.).
26. Tight.
28. Term which does not involve the square root of minus 1.
30. Audio frequency range.
31. Priest's white linen robe.
33. Exclamation of resignation.
34. Going up.
36. Gathering for a single purpose.
38. French "it."
39. Titles of Roman rulers from Augustus to Hadrian.
41. Preposition, having to do with.
43. Undeflected CRT beam.
45. Gear which transmits power between two others.
46. Anthropoid.
47. Cloth in front of loudspeaker.
48. Covered inside.
49. Thought waves (abbr.).
50. Common name for compounds containing sodium.
51. A radioactive element (abbr.).

DOWN

1. West Indian drum.
2. Voltage at the screen grid (schematic notation).
3. Sesame plant.
4. Concerning.
5. Areas lacking.
6. Predominant harmonics in square wave.
7. Cover.
8. Spring flower.
9. Egyptian city.
10. Short literary composition.
11. Diminutive.
12. Indicates current.
22. Name of series tube in power-supply regulator.
23. Audio characterized by rhythm.
24. Closes up.
25. Supports ceiling.
26. Makes to specification.
27. Female ham.
29. Expose.
30. Type of rectifier circuit.
31. Old.
32. Hillside (Scot.).
35. For holding pieces of wood together.
37. Association of hams.
40. Conveyance.
42. Gave food.
44. Part of a soldering iron.
46. Picks up r.f. (abbr.).



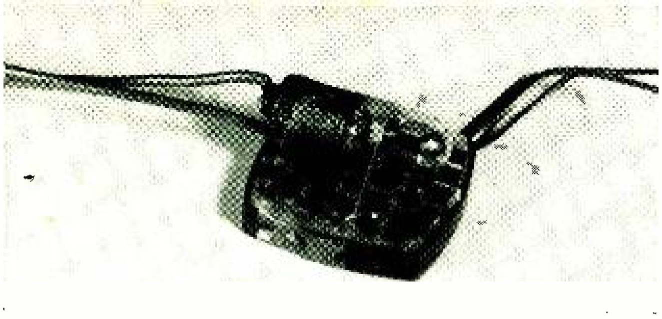


Fig. 1. The small pilot lamp, with leads soldered to its base, is simply attached to the photocell window by means of transparent tape. Assembly is then enclosed in light-tight box.

SIMPLE PHOTOELECTRIC AMPLIFIER

By RUFUS P. TURNER

Lamp-photocell combination provides high d.c., a.c. gains for control circuitry.

THE familiar combination of low-voltage filament-type lamp and high-voltage photocell can provide amplification, both a.c. and d.c., under certain conditions of operation. The lamp-cell pair is far from being a high-fidelity device, but it has many possible applications in control systems. One distinct advantage is the excellent isolation of input and output circuits—superior to that of either transistors or vacuum tubes.

The operating principle is simple: A cadmium sulphide photocell, biased with high d.c. voltage in series with a load resistor, is illuminated by a low-voltage lamp. The lamp is lighted by the input d.c. signal voltage and the photocell current is proportional to the brightness of the lamp. This current produces a voltage drop, which is the output d.c. signal, across the load resistor. When the lamp is dark, the photocell resistance is so high (1 megohm or better) that no output voltage is obtained. The d.c. voltage amplification results from the fact that the output-voltage swing is much greater than the input-voltage swing. To obtain a.c. amplification, the lamp brightness is modulated by injecting an a.c. input signal voltage in series with the lamp d.c. voltage.

This system does not provide current amplification, although a small amount of power amplification may be obtained, as will be discussed later in this article.

To test operation, a lamp-cell pair was constructed by taping a 2-volt, 60-ma. pilot lamp (No. 48, pink bead) to the transparent window of a cadmium sulphide photocell (*International Rectifier* CS 120M6). For maximum illumination, the plane of the lamp filament must be parallel to the face of the cell. This lamp does not heat enough to affect the cell. The assembly, which is about the size of a quarter (see Fig. 1), was placed in a light-tight box.

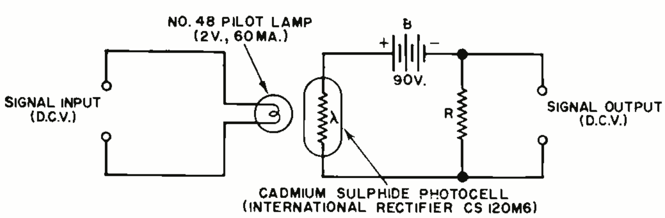
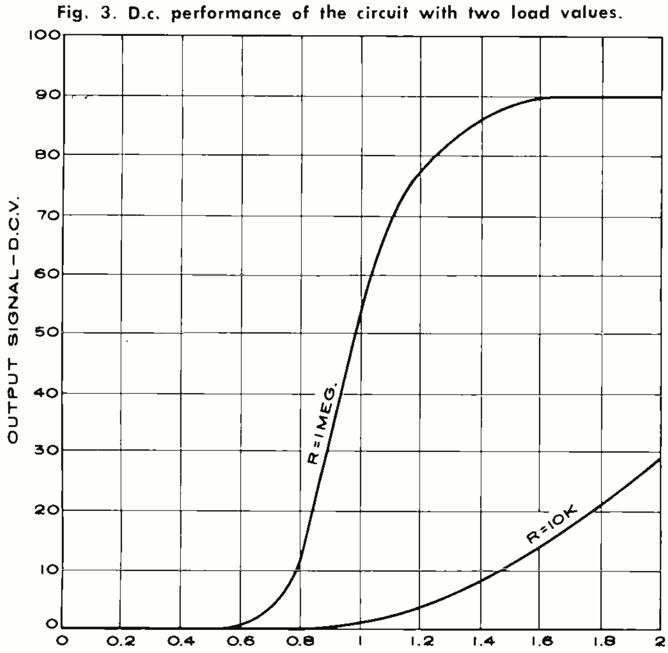


Fig. 2. Circuit arrangement used to show d.c. amplification.

Fig. 3. D.c. performance of the circuit with two load values.



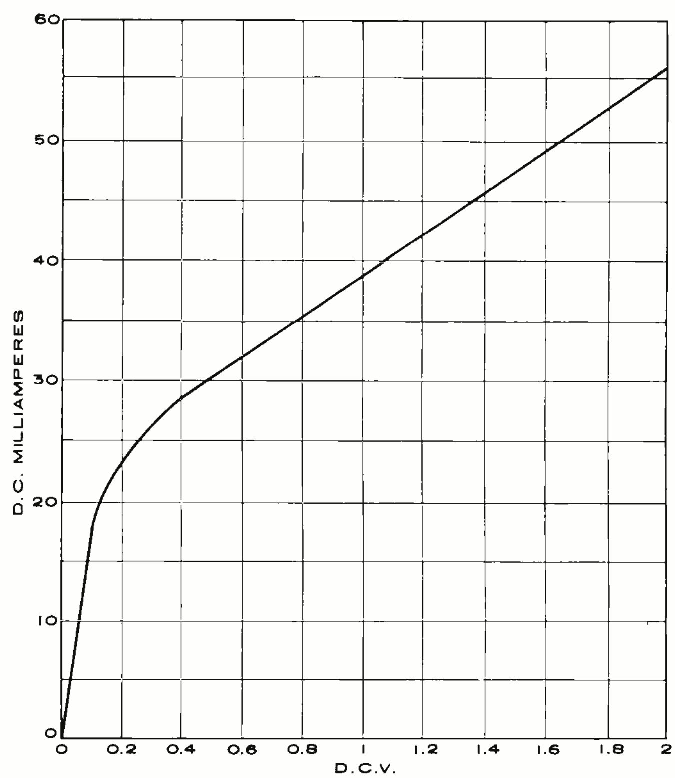


Fig. 4. Note the non-linear voltage-current characteristics.

Fig. 2 shows the d.c. amplifier circuit, while Fig. 3 shows the response of this circuit with the load resistance $R = 1$ megohm and $R = 10{,}000$ ohms. Note that a 1.8-volt input signal produces a 90-volt output signal. The steepest and most linear portion of the 1-megohm response curve lies between 0.8-volt and 1-volt input, corresponding to 10-volt and 55-volt output. In this region, an input voltage change of 0.2 volt thus produces a 45-volt output change (voltage gain = 225 = 47 db). To obtain this gain, pre-bias the lamp to 0.8-volt d.c., then add the 0.2-volt d.c. input signal to this bias. The bottom curve shows lowered response when R is reduced to 10,000 ohms. Since the most favorable output signal voltage is developed across a 1-megohm resistance, the amplifier can feed only those d.c. loads higher than 1 megohm. In some applications this is a disadvantage.

The d.c. circuit does not produce current gain since the lamp (input) circuit draws more current than flows in the photocell (output) circuit. Fig. 4 shows the lamp d.c. volt-ampere characteristic. Note that this is a non-linear response, the filament resistance varying with applied voltage from about 6 ohms at 0.1 volt to about 34 ohms at 1.8 volts.

Fig. 5 shows the a.c. amplifier circuit. Here, battery *B1* through adjustment of rheostat *R1*, biases the lamp to the most favorable portion of the d.c. response curve. (This is around the 0.9-volt, 37-ma. point for the individual lamp used by the author. See Figs. 3 and 4.) The a.c. signal is injected through transformer *T*. The d.c. resistance of the secondary winding of this transformer must be so low (1 ohm or less) that it does not significantly reduce the filament current. Also, the transformer must be able to handle the approximately 60-ma. maximum filament current without saturating, and must have a 1:1 turns ratio. These conditions are all satisfied by the power transistor output transformer specified in Fig. 5. The 1000-μf. capacitor, *C*, bypasses the input audio signal around the filament rheostat in the circuit shown.

The circuit has a highest voltage gain of 29, or 29 db, corresponding to 5.8-volt r.m.s. output for 0.2-volt r.m.s. input. The output resistance is 10,000 ohms. Measured input current is 5 ma. r.m.s. These conditions show input power to be 1 milliwatt and output power 3.4 milliwatts, representing a power gain of 3.4. This is the equivalent of 5.3 db.

The a.c. amplification is best at low frequencies, because of the thermal lag of the lamp filament (it just can't wink fast enough to keep up with high frequencies) and the limited frequency response of the photocell. Fig. 6 shows the frequency response. The circuit was also tested with a Type 112 lens-type 1.2-volt flashlight bulb. This lamp has somewhat better frequency response and gives approximately five times the voltage gain at all points on the curve in Fig. 6, but it requires a d.c. bias current in the order of 200 milliamperes in this application.

General Characteristics

Good points of this amplifier include (1) excellent input-output isolation, (2) high gain, (3) easy adaptability to a.c. or d.c., (4) low current drain: 90 μa. maximum with 1-megohm load, and (5) simple circuitry.

Its disadvantages for conventional applications are: (1) poor frequency response, (2) high output impedance or resistance: 10,000 ohms to 1 megohm, and (3) low input impedance or resistance: 6 to 40 ohms.

The amplifier operates well into high-resistance instruments, such as d.c. oscilloscopes, v.t.v.m.'s, and potentiometric recorders. Working into a standard 1.5-volt d.c. v.t.v.m., for example, it will give full-scale deflection on 6.7-mv. input, after the initial deflection has been balanced out. As an a.c. amplifier, it also serves as a low-frequency, low-pass filter giving an average attenuation of approximately 4 db per octave between 20 and 200 cps. ▲

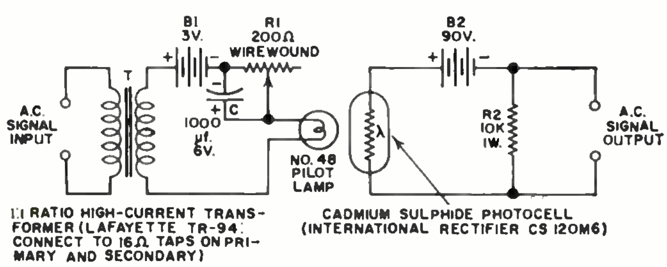
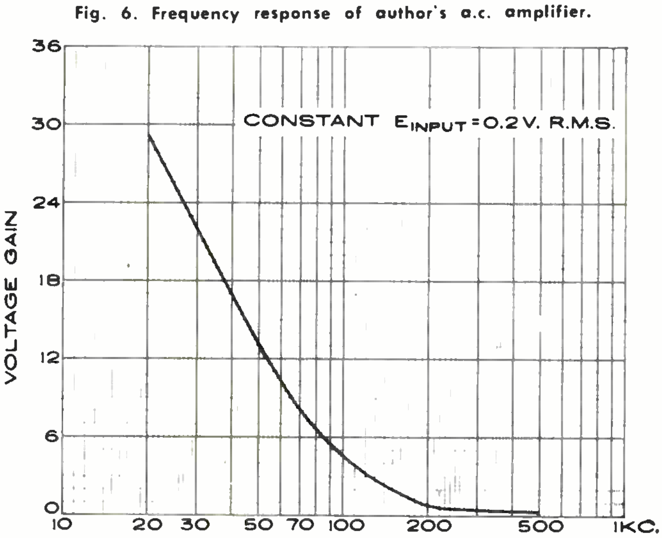


Fig. 5. Circuit diagram of the a.c. amplifier discussed.

Fig. 6. Frequency response of author's a.c. amplifier.



Will the Space Age eliminate your job in

MANY HOURS OF ROUTINE WORK required to put together conventional circuitry are eliminated by the molecular circuitry used in this tiny video amplifier.

(Photo courtesy of Westinghouse)

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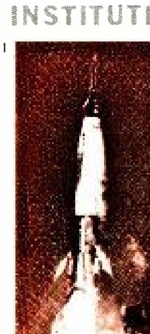


9-INCH COLOR-TV SET

COLOR-TV in Japan is getting a hard push from Japanese manufacturers in order to take advantage of the color transmission of the Summer Olympic Games, soon to be held in Tokyo. It is hoped that these programs will also be transmitted to the U.S. *via* communications satellite.

Many Japanese manufacturers have started production of 14-, 16-, and 21-inch shadow-mask types of color sets in preparation for the expected demand. Some, however, have been experimenting with different approaches to a small-screen color set. Although development of such sets has been reported in the past, the GTC-9, using a 9-inch, one-gun color CRT, and completely transistorized, has been made by *Yaou Electric Co. Ltd.*, and is the first small-screen color-TV set being prepared for sale at the present. This new set is slightly deeper than the same company's 9-inch black-and-white set. Both sets are shown in the photograph.

The new 9-inch color tube, called a "Colornetron," is a single-gun tube, similar in operation to the old one-gun Lawrence tube, and is a result of joint research by both *Yaou* and *Kobe Kogyo Co. Ltd.* Although complete details of both the color tube and associated color circuits are not available due to patent considerations, it is known that the tube uses a form of post-deflection acceleration and focusing in order to keep sweep requirements at a minimum and to permit the manufacturer to use readily available deflection components. This also helps reduce the price of the set (unknown at the present writing). Among the circuits used are "three interval automatic phase loop, offset subcarrier demoduation, and a storage-counter circuit." It is not known just what these circuits are or how they operate since clearance has not been given yet by the company's patent attorney.

The line-sequential system of color generation is used in this new tube. In this approach, color phosphors are laid down in fine horizontal lines with the three colors alternating down the screen. The electron beam is made to scan one color line at a time, modulating it with that color's video only. During the horizontal retrace interval, the video information is electronically switched so that the next color's video is now present as the electron beam sweeps that color line. This process continues down the screen so that each color line receives its own particular video while the beam is landing on it.

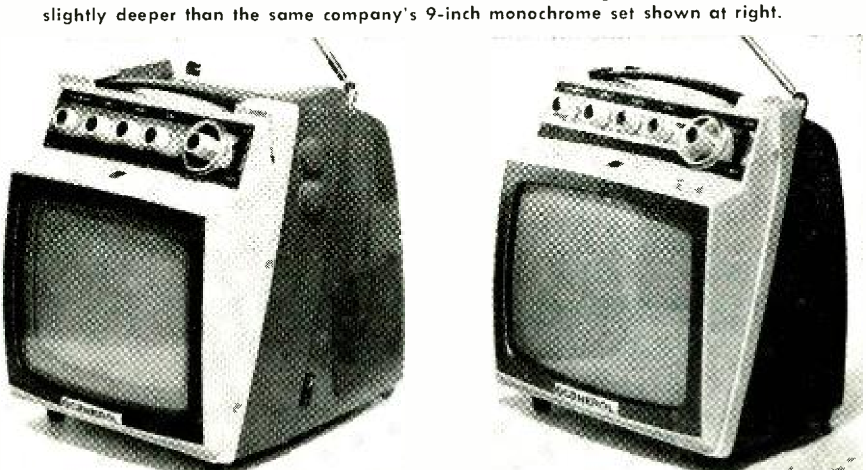
This method of generating colors has not been used on the larger screen CRT's because in operation it appears that the colors "crawl" down the raster. This is due to the fact that on a large-screen tube, the scanning lines are relatively far apart. However, on a small-screen tube the raster lines are much closer together so that "color crawl" is not so apparent.

In previous versions of the one-gun Lawrence tube, the beam-switching grid, located very near the faceplate, had to be excited by a relatively high-power r.f. source in order to guide the electron beam to the desired color phosphor. Shielding had to be employed to make sure that this r.f. power did not leak out to cause interference to other receivers. In this new small color tube, switching the electron beam from line to line is done by conventional sweep techniques.

Because of the single-gun technique, this new tube does not require convergence circuits, and also, not using a shadow mask, the tube does not need degaussing. Intercarrier sound is used.

Power consumption is 22 watts from a 12-volt source and 30 watts from a 117-volt line. ▲

The "Colornet" color-TV set shown at left uses a 9-inch, one-gun CRT and is only slightly deeper than the same company's 9-inch monochrome set shown at right.



Shielded Cables

(*Continued from page* 38)

in low-frequency equipment furnish weak signals which can be completely swamped by noise picked up from the brushes of a motor or the arcing of relay contacts. Even such mechanical noise sources as building vibrations due to trains or trucks can present serious interference problems. For these reasons, especially good shielding is often required.

Coaxial cable is sometimes inadequate when it comes to solving noise and interference problems and, in many applications it is necessary to keep the signals completely insulated from ground. When many different signals are carried in a common cable, interference and crosstalk between them must be kept to a minimum. In this case, balanced, twisted-wire pairs in a shielded jacket are usually used. Shielded cables are available for all requirements, but again consideration must be given to size and weight.

One manufacturer in the wire and cable field has developed a method of bonding Mylar to very thin aluminum foil which combines the electrical shielding properties of aluminum with the tensile strength of Mylar. In addition, the Mylar portion can also serve as insulator and the bonding material can be colored to provide color-codes for the shielded cable. A good example of the advantages of this type of construction is shown in Fig. 5, a single-wire shielded cable suitable for audio and lower range r.f. signals. The center conductor is stranded, tinned copper, surrounded by a conventional insulator such as rubber, polyethylene, etc. This is covered with a spiral-wound Mylar-aluminum tape, the edges of which are folded over as shown. This "Z" bend provides contact between the aluminum foil and this has the same electrical effect as a solid aluminum tube. The outer Mylar layer also serves as insulating outer jacket for the cable. Since it would be difficult to make a soldered connection to the aluminum foil, a ground or drain wire runs between the aluminum foil shield and the inner insulator. This is a flat tinned ribbon which makes continuous contact with the aluminum foil and can be easily soldered to the chassis or the connector ground.

Fig. 6 illustrates the advantages of aluminum foil in a multi-cable arrangement. Here the individual shields are insulated from each other by the Mylar portion of the tape which permits either individually selected grounds or a single common ground point for all shields. The drain wire is a conventional stranded wire and the internal conductors are a twisted pair, typical for that used in audio work. In some cables the aluminum layer is on the outside with the drain wire held in place by an outer jacket, usually made from neoprene rubber. *Belden* makes a variety of tape-shielded cables which are widely used in audio, stereo, and intercom applications where good shielding is required. Signal separation as high as 90 db between adjacent twisted-pair cables is possible and this is often required in high-gain, low-level applications. A number of other manufacturers also offer tape-shielded cables similar to those described.

For instrumentation or other applications where cable noise is a special problem, *Microdot* now offers a process in which the surface of the dielectric covering the inner conductor is treated to dissipate electrical energy. In effect, a resistive surface exists between the outer conductor and the dielectric. Interference between adjacent cables is thereby reduced and cable-generated noise, such as mechanical vibrations, etc., tends to dissipate in the resistive shell. While used primarily on coaxial cable, this process is also available for other types of shielded cables. ▲

ADDITIONAL NOTES ON AUDIO SWEEP GENERATOR

By FRANK J. MANUS

ROBERT H. Douglas beat me to the punch when his audio sweep generator article was published in the August issue (page 71). But, having had some experience with this type of instrument, I would like to pass along some information and changes pertaining to his circuit.

Although I was unable to obtain the diodes listed for *D1*, I built the instrument intending to use a diode which had proved successful in another audio sweep generator I had built. This is the 1N536 diode. Any of the 750-ma. silicon top-hat diodes may be used as a voltage-sensitive capacitor in lieu of specially designed units and at much lower prices. However, Mr. Douglas' circuit will not provide a saw-tooth of sufficient amplitude to utilize the capacitance-change ability of the top-hat diodes.

Increasing the "B+" voltage to 12 volts will help without the need for higher voltage transistors. With the 1N536 diode, the circuit will sweep up to 11 kc., but can be increased, as will be explained later.

With the 12-volt "B+" you should have 7.5 volts on the collectors of *Q1* and *Q3* and 8 volts on *Q2* and *Q4*. The other collector voltages are 4, 7.5, 6.7 and 8.4 volts on *Q5* to *Q8* respectively. Base 2 of the unijunction transistor will be at 7.5 volts.

The following are changes I have made in addition to increasing the "B+" value. *C21* is connected directly to *R24* since the logarithmic display is more useful than the linear display. The sweep limit pot, *R23*, is replaced by an 82k resistor with *C20* going to the junction of it and *C21*. (*C1* is used to control sweep range.) Looking at *R16* from the front, its right-hand lug is connected to ground. If other than a metal chassis is used, ground both transformer cases. They may be mounted on the same side if they are at least three inches apart.

Alignment is as follows: Set *C1* and *T1* to their midpoints—5 turns from the bottom for *T1*. Turn *R16* fully clockwise for maximum output. Then set *T2*'s slug 4 turns from the bottom. Turn the instrument on and after a minute, turn *T2*'s slug outward until the pattern of Fig. 3 of the original article appears. While adjusting *T2*'s slug, amplitude of the display will be increasing. At a certain point sine waves will appear with a gap between them. Bring the center of this gap to the left end of the display. This is the oscillator's null point where the sweep starts. Further slight adjustments of *T1* and *T2* will result in a pattern without drift.

Warm-up time is 2-3 minutes. After this time, pattern drift is due to an insufficient sync voltage for some scopes. *C1* may be used to compensate for the slight drift which may occur when in the 0-11 kc. mode—*C1* being at half mesh. Turning *C1* slightly clockwise so the low-frequency end of the display moves away towards the left will increase the upper end of the sweep while also increasing the minimum frequency. A higher amplitude saw-tooth will give a 20-kc. sweep but this would necessitate redesigning the circuit.

The upper frequency may be checked by counting cycles in a given short space with the scope's horizontal gain at maximum and the right end of the display near the scope screen's center. Then compare it with an audio generator waveform until the same number of cycles appear in the same space.

The instrument can be checked out with sharp cut-off filters. Once the user becomes familiar with this instrument, he will see how useful it is in audio work such as in filter and crossover design. ▲

Computer Input-Output

(*Continued from page 54*)

at these speeds the desired data may be many seconds away from the reading station. Because of this *long access time*, magnetic tape is used for bulk storage of data, and a high-speed memory is available internally in the central computer. Blocks of data from the tape can be transferred from time to time into the main memory of the computer.

Printers

Ultimately, the results of data processing and calculation must be presented in printed form. Punched cards and tapes are useful for presenting data to the computer, but humans prefer to have data presented to them in printed form. The printing device should be capable of producing numerals, alphabetic characters, punctuation marks, and some special symbols such as #, $, %, etc.

Printers may be operated either on-line or off-line. In either case, high-speed printing is desirable. For on-line operation, the printer is controlled by electrical signals from the central computer, and it is undesirable to keep the computer occupied too long with this "menial" task. For off-line operation, the printer converts data from card or tape to printed page. Here, too, speed is desirable, although not so critical, because of the large amount of data that must often be printed.

The electric typewriter, in modified form, can be employed as a printer. Since it prints only one character at a time, this is a relatively slow device—typically 10 to 30 characters per second. A perforated tape unit may be incorporated in the typewriter. With this arrangement, a typewritten copy can be produced from a perforated tape, or a perforated tape can be produced as the operator types in data.

High-speed printers can print a whole line at a time and achieve speeds of 600 to 1000 lines a minute. These printers employ solenoid-actuated hammers that press the paper and ribbon against a wheel or chain carrying raised letters, numerals, etc. So fast are the hammers that the wheel or chain revolves continuously and the hammer strikes as the desired character passes in front of the paper.

We have shown in this article that the computer can not function alone but that it must be communicated with by means of various peripheral input-output devices. For the present, most computers employ punched cards, perforated tape, and magnetic equipment for this purpose. There is an increasing use, however, of magnetic and optical readers that are able to convert printed information into electrical signals. ▲

Semiconductor Rectifiers

(*Continued from page* 30)

in the order of 10 milliamperes, as indicated in Fig. 5.

With its low voltage drop when in conduction, germanium rectifiers are used in relatively low-voltage power supplies where its superior efficiency is desirable. Also, in some applications germanium rectifier diodes have been credited with developing less radio interference than typical silicon rectifiers because of the lower conducting voltage of germanium and its favorable commutating characteristics.

Outside of the foregoing exceptions, new rectifier-equipment designs use silicon diodes almost exclusively in applications ranging from "B-plus" supplies delivering a few hundred milliamperes to power-conversion equipment delivering as much as 100,000 amperes d.c. to electrolytic aluminum refinement processes.

Success with Silicon Rectifiers

While silicon has proven to be the key to expanded use of d.c. in many applications because of its long term reliability, compactness, and attractive costs, equipment designers have found certain precautions necessary in its use if headaches and premature failures are to be avoided.

While a typical silicon rectifier may sustain 1000 volts indefinitely without damage, a 1500-volt transient spike lasting only a few millionths of a second may destroy the rectification characteristics by causing a short circuit across the junction. Transient disturbances are practically unavoidable in useful rectifier circuits due to such circumstances as switching, lightning, and commutation. (In fact, short transients as high as 5600 volts have been measured on seemingly innocent 120-volt a.c. distribution lines.) For this reason, successful silicon rectifiers generally incorporate healthy voltage safety factors, transient filters or suppressors, or a combination of these precautions. In the past few years, so-called "controlled-avalanche" silicon rectifiers introduced by some manufacturers have demonstrated their ability to operate in many transient-prone applications without separate suppressors or high safety factors. These controlled-avalanche rectifiers have zener-diode type characteristics in their reverse blocking direction that can clip voltage transients and dissipate transient energy without damage to themselves. Expressed differently, these rectifiers have their own built-in transient voltage suppression, similar to some types of selenium rectifiers.

Because of the high current densities at which silicon rectifiers are rated to operate, little margin is available for heavy overloads and short circuits compared to selenium or tube rectifiers. A typical silicon rectifier capable of carrying one ampere continuously will fail with three amperes flowing through it for only one second. Fifteen amperes will damage it in less than 0.01 second. Such quick failure when a short circuit or other circuit malfunction occurs requires special fast fuses or circuit breakers if the rectifier is expected to survive. Where heavy inrush currents flow into the capacitor filter when a power supply is energized, a surge resistor is often used to limit currents within the silicon rectifier's rating. Where neither of these approaches is feasible, rectifiers with higher surge current ratings are used. For example, the earlier-mentioned rectifier which failed in one second with a three-ampere overload can be replaced by one that can carry 30 amperes for several seconds without failing, thereby allowing overload protection by means of conventional branch circuit fuses. This ten-fold improvement in surge current capability costs about 2½ times the price of the smaller rectifier, a slight premium over the cost of an expendable special high-speed fuse.

Applications

The circuits in which semiconductor rectifiers are used to convert a.c. power to d.c. power are almost too limitless to catalogue. They range from simple half-wave rectifier circuits which employ a single rectifier diode cell for low-current applications to 24 or more phase circuits which use literally hundreds of individual diodes in series and parallel connected arrays for heavy industrial applications. Design engineers base their selection of a particular circuit on such factors as the voltage and current requirements, ripple voltage on the d.c. output, the transformer design, and over-all economics. Table 2 illustrates five basic rectifier circuits commonly used with semiconductor types together with the voltage and current relationships characteristic of each.

Many overlook some of the useful tasks other than power rectification that semiconductor rectifier diodes can perform. Here are three typical applications.

Fig. 6A shows a two-step voltage control. A silicon rectifier in series with the a.c. line prevents the negative half cycle from reaching the load, thereby reducing the r.m.s. voltage on the load to 70%. With a suitable selector switch, the simple circuit shown provides almost lossless two-step control of voltage in such loads as incandescent lamps, soldering irons, and universal motors.

Fig. 6B shows a reverse current relay replacement. When the d.c. generator is driven, it charges the battery and supplies current to the load. When the generator slows down or stops, its terminal voltage drops below the battery voltage. The rectifier diode prevents battery current from discharging through the low-resistance generator winding. Typical applications are emergency power supplies, automotive generators, and railroad car lighting.

Fig. 6C is a power-logic circuit. The rectifier diodes control the operation of two loads over a single pair of wires. When switch A is closed, only load A is energized from the a.c. supply. Switch B controls only load B.

The alert designer, engineer, or technician will find countless other uses for these easy-to-use and economical semiconductor rectifier cells in his favorite applications. ▲

INEXPENSIVE NANOAMP METER

By DONALD BELANGER

WITH silicon semiconductors becoming commonplace on both the engineer's and technician's bench, a need for sensitive measuring equipment exists. Nano- (10^{-9}) and picoammeters (10^{-12}) are not very common; however, most persons involved in electronics have d.c. vacuum-tube voltmeters. The low leakage currents of silicon devices may be readily measured by the use of such a meter and an external voltage source.

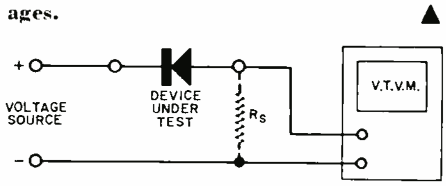
The input resistance of many v.t.v.m.'s is 11 megohms. For each volt appearing across the 11-meg resistance, 90.9 nanoamperes must flow through it. Whether the v.t.v.m.'s lowest scale is 1, 1.2, 1.5, or 3 volts does not matter. What does matter is the accuracy of the 11 megohms and the basic accuracy of the voltmeter.

Suppose the v.t.v.m. in the figure reads .56 volt. Since the current is equal to 90.9 nanoamps per volt (across 11 megs), the leakage current flowing in the silicon diode is .56 x 90.9 = 50.9 nanoamps.

By putting a 1.1-meg resistor across the input to the v.t.v.m. we have a current meter that reads 1 volt per microamp. For v.t.v.m.'s with high input impedance, such as the Hewlett-Packard 410, they may be shunted to the desired current range in a similar manner.

To achieve the proper voltage for the measurement, an external voltage source must be used, and it should be adjusted for slightly over the voltage at which the measurement is to be made. For example, assume the reverse current is to be measured at a reverse voltage of 10 volts and the meter reads .8 volt at slightly over 10 volts input. The voltage source should then be set to exactly 10.8 volts to offset the voltmeter loss.

This technique may also be used to measure saturation currents at low voltages. ▲



Vibration Instrumentation

(*Continued from page 58*)

of the vibration signal, it is necessary to switch in an integrating network whose time constant depends on the operating frequency range of the instrument. Fig. 5B shows the basic form of an integrating circuit consisting of a simple RC network ($R1$, $C1$) which converts the signal to a velocity-proportional signal across $C1$. Assuming that $R1$ is much greater than the capacitive reactance of $C1$, the voltage across $C1$ is inversely proportional to the frequency when compared to the input voltage of the network. When it is necessary to measure the displacement component of the vibration, the signal is fed to a second integrating network ($R2$, $C2$) and a displacement-proportional signal appears across $C2$. The voltage across $C2$ is inversely proportional to the square of the frequency. Thus, conversions of acceleration potentials can be obtained by merely switching in the appropriate network to give velocity and displacement readings on the meter. To compensate for the insertion losses of the integrating networks, the signal is applied to a fixed, stable amplifier (A_2).

The output of A_2 connects to an indicating meter which may be calibrated in terms of peak, peak-to-peak, or average values of the measured variables. In addition, a high-impedance output jack provides a connection to an oscilloscope when it is desired to simultaneously observe the vibration waveforms. If a permanent record is required, a recording galvanometer may be connected to the low-impedance jack. An auxiliary output terminal may be used to feed automatic control or warning devices for the detection of dangerous vibrations.

Internal calibration of the instrument is accomplished by switching in a feedback network at the output of A_2, which applies a 400-cps oscillation to the input of A_1. The signal is adjusted by a calibrated attenuator to the proper value which permits a direct reading of the measured parameter on the indicating meter.

If the vibration waveform is not sinusoidal, a vibration meter cannot give information about the frequencies of the individual vibration components. For this reason, it is often necessary to employ a vibration analyzer to separate the frequency components of any complex signal within the range of the instrument and indicate their magnitudes. Vibration analyzers can be operated directly from the output of the transducer system, or if greater sensitivity is required, from the electrical output of the vibration meter. Several types of analyzers are available for evaluating the waveshape of complex vibrations, the choice of which is determined by the amount of detailed information required to solve a particular vibration problem.

If, for example, a detailed analysis of the vibration spectrum is not essential, an octave-band analyzer is adequate for rapid measurement. This instrument is particularly useful in the analysis of broadband acoustic noise or airborne vibration, such as that produced by jet-engine turbulence, where there exists a random distribution of sound energy spread over a wide band of frequencies. Such an analyzer comprises a preamplifier which feeds the transducer signal to a set of bandpass filters. The filters divide the audio spectrum into bands of one octave (2:1 frequency ratio) in width and are designed with center frequencies ranging from 20 cps at the lowest band to 15,000 cps at the highest band. The signal is then applied to a band-level attenuator and an output amplifier which drives an indicating meter. A monitor output feed is taken through an isolated stage which prevents any load from affecting the meter indication.

If the vibration signal is a periodic complex wave rather than one of a random nature, each individual frequency component can be readily separated with a wave analyzer. A typical instrument of this type employs a set of narrow-bandwidth filters in a tunable heterodyne system which operates in a frequency range of 10 cps to 50 kc. This device includes a preamp circuit which incorporates a 50-kc. low-pass filter to reduce response to signals beyond the operating frequency range of the unit. This filtering is necessary to attenuate the i.f. filter frequency that could otherwise introduce serious measurement errors. The i.f. is the difference frequency produced by beating the transducer signal with a stable variable-frequency oscillator. Included in the i.f. circuit is a group of four highly selective crystal filters whose bandwidth can be switched to 5, 10, 20, or 50 cps, depending on the degree of resolution required. Thus, each filter output contains only signals relating to its bandwidth and excludes information from adjacent bands so that frequency components close to each other which have a considerable difference in amplitude may be accurately measured.

The amplified output of the instrument drives a metering circuit and supplies voltage to a chart recorder. If desired, the basic wave-analysis system can be extended by adding a servo device to provide continuous automatic tuning throughout the operating frequency spectrum. Instruments of this type are particularly effective in the vibration analysis of rotating and reciprocating machinery, electric motors and turbines. ▲

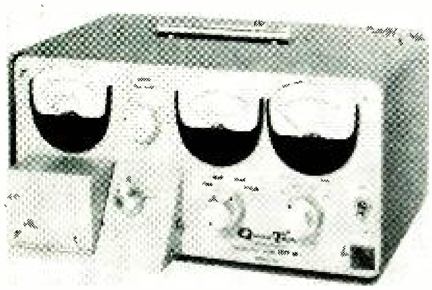
NEW PRODUCTS & LITERATURE

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, simply fill in the coupon appearing on page 15.

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

TRANSISTOR TEST SETS

1 **Quan-Tech Laboratories** is currently introducing three new noise test sets which provide a convenient means of making rapid measurements of electrical noise in transistors as an



aid to elimination of failure-prone devices prior to installation as well as to achieve optimum signal-to-noise ratio.

The three units are similar except for their collector-current and frequency ranges. The Models 510, 511, and 512 have collector-current ranges of 0.1 to 10 ma., 3 to 300 μa., and 10 μa. to 1 ma., respectively. Noise voltage and current spectral densities are measured in the Models 510 and 511 at 1 kc. and in the Model 512 broad-band noise figure measurements are made over a frequency range from 10 cps to 15.7 kc.

SAFETY VENTED BATTERY

2 **General Electric's** Battery Product Section has developed a new resealing safety vent which, according to the company, makes nickel-cadmium battery power more practical for a variety of electronics products.

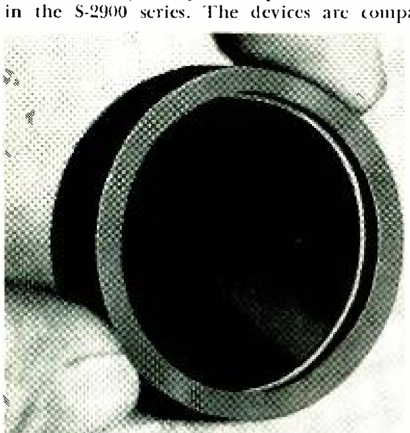
The new vent is now standard on all of the firm's sealed, cylindrical-cell batteries. A guard against the results of inadvertent cell or battery abuse, the vent assures a continuous safe power source for cordless appliances.

The resealing safety vent relieves pressure build-up caused by overcharging and thus prevents cell rupture or escape of large amounts of gases.

SOLAR-CELL MODULES

3 **International Rectifier Corporation** has announced a series of compact, high-efficiency round silicon solar-cell modules for the conversion of radiant energy into electrical energy for powering electronic devices.

An efficiency of up to 10 percent is achieved in the S-2900 series. The devices are compact,



measuring only 1.125 inches in diameter, with a cell area of one inch. The active area of the module is 0.7854 in.^{2}

The load voltage for the series is 0.4 volt and the load current ranges up to 120 ma. minimum. Output power is up to 48 mw. minimum and the efficiency rating is up to 10 percent, based on an illumination level of 100 mw./cm.^{2} (average bright sunlight).

BREADBOARD CIRCUIT KIT

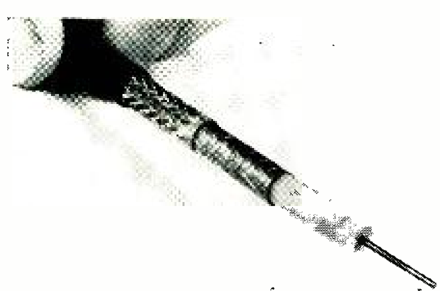
4 **Buckeye Stamping Company** is now offering a solderless breadboard circuit kit especially for transistor circuit designers and experimenters.

Model BB-1 is equipped with two types of plug-in connectors, a sturdy perforated chassis, and an optional d.c. power supply. Included are 10 T-3 connectors which have three electrically connected lugs for plugging in a number of components, and 10 T-3S connectors which have three electrically isolated lugs for accepting individual component leads.

The optional power supply, Model PS-100, is a dual-voltage, transistor regulated unit which has individual controls and can supply up to 30 ma. simultaneously from two outputs.

PAY-TV TRANSMISSION CABLE

5 **Amphenol Cable** has introduced a new double-shield cable designed to replace present solid- and braid-shielded television transmission cable. Designated 621-149, the new cable is designed primarily for pay-TV and community-cable applications. It has a solid copper center



conductor insulated with a polyethylene-foam dielectric, over which a thin copper foil has been longitudinally wrapped. A standard copper-wire braid layer covers the foil and the entire cable is jacketed in black polyvinyl chloride.

PICOMINIATURE TRANSFORMERS

6 **Microtran Company** is now offering its picominiature transformer series in open-frame construction. Developed for application in equipment using micro-circuitry modules, the units measure .375" x .250" x .406" and weigh .05 ounce. They are supplied with 4" #30 color-coded leads.

Available in seven impedance ranges from 3.2 to 25,000 ohms, the transformers are vacuum resin impregnated to assure long life.

INDUSTRIAL LASER

7 **Raytheon Company** has announced the development of a new high-repetition-rate laser developed especially for industrial applications.

The Model LE-1 features precisely controlled reproducibility for use in repetitive manufacturing processes. It is expected to be used for micro-drilling, micro-welding, micro-metal removal, and precision hole drilling. Typical applications include balancing gyros and balance wheels, trimming resistors, and drilling filters and spinnerets for the textile industry.

This water-cooled laser employs a 6⅜" x ⅝" ruby rod and is capable of producing more than 10 joules of energy per pulse at a rate of one per second. Pulse width is variable from 1 to 10 milliseconds.

CIRCUIT-BREAKER PLUG

8 **Hopax Electric, Inc.** has developed a circuit-breaker plug which is designed to fit on the end of a cord to protect power tools and electrical equipment from fire hazard and damage.

The unit will automatically cut off power when motor or appliances are overloaded. A reset lever resets the circuit breaker. The units are available in from 3 to 10 amps and carry UL approval.

MOLDED WIREWOUND RESISTOR

9 **International Resistance Company** has just introduced a new ½-watt molded wirewound resistor which the company claims offers tight tolerance and exceptional stability at low cost.

In its hot-clamp termination, a special cup-lead assembly is actually heated and flowed around the resistance wire, tightly imbedding several turns of the wire in the cup. This prevents wire shifting and shorting often caused by adverse operating conditions. The resistors have a phenolic plastic jacket and electroplated leads.

The BW-20 is identical in size and shape to ordinary ½-watt composition resistors. It is available in resistances from .24 ohm to 750 ohms in EIA/MIL standard values with tolerances of ± 5% and ± 10%. Units with ± 2% tolerance are available on special request.

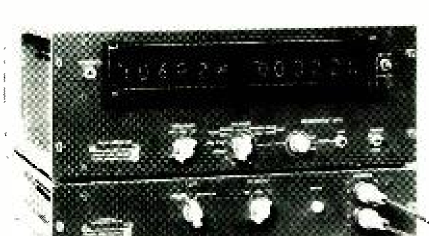
NEW ZENER DIODE

10 **Trio Laboratories, Inc.** has developed the "Super/reg"—a synthesized ideal zener diode. According to the company, the unit offers all the capabilities of the zener principle without the limitations imposed by the unalterable characteristics of the silicon atom. Like the zener, the new diode can be connected across a d.c. voltage source to provide a regulated d.c. output that is stabilized at a fixed level. Unlike the zener, however, the new unit provides output voltage that can be adjusted ±10% from its nominal value without derating or degrading its performance.

Zener impedance is on the order of a few milliohms; a typical 12-volt unit exhibits a voltage change of 0.006 volt for a 2-amp load swing.

AUTOMATIC CAPACITANCE BRIDGE

11 **General Radio Company** has announced an automatic capacitance bridge which selects range, achieves balance, and presents the measured value in digital in-line form.



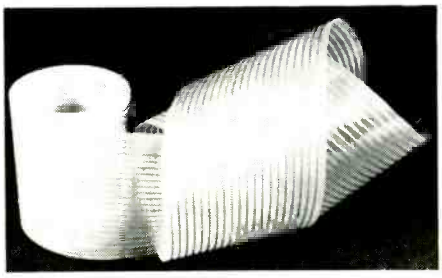
The Type 1680-A includes a built-in transistor oscillator (120, 400, and 1000 cps) as well as bridge and detector circuits. It measures parallel capacitance from 0.01 pf. to 1000 μf. at 120 cps. Basic accuracy is ±0.1% of reading. The bridge also measures dissipation factor from 0.0001 to 1.0 and parallel conductance from 0.1 nanomho to 1 mho.

The bridge is available in rack and bench versions.

MULTICONDUCTOR CABLE

12 **Flexible Circuits Inc.** is now marketing its "Circuitstrip" custom wiring which offers the advantages of pre-positioned conductors, lower installed cost, fewer assembly errors, and weight and space savings.

"Circuitstrip" can be manufactured from 1/8" to 10" wide in continuous lengths. Conductors



can be solid flat, solid round, or stranded wire with spacing to suit customer requirements. It is available in all popular insulating materials, the most economical being polyester or vinyl.

CALIBRATION INSTRUMENT

13 **Medicon** has developed a precision instrument for calibrating electromagnetic flow meter probes.

Designed for compactness and ease of use, the Model B-1000 is completely self-contained and requires only the availability of saline solution to perform calibrations. Calibration ranges are 0-30, 0-160, 0-900, and 0-6000 ml./min.

Basically, the kit consists of two receptacles for saline solution, a constant flow pump, and a precision flow monitor. Two Lucite standards mounted in one receptacle provide support for the "Flo-Probe" and a section of artificial artery. The probe can be surrounded with saline to simulate in vivo environments.

MAGNETIC CEMENT

14 **GC Electronics** has added a magnetic cement to its line of chemicals for the electronics industry. The product is designed for the quick and simple repair of flyback and yoke cores, broken ferrite loop antennas, iron cores and slugs.

According to the company, the new cement can permanently bond all powdered iron-core components.

SEALED LEAD-ACID BATTERIES

15 **The Electric Storage Battery Company** is now offering a completely redesigned lead-acid storage battery which is compact and lightweight, sealed against leakage of acid and gases, and requires no maintenance except recharging.

The new battery has been especially designed to serve as a versatile and economical high-power source for such portable electrical devices as TV sets, tools, lanterns, home appliances, and toys. It can be built into the tools or appliances it is powering or can be carried by shoulder strap or belt hooks for outboard power applications.

The battery is now available in 6- and 12-volt ratings as the MF-1 and MF-2 respectively.

HI-FI—AUDIO PRODUCTS

NEW RECORDING TAPE

16 **Pfanstiehl Chemical Corporation** has recently introduced a new line of magnetic tapes which is being offered in two quality grades.

This professional tape is made of a plastic base and is guaranteed to be splice-free. It comes in standard reel sizes in both 1.5- and 1-mil thicknesses and features low print through and high fidelity.

A high-frequency response tape made of polyester in 1-mil and .5-mil thicknesses is also available in standard reel sizes.

BOOKSHELF SPEAKER

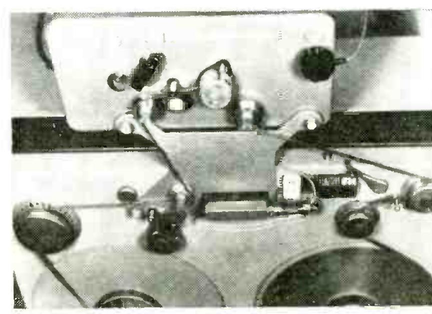
17 **Acoustic Research, Inc.** has added the AR-4 bookshelf speaker to its line of acoustic suspension speakers. Designated the AR-4, it has an 8" woofer and 3½" wide-dispersion tweeter.

The speaker measures 19" x 10" x 9" in depth and is available in oiled walnut and unfinished versions.

TAPE TEMPO REGULATOR

18 **Gotham Audio Corporation** is handling the U.S. distribution of the "Eltro" Model MLR 38/15 tempo regulator designed to be used with any professional tape recorder.

The unit is simply placed in front of any recorder using its wind motors and playback amplifier(s). It features a unique rotating head assembly and a variable speed capstan drive which permit a tempo range from 50-180% of normal speed without change of pitch, and a pitch change



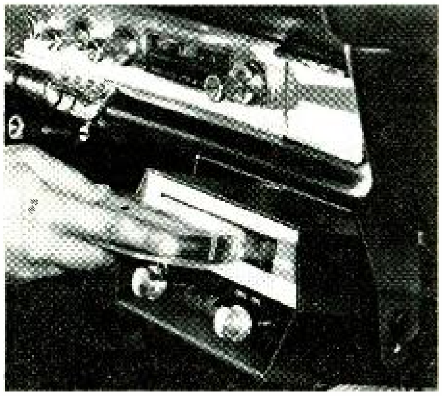
of approximately seven half tones above and over three octaves below normal without change of tempo.

The unit is available on special order for stereo, three-track and four-track tape in widths up to one inch.

TAPE PLAYER FOR CARS

19 **J. Herbert Orr Enterprises** is now marketing a new cartridge-type tape player designed to be used in cars.

The "AutoMate" is designed to accept a sealed,



transparent cartridge containing a continous two-track magnetic tape. The player can be loaded and unloaded in a second. The two-track tapes are available in half-hour and one-hour lengths.

The unit incorporates a special universal bracket to permit rapid installation and at no time is it necessary to remove the car radio to make the installation. The player can be suspended from the instrument panel or mounted on the transmission "hump." Simple plug-in-type fittings connect the unit to the vehicle radio and speaker system.

The player contains its own transistorized amplifier-oscillator circuit. A simple switch serves to disconnect the vehicle's antenna from the radio while the tape player is in operation.

TRANSISTORIZED RECORDER

20 **Alco Electronics, Inc.** is now marketing two transistorized tape recorders, the "Executive 61" and the "Senior 75." Both models use 7 transistors and both come complete with accessories.

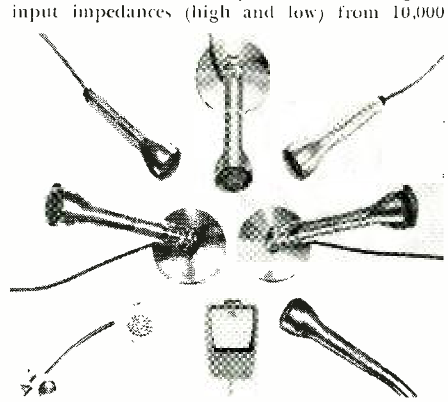
The "Executive 61" is a three-speed model (15/16, 1⅞, & 3¾ ips) with tone control, level control, and vu meter. It is powered by six "C" cells or an a.c. adapter. It also has a remote-control dynamic microphone.

The "Senior 75" will handle 5" reels and has a full watt of audio power. It has a remote-control dynamic microphone, level, and vu meter, fast-forward, and tape indexer. It is completely push-button controlled and operates from "D" cells or from its built-in adapter.

LOW-IMPEDANCE MIKES

21 **Sonotone Corporation** has just introduced a new line of ceramic microphones in low-impedance versions especially for transistorized applications.

The new ceramic microphones cover a range of input impedances (high and low) from 10,000 ohms through 5 megohms. Frequency responses of 200-9000 cps for speech and 50-12,000 cps for music pickup are now available. Open circuit sensitivity up to −49 db re 1 v./microbar can be realized.



Available in slim die-cast hand and table models and in high-impact plastic cases, all mikes come complete with necessary hardware. Factory matched pairs for stereo applications are included in the line.

REVERBERATION KIT

22 **Cleveland Electronics, Inc.** has announced the availability of an all-transistor reverberation kit for use with 12-volt negative ground car radios. This unit has an electromechanical device to reverberate the incoming sound which it amplifies and plays through a separate speaker.

Its power supply is 12.6 volts d.c. (negative ground) with a 2-watt power output and a current of 0.7 amp. It includes a complete fader control between speakers with switch off and volume control of the rear speaker with the switch on.

The Model RU-104 standard kit is for automobiles not requiring speaker and grille while the deluxe Model RU-101 is for cars requiring a speaker and grille.

TRANSISTOR STEREO RECORDER

23 **Chancellor Electronics, Inc.** is marketing a transistorized tape recorders made by **Oki Electric Industry Co., Ltd.**, of Tokyo.

The Model 555 is a 4-track stereo recorder. The amplifier circuits are of the OTL type, containing 27 transistors, 6 diodes, and 4 silicon rectifiers. A pair of detachable 2-way slim-line speakers employ highly effective baffle systems and back-loaded screen dampers for more powerful reproduction of the bass.

Tape speed is 7½ & 3¾ ips and the unit will handle up to 7" reels. Frequency response is 20-22,000 cps at 7½ ips and 30-15,000 cps at 3¾ ips. Signal-to-noise ratio is better than 50 db. The

unit operates from 117 v., 60 cps or from a car battery by means of a special inverter (available as an optional accessory).

Total weight of the unit (recorder and speakers) is 21.6 pounds.

STEREO TAPE RECORDER

24 **Lafayette Radio Electronics Corporation** has added the "Criterion 1000" to its line of tape recorders.

The recorder is a self-contained, 4-track stereo tape unit incorporating transistorized stereo preamplifiers and push-pull power amplifiers which deliver 6 watts per channel. Three-speed operation gives frequency responses of 50-15,000 cps @ 7½ ips, 50-10,000 cps @ 3¾ ips, and 55-5000 cps @ 1⅞ ips all ± 3 db. Wow and flutter is kept to .2% @ 7½ ips by using a heavy-duty 4-pole capacitor-start motor.

An automatic shut-off feature electrically and mechanically returns the recorder to neutral position at the end of the tape. Sound-with-sound

recordings are made possible with separate channel record controls. Two 6" x 4" speakers with adjustable wing panels deflect sound for proper stereo separation.

Housed in a genuine teakwood cabinet, the recorder measures 17¼" w. x 7¼" h. x 12¾" d.

CB-HAM-COMMUNICATIONS

MONITOR RECEIVER

25 **Regency Electronics, Inc.** is now offering its "On-Call" Monitoradio which has been developed specifically as a fire-police department alerting receiver.

The unit is completely transistorized and features a 3-way power supply which permits operation on 117 volts a.c., 12 volts d.c., or with an optional battery pack. The fail-safe emergency battery is automatically activated if there is a power-line failure. Nickel-cadmium rechargeable batteries are used in the built-in pack.

Four basic models are available: single-channel crystal or multi-channel with up to six crystals. Either variation may be in the high (150 to 175 mc.) or low (30 to 50 mc.) range. Special frequencies are available on request.

All models are housed in blue vinyl laminated steel cabinets measuring 11" long x 4¾" wide x 7½" deep. The weight is 5½ pounds.

100-MW. CB TRANSCEIVER

26 **Cadre Industries Corporation** has added a 100-mw. transceiver to its line of two-way radio equipment.

The Model C-60 provides license-free dual-channel communications in the 27-mc. band. The battery-powered unit employs advanced solid-state circuitry. Features include: two crystal-controlled channels, provision for either penlight cells or nickel-cadmium batteries, low-impedance earphone jack, built-in antenna and speaker/microphone, and high-impact plastic cabinet.

Extended range results from over 70 mw. output and better than 1 μv. sensitivity. The unit weighs less than two pounds and measures 8" x 4" x 2".

23-CHANNEL TRANSCEIVER

27 **B&K/Mark, Division of Dynascan Corporation** is now offering a 23-channel AM transceiver for Citizens Band service.

The Model CAM-88 "Cobra," with integral crystal synthesizer, comes complete and ready to operate. The double-conversion superhet receiver

provides two separate i.f. frequencies and two stages of i.f. amplification for effective rejection of adjacent-channel images or other types of interference to achieve finer sensitivity and selectivity.

A dual-purpose meter on the front panel measures incoming signal strength on receive and relative "power output" on transmit. Delta-tune control provides fine tuning. An adjustable squelch control eliminates background noise and silences the receiver during stand-by.

The transistorized a.c.-d.c. power supply operates on both 117 v. a.c. and 12 v. d.c. Both power cables are included (operation at 6 volts d.c. is not available).

CRYSTAL FILTERS

28 **Motorola's Communications Division** has developed two new precision crystal filters designed for channel frequency operation in two-way radio systems operating on frequencies in the 25-50 mc. and 136-174 mc. bands.

Used to increase the reception performance of communications receivers, the new bandpass filters exhibit a 1-db bandwidth at ± 7kc. centered on the desired carrier frequency; a 13-db bandwidth of 60 kc. maximum; and a 25-db bandwidth of 120 kc. maximum. Other characteristics include ultimate attenuation at frequencies in proximity to the passband of at least 23 db and a maximum insertion loss of 6 db. The filters require terminating impedances of 50 ohms.

V.H.F.-FM TWO-WAY RADIO

29 **Aeronautical Electronics, Inc.** has announced a new v.h.f.-FM two-way radio that is completely transistorized and feature extremely low battery drain.

The Model 6AT15 weighs only 7 pounds, 8 ounces and uses plug-in transistors to facilitate maintenance. The set incorporates a standby switch which allows the operator to keep the set ready to transmit with only 70 ma. drain. It has provision for the company's "Unicall," a

tone-squelch device for "private channel" operation.

Housed in an all-aluminum cabinet, the unit is designed for dash mounting inside the vehicle or, where space is at a premium, may be mounted in the trunk. In this latter type of installation, the set is operated from a compact remote-control panel.

The Model 6VT15 comes complete with microphone, whip antenna, all mounting hardware, and crystals for single-channel operation in the 148-174 mc. range. The set may be equipped for dual-channel operation at slight additional cost.

NEW HAM RECEIVER

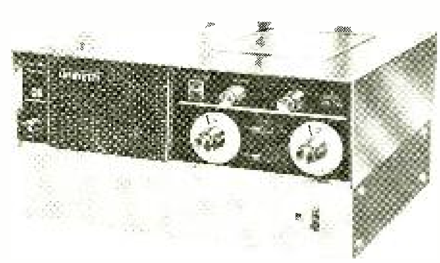
30 **Hammarlund Manufacturing Company** has redesigned its HQ145X amateur receiver to provide improved operating features and is now offering it as the HQ145A.

Added features include separate detectors for AM, SSB, and c.w., better electrical and mechanical stability, silicon rectifiers, and universal 115/230, 50/60 cps operation.

General specifications are: 540 kc. to 30 mc. tuning in four bands; calibrated electrical bandspread on 80, 40, 20, 15, and 10 meter bands; dual conversion above 10 mc.; six-position crystal filter plus adjustable slot filter with up to 60-db attenuation; adjustable high-stability b.f.o. for SSB and c.w.; 1-μv. sensitivity gives 10:1 signal-to-noise ratio.

TRANSISTORIZED CB UNIT

31 **Lafayette Radio Electronics Corporation** has added an all-transistor unit to its line of CB equipment. The HB-500 transceiver's receiving section features a 455-kc. mechanical filter which



provides 60-db attenuation at 10 kc. on either side of the center frequency. Sensitivity is better than .5 μv. for 10-db signal-to-noise ratio.

There are 12 crystal transmit/receive positions and the 23-channel receiver vernier tuning control provides versatile operation. The use of 15 transistors, 3 diodes, a zener diode, and a thermistor offers a low current of less than 1 amp at 100% modulated transmission.

The transceiver includes an "S" meter, phone jack, low-loss SO-239 antenna jack, and push-to-talk dynamic microphone. A 12-volt d.c. mobile power supply is built-in and a fixed station solid-state a.c. power supply is available. The unit measures 11-7/16" x 6-11/16" x 3-3/32".

PHASE COMPARATOR

32 **Specific Products** is now marketing a new phase comparator and timing receiver designed to receive the 24-hour continuous broadcasts of the NBS WWVB 20- and 60-kc. transmissions.

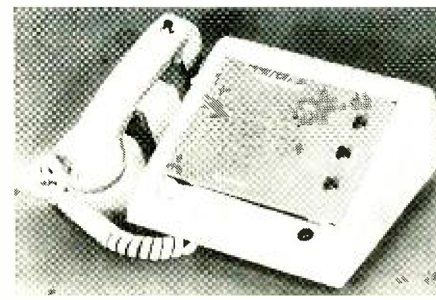
Designated the Model VLA-26, the new receiver is arranged so that timing pulses on 60-kc. from NBS will be usable. Of all-solid-state construction, it can be used to feed a recorder directly. When used with an external recorder, it is entirely adequate for frequency accuracies of 5 parts in 10^{10}. If higher accuracies or faster read-out is required, the company's Model SRA servo phase shifter can be used in conjunction with the VLA-26.

Standard frequency to be calibrated is 100 kc. normal. However, the unit can be supplied to operate with 1-mc. input if required.

REMOTE-CONTROL SET

33 **Communications Service, Inc.** has announced a new and improved version of its transistorized remote phone which is designed to work with two-way radio systems to allow the base station to be remotely controlled from a distance.

The control function can be accomplished over a single pair of normal-grade telephone wires. The phone is completely transistorized and oper-



ates from a standard 117-volt source. It is designed to control and operate two frequency transmitters and receivers. It comes complete with intercom functions, as well as the necessary controls for continuous tone systems.

EXTENDER AMPLIFIER

34 **Entron, Inc.** is now offering a new extender amplifier designed to feed low and high v.h.f. and FM band signals into a transmission line.

The Model LHE 501 R has two output terminals; one is used to extend feeder lines; the second (−20 db), may be used to split the line or feed a distribution amplifier. The well-matching input terminals makes the unit suitable for use as a bridging amplifier when combined with a directional coupler.

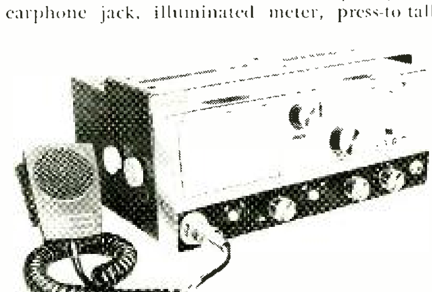
Other features include separate low- and high-band gain and tilt controls, flat frequency response, long-life silicon rectifiers; 10,000 hour tubes, and highly reliable compactrons throughout.

CB TRANSCEIVER

35 **United Scientific Laboratories** is now marketing a new CB transceiver which has been tradenamed "Contact."

Among the features is a translucent control strip on the front panel that permits illumination of the control markings, making them more readable. The front panel itself is sloped to improve visibility and control adjustment. Another feature is a set of external crystal sockets, for transmitting and receiving, that eliminates the necessity for groping inside the set to insert the proper channel crystals.

The 23-channel transceiver has an easy-mount automobile bracket that holds the radio in place with four knobs. The unit also has a p.a. system, earphone jack, illuminated meter, press-to talk



hand mike, channel-spotting switch, and built-in 117 v.a.c. and 12-volt d.c. power supply.

SELECTIVE-CALLING UNIT

36 **Cadre Industries Corp.** has developed the Model 524 which provides 24 tone combinations in a unique three-tone sequential system. Designed to work with the firm's solid-state 5-watt transceivers and other 12-volt two-way radios, this compact encoder-decoder uses a special resonant reed relay with a new and more reliable tone generator.

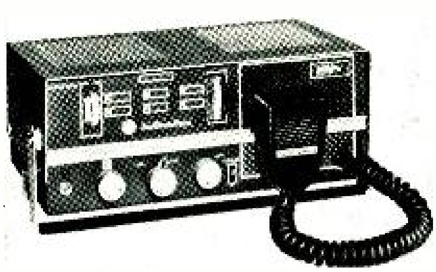
The unit is completely transistorized and current drain is negligible. Connections are made through the speaker and power supply of the transceiver, with a microphone adapter plug furnished.

COMPACT CB SET

37 **The Hallicrafters Co.** is now marketing the CB-9, a compact tube transceiver in the low-price class.

The unit offers six crystal-controlled channels plus full-channel receiver tuning with spotting switch and "S" meter. It employs the firm's new all-electronic push-to-talk circuitry. Full 100% modulation and receiver sensitivity of 1 μv. for 10-db signal-to-noise ratio are claimed. Output is 3.2 watts.

The CB-9 incorporates the "drop-down" chassis feature, greatly simplifying crystal changes and service. Weighing only 14 pounds, the unit measures 12" x 7" x 5". It is furnished ready to operate either base or mobile, including power cords and mobile mounting bracket.



MANUFACTURERS' LITERATURE

INTEGRATED CIRCUIT CATALOGUE

38 **Semiconductor Specialists, Inc.** is now offering a 12-page catalogue of integrated circuits from such firms as **Fairchild, Motorola, Philco, Siliconix,** and **Westinghouse** which the distributor is prepared to supply from stock.

The ring-binder-punched catalogue includes 216 circuit packages and accessories, useful to design, applications, systems, and evaluation engineers.

ZENER DIODE EVALUATION

39 **Motorola Semiconductor Products Inc.** has published the results of a year-long reliability evaluation of the company's 10-watt zener diode line in a 12-page brochure.

Graphically illustrated, the booklet presents a discussion of the importance of specific reliability tests and gives a detailed description of procedures for high-reliability fabrication and evaluation.

ELECTRONIC ORGANS

40 **The Schober Organ Corporation** has recently issued a catalogue of its electronic organ kits. The brochure includes illustrations, a price list, demonstration record, and a listing of instruction books available. It also contains a section on facts and questions about the company's organs.

TRANSFORMER CATALOGUE

41 **Microtran Company, Inc.** has announced the publication of an 8-page catalogue of transformers available from stock. The listing contains information on the firm's line of low-level, hermetically sealed chopper input transformers, printed-circuit miniature open-frame transformers, and contour-molded microminiature, subminiature, and miniature transformers. Illustrations are included.

TV CAMERA LENS SELECTION

42 **Cohu Electronics, Inc., Kin-Tel Division** is offering a guide to lens selection for TV cameras. Printed in two colors, the 4-page data sheet includes field-of-view tables, depth-of-field tables, lens selection chart, and discussions of zoom lenses and the properties of fixed focal length lenses.

FREQUENCY MEASUREMENT

43 **General Radiotelephone Company's** Instrumentation Division has issued an 8-page illustrated catalogue which describes its line of frequency measurement r.f. generator equipment. Complete with technical specifications and prices, the listing highlights the firm's "counter-generators," which combine a direct readout frequency counter with an r.f. generator that can be monitored by the counter section while it is being used.

ELECTRONIC EQUIPMENT

44 **Heath Company** is now offering a flyer listing prices and specifications on its "Heathkit" line of electronic products, including CB equipment, units for marine use, stereo and hi-fi items, amateur radio products, and test instruments. The 32-page booklet is fully illustrated with drawings and photographs.

SCR DESIGN GUIDES

45 **International Rectifier Corporation** is now distributing two design guides, both relating to SCR's and one to power rectifiers as well. The first study (AD-513) deals with the type of fuses and associated circuitry necessary to protect the silicon rectifier and controlled rectifier without degrading the performance of the rectifier assembly as a whole.

The second study (AD-514) offers constructive suggestions for the design engineer facing the problem of the rate-of-rise of forward voltage. Both guides are illustrated with graphs.

CCTV CATALOGUE

46 **Blonder-Tongue Laboratories, Inc.** describes the company's full line of CCTV equipment in a new catalogue recently released. The listing covers cameras, monitors, lenses, housings, and video and distribution equipment and accessories for educational, institutional, and industrial use.

DIODE ENGINEERING DATA

47 **National Transistor,** a subsidiary of **ITT,** has just released a 4-page engineering data sheet covering miniature glass silicon computer diodes. The bulletin, designated B-101R, lists the specifications and characteristics for more than 150 different EIA types, including pertinent military specifications where applicable.

LIGHTING EQUIPMENT

48 **Leecraft Mfg. Co., Inc.** is now making available an 8-page catalogue presenting the company's line of lampholders, indicator lights, pilot-light sockets, special assemblies, and wiring harnesses.

Printed in two colors, the listing is illustrated with dimensional drawings and contains catalogue number charts and specifications.

LASER CAPACITORS

49 **Cornell-Dubilier Electronics** is now distributing a 16-page brochure which covers design considerations for the application of low-inductive energy-storage laser pumping capacitors. Among the topics discussed are electrical factors, environmental factors, dielectric materials, "Q," and physical factors.

Illustrated with graphs and photographs, the reference also contains a listing of the company's low-inductance capacitors.

R.F. COAXIAL FILTERS

50 **Bird Electronic Corporation** has recently published a 6-page guide on how to specify an r.f. coaxial filter to avoid over-design. Nine graphs or drawings are provided in the bulletin, which deals with the practical application to over-all system performance of such filter parameters as cut-off frequency, insertion loss, and selective stop-band attenuation. Also described are preferred test methods.

POWER SUPPLY CATALOGUE

51 **Kepco, Inc.** has announced publication of a 52-page catalogue covering complete specifications for its line of voltage- and current-regulated power supplies, as well as a glossary of power-supply terms and explanations of regulated power-supply capabilities.

Of special interest are VIX mode signaling devices, two new lines of modular power supplies, various programmers, high-voltage isolation enclosures and various rack and panel adapters. The listing (B-648) is designed for engineers and purchasing agents.

INDUCTOR SELECTOR CHART

52 **Aladdin Electronics** has made available a chart for the selection of inductors which includes 27 physical shapes and sizes. The drawings and photographs on the chart are cross-referenced to engineering bulletins which contain performance data for the units shown.

Intended for design engineers and purchasing personnel, the list covers both fixed and variable types of inductors.

PHONO DRIVE CHART

53 **Walsco Electronics,** a division of **GC-Textron Electronics, Inc.,** has announced the availability of a 22" x 34" wall chart containing complete listings of all popular round rubber belts, rubber tires, flat rubber belts, and fabric drive belts. Also included are idler wheels, pressure rollers, turret drives, pulleys, drive wheels, interwheels, and miscellaneous phono drive items. All units are illustrated actual size on the front side of the chart, and the reverse gives full cross-reference information.

The chart is aimed for those in phono/recorder servicing and carries the designation FR-236-W.

FERRITE MEMORY CORES

54 **RCA Electronic Components and Devices** is now offering a quick-reference guide which summarizes the pertinent data on the firm's most widely used ferrite memory cores.

The 8½" x 11" guide is punched and tapped for insertion into technical data binders. Information on the company's new wide-temperature range, low-drive cores as well as conventional cores is included.

ADHESIVE PROPERTIES

55 **Emerson & Cuming, Inc.** is now making available a two-tone reference chart, suitable for wall mounting, which describes the company's "Eccobond" adhesives. Products with similar properties, such as general-purpose liquid epoxy adhesives, general-purpose epoxy pastes, or electrically conductive adhesives are grouped together. In each of these groups, properties such as bond strength, service temperature, thermal conductivity, and volume resistivity are defined.

In addition to illustrations, the chart also included a reference to the technical bulletin that discusses the product in detail.

MAGNETIC TAPES

56 **Reeves Soundcraft,** a division of **Reeves Industries Inc.,** has published a 6-page brochure describing the electromagnetic and physical properties of magnetic tapes.

The color catalogue provides both properties and complete specifications for Mylar and cellulose acetate base tapes for sound recording.

HARNESS TYING METHOD

57 **The Thomas & Betts Co.** has released a 4-page technical bulletin (T-75) describing high-speed tying, clamping, and identification of wire bundles and harnesses through the use of the firm's "Ty-Rap" ties.

Full-size illustrations of cable ties, mountable cable straps, identification ties and plates are provided, along with catalogue information on the range of bundle accommodated and tensile unlocking strength. Various accessories are shown, and both the twist-type and the self-locking "Ty-Raps" are discussed.

RELAY TYPES

58 **Potter & Brumfield Division** has just published a 12-page illustrated catalogue which includes data and prices of more than 50 relay series. The listing offers a selection of new solid-state time-delay relays, sensitive polarized relays, and general purpose relays.

Among the products offered are mercury-wetted contact, high-performance, special purpose, telephone, and power relays.

ZENER DIODES

59 **Motorola Semiconductor Products Division** is offering a 19-page cross-reference and interchangeability guide for zener and reference diodes. The brochure lists over 4000 device types, together with their nearest equivalents and recommended replacement types. The replacement chart is keyed to voltage and power ratings.

CAPACITOR REPLACEMENT

Sprague Products Company, 51 Marshall St., North Adams, Mass. is offering a revised 48-page edition of its electrolytic capacitor replacement manual. The booklet covers 291 different units for use in TV sets, home radios, auto radios, and portable radios.

The manual, available for 10¢, lists original part numbers, followed by ratings, the recommended company replacements, and list prices.

COMMUNICATIONS SLIDE-RULE

Electro-Voice Inc., Buchanan, Michigan has just introduced their latest "Q Dial" circular slide-rule.

This is a useful compilation of frequently used reference material for efficient ham and CB communications and provides, in addition, logging space for all states and U.S. possessions on three modes of transmission.

It includes capital, time zone, conversion factor to GMT, CB district and prefixes, amateur prefixes, etc. for all U.S. possessions and states. It lists amateur radio allocations from 3.5-144 mc., lists QSL bureaus, covers NBS radio services, lists "Q" signals and c.w. abbreviations, includes an ARRL phonetic alphabet and the most commonly employed 10-code signals, a Universal Time Conversion and Morse Code charts, and the standard R-S-T reporting system.

The rule is available for $1.00 a copy from the company or its distributors. ▲

	B	E	T	A				V	O	L	T	
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Answer to Electronic Crosswords Appearing on page 103

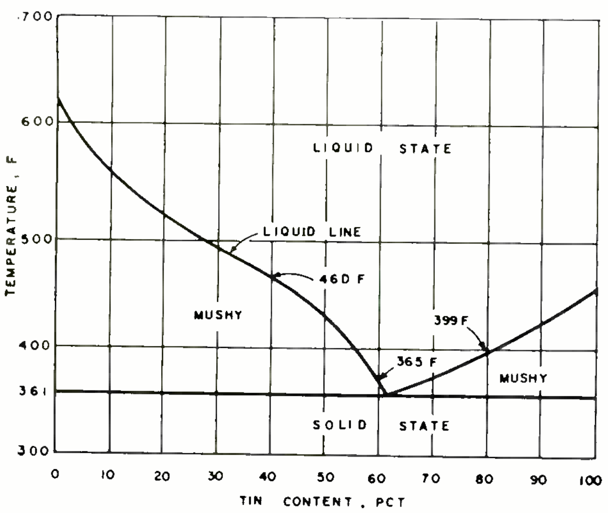
PHOTO CREDITS

Page	Credit	Page	Credit
22	Allied Radio Corporation	53 (photo)	Control Data Corp.
24	Eico Electronic Instrument Co., Inc.	53 (card), 54 (bottom)	IBM
27, 28, 29	General Electric Company	54 (top)	Univac Div., Sperry Rand Corp.
37	Phelps-Dodge Corporation	54 (center)	Friden, Inc.
38	FXR-Amphenol	55	Litton Industries
38 (Figs. 5 & 6)	Belden Manufacturing Co.	68	Seco Electronics, Inc.
40	Roanwell Corp.	70	H.F. Parks Laboratory
48, 49, 50	Motorola Inc.	72	Texas Crystals

SOLDER CHARACTERISTICS

SOLDER is an alloy consisting of a mixture of lead and tin, both having low-temperature melting points. Tin has a melting point about 460°F while lead melts at about 625°F. When the two are combined, they have a lower melting point than either one alone. The lowest melting point (eutectic) is reached when the mixture is about 62% tin and 38% lead. This percentage, usually written as 62/38, melts at about 361°F. Graph, taken from a recent issue of RCA Victor "Technical Tips," shows the various solid and liquid states of tin and lead alloys over a given temperature range.

Since tin is more expensive than lead, the cheaper solder of 40/60 or 50/50 is used. However, in printed-circuit repairs, a 60/40 mixture is recommended because a lower temperature is required to melt the solder, thus protecting the circuit components. ▲



ELECTRONICS
MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 60¢ per word (including name and address). Minimum order $6.00. 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. 35¢ 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:** 5th of the 2nd preceding month (for example, March issue closes January 5th). Send order and remittance to: Martin Lincoln, ELECTRONICS WORLD, One Park Avenue, New York, New York 10016

FOR SALE

TRANSISTOR Ignition coils, components, kits. Advice Free. Anderson Engineering. Wrentham 5, Mass.

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, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Nahant, Mass.

TRANSISTORIZED Products importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

DIAGRAMS for repairing Radios $1.00. Television $2.50. Give make model. Diagram Service, Box 1151 E, Manchester, Connecticut 06042.

INVESTIGATORS, free brochure, latest subminiature electronic surveillance equipment. Ace Electronics, 11500-J NW 7th Ave., Miami 50, Fla.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics. Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

NEW transistor buried treasure, coin detectors. Kits, assembled models. $19.95 up. Free catalog. Relco, A-22, Box 10563, Houston 18, Texas.

WEBBER Labs. Transistorized converter kit $5.00. Two models using car radio 30-50Mc or 100-200Mc, one Mc spread. Easily constructed. Webber, 40 Morris, Lynn, Mass.

COPYRIGHTED theory gravitation caused by pushing radiation from stars. Important spaceage implications. $1.00 refundable. Carnahan, 4407 Ave. H, Austin, Texas.

RESISTORS precision carbon-deposit. Guaranteed 1% accuracy. ½ watt 8¢. 1 watt 12¢ 2 watt 15¢. Rock Distributing Co., 902 Corwin Road, Rochester 10, N.Y.

CONVERT any television to sensitive, big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco, Box 10563, Houston 18, Texas.

COMPLETE KNIFE catalog 25¢. Hunting, Pocket, Utility. Heartstone, Dept. ZD, Seneca Falls, New York.

TV CAMERAS, transmitters, converters, etc. Lowest factory prices. Catalog 10¢. Vanguard, 190-48 99th Ave., Hollis, N.Y. 11423.

SALVAGE CIRCUIT BOARDS packed with dozens of transistors, diodes, miniature transformers, capacitors, etc. Assortment "A" $5.00, "B" $4.00, "C" $3.00, all different, postpaid. ENGINEERING ASSOCIATES, 434 Paterson Road, Dayton, Ohio 45419

TAPE RECORDER & TELEVISION SALE. Latest models, $10.00 above cost. Arkay Sales, 22-02 Riverside Ave., Medford, Mass. 02155.

$100.00 WEEKLY Spare Time selling Banshee TS-30 Transistor Ignition Systems and Coils. Big Demand. Free money making Brochure. Slep Electronics, Drawer, 178ZD-EW Ellenton, Fla. 33532.

LOS ANGELES: visit A-OK ELECTRONICS, 5405 Hollywood Blvd. Phone: 465-8773. SURPLUS TEST EQUIPMENT AND SMALL PARTS——resistors, capacitors, meters, diodes, transistors, etc. ALL NEW, VERY LOW PRICES 9 AM to 6 PM Monday thru Saturday.

DIAGRAMS Radios $1.00 Televisions $1.50. Schematics, 618 Fourth Street, Newark, N.J. 07107.

RESISTORS, NEWEST TYPE METAL OXIDE FILM, ⅛, ¼, ½, 1 watt $.07-$.12 each, 18-470,000 ohms RESISTOR KITS, COPPER CIRCUIT BOARD, CAPACITORS, BATTERY MOTORS, HIGH BARRIER TERMINAL BLOCKS, etc. Write: FARNSWORTH ELECTRONIC COMPONENTS, 88 Berkeley St., Rochester 7, New York.

METERS—Surplus, new, used, panel and portable. Send for list. Hanchett, Box 1898, Riverside, Calif.

NEW! Elecom 1-Watt 13 transistor CB transceiver, pair for $85.00. Further details free. Hans Kaiser, 69 Heidelberg, POB 1054, W. Germany.

HEAT SHRINKABLE TUBING—4 foot assortment 89¢. Free catalog. BIGELOW ELECTRONICS, BLUFFTON, OHIO.

CIRCLE NO. 172 ON READER SERVICE PAGE

"TAB", SILICON 750MA* DIODES

Factory Tested! Gtd.!

**NEWEST TYPE! LOW LEAKAGE*

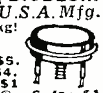
Piv/Rms	Piv/Rms	Piv/Rms	Piv/Rms
50/35 .05	100/70 .09	200/140 .12	300/210 .16
400/280 .20	500/350 .24	600/420 .32	700/490 .40
800/560 .48	900/630 .55	1000/700 .70	1100/770 .75

ALL TESTS AC & DC & FWD & LOAD!

1700 piv/1200 RMS @ 750 Ma $1.20 @ ....10 for $10
Same 1100 piv/770 RMS $.75 @ .....16 for $11

"TAB" ★ SCR's ★ TRANSISTORS ★ DIODES!!!

Full Leads Factory Tested & Gtd! U.S.A. Mfg.



PNP 50Watt/15Amp HiPower TO36 Pckg! 2N441, 442, 277, 278, DS501 up to 50 volts/VCBO $1.25 @, 5 for $5
2N278, 443, 174 up to 80v $3 @ 2 for $5.
PNP/10Watt/3A-2N155, 156, 235, 242, 254, 255, 256, 257, 301, 351; ¢35 @, 4 for $1
PNP/Signal up to 350MW TO5, ¢25 @, 6 for $1
NPN/Signal IF, RF, OSC, TO5, OV5, ¢25 @, 6 for $1
PNP 2N670/300MW ¢35 @, 4 for $1
PNP 2N671/1Watt ¢50 @, 3 for $1

Silicon PNP TO5 & TO18, Pckg ¢25 @, 5 for $1
TO36, TO3 Pckg Mica Mtg Kit 5 for $1
Power Heat Sink Finned 80 Sq $1.25 @ 5 for $5
3Amp/TO3/Pwr Transistors Untested! ....10 for $1
Stabistor Diodes up to one watt ....5 for $1
Silicon Diodes 35Amp Studs Untested ......3 for $1
Silicon Diodes epoxy/750Ma Untested ....25 for $1

2N1038 4/$1, 1039 3/$1, 1040 2/$1, 1041 $1
2N538, 539, 540/3 Amp .... 2 for $1
Zener 50/60V Auto Ignition $1
100V Auto Ignition Transistor $3
Kit Zeners 400 Mw to 10W Asstd ...... 3 for $1

SILICON POWER DIODES STUDS & P.F.*

DC AMPS	50Piv 35Rms	100Piv 70Rms	150Piv 105Rms	200Piv 140Rms
3	.12	.18	.22	.30
12	.40	.60	.70	.85
18*	.25	.45	.60	.85
35	.85	1.10	1.40	1.60
100	1.75	2.15	2.50	3.10
240	4.50	5.70	6.90	8.40
D.C. AMPS	300Piv 210Rms	400Piv 280Rms	500Piv 350Rms	600Piv 420Rms
3	.40	.45	.50	.60
12	1.00	1.25	1.40	1.55
18*	1.00	1.30	Query	Query
35	2.25	2.50	2.85	3.40
100	3.75	4.60	5.65	8.00
240	16.50	24.50	Query	Query

"SCR" SILICON CONTROLLED RECTIFIERS!

PRV	7A	16A	25A	PRV	7A	16A	25A
25	.50	.85	1.20	250	2.40	2.75	3.20
50	.85	1.20	1.40	300	2.70	3.20	3.60
100	1.35	1.80	2.20	400	3.25	3.60	4.25
150	1.65	2.20	2.70	500	4.00	4.45	4.90
200	1.85	2.50	3.00	600	4.50	5.15	5.65

Silicon Diodes 3&6 Amp Studs Untested 12 for $1
Glass Diodes 1N34/48/60/64 Untested 20 for $1

"TAB" TERMS: Money Back Guarantee! Our 18th year. $2 Min. order F.O.B. N.Y.C. Add shpg charges or for C.O.D. 25% Dep. Prices shown subject to change.

111-WP Liberty St., N. Y. 6, N. Y.

Send 25¢ Phone: REctor 2-6245 *for Catalog*

CIRCLE NO. 225 ON READER SERVICE PAGE

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GUARANTEED ONE FULL YEAR! NOT USED! NO PULLS! **WHY PAY MORE?**

Tube	Price
OA2	.80
OA3	.90
OA4G	1.35
OB2	.80
OB3	1.20
OC3	.75
OD3	.73
OG3	2.75
OY4	1.20
OZ4	.77
1A3	.73
1A5	.73
1A6	.73
1A7	1.39
1AB5	.77
1AE4	1.34
1AF4	1.30
1AG4	2.20
1AJ5	.48
1AX2	.60
1B3	.77
1B5	.98
1C5	.73
1C6	.73
1DN5	.53
1D5GP	.98
1D7	.78
1D8	2.20
1E5GP	.98
1E7	.87
1F4	.68
1F5	.73
1F6	1.20
1G3	.77
1G4	.69
1G6	.80
1H4	.95
1H5	.87
1H6	.73
1J3	.77
1J5	.98
1J6	.98
1K3	.77
1L4	.66
1LA4	.87
1LA5	2.50
1LA6	.87
1LB4	.87
1LC5	1.05
1LC6	.87
1LD5	1.95
1LE3	.87
1LG5	1.98
1LH4	.87
1LN5	.57
1N5	.87
1P5	.98
1Q5	.98
1R4	.80
1R5	.75
1S4	1.05
1S5	.70
1T4	.70
1T5	.80
1U4	.70
1U5	.63
1V	1.05
1X2B	.80
1Z2	3.25
2A3	2.50
2A5	1.25
2A6	1.10
2A7	1.50
2AF4A	.93
2AH2	1.23
2AS2	.70
2B3	.98
2B7	.70
2BN4	.62
2CY5	.68
2D21W	.79
2EA5	.68
2EN5	.49
2ER5	1.65
2FH5	.74
2FQ5	.99
2FS5	1.47
2GK5	.59
2GW5	2.40
2HK5	.98
2X2	.60
2X2A	1.30
3A2	1.20
3A3	.74
3A4	.58
3A5	1.10
3AF4	.99
3AL5	.44
3AT2	.71
3AU6	.52
3AV6	.40
3AW3	.72
3B2	3.45
3B7	1.35
3BA6	.49
3BC5	.61
3BE6	.54
3BN4	.76
3BN6	.73
3BU8	.76
3BY6	.56
3BZ6	.54
3CB6	.54
3CE5	.56
3CF6	.62
3CS6	.56
3CY5	.69
3D6	1.48
3DG4	.83

Tube	Price
3DK6	.58
3DT6	.52
3DZ4	.79
3EH7	.60
3EJ7	.60
3ER5	.86
3FH5	.63
3FS5	.74
3GK5	.59
3GW5	.53
3HA5	.99
3HK5	.59
3HS8	1.29
3Q4	.61
3S4	.73
3V4	.61
4AU6	.52
4AV6	.40
4BA6	.85
4BC5	.56
4BC8	1.00
4BL8	.61
4BN6	.72
4BQ7	.99
4BS8	.96
4BU8	.71
4BZ6	.56
4BZ7	1.00
4CB6	.55
4CS6	.59
4CY5	.70
4DE6	.60
4DK6	.58
4DT6	.53
4EH7	.60
4EJ7	.60
4EM6	.94
4ES8	1.90
4EW6	.56
4GK5	.59
4GM6	.58
4GS8	1.29
4GZ5	1.49
4GZ6	.59
4HC7	.73
4HM6	.56
4HS8	.71
4HT6	.99
4JC6	1.64
4JD6	1.64
5AM8	.77
5AN8	.88
5AQ5	.52
5AR4	1.40
5AS8	1.75
5AT8	.81
5AV8	.98
5AZ4	.73
5B8	1.30
5BC3	.50
5BE8	.81
5BK7	.84
5BQ7	.99
5BR8	.81
5BT8	.79
5BW8	1.31
5CG8	.79
5CL8	.74
5CM8	.88
5CQ8	.82
5CZ5	.70
5DE8	.81
5DJ4	.77
5EA8	.78
5ES8	1.11
5EU8	.78
5EW6	.56
5FG7	.67
5FV8	.77
5GH8	.62
5GM6	1.04
5GX6	.54
5HC7	1.49
5HG8	.80
5J6	.70
5KE8	1.24
5T4	.84
5T8	.84
5U4	.58
5U8	.82
5V3	.88
5V4	1.45
5V6	.54
5W4	1.75
5X4	.90
5X8	.80
5Y3	.44
5Z3	1.50
5Z4	1.75
6A3	2.75
6A4	.78
6A5	3.00
6A6	1.95
6A7	1.10
6A8GT	1.10
6A8M	1.15
6AB4	.44
6AB5	3.00
6AB7	1.00
6AC5	1.95
6AC7	.93
6AD7	3.25
6AE5	2.50
6AF3	.71
6AF4	.99
6AF4A	.99
6AF6	2.50
6AF11	1.98
6AG5	.68

Tube	Price
6AG7	1.35
6AH4	.79
6AH6	1.05
6AJ5	1.95
6AJ8	1.73
6AK5	.90
6AK6	.80
6AL5	.35
6AL7	2.10
6AL11	1.05
6AM8	.76
6AN4	1.59
6AN5	2.65
6AN6	2.45
6AN8	.91
6AQ5	.52
6AQ6	1.00
6AQ7	1.73
6AQ8	.77
6AR5	.53
6AR6	.87
6AR8	2.00
6AR11	1.70
6AS5	.59
6AS6	.78
6AS7	2.75
6AS8	.83
6AS11	1.98
6AT6	.47
6AT8	.84
6AU4	.83
6AU5	.50
6AU6	.50
6AU7	.70
6AU8	.85
6AV5	.89
6AV6	.39
6AV11	1.65
6AW8	.88
6AX3	.93
6AX4	.64
6AX5	.73
6AX7	.62
6AX8	1.45
6AY3	.59
6AZ8	1.30
6B4	3.80
6B5	4.00
6B7	2.00
6B8	2.00
6B10	1.39
6BA3	1.15
6BA6	.48
6BA7	.98
6BA8	.88
6BC4	2.10
6BC5	.59
6BC7	.88
6BC8	1.00
6BD5	1.20
6BD6	.55
6BE3	.71
6BE6	.53
6BF5	.88
6BF6	.42
6BF8	1.70
6BG6	1.65
6BH6	.66
6BH8	.94
6BJ6	.63
6BJ7	.77
6BJ8	1.45
6BK4	1.78
6BK5	.91
6BK7	.84
6BL7	1.05
6BL8	.97
6BN4	.60
6BN6	.70
6BN8	.74
6BQ5	.63
6BQ6/ 6CU6	1.08
6BQ7	.98
6BR8	.80
6BS8	.93
6BU8	.68
6BV8	1.23
6BW8	1.35
6BX7	1.09
6BY5	1.24
6BY6	.60
6BY8	.64
6BZ6	.54
6BZ7	.99
6BZ8	1.06
6C4	.43
6C5	1.40
6C6	.87
6C8	.88
6CA7	1.35
6C10	1.55
6CA4	.47
6CA5	.77
6CB5	2.05
6CB6	.53
6CD6	1.47
6CF6	.95
6CG7	.59
6CG8	.78
6CK4	.69
6CL6	.92
6CL8	.77
6CM6	1.45
6CM7	.67
6CM8	1.02
6CN7	.68
6CQ4	1.35
6CQ7	1.80

Tube	Price
6CQ8	.90
6CR6	.58
6CS6	.55
6CS7	.67
6CU5	.56
6CU6	1.05
6CU8	.99
6CW4	1.09
6CW5	.78
6CX8	1.82
6CY5	.68
6CY7	.69
6CZ5	1.80
6CZ7	1.95
6D4	1.75
6D6	.67
6D10	1.95
6DA4	.66
6DA5	1.28
6DB5	.67
6DC6	1.30
6DC8	1.33
6DE4	.68
6DE6	.59
6DE7	.73
6DG6	.60
6DJ8	1.17
6DK6	.57
6DN6	1.76
6DN7	1.35
6DQ5	1.89
6DQ6	1.05
6DR7	.73
6DS4	1.40
6DS5	1.30
6DT5	.79
6DT6	.51
6DT8	.92
6DV4	2.65
6DW4	.90
6DW5	.99
6DZ4	.78
6E5	2.25
6EA7	.88
6EA8	.77
6EB5	.71
6EB8	.91
6EH5	1.33
6EH7	.59
6EH8	.77
6EJ7	.77
6EM5	.75
6EM7	.80
6EQ7	.70
6ER5	.88
6ES5	.68
6ES8	1.39
6ET7	1.04
6EU7	.66
6EU8	.77
6EV5	.73
6EW6	.55
6EW7	.78
6EY6	.73
6EX6	3.65
6EZ5	.88
6EZ8	.93
6FA7	1.32
6FD7	.83
6FJ7	1.79
6F4	2.35
6F5GT	1.10
6F5M	1.50
6F6	.67
6F6M	1.25
6F7	2.50
6F8	1.25
6FG5	2.15
6FG7	.67
6FG8	.65
6FH5	.73
6FJ5	2.25
6FM7	.77
6FQ7	.56
6FS5	.74
6FV6	.68
6FV8	.77
6FW5	1.96
6FW8	4.25
6FY5	1.25
6G5	1.23
6G6G	1.00
6GE5	.92
6GF5	1.75
6GH8	.78
6GK5	.59
6GK6	.77
6GL7	2.35
6GM5	.78
6GM6	.58
6GN8	.92
6GR7	.78
6GT5	1.00
6GV5	.98
6GV6	1.85
6GW6	1.00
6GW8	1.50
6GX6	.55
6GX8	1.25
6GY5	.53
6GY6	.60
6GZ5	.53
6HA5	.99
6HF5	1.90
6HF8	.97
6HG8	.79
6HJ8	.80
6HK5	.59
6HL8	.71

Tube	Price
6HS8	.79
6HZ6	.56
6H6	.56
6J4	2.95
6JB6	.98
6JC8	.74
6JE6	2.00
6JE8	.98
6J5	.92
6J6	.69
6J7	1.65
6J8	1.40
6J11	1.83
6JH6	.55
6JH8	1.85
6JK8	.68
6JT8	1.03
6JV8	.68
6JZ8	.83
6K6	.61
6K7	.95
6K7G	.75
6K8GT	.87
6K8M	1.85
6K11	1.50
6KD8	.62
6KT8	.80
6KU8	1.05
6KZ8	.67
6LB8	1.00
6L5	.90
6L6GA	1.40
6L6GB	1.50
6L6G	.98
6L6GC	1.65
6L6M	2.50
6L7	1.05
6M11	1.85
6N6	1.45
6N7	.96
6P5	.95
6Q7GT	1.27
6Q7-M	1.45
6Q11	1.05
6R7	1.25
6S4	.49
6S7	.90
6S8	.74
6SA7GT	.97
6SA7-M	1.25
6SB7Y	1.15
6SC7	1.35
6SD7	.70
6SF5	.75
6SF7	1.00
6SG7	1.10
6SH7	.97
6SJ7GT	.90
6SJ7-M	1.02
6SK7GT	.63
6SK7-M	1.46
6SL7GT	.81
6SN7	.63
6SQ7	.92
6SR7	1.00
6SS7	.95
6SZ7	.95
6T4	.96
6T8	.83
6U5	1.75
6U8	.81
6V3	1.10
6V6GT	.52
6V6M	2.50
6W4	.60
6W6	.69
6X4	.39
6X5	.51
6X8	.78
6Y6	1.00
7A4	.87
7A5	.87
7A6	1.15
7A7	.87
7A8	.66
7AD7	1.15
7AF7	1.45
7AG7	.87
7AH7	1.25
7AU7	.63
7B4	1.45
7B5	.87
7B6	.87
7B7	.87
7B8	1.25
7C5	1.35
7C6	.87
7C7	.89
7E5	.87
7E6	1.15
7E7	1.25
7EY6	.73
7F7	1.75
7F8	.88
7G7	1.25
7H7	1.35
7HG8	1.67
7J7	1.95
7K7	1.95
7L7	1.95
7N7	1.95
7Q7	.87
7R7	.87
7S7	.87
7V7	1.85
7W7	1.85
7X6	1.25
7X7	1.85
7Y4	.67

Tube	Price
7Y7	1.25
7Z4	.87
8AU8	.88
8AW8	.91
8BH8	.87
8BQ5	.61
8CG7	.63
8CM7	.69
8CN7	.95
8CS7	.72
8CX8	.89
8EB8	.92
8EM5	.84
8ET7	1.08
8FQ7	.54
8GN8	.97
8JV8	.93
8KA8	.84
9A8	.98
9AU7	.67
9BR7	1.32
9CL8	.77
9EA8	.66
9U8	.80
10AL11	1.09
10BQ5	.89
10C8	1.03
10DE7	.73
10EG7	.86
10EM7	1.75
10EW7	.97
10GN8	.93
10HT8	1.12
10JA8	.92
10KU8	1.07
10Y	.73
11CY7	.73
11JE8	.89
11KV8	1.52
12A4	.59
12A5	.95
12A6	.85
12A7	1.45
12A8	3.00
12A11	1.74
12AB5	.58
12AC6	.53
12AD6	.55
12AE6	.48
12AE7	.92
12AF3	.71
12AF6	.65
12AG6	.60
12AJ6	.60
12AL5	.45
12AL8	.93
12AL11	1.06
12AQ5	.58
12AT6	.48
12AT7	.74
12AU6	.49
12AU7	.59
12AV5	.93
12AV6	.39
12AV7	.80
12AW6	.98
12AX3	.63
12AX4	.65
12AX6	.62
12AX7	.61
12AY7	1.42
12AZ7	.84
12B4	.66
12BA6	.49
12BA7	.82
12BD6	.48
12BE3	.67
12BE6	.51
12BF6	.58
12BH7	.75
12BK5	.98
12BL6	.54
12BN6	.97
12BQ6/ CU6	1.11
12BR7	.72
12BV7	.74
12BW4	1.09
12BY7	.75
12BZ6	.75
12BZ7	.84
12C5	.56
12CA5	.60
12CN5	.54
12CR6	.65
12CS6	.63
12CT8	1.60
12CU6/ BQ6	1.05
12CX6	.52
12D4	.67
12DB5	.67
12DE5	.60
12DE8	.81
12DL8	.85
12DQ6	1.02
12DQ7	1.33
12DS7	.82
12DT5	.74
12DT7	.77
12DT8	.76
12DW7	1.20
12DW8	.87
12DY8	1.75
12DZ6	.60
12EA6	.99
12EC8	1.38
12ED5	.60
12EG6	.60

Tube	Price
12EK6	.60
12EL6	.48
12EL8	.86
12EZ6	.55
12F5	1.50
12F8	.64
12FA6	.77
12FK6	.48
12FM6	.48
12FQ8	.78
12FR8	.95
12FX5	.64
12FX8	.88
12GA6	.63
12GC6	1.04
12GE5	.93
12GW6	1.02
12J5	.95
12J8	.82
12K5	.73
12K8G	.87
12K8M	2.75
12L6	.71
12L8	.50
12Q7GT	1.35
12Q7M	2.50
12R5	.75
12SA7GT	.87
12SA7M	2.50
12SC7	.78
12SF5GT	.98
12SF5M	1.75
12SF7GT	.65
12SF7M	1.75
12SG7	.95
12SG7M	1.10
12SH7	1.39
12SJ7GT	.99
12SJ7M	1.75
12SK7GT	.93
12SK7-M	2.00
12SL7	.78
12SN7	.65
12SQ7GT	.89
12SR7	.98
12U7	.60
12V6	.62
12W6	.69
12X4	.45
13DE7	.73
13DR7	.72
13EM7	1.22
13FD7	.84
13FM7	.78
13GF7	.78
14A4	1.25
14A5	1.10
14A7	.87
14AF7	1.35
14B6	.87
14B8	1.75
14C5	1.50
14C7	1.75
14E6	1.25
14E7	1.25
14F7	.87
14F8	1.75
14GT8	.80
14H7	1.60
14J7	1.45
14N7	1.25
14Q7	.87
14R7	.87
14S7	1.65
14W7	1.25
14x7	1.25
14Y4	1.25
15AF11	1.95
15CW5	1.15
15FY7	1.29
15HB6	1.28
15KY8	.83
16AQ3	1.42
16GK6	.57
17AX3	.51
17AX4	.65
17AY3	.68
17BE3	.57
17BQ6	1.10
17BS3	.86
17C5	.56
17C9	1.18
17D4	.67
17DE4	1.29
17DM4	.78
17DQ6	1.04
17DQ7	1.85
17GE5	1.70
17GJ5	.99
17GV5	.99
17GW6	1.01
17H3	.95
17HC8	1.18
17JB6	1.12
17L6	.56

Tube	Price
17JZ8	.93
17LD8	1.20
17W6	.68
18A5	.99
18FW6	.47
18FX6	.51
18FY6	.84
19	.75
19AU4	.85
19BG6	1.35
19C8	1.05
19CL8	.57
19EA8	.77
19HV8	1.44
19JN8	1.20
19Q9	.75
19T8	.83
2050	1.05
21EX6	1.47
21GY5	1.02
22BH3	.74
22BW3	1.43
22DE4	.67
22JG6	1.06
25A7	3.00
25AC5	2.00
25AK4	.66
25AV5	1.00
25AX4	.68
25B8	1.73
25BK5	.89
25BQ6	1.12
25C5	.51
25CA5	1.85
25CD6	1.50
25DK4	1.05
25DN6	1.50
25EH5	.53
25F5	.56
25L6	.55
25W4	.66
25Z5	1.10
25Z6	.73
27GB5	1.59
32ET5	.53
32L7	.85
33GY7	1.40
34DG5	.51
34GD5	.79
35A5	.85
35B5	.95
35C5	.49
35EH5	.55
35L6	.58
35W4	.40
35Y4	1.63
35Z3	1.20
35Z5	.58
50A5	1.49
50B5	.68
50C5	.51
50DC4	.46
50EH5	.95
50HC6	.86
50HK6	.54
50L6	.59
50X6	.67
50Y6	.95
50Y7	1.10
60FX5	.60
70L7	.89
117L7	2.50
117N7	3.95
117P7	3.95
117Z3	.83
22	.95
24A	.95
26	1.10
27	1.50
28D7	1.50
30	1.15
32	1.00
33	.85
34	.79
35-51	.85
36	.95
37	.70
38	.90
39/44	.85
41	.95
42	1.25
43	1.20
45	2.00
46	.95
47	2.10
48	3.50
50	1.45
53	2.98
55	1.90
56	.95
57	1.35
58	1.85
59	2.50
71A	.95
75	1.90
76	1.40
77	1.25
78	1.15
80	1.25
81	1.25
82	1.23
83	2.10
84/6Z4	.95
85	.98
5881	2.95
6336	5.95
6146	3.95
6550	3.75
807	.70

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CIRCLE NO. 167 ON READER SERVICE PAGE

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ADVERTISERS INDEX

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CIRCLE NO. 133 ON READER SERVICE PAGE →

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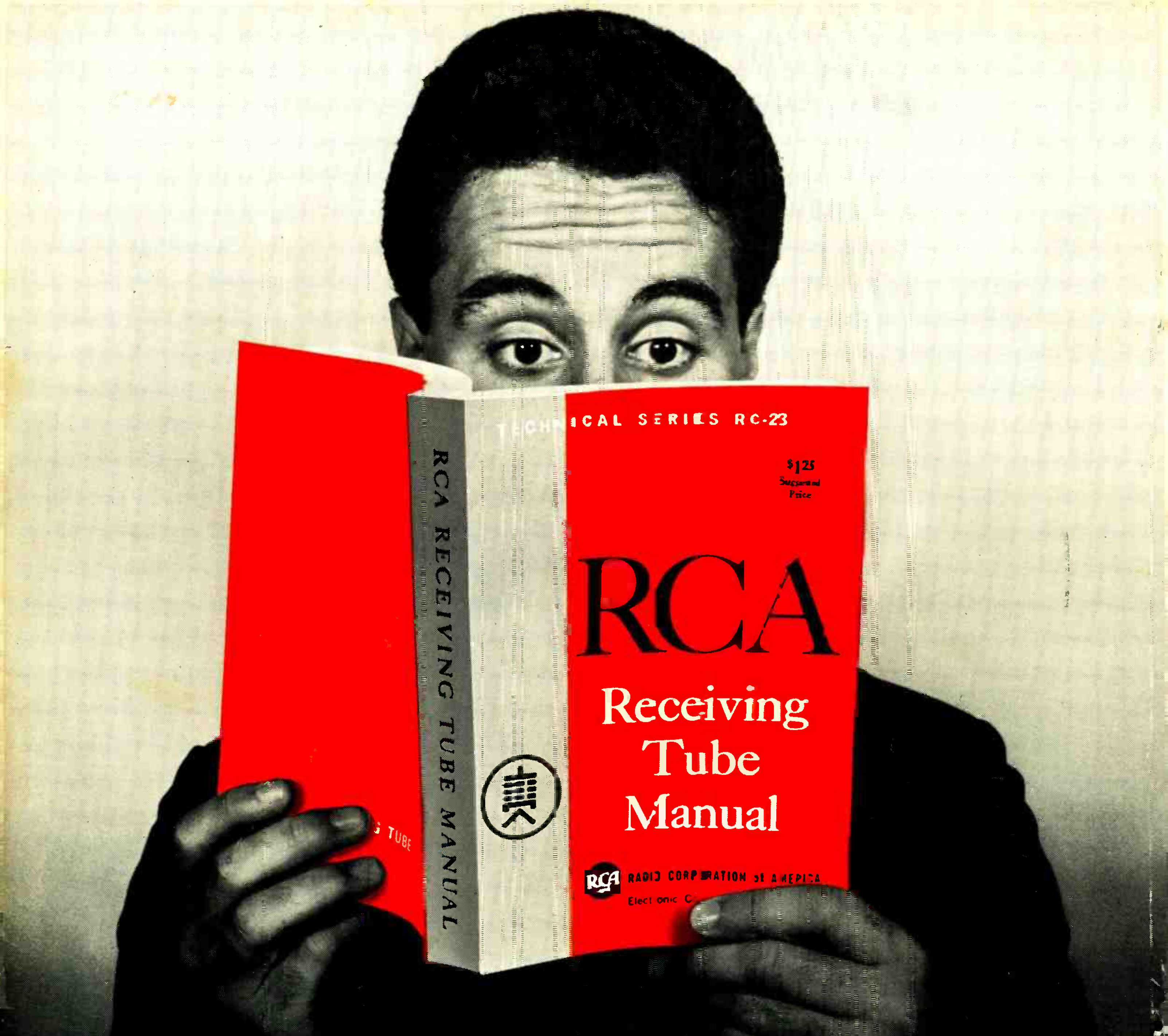

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