Electronics World

JANUARY, 1964
50 CENTS

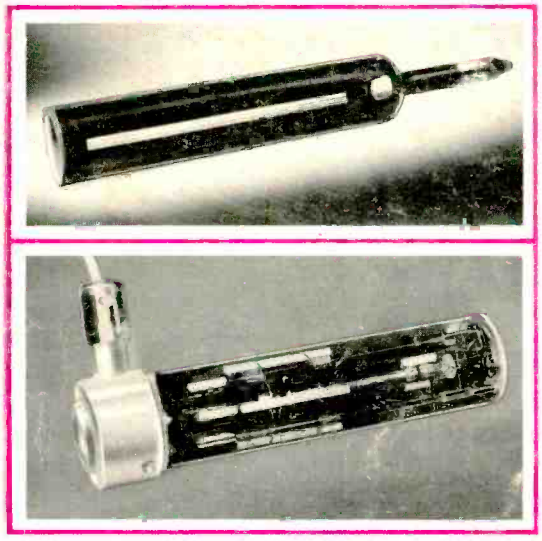
AUTOMATION IN ELECTRONIC TESTING TECHNIQUES

CB RANGE NOMOGRAM ■ SCR TESTER

LOUDSPEAKERS FOR TRANSISTOR AMPLIFIERS

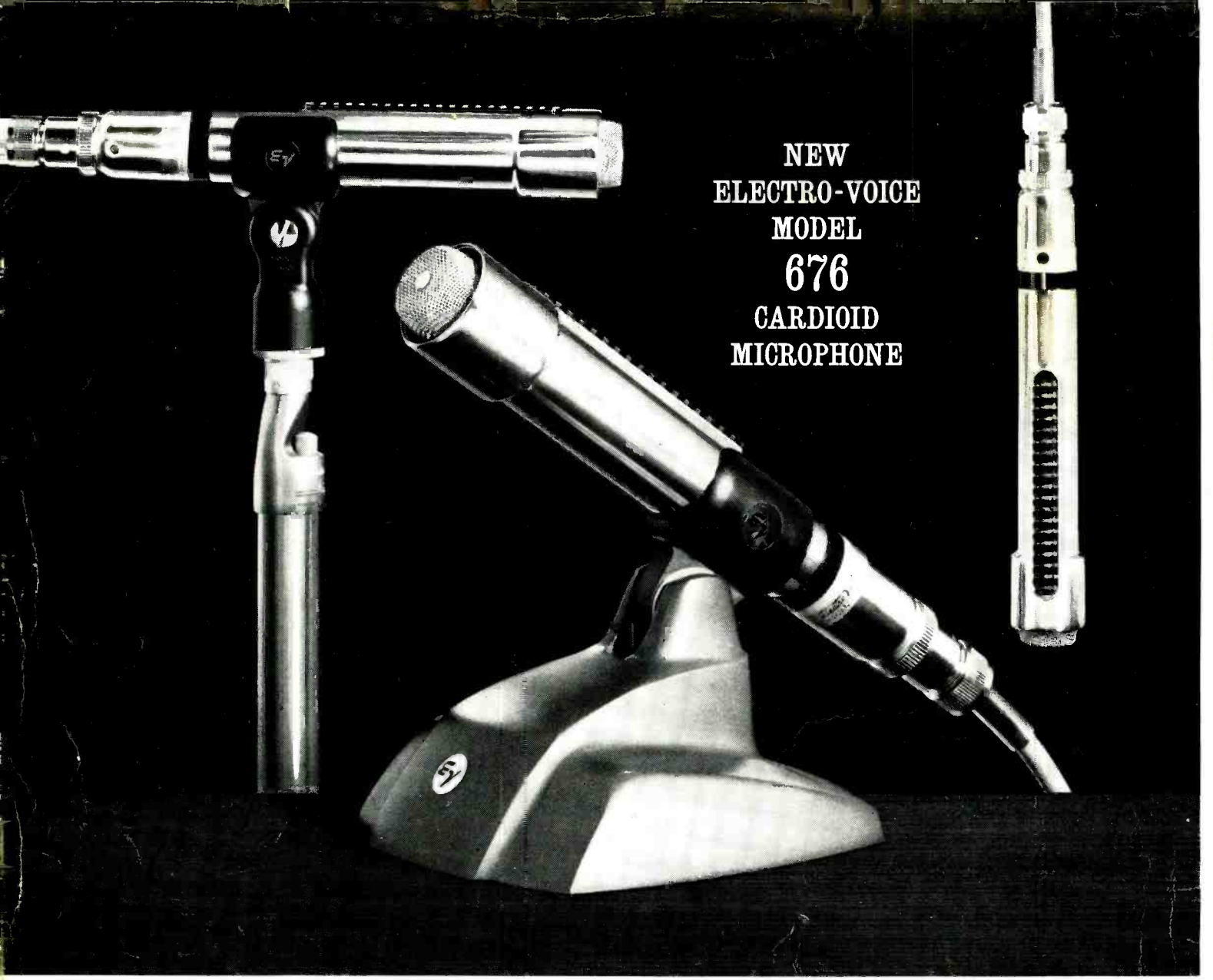
SIMPLIFIED SOLID-STATE COLOR ORGAN

UNIQUE PICTURE TUBES for COLOR TV



Banana tube (top) and Harries tube are both used in projection systems

TWO-COLOR THINTUBE



Outperforms them all...or your money back!

In the last 36 years, Electro-Voice engineers have developed many important microphone firsts*, but their latest achievement, the new E-V Model 676, may well be their most significant contribution.

The goal of 676 design was to overcome some of the most basic problems in PA, hi-fi recording, and communications. The result of this engineering effort is a uniquely versatile dynamic cardioid microphone with the best field performance of any we have tested. In short, the 676 does *everything* a little better.

For instance, response is wide, uniform, and smooth in the E-V tradition of natural sound. But the 676 also allows you to *change* response. Now you can "neutralize" room reverberation and rumble (usually encountered in larger rooms). A built-in three-position switch allows selection of flat response (for small rooms or recording), or bass attenuation "tilted off" from about 800 cps, with response down either 5 db or 10 db at 100 cps.

This means you get higher average sound levels, better intelligibility, and less likelihood of feedback. Yet there is no "missing bass" effect, common with most tone controls or filters, because of the flat-slope characteristic of the 676 bass tilt-off.

The cardioid pattern and response superiority of the 676 results from a creative variation of the famed E-V Variable-D® principle, called Continuously Variable-D (CV-D). It reduces size and weight without compromising quality, and it's responsible for reducing wind noise and shock noise pickup far below that of any other small cardioid. Bass-boosting "proximity effect" is gone, too, to give you well-balanced sound, even when performers work ultra-close.

Basis of the CV-D™ design is a slotted tube, coupled to the back of the 676 diaphragm. The CV-D tube appears to vary in length—acoustically (and automatically)—so that low tones "see" a long tube, while high tones "see" a short tube. The apparent length of the tube is always just right to phase out sound arriving at the back—for maximum front-to-back cancellation.

Modern styling by noted designer Lute Wassman adds grace and beauty to 676 practicality. The ore-inch case fits all present E-V slip-on stand mounts, and its balanced weight distribution is just right for hand-held use.

But there's more to the 676 than just new features—built into it are the many characteristics that make E-V the choice of more professional sound engineers than any other brand: high output level, exclusive E-V Acoustalloy® diaphragm, dual impedance selection, efficient dust and magnetic filters, and the most important ingredients of all—fine materials and quality workmanship.

Accept our invitation to try the 676 soon—and the more difficult the job, the better. We guarantee you'll find the 676 will outperform any other PA cardioid microphone you are now using . . . or your money back!

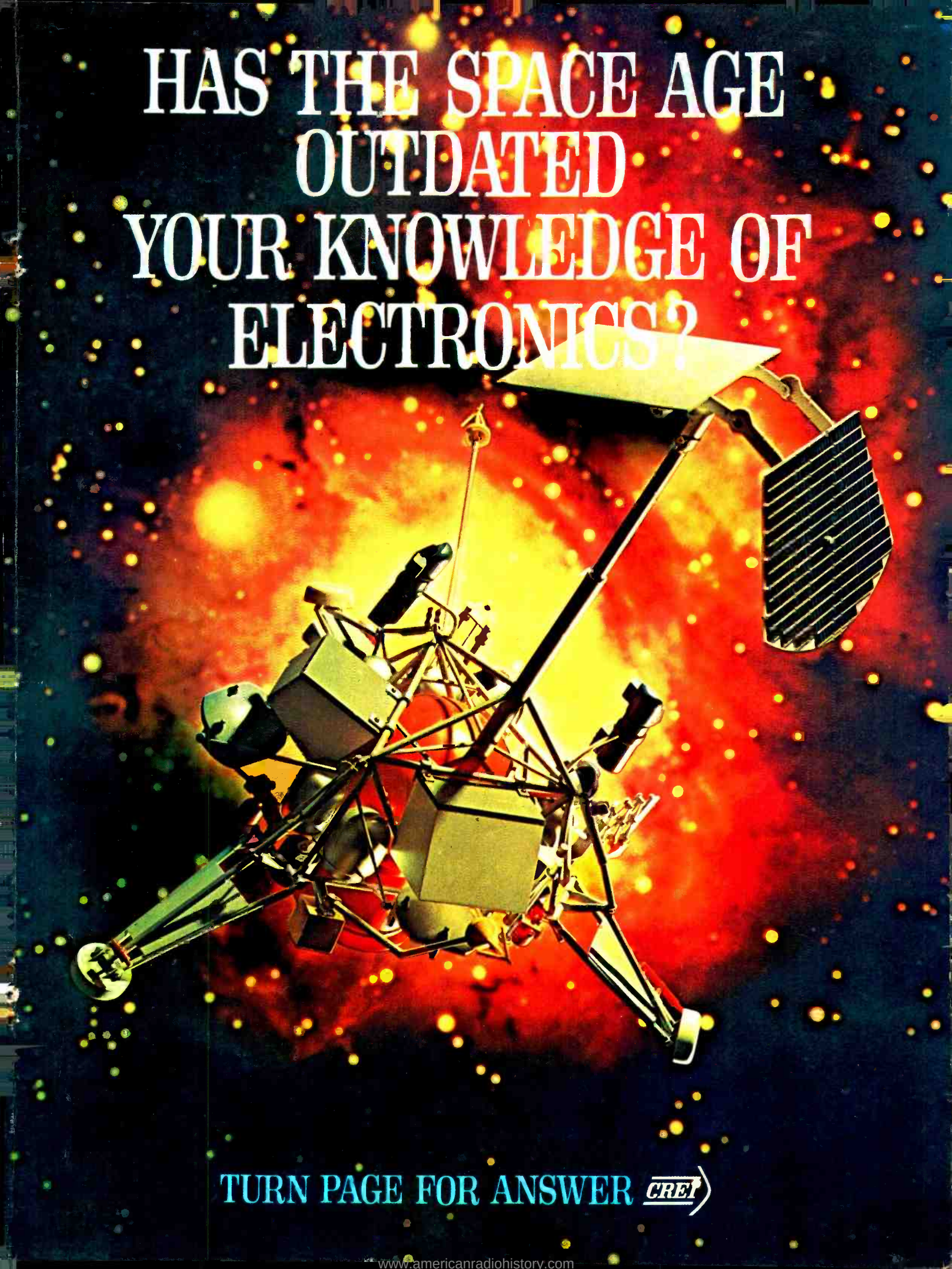
Model 676—$100.00 list (less normal trade discounts). Complete specifications available at your E-V sound specialist's or write to: ELECTRO-VOICE, INC., Dept. 142N, Buchanan, Michigan.

Electro-Voice®
SETTING NEW STANDARDS IN SOUND

*Some of the E-V microphone firsts include: The Differential, Mechanophase, Variable-D®, Cardioline and Sound Spot®, plus slim dynamic and lavalier microphone designs, Acoustalloy® and Acoustifoam. And the E-V Model 642 has earned the first Academy Award microphone citation in 22 years, for its contribution to motion picture sound.

CIRCLE NO. 111 ON READER SERVICE CARD

HAS THE SPACE AGE OUTDATED YOUR KNOWLEDGE OF ELECTRONICS?



TURN PAGE FOR ANSWER CREI

WHAT HAPPENS TO TRANSISTORS IN THE VAN ALLEN BELT? HOW ARE VACUUM TUBES USED IN SPACE? WHY CAN'T REGULAR LUBRICANTS BE USED ON MOVING PARTS IN A SPACECRAFT? TO WHAT EXTENT HAS THE SPACE EFFORT CHANGED RELIABILITY STANDARDS?

The answers to these questions reflect the changes taking place with space applications of electronics. For space electronics involves new and different uses of electronic principles. Conventional systems and components are frequently outdated. Technical breakthroughs come almost daily. Space electronics is as different from the electronics you know as the superheterodyne receiver is from the crystal set.

WHAT DOES THIS CHANGE MEAN TO YOU?

It means specialized knowledge of space electronics is essential for a career in this field. Nearly every major electronics organization and a good many of the smaller companies have become part of the space program. Guiding space vehicles, communicating with them through space and processing the vital information they gather demands knowledge that did not exist when you studied electronics. And this knowledge can't be acquired on the job, unless you are one of the few men privileged to work for a key space engineer or scientist.

Developments in space electronics are affecting almost every area of electronics. For instance, the same techniques used in the space program are used in electronic packaging to reduce computers and television sets to a much smaller size. So knowledge of space electronics is an asset to a man in any field of electronics.

No question about it, for your career in electronics, you must supplement your present knowledge and experience with considerable new knowledge of space electronics.

CREI CAN HELP YOU PROTECT YOUR FUTURE

CREI now offers a new Home Study Program planned to help you protect your future in electronics by updating your education to space age requirements.

CREI's Program in Space Electronics enables you to study at home, on your own schedule through methods developed in CREI's 36 years of experience in technical education through home study.

Long and painstaking effort has been devoted to the preparation of this program. CREI faculty members have visited 14 government and private technical organizations in the space effort to determine exactly what knowledge of electronics they want in men they employ. Engineers and scientists from some of these organizations have been retained as consultants to supply the technical material that makes up the program.

PHOTOGRAPHS COURTESY OF NATIONAL AERONAUTICS & SPACE ADMINISTRATION

CREI ANNOUNCES A UNIQUE HOME STUDY PROGRAM IN SPACE ELECTRONIC ENGINEERING TECHNOLOGY

with your choice of these specialties

SPACE DATA SYSTEMS Includes analog and digital computers, information theory, data acquisition and processing.

SPACE TRACKING SYSTEMS Includes microelectronics, space propagation, masers, lasers, infrared techniques.

SPACECRAFT GUIDANCE AND CONTROL Includes inertial navigation, space radar, star tracker systems, tracking networks.

- The first educational program developed specifically to help electronics men apply their experience to the space effort.
- Content of program developed to meet employment requirements as determined by consulting government and private organizations in the space field.
- Text material prepared with the help of engineers and scientists holding key positions in leading space-oriented organizations. (Names on request.) You study exactly the material technical organizations in the space effort want their employees to know.

YOU ARE ELIGIBLE FOR THIS PROGRAM IF YOU WORK IN ELECTRONICS AND HAVE A HIGH SCHOOL EDUCATION.

FREE BOOK GIVES FULL INFORMATION. TEAR OUT AND MAIL POSTPAID CARD or write CREI,
Department 1101-B, 3224 Sixteenth Street, N. W.,
Washington 10, D. C.

CREI

The Capitol Radio Engineering Institute
Founded 1927 Accredited Member of the National Home Study Council
Dept. 1101-B, 3224 Sixteenth St., N. W.
Washington 10, D. C.

Please send me FREE book describing CREI Home Study Programs including new Program in Space Electronics. I am employed in electronics and have a high school education.

Name _____ Age _____

Address _____

City _____ Zone _____ State _____

Employed by _____

Type of present work _____

Check: ☐ Home Study ☐ Residence School ☐ G.I. Bill

NOW CREI OFFERS SPECIALIZED EDUCATION IN EVERY IMPORTANT AREA OF ELECTRONICS

SPACE DATA SYSTEMS (NEW)

SPACE TRACKING SYSTEMS (NEW)

SPACECRAFT GUIDANCE AND CONTROL (NEW)

COMMUNICATIONS

AERONAUTICAL AND NAVIGATIONAL

TELEVISION

AUTOMATION AND INDUSTRIAL

NUCLEAR

SERVOMECHANISMS AND COMPUTERS

FREE BOOK GIVES COMPLETE INFORMATION ON CREI HOME STUDY PROGRAMS INCLUDING NEW PROGRAMS IN SPACE ELECTRONICS. TEAR OUT AND MAIL POSTPAID CARD FOR YOUR COPY TODAY.

FIRST CLASS
Permit No. 288-R
Washington, D. C.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

VIA AIR MAIL

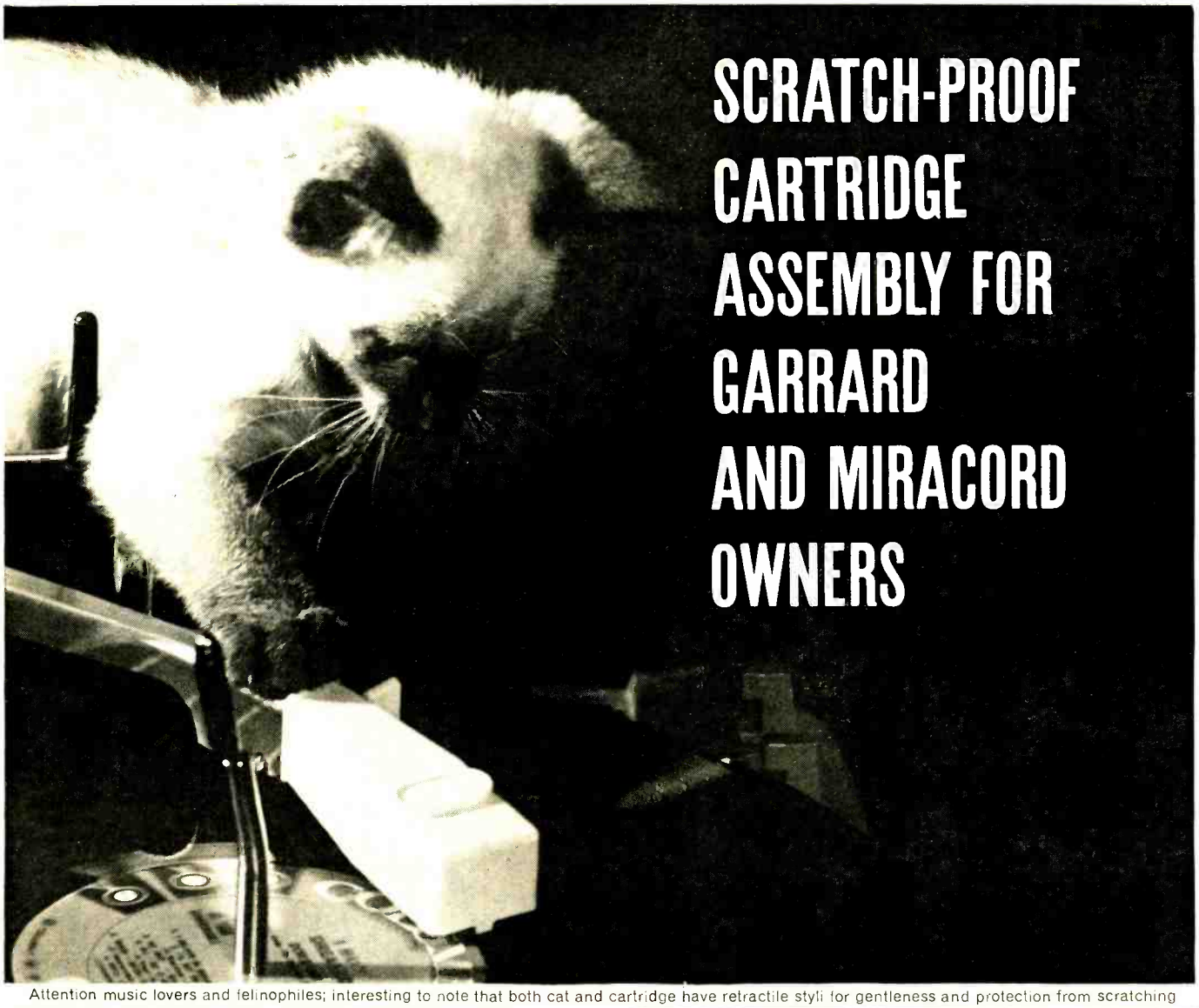
Postage will be paid by

CREI

The Capitol Radio Engineering Institute
3224 Sixteenth Street, N.W.
Washington 10, D. C.

new from SHURE

originators of scratch-proof high fidelity tone arms



Attention music lovers and felinophiles; interesting to note that both cat and cartridge have retractile styli for gentleness and protection from scratching

GREATER RECORD AND NEEDLE PROTECTION . . . FINER RECORD REPRODUCTION

Now, owners of Garrard Laboratory® Type "A" and AT-6 and Miracord Model 10 and Model 10H Automatic Turntables can assure themselves unprecedented and unparalleled record and needle protection, and highest sound quality simply by plugging in the Shure Stereo Dynetic GARD-A-MATIC "floating" cartridge assembly. Nothing else to buy . . . no wiring, no soldering, just plug in.

Ingenious GARD-A-MATIC cartridge inside a special tone-arm shell ends scratching due to dropping the tone arm or accidentally dragging it across the grooves . . . records stay new, sound new. Needles last longer—can't be damaged by pressing arm on record. Does away with tone arm "bounce" from floor vibrations, etc. Even plays warped records. And, the performance characteristics are those of the famed Shure Stereo Dynetic cartridges.

SPECIFICATIONS

Frequency Responses:	From 20 to 20,000 cps
Output Voltage:	6 millivolts per channel
Channel Separation:	more than 22.5 db at 1000 cps
Recommended Load Impedance:	47,000 ohms
Compliance:	20.0 x 10^{-6} cm per dyne
Tracking:	1.5 to 3.0 grams
Inductance:	600 millihenries
D. C. Resistance:	750 ohms
Stylus:	.0007" diamond
Stylus Replacement:	N99

MODEL M99/A. Fits Garrard Laboratory® model "A". Includes tone arm head, factory mounted cartridge, .0007" diamond. **MODEL M99/AT6.** Fits Garrard AT-6. Includes tone arm head, factory mounted cartridge, .0007" diamond. **Model M99/M10.** Fits Miracord Models 10 or 10H. Includes tone arm head, factory mounted cartridge, .0007" diamond. **MODEL N99.** Replacement stylus assembly, .0007" diamond.

SHURE Stereo Dynetic® GARD-A-MATIC T.M.

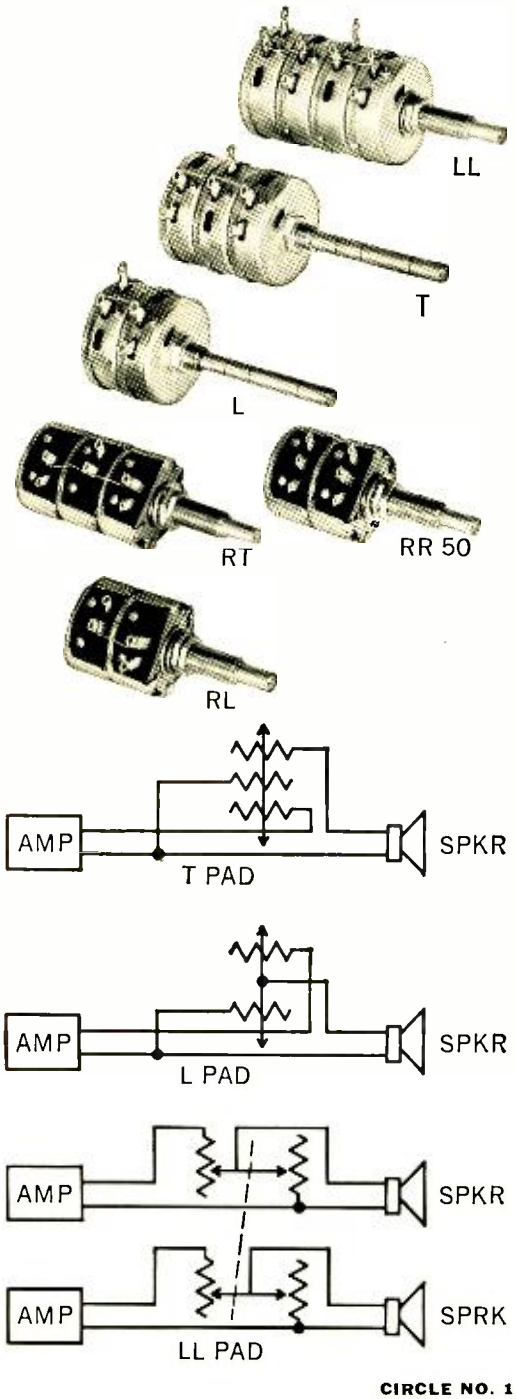
Patented and Patents Pending

CARTRIDGE ASSEMBLY

WRITE FOR DETAILS TO: SHURE BROTHERS, INC., 222 HARTREY AVE., EVANSTON, ILLINOIS

Manufactured under one or more of the following U.S. Patents: 3,055,988; 3.077,521; 3.077,522; D193,006; D193,934; other patents pending.

Choosing and using audio attenuators



Ever notice that a hi-fi rig sounds *best* about mid-range on the level (volume) control? Man, those drums, fifes, bugles and train whistles sound GREAT! But, oh, those grouchy neighbors. Somehow they fail to appreciate three or four solid hours of this "pure" sound.

Fear not! There's a simple way to keep true hi-fi sound as well as your neighbors. All you need is an audio attenuator (a fancy name for audio control). There are two basic types of audio attenuators: T pads and L pads.

If yours is the *ultimate* in hi-fi rigs you need a T pad. It maintains a constant impedance between the amplifier and the speaker. You simply turn the amplifier up to optimum performance (somewhere around mid-range) (pretty doggone *loud*) and control *listening* level with the T pad. The "fi" is very "hi" but the level is reasonable and so are the neighbors.

Not all of us can afford the "ultimate". Budgets being what they are, we make a few compromises. Not that our hi-fi doesn't sound great—it does. It's just that it won't break the picture window. We may be able to get by with an L pad. This presents a constant impedance only to the amplifier. Strangely enough, an L pad often seems to *improve* the performance of an inexpensive speaker. Try it—you'll see!

If you have stereo, try an LL pad. That's a pair of L pads with a common shaft. You can balance your rig at the amplifiers and control level at the speakers with only one knob.

How about money? Mallory T, L, and LL pads will handle an "ear-busting" 15 watts of audio power! But if yours is the usual 10 watt system you'll need only an RT or RL pad . . . same extreme quality—only smaller and more economical.

Speaking of economy, try the new Mallory RR 50 Stereo Control. It does a terrific job on most popular stereo outfits. Just what you need for the recreation room or patio.

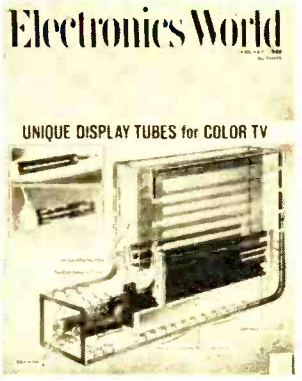
The whole point of this "tip" is to let you know that your Mallory Distributor has exactly the audio attenuator you need. All kinds of values and several price ranges. He's your "one stop" source for *all* of your electronic requirements. Stop in soon.

Electronics World

CONTENTS

JANUARY 1964
VOL. 71, NO. 1

MONTHLY FEATURES

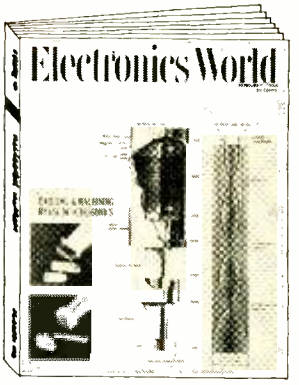


OUR COVER shows three different approaches to the problem of producing a color TV image. The two-color, direct-view Thintube is an artist's conception of a laboratory sample of this device. The other two tubes shown are used with projection systems. To show the international flavor of color TV research, the Banana tube is English, the Harries tube is from Bermuda, and the Thintube is American. Many other color TV approaches are given in the article starting on page 34. . . . . (Cover illustration by Otto E. Markevics.)

ZIFF-DAVIS PUBLISHING COMPANY

Publisher
PHILLIP T. HEFFERNAN
Editor
WM. A. STOCKLIN
Technical Editor
MILTON S. SNITZER
Associate Editor
LESLIE SOLOMON
Associate Editor
P. B. HOEFER
Editorial Consultant
OLIVER READ
Industrial Consultant
WALTER H. BUCHSBAUM
Art Editor
MILTON BERWIN
Art and Drafting Dept.
J. A. GOLANEK
Advertising Sales Manager
LAWRENCE SPORN
Advertising Service Manager
ARDYS C. MORAN

COMING NEXT MONTH



ADVANCES IN ULTRASONICS
This first article in a two-part series by Cyrus Glickstein describes some of the many applications for ultrasonics. Industrial, medical, military, and experimental use of this technique has expanded steadily since World War I.

THE INTEGRATED AMPLIFIER-SPEAKER
Although the concept of designing an amplifier for a specific speaker is not new, package radio-phono makers have been doing it for years, it is new in the hi-fi field. Ken Gilmore advances the reasons why such a concept is suited to hi-fi applications and how such units are designed.

MODULATION CIRCUITS FOR SOLID-STATE CB TRANSMITTERS
A description of novel linearized base-modulation and double-modulation circuits which eliminate excessive current drain, high distortion, large weight and size of conventional types of CB modulating circuits.

CONSTRUCT A MILLIWATT METER
Good to 500 mc., the milliwatt meter described in this article measures power from less than 1 mw. to 300 mw. The author also provides details on designing an attenuator network. A useful device for hams and experimenters who design and build their own transistor circuits.

STATE-POLICE MICROWAVE
Indiana State Police use an 800-mile, 9-terminal station system for communications. This entire system is maintained by only six full-time electronics technicians who travel close to 4000 miles each month to do troubleshooting and routine servicing. Here's how it is handled by one of the pioneers in the use of police microwave.

UNIJUNCTION C.W. MONITOR
John Cleary of General Electric tells how to construct an r.f.-powered c.w. monitor using a unijunction transistor. The device can also be used to mute the receiver during "key-down" conditions. Only eight parts are required.

U.H.F. TV CONVERTERS
Converters will be used with millions of u.h.f.-only TV sets in order to receive u.h.f. broadcasts. There are several different types of converters available—each with unique features. This article covers the operation of converters, why certain circuits were chosen, plus general information on frequency conversion and converter design.

All these and many more interesting and informative articles will be yours in the FEBRUARY issue of ELECTRONICS WORLD . . . on sale Jan. 21st.

ZIFF-DAVIS PUBLISHING COMPANY

William B. Ziff
Chairman of the Board (1946-1953)

William Ziff
President

W. Bradford Briggs
Executive Vice President

Hershel B. Sarbin
Vice President and General Manager

M. T. Birmingham, Jr.
Vice President and Treasurer

Robert P. Breeding
Circulation Director

Stanley R. Greenfield
Vice President

Phillip T. Heffernan
Vice President

ZIFF-DAVIS PUBLISHING COMPANY
Editorial and Executive Offices
One Park Avenue, New York, N.Y. 10016
212 ORegon 9-7200

MIDWESTERN and CIRCULATION OFFICE
434 South Wabash Avenue, Chicago, Ill. 60605
312 WAbash 2-4911
Midwestern Advertising Manager, Gilbert J. Jorgenson

WESTERN OFFICE
9025 Wilshire Boulevard, Beverly Hills, Cal. 90211
213 CRestview 4-0265
Western Advertising Manager, Bud Dean

FOREIGN ADVERTISING REPRESENTATIVE
D. A. Goodall Ltd., London, England

Member Audit Bureau of Circulations

Radio & TV News • Radio News • Radio-Electronic Engineering Trademarks Reg. U.S. Pat. Off.

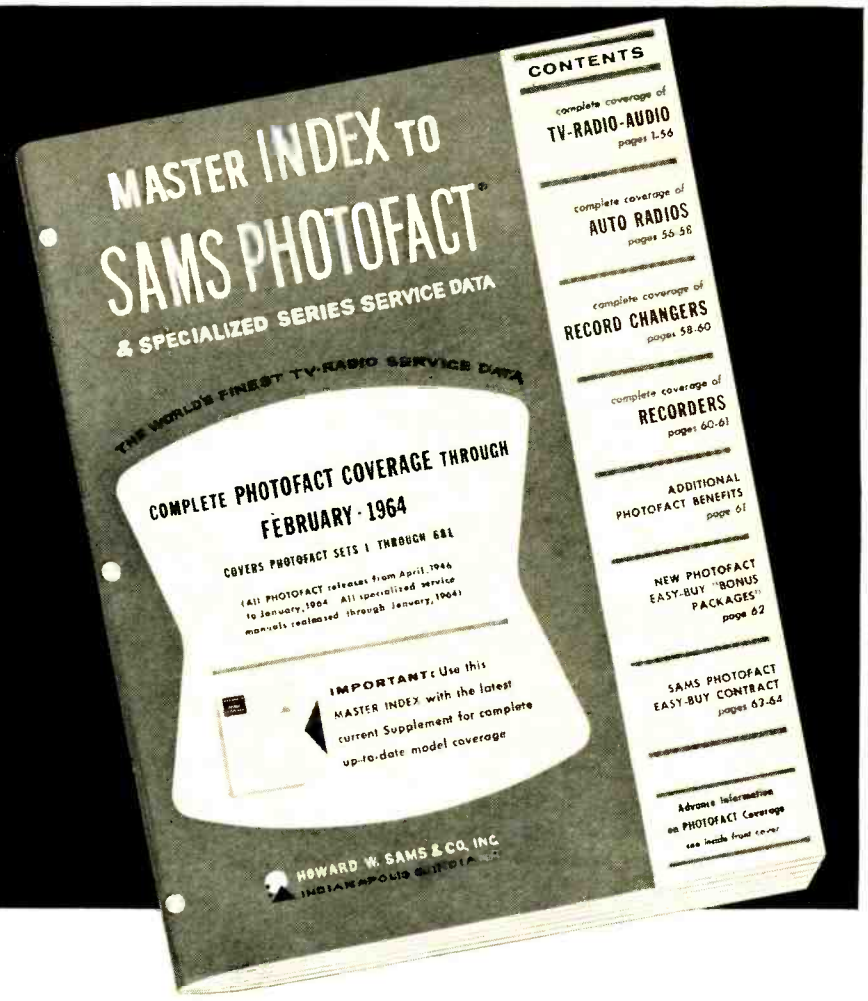
SUBSCRIPTION SERVICE: All subscription correspondence should be addressed to Electronics World, Circulation Dept., 434 South Wabash Ave., Chicago, Ill. 60605. Please allow at least six weeks for change of address. Include your old address as well as new—enclosing if possible an address label from a recent issue.

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

ELECTRONICS WORLD is published monthly by Ziff-Davis Publishing Company at 434 South Wabash Avenue, Chicago, Ill. 60605. (Ziff-Davis also publishes Popular Photography, Popular Electronics, HiFi/Stereo Review, Popular Boating, Car and Driver, Flying, Modern Bride, Amazing, and Fantastic.) Subscription rates: one year United States and possessions $5.00; Canada and Pan American Union countries $5.50; all other foreign countries $6.00. Second class postage paid at Chicago, Illinois and at additional mailing offices. Authorized as second class mail by the Post Office Department, Ottawa, Canada and for payment of postage in cash. January 1964. Vol. 71, No. 1.

PAYMENT MAY ALSO BE REMITTED in the following foreign currencies for a one year subscription: Australian pounds (2/16); Belgian francs (310); Danish kroner (43); English pounds (2/4/6); French francs (31); Dutch guilders (22); Indian rupees (31); Italian lire (3900); Japanese yen (2100); Norwegian kroner (45); Philippine pesos (25); South African rands (4.50); Swedish kronor (33); Swiss francs (27); West German marks (25).

need reliable service data?



Free SEND TODAY FOR YOUR NEW INDEX TO PHOTOFACT®!

your handy guide to the world's finest electronic service data

covers over 56,000 listings of:

- TV Receivers
- Home & Auto Radios
- Phonos & Hi-Fi
- Tape Recorders
- CB Radios
- Record Changers

Send today for this valuable 68-page guide covering virtually every model of home-entertainment electronic equipment produced since 1946! Helps you locate the proper PHOTOFACT Folder to quickly solve any service problem in any model. PHOTOFACT provides *everything* you need in complete, uniform style for quick, effective repairs: Famous Standard Notation Schematics packed with the service details you need; Full Photo Coverage of all chassis views; Complete Replacement Parts Lists; Tube Placement Diagrams; Alignment Instructions; CircuiTrace® for printed boards; Disassembly Instructions; Dial Cord Diagrams; Changer and Recorder "Exploded Views"—plus dozens of other great features. Send coupon for your FREE copy of the latest PHOTOFACT Index to the service data you need!

Take the Right Step to Time-Saving, Profit-building Servicing...See your Sams Distributor for details on an Easy-Buy PHOTOFACT Library and Standing Order Subscription.

NOW! INDEX INCLUDES MODELS COVERED IN THE PHOTOFACT SPECIALIZED SERIES MANUALS...

Lists all models now covered in the PHOTOFACT Specialized Series: Transistor Radios, Auto Radios, CB Radios, and Tape Recorders—absolutely complete!

SEND FOR FREE INDEX

HOWARD W. SAMS & CO., Dept. EWF-1
4300 W. 62nd St., Indianapolis 6, Indiana

☐ **Send FREE Photofact Index**

☐ Send full information on Easy-Buy Plan and Standing Order Subscription

My Distributor is _____

Shop Name _____

Attn.: _____

Address _____

City _____ Zone ____ State _____

For the record

WM. A. STOCKLIN, EDITOR

R & D AND UNEMPLOYMENT

OVER $20-billion will be spent this year on research and development in this country, and one can present many good arguments that this is insufficient. Certainly the strongest argument is that the Government pays for about ⅘ of all R & D and directs at least half of this towards our space program.

We need new ideas, new industries now—not tomorrow—if we hope to halt our ever-increasing unemployment. Our pre-war industries will not help since they need fewer employees as time goes on, in view of new competitive products and the increasing use of automation to take over a greater number of functions.

Imagine what our employment situation would have been like today if R & D funds had not developed such post-war innovations as television, jet airliners, new plastics, new drugs, and certainly an array of other products, including many new electronic systems. R & D is the only answer since new ideas must first appear in embryonic form in our research laboratories.

An ideal example is the development of the laser, which, no doubt, will be one of the greatest inventions of our decade.

A recent report from Tufts—New England Medical Center reflects some highly optimistic results obtained so far in the treatment of human cancer, transplanted in laboratory animals, by the use of lasar light energy.

Fourteen thyroidal carcinoma tumors were laser-treated. The malignant tumors disappeared completely in 13 of the 14 treated animals from 5 to 29 days following exposure to laser energy. The 14th died after 26 days from causes not connected with the treatment. A biopsy of this animal showed the tumor had been reduced by 90 percent. The successful results in all treated animals were verified by both visual and microscopic examination.

Eighteen malignant tumors arising on the skin and glands were treated; 17 more were controls. In the laser-treated group, 13 recovered completely in a period varying from 15 to 29 days following treatment. Seven of the treated animals retained for long-term study remained grossly free of tumor at periods ranging from 120 to 215 days. In all control tumors, the cancers continued to grow. In the 2 control animals retained for long-term study, the tumors were still viable at the end of 7 months. Distinct stages in the improvement of the treated animals could be noticed among all the reported cancers.

The lasers used in these experiments were various *Raytheon*-developed ruby-red solid-state pulsing devices ranging in output from ½ to 360 joules. Exposure time of the tumor to the laser light ranged from ½ to 3 milliseconds. The high-powered unit delivers an intensity of 360,000,000 watts per square foot.

Bear in mind that the work done so far is only experimental and on animals —not human beings—and much more research is necessary. Not only are these results promising, but the laser will eventually open a new industry with possibly hundreds of thousands of employees.

There are many other areas for R & D in connection with the laser. Its beam is extremely narrow, as small as 1/2000th of a degree in some cases. It is intense; *Raytheon's* LHM-4 produces a beam with an intensity of 500,000,000 watts per square foot, about 80 times more powerful than the sun. Pulse radars using lasers can measure distances over many miles and be accurate within two feet; c.w. lasers can have accuracies within fractions of an inch. A simple laser beam can carry 1 billion telephone conversations or 200,000 television programs. It can be used for vehicle guidance and control; it will produce a hole 2/10,000ths of an inch or about 300 holes on a pin head; it can weld microminiature circuits.

These are only a few of its many possibilities, yet for the most part the laser is still in the laboratory. R & D must find commercial applications.

Do we need more funds for R & D in this area? The answer is quite obvious—that funds are needed now, not tomorrow! And there are many other similar programs drifting along in other industries.

There are other problems, of course, particularly in retraining our present unemployed, but yet all other efforts, including the planned tax-relief program, are only temporary solutions. All major efforts must be directed towards making available more funds for basic research in our consumer and industrial areas—not just in our space program. ▲

Do you WISH you were EMPLOYED in ELECTRONICS?

F.C.C. License — The Key to Better Jobs

An F.C.C. *commercial* (not amateur) license is your ticket to higher pay and more interesting employment. This license is Federal Government evidence of your qualifications in electronics. Employers are eager to hire *licensed* technicians.

Which License for Which Job?

The THIRD CLASS radiotelephone license is of value primarily in that it qualifies you to take the second class examination. The scope of authority covered by a third class license is extremely limited.

The SECOND CLASS radiotelephone license qualifies you to install, maintain and operate most all radio-telephone equipment except commercial broadcast station equipment.

The FIRST CLASS radio telephone license qualifies you to install, maintain and operate every type of radio-telephone equipment (except amateur) including all radio and television stations in the United States, its territories and possessions. This is the highest class of radiotelephone license available.

Grantham Training Prepares You

The Grantham course covers the required subject matter completely. Even though it is planned primarily to lead directly to a first class FCC license, it does this by TEACHING you electronics. Some of the subjects covered in detail are: Basic Electricity for Beginners, Basic Mathematics, Ohm's and Kirchhoff's Laws, Alternating Current, Frequency and Wavelength, Inductance, Capacitance, Impedance, Resonance, Vacuum Tubes, Transistors, Basic Principles of Amplification, Classes of Amplifiers, Oscillators, Power Supplies, AM Transmitters and Receivers, FM Transmitters and Receivers, Antennas and Transmission Lines, Measuring Instruments, FCC Rules and Regulations, and extensive theory and mathematical calculations associated with all the above subjects explained simply and in detail.

Our Warranty

If you should fail the F.C.C. exam after finishing our course, we give additional training at NO ADDITIONAL COST. Read details in our free booklet.

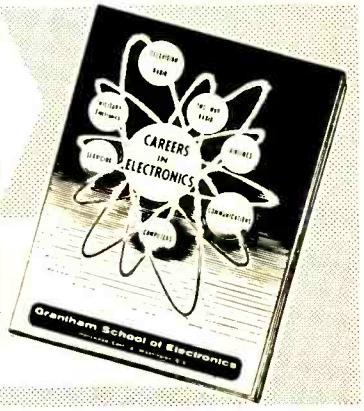
GET YOUR FIRST CLASS COMMERCIAL F.C.C. LICENSE QUICKLY!

Learn by Correspondence or in Resident Classes

Grantham training is offered by correspondence or in resident classes. Either way, we train you quickly and thoroughly – teach you a great deal of electronics and prepare you to pass the F.C.C. examination for a first class license. Get details now. Mail coupon below.

THIS 44 PAGE BOOKLET **FREE!**

This free booklet gives details of our training and explains what an F.C.C. license can do for your future. Send for your copy today.



HERE'S PROOF that Grantham students prepare for F.C.C. examinations in a minimum of time. Here is a list of a few of our recent graduates, the class of license they got, and how long it took them:

	License	Weeks
Robert J. Maickel, 520 Market St., Havre De Grace, Md.	1st	20
James D. Neidermyer, R.D. 1, Leola, Pa.	1st	10
Denis Christopherson, 4402 Waite Lane, Madison, Wisc.	1st	12
Guy C Dempsey, 1326 19th St., Washington, D.C.	1st	12
Charles Bartchy, 1222 S. Park Ave., Canton 8, Ohio	1st	10
William I. Brink, 12 Meade Ave., Babylon, L.I., N.Y.	1st	12
Earl J. Mahoney, Box 296, Newport, Vt.	1st	12
Hall Blankenship, Route 2, Rockwood, Tenn.	1st	12
David Kaus, 5218 Canterbury Way S.E., Washington, D.C.	1st	30
John A. Cork, 3535 N. Utah, Arlington 7, Va.	1st	12
Charles Deitzel, 342 Walnut St., Columbia, Pa.	1st	8½
Norman Tilley, Jr., 8613 Piney Branch, Silver Sprg, Md.	1st	30

GRANTHAM School of Electronics

NATIONAL ACCREDITED SCHOOL — NHSC — NATIONAL HOME STUDY COUNCIL

FIVE CONVENIENT TRAINING DIVISIONS:

Los Angeles, Calif. 1505 N. Western Ave., Los Angeles, Calif., 90027	HO 7-7727
South Gate, Calif. 9320 Long Beach Blvd., South Gate, Calif., 90280	564-3421
Seattle, Wash. 408 Marion Street, Seattle, Wash., 98104	MA 2-7227
Kansas City, Mo. 3123 Gillham Rd., Kansas City, Mo., 64109	JE 1-6320
Washington, D.C. 821 – 19th Street, NW, Washington, D.C., 20006	ST 3-3614

MAIL COUPON NOW...NO SALESMAN WILL CALL

mail in envelope or paste on postal card

To: **GRANTHAM SCHOOL OF ELECTRONICS**
NATIONAL HEADQUARTERS OFFICE
1505 N. WESTERN AVE., LOS ANGELES, CALIF., 90027

Please send me your FREE 44 page booklet telling how I can get my commercial F.C.C. license quickly and can continue into advanced electronics if I wish. I understand there is no obligation and no salesman will call.

Name _____ Age _____
(PLEASE PRINT)

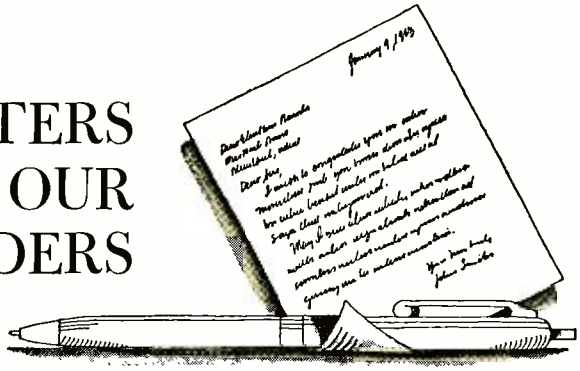
Address _____

City _____

State _____

I AM INTERESTED IN: ☐ HOME STUDY ☐ RESIDENT CLASSES 46A

LETTERS FROM OUR READERS



14-WATT TRANSISTOR AMPLIFIER

To the Editors:

I have received some letters from readers who have been unable to duplicate the results described in my article "14-Watt Transistor Hi-Fi Amplifier" (May, 1963 issue). The schematic as it appeared in the magazine has no errors. There have been several amplifiers built from the magazine that I know about; they all worked except where the builder did not follow good transistor techniques.

The problem of thermal runaway can exist only if the output transistors are not of the proper collector-to-emitter breakdown voltage (40 volts or higher) or if their I_{CEO} is excessive. Many power transistors have very large I_{CEO} which will cause this thermal instability the second they are heated. If good 2N441's are used, they should work satisfactorily. This parameter can, of course, be tested for before use if the transistors are of doubtful origin. Of the more than twenty amplifiers I have built for customers, I have never had any problem if the power transistors are tested for excessive I_{CEO} before use. A much better transistor type to use is the *Delco* 2N553.

A second problem that can cause trouble is again related to collector-to-emitter breakdown voltage, *not* collector-to-base breakdown voltage, which is always higher. Even a transistor like the 2N2043, which is listed with a breakdown voltage (collector-to-emitter) of 55 volts starts breaking up at 30 to 40 volts when used as a class-A amplifier. If the transistor types as specified in the text and parts list are used and the check-out procedure mentioned is used, the amplifier will work.

The d.c. voltages are included in the schematic. Again, if these are used in troubleshooting, the trouble caused by a defective component or incorrect wiring could be found. Also, it is important to use the 10,000-ohm pot method of applying the −50 v.d.c., as described in my article.

DAVID F. REHBERGER
Levittown, N. J.

* * *

AIRBORNE FIELD ENGINEERS

To the Editors:

I read with interest your article "Electronics Field Engineers Around the World" in the September issue of EW.

I am well acquainted with the exploits of these gentlemen in time of need, having been assisted by their services while serving as a navigator-bombardier in the B-47's of SAC.

It is with this background that I noted the center picture at the bottom of page 43, and the caption "Field engineer boards a B-58 . . . .". I hope he wasn't too disappointed when he found a B-47 at the top of the ladder, instead of a B-58. I've logged many two-way trips and even a one-way trip on those ladders and always found the view at the top typical of a B-47—exciting.

My hat is off to these gentlemen, whose motto seems to be, "It's not impossible, it'll just take a while."

DAVID P. JEHLIK
Concord, California

* * *

NAVAL OBSERVATORY TIME SIGNALS

To the Editors:

I was pleased to note that the August, 1963 issue of ELECTRONICS WORLD contained an article describing Naval Observatory time signals. However, the article contains a number of inaccuracies and it does not provide the latest information on time signals controlled by the U.S. Naval Observatory.

(1) Page 30, Table I: NSS frequency 121.95 kc. should be 162 kc.

(2) Page 83, line 2: The accuracy of the NSS time signal is given as 0.01 second. The accuracy of the NSS time signal is 0.0001 second, that is 0.1 millisecond. This is also the accuracy of the continuous transmissions of time signals on 18.0 kc. from NBA.

The first paragraph of the article is interestingly written, but (1) the award for developing the first practical chronometer was 20,000 pounds, and (2) the date of construction of the chronometer was 1759. It happens that this chronometer is now on exhibition at the U. S. Naval Observatory, through loan from the British Admiralty.

CAPT. T. S. BASKETT, USN
Supt., U.S. Naval Observatory
Washington, D. C.

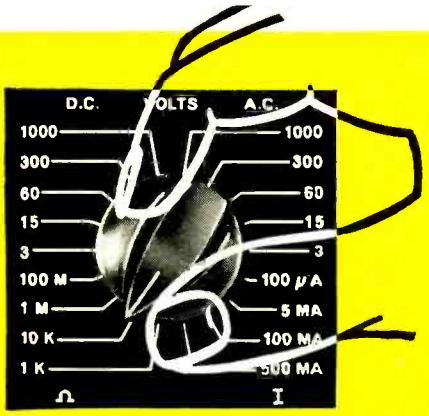
Thanks to Capt. Baskett for sending us some recent information on the Naval Observatory as well as the photos (one of which is shown here) of John Harri-

See Only the Scale You Want...in the Exact Range You Want

just set the range switch

and the correct scale appears

AUTOMATICALLY



in the new B&K

VOM and VTVM

V O MATIC 360

WITH BURN-OUT PROOF METER MOVEMENT

AUTOMATIC VOLT-OHM MILLIAMMETER

Greatly simplifies your VOM use. Individual full-size scale for each range—and only one scale visible at any one time, automatically. Once you set the range switch, it is impossible to read the wrong scale. Reading in the range you want is amazingly easy—and direct. No reading difficulties, no multiplying, no errors.

Sensitivity 20,000 ohms per volt DC; 5000 ohms per volt AC. **Accuracy** ±3% DC; ±5% AC; (full scale). DC Volts in 6 ranges 0-6000. **AC Volts** in 6 ranges 0-6000. **AF** (Output) in 4 ranges 0-300 volts. **DC Current** in 5 ranges 0-10 amps. **Resistance** in 4 ranges 0-100 megohms. Supplemental ranges also provided on external overlay meter scales. Meter protected against extreme overload and burn-out. Polarity reversing switch. Automatic ohms-adjust control. Mirrored scale. Complete with 1½-volt and 9-volt batteries, test leads, and easy-viewing stand.

Net, $59.95

DYNAMATIC 375

AUTOMATIC VACUUM-TUBE VOLTMETER

Once you set the range switch, you automatically see only the scale you want and read the exact answer directly. Saves time, eliminates calculation, avoids errors. Individual full-size direct-reading scale for each range. Simplifies true reading of peak-to-peak voltages of complex wave forms in video, sync and deflection circuits, pulse circuits, radar systems, etc. Includes DC current ranges, too.

Accuracy ±3% full scale AC and DC. **Sensitive** 100 microampere meter movement. **DC Volts** in 7 ranges 0-1500. **AC Volts** (rms) in 7 ranges 0-1500. **AC Volts** (peak-to-peak) in 7 ranges 0-1500. **DC Current** in 3 ranges 0-500 ma. **Ohms** in 7 ranges 0-1000 megohms. Utilizes single DA-AC ohms probe and anti-parallax mirror. Swivel stand converts to carry-handle. Includes 1½ volt battery.
Operates on 117 volts 50-60 cycle AC.

Net, $89.95

Ask Your B&K Distributor for Demonstration, or Write for Catalog AP21-N

B&K

B&K MANUFACTURING CO.
Division of DYNASCAN CORPORATION
1801 W. BELLE PLAINE AVE. • CHICAGO 13, ILL.
Canada: Atlas Radio Corp., 50 Wingold, Toronto 19, Ont.
Export: Empire Exporters, 253 Broadway, New York 7, U.S.A.

son's early chronometer. The photo does not do justice to the timepiece.—Editors.

° ° °

NOVEL ELECTROMETER TUBE

To the Editors:

In the most interesting article by C. E. Atkins on the *Tung Sol* 781 electrometer tube in your October, 1963 issue, could there be an error in the value of the dropping resistor specified for the 7851 tube? If, as indicated in the text, the tube heater requires 200 ma. at 2.5 volts, its apparent resistance is 12.5 ohms, and with only an 8-ohm resistor to an 8-volt source it would certainly be subjected to more than 2.5 volts. This would seem particularly important in view of the extreme sensitivity of the input impedance to small changes in the heater voltages. Also, where can the 7851 tubes be obtained?

Charles D. Geilker
Research Associate
Vanderbilt University
Nashville, Tennessee

The value of the dropping resistor should be 28 ohms instead of 8 ohms as shown on the circuit diagram. Somehow or other the 2 in front of the 8 got lost in printing. Also, the 7851 tubes can be obtained from any local Tung Sol distributor.—Editors.

° ° °

LASER CONSTRUCTION

To the Editors:

Can you send me plans so that I can build a laser? As an alternate, I would like details for constructing the circuit shown in Fig. 3 of the article "Electronic Anesthesia" in your September issue.

Barry Whitmore
Chicago, Illinois

Glad to hear that our articles are of interest, but all articles of this type are designed to inform and not serve as do-it-yourself projects. Besides, we feel there is much danger in inexperienced people working with potentially dangerous equipment. The laser, for example, is able to produce severe retinal burns if the beam is allowed to strike the eye. In the case of the anesthesia story, we intentionally omitted all parts values to discourage just this type of experimentation.—Editors. ▲

READER SERVICE PAGE

Please use the coupon at the bottom of this page to obtain more information about products advertised in this issue.
Simply circle the number on the coupon that corresponds to the number at the bottom of the advertisement in which you are interested.

Additional information on items mentioned in **"New Products," "Hi-Fi Product Report,"** and **"Test Equipment Product Report"** can also be obtained by following this same procedure.

PRINT your name and address on the coupon and mail it to:

ELECTRONICS WORLD
P.O. BOX 7842
PHILADELPHIA 1, PA.

Your requests for literature will be forwarded to the manufacturers who will be glad to fill them promptly.

ELECTRONICS WORLD
P.O. BOX 7842
PHILADELPHIA 1, PA.

TOTAL NUMBER OF REQUESTS ☐

Please send me additional information concerning the products of the advertisers whose code numbers I have circled.

100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139
140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179

NEW PRODUCTS		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
42	43	44	45	46	47																

(Key numbers for advertised products also appear in Advertisers Index)

NAME *(PRINT CLEARLY)* _____

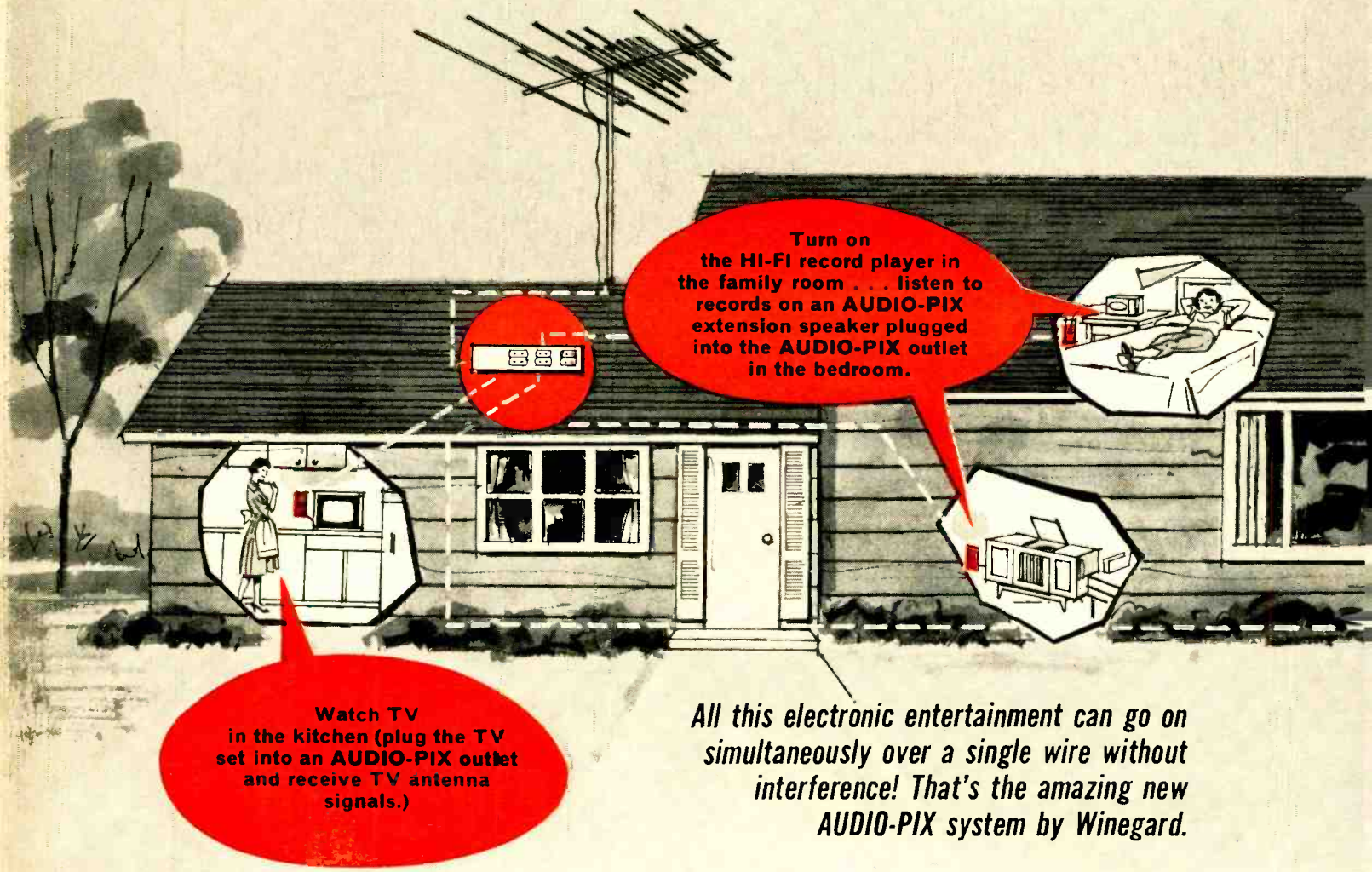
ADDRESS _____

CITY _____ ZONE _____ STATE _____

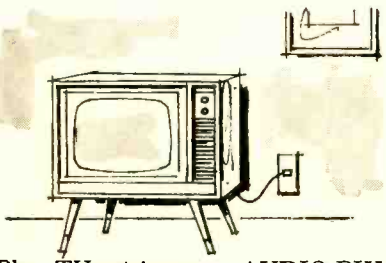
VOID AFTER JANUARY 31, 1964 **1**

NEW IDEA

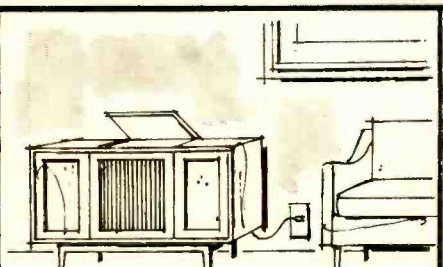
Winegard Introduces An Amazing New Home TV and Music Outlet System



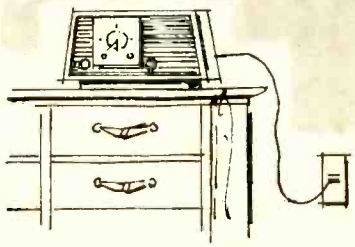
All this electronic entertainment can go on simultaneously over a single wire without interference! That's the amazing new AUDIO-PIX system by Winegard.



Plug TV set into any AUDIO-PIX outlet. Run one or more sets simultaneously from a single antenna.



Run a HI-FI (record player, FM or AM, or tape recorder) and feed the sound into the system to be picked up at any AUDIO-PIX outlet.)



Plug an FM receiver into the AUDIO-PIX. The AUDIO-PIX serves as an FM antenna signal source, and at the same time automatically feeds the FM sound back into the system to the extension speakers.

AUDIO-PIX delivers TV, FM or HI-FI

Anywhere Inside or Outside the House Over a Single Wire

Watch TV on the patio (the portable TV set is plugged into an AUDIO-PIX outlet and is receiving TV signals from the same antenna.)

Audio-Pix comes beautifully packaged in a Winegard selling display carton with built-in carrying handle.

AUDIO-PIX is two systems wrapped into one simple, inexpensive installation. It is both a TV-FM system (distributes TV/FM antenna signals) and a HI-FI music system at a price any home owner can afford. No new home is truly modern without AUDIO-PIX.

The AUDIO-PIX is a revolutionary new electronic entertainment convenience for the home which—

(1) . . . feeds TV (Ch. 2-83) and FM antenna signals to each AUDIO-PIX outlet.

(2) . . . feeds sound from a HI-FI (record player, FM and tape recorder) to the same AUDIO-PIX outlets.

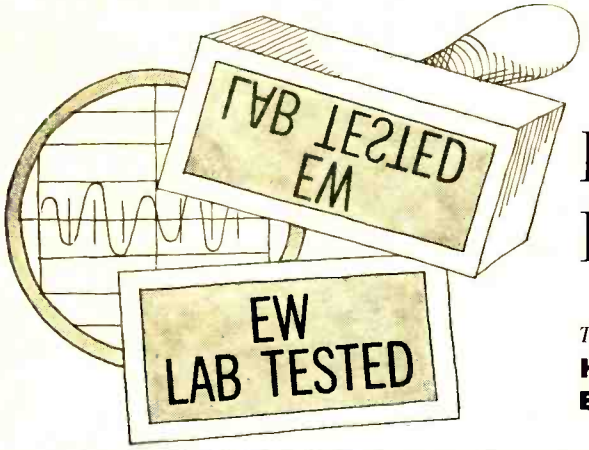
The complete Winegard AUDIO-PIX system comes in a kit which contains a special AUDIO-PIX 6-outlet coupler*, 4 AUDIO-PIX outlets and plugs (any number of additional outlets may be added if desired), special AUDIO-PIX HI-FI extension speaker, a special AUDIO-PIX attachment for FM or HI-FI system, and 100 ft. of lead-in wire. Model APK-360, list price $49.95.

Start selling AUDIO-PIX to your customers now. Write for spec sheets or ask your distributor.

*Pat. Pend.

Winegard
ANTENNA SYSTEMS
3003-1 Kirkwood, Burlington, Iowa

CIRCLE NO. 142 ON READER SERVICE PAGE



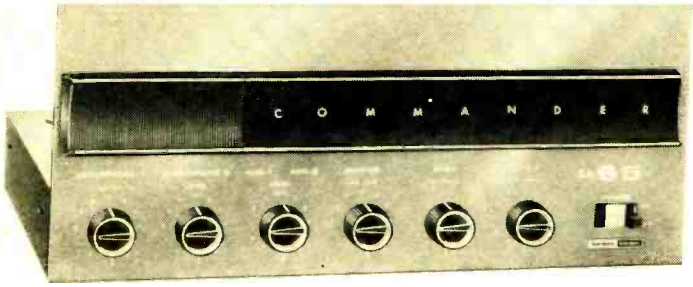
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Harman-Kardon CA-65 P.A. Amplifier
Electro-Voice 717 Microphone

Harman-Kardon CA-65 P.A. Amplifier

For copy of manufacturer's brochure, circle No. 43 on coupon (page 15).



PUBLIC-address amplifiers, like those used in home-music systems, must satisfy many types of users with widely differing requirements. Such p.a. installations may vary in complexity from simple background-music systems with only a single input and one or two speakers for small restaurants, to elaborate multi-speaker systems with several inputs for microphones, as well as separate inputs for tuner, phonograph, and tape recorder.

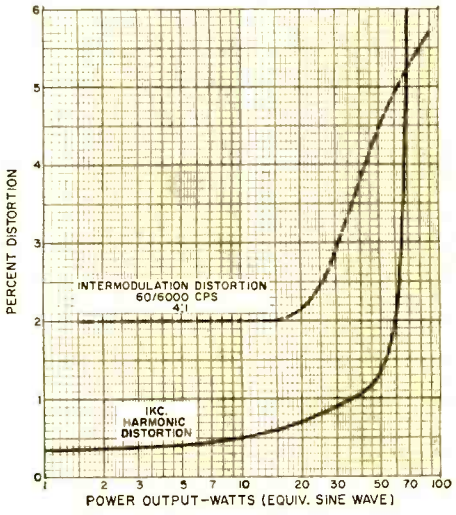
The *Harman-Kardon* "Commander" series of amplifiers is designed with high flexibility, so as to be adaptable to both the simplest and most complex applications with a maximum use of their capabilities. The "Commander" series includes several amplifiers of different power ratings, up to 100 watts. This report describes the Model CA-65, rated at 65 watts.

The CA-65 is interesting for its modular construction, which allows the user, in effect, to assemble a custom amplifier to suit his particular requirements. The basic amplifier is a 65-watt unit, with two microphone and two high-level inputs. It uses a pair of 8417 output tubes, and silicon rectifiers in the power supply. Each microphone input has its own level control, and a single control varies the level of the two high-level inputs and allows smooth fading between them. In addition, there is a master gain control and separate bass and treble tone controls. On the rear apron are the various input and output connectors, for high- or low-impedance microphones, speaker loads from 4 to 16 ohms, and a pair of five-pin sockets with a 77-ohm output plus the 4-, 8-, and 16-ohm outputs, and both 25-volt and 70.7-volt balanced and unbalanced line outputs.

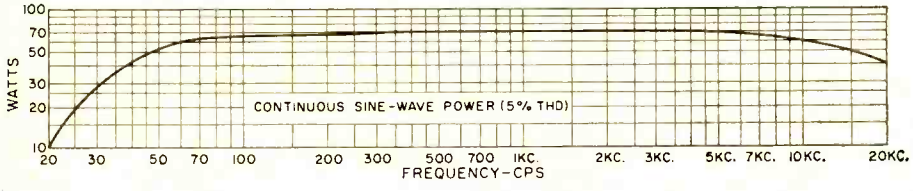
The amplifier has phono-jack inputs for high-level signals, and outputs for feeding a tape recorder either ahead of the tone controls or after them, or for bridging more than one amplifier for increased power capability. If low-impedance microphones are used, plug-in matching transformers are required. The sockets for them are already mounted and wired. Transformers are available for microphones with impedances from 30 to 600 ohms.

When a magnetic phono cartridge or tape head is used for a signal source, the plug-in Model CPE-3 equalizing preamplifier module is installed. It feeds one of the "Aux" inputs, and has a switch to select RIAA, 7½-ips, or 3¾-ips tape playback equalization. When more than two microphone inputs are required, the Model CPR-2 two-channel microphone amplifier is plugged into another socket on the chassis. This duplicates the normal input facilities, with its two level controls appearing on the front panel, which is already marked for them. A removable cover plate hides the holes and markings if the Model CPR-2 is not used.

An interesting optional feature of the CA-65 is the "Electronic Precedence Switching," Model EPS-1. This is a plug-in diode switch which is actuated by the press-to-talk switch of a microphone or any other s.p.s.t. switch which can be connected to the terminals in the rear of the amplifier. When the terminals are connected, all inputs except for one microphone are silenced, so that announcements may be inserted at any time without disturbing the other control settings. When the actuating switch is opened, the normal program fades in smoothly.



An 8-position area/speaker switching assembly, Model SS-8, can be mounted on the chassis with all its switches appearing on the front panel in place of the removable cover plate which is ordinarily mounted there. Up to eight speakers may be independently switched on or off with the Model SS-8. A rotary switch on the SS-8 permits any group of speakers to be programmed, without

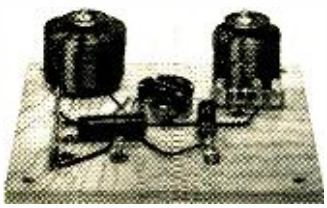


Who can build all this into a 6½″ deep cabinet?

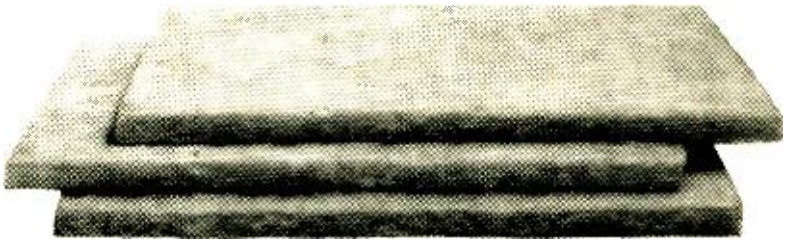
12″ woofer with 6-lb. magnet structure, 2″ voice coil, half-roll cotton surround, and 25 cps free-air resonance

5″ midrange driver with Butyl-coated surround and sealed metal back

3″ cone-type tweeter with 2-lb. magnet structure, hemispherical dome bonded directly to 1″ voice coil, and sealed metal back



3-way inductive-capacitive dividing network with 1200 cps and 2800 cps crossovers, and continuously variable tweeter control



High-absorbency AcoustiGlas padding

You!

(with the Fisher KS-2 StrataKit)

You install the three drivers, wire them to the dividing network, put in the padding, complete the assembly of the cabinet—and you are the owner of the most advanced slim-line speaker system available today, only 6½″ deep by 25″ high by 20″ wide. Despite its moderate dimensions, the Fisher KS-2 StrataKit has virtually uniform response from 35 to 20,000 cps and rivals the most advanced professional loudspeakers in clarity, transient response and over-all 'bigness' of sound. And —it is priced at only $89.50.* The Fisher KS-1 StrataKit, a slightly smaller and even slimmer (5¾″ deep) 3-way speaker system, costs only $59.50.**

FREE! $1.00 VALUE! The Kit Builder's Manual, an illustrated guide to high fidelity kit construction, complete with detailed specifications of all Fisher StrataKits.

The Kit Builder's Manual

Fisher Radio Corporation
21-38 44th Drive
Long Island City 1, New York

Please send me the free Kit Builder's Manual.

Name _____

Address _____

City _____ State _____

07111

*In sanded but unfinished birch. Also available in unfinished walnut, $94.50. Factory assembled, in finished birch, $114.50; in oiled walnut, $119.50.
**In sanded but unfinished birch. Also available in unfinished walnut, $64.50. Factory assembled, in finished birch, $84.50; in oiled walnut, $89.50. All prices slightly higher in the Far West. Overseas residents write to Fisher Radio International, Inc., Long Island City 1, New York. Canadian residents write to Tri-Tel Associates, Ltd., Willowdale, Ont.

disturbing their normal operation, so that turning the switch leaves only the desired speakers in use. This is convenient for selective paging announcements where a number of locations are served by the same amplifier.

Other optional accessories include a phono top, with four-speed record player; a cover plate to conceal the front-panel controls; a rack-mounting tray; a carrying case; plug-in level equalizers which convert the microphone inputs to high-level inputs; and a dust cover.

Obviously, the CA-65 can be adapted to almost any public-address requirement, including some with rather involved control setups. Apart from its operating features, the CA-65 proved to be a conservatively rated, good-quality amplifier. It delivered over 70 watts with the rated 5% distortion at middle frequencies, with somewhat less power available below 60 cps and above 10,000 cps. Its frequency response was flat within ± 0.5 db from 20 to 20,000 cps. The RIAA phono equalization was very accurate, but the 7½-ips tape playback equalization fell off below 200 cps, to −9 db at 30 cps.

The harmonic distortion at 1000 cps was under 0.5% up to 10 watts, reaching 2% at 60 watts output. The IM distortion had a residual level of about 2%, rising above 20 watts. This reflects the reduced power handling ability of the amplifier at 60 cps and below.

The hum level, referred to rated output, was − 82 db on high-level inputs, −56 db on phono, and − 42 down on tape inputs. The high gain of the phono preamplifier requires only about 3 millivolts to drive the amplifier to a full 65-watt output, so it can be used with high-quality magnetic cartridges which sometimes have a low output level.

To summarize, the CA-65 is an unusually flexible, high-quality public address amplifier. It meets or exceeds practically all of its performance specifications which we were able to check. The basic unit is listed for $166.13; the two-channel mike module is $29.38; the magnetic phono, tape-head module is $19.00; and the area selector switching assembly is $23.75. ▲

Electro-Voice Model 717 Microphone

For copy of manufacturer's brochure, circle No. 44 on coupon (page 15).

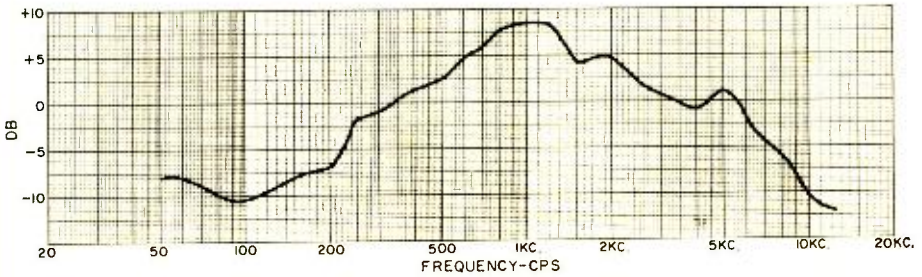
THE *Electro-Voice* Model 717 is a close-talking ceramic microphone designed mainly for communications service. It is housed in a rugged, attractive molded plastic case, which is impact resistant and designed to feel comfortable at almost any temperature when hand-held.

The Model 717 is a high-impedance, noise-cancelling microphone with a cardioid pattern. Sounds from the rear and sides are rejected by as much as 67% by admitting them to a port in the rear of the microphone so that they arrive out of phase with the frontal sounds. Its rated frequency response is 100 to 7000 cps, with the response curve shaped for high intelligibility.

The mike has a "push-to-talk" button which shorts the microphone elements in the "off" position and operates an external relay circuit in the "on" position. The attached three-wire cable is a coiled cord, 10 inches long when retracted and about four feet when fully extended. The microphone is supplied with a bracket for hanging it on a vehicle dashboard or other surface when not in use.

We measured the frequency response of the unit at a distance of one foot from a loudspeaker, comparing its output with that of our calibrated lab microphone in the same position. Its effective response appeared to extend from below 50 cps to at least 10,000 cps. There was a broad mid-range rise, peaking at 1000

(*Continued on page 69*)



NOW...GET THE FINEST STEREO TEST RECORD ever produced for just...$4.98

Featuring Tests Never Before Available Outside Of The Laboratory

UNIQUE FEATURES OF HiFi/STEREO REVIEW'S
MODEL 211 STEREO TEST RECORD

- Warble tones to minimize the distorting effects of room acoustics when making frequency-response checks.

Warble tones used are recorded to the same level within ± 1 db from 40 to 20,000 cps, and within ± 3 db to 20 cps. For the first time you can measure the frequency response of a system without an anechoic chamber. The frequency limits of each warble are within 5% accuracy.

- White-noise signals to allow the stereo channels to be matched in level and in tonal characteristics.
- Four specially designed tests to check distortion in stereo cartridges.
- Open-air recording of moving snare drums to minimize reverberation when checking stereo spread.

Why We Make the Model 211 Available Now

Although there are many stereo test records on the market today, most critical checks on existing test records have to be made with expensive test equipment.

Realizing this, HiFi STEREO REVIEW decided to produce a record that allows you to check your stereo rig, accurately and completely, just by listening! A record that would be precise enough for technicians to use in the laboratory—and versatile enough for you to use in your home.

The result: the HiFi STEREO REVIEW Model 211 Stereo Test Record!

Stereo Checks That Can Be Made With the Model 211

- Frequency response—a direct check of eighteen sections of the frequency spectrum, from 20 to 20,000 cps.
- Pickup tracking — the most sensitive tests ever available on disc for checking cartridge, stylus, and tone arm.
- Hum and rumble—foolproof tests that help you evaluate the actual audible levels of rumble and hum in your system.
- Flutter—a test to check whether your turntable's flutter is low, moderate, or high.
- Channel balance — two white-noise signals that allow you to match your system's stereo channels for level and tonal characteristics.
- Separation—an ingenious means of checking the stereo separation at seven different parts of the musical spectrum—from mid-bass to high treble.

ALSO:

- Stereo Spread
- Speaker Phasing
- Channel Identification

PLUS SUPER FIDELITY MUSIC!

The non-test side of this record consists of music recorded directly on the master disc, without going through the usual tape process. It's a superb demonstration of flawless recording technique. A demonstration that will amaze and entertain you and your friends.

All Tests Can Be Made By Ear

HiFi/STEREO REVIEW's Model 211 Stereo Test Record will give you immediate answers to all of the questions you have about your stereo system. It's the most complete test record of its kind—contains the widest range of check-points ever included on one test disc! And you need no expensive test equipment. All checks can be made by ear!

Note to professionals: The Model 211 can be used as a highly efficient design and measurement tool. Recorded levels, frequencies, etc. have been controlled to very close tolerances—affording accurate numerical evaluation when used with test instruments.

DON'T MISS OUT—SUPPLY LIMITED

The Model 211 Stereo Test Record is a disc that has set the new standard for stereo test recording. Due to the overwhelming demand for this record, only a limited number are still available thru this magazine. They will be sold by ELECTRONICS WORLD on a first come, first serve basis. At the low price of $4.98, this is a value you won't want to miss. Make sure you fill in and mail the coupon together with your check ($4.98 per record) today.

FILL IN AND MAIL TODAY!

Stereo Test Record
Electronics World—Dept. SD
One Park Ave., New York 16, N.Y.

Please send me _____ test records at $4.98 each. My check (or money order) for $_____ is enclosed. I understand that you will pay the postage and that each record is fully guaranteed. (Orders from outside the U.S.A. add 50c to partially defray postage and handling costs.)

Name _____
(Please Print)

Address _____

City _____ Zone _____ State _____

SORRY—No charges or C.O.D. orders! EW-14

TUNER SECTION: In the kit, the two most critical sections —the front end and the IF strip—are supplied prewired and pre-aligned; and a high quality circuit board and pre-aligned coils are provided for the stereo demodulator circuit. The IF strip has 4 amplifier-limiter stages and a wideband ratio detector for perfect limiting and flat frequency response. Sensitive bar-type electron-ray tuning indicator pinpoints the center of each broadcast channel for lowest distortion, and also serves as the stereo program indicator.

Antenna input: 300 ohms balanced ☐ IHFM usable sensitivity: 3 μv (30 db quieting), 1.5 μv for 20 db quieting ☐ Sensitivity for phase locking (synchronization) in stereo: 3 μv ☐ Full limiting sensitivity: 10 μv ☐ IF bandwidth: 280 kc at 6 db points ☐ Ratio detector bandwidth: 1 mc peak-to-peak separation ☐ Audio bandwidth at FM detector: flat to 53 kc ☐ IHFM signal-to-noise ratio: 55 db ☐ IHFM harmonic distortion: 0.6% ☐ Stereo harmonic distortion: less than 1.5% ☐ IHFM capture ratio: 3 db ☐ Channel separation: 30 db.

AMPLIFIER SECTION: High quality Baxandall bass and treble controls do not interact or affect loudness, permit boost or cut at extremes of range without affecting mid-range. Balance control is infinitely variable, permitting complete fade of either channel. Blend control is variable from switch-out, for maximum separation, to full blend. Tape Monitor switch permits off-the-tape monitoring with the Eico RP100 Stereo Tape Recorder.

Power: 36 watts IHFM music, 28 watts continuous (total) ☐ IM distortion (each channel): 2% at 14 watts, 0.7% at 5 watts, 0.2% at 1 watt ☐ Harmonic distortion (each channel): 0.6% at 10 watts, 40 cps to 10 kc; 0.2% at 1 watt, 30 cps to 20 kc ☐ IHFM power bandwidth at rated continuous power, 1% harmonic distortion: 30 cps to 20 kc ☐ Frequency response ±1 db, 15 cps to 40 kc ☐ Speaker output: 8, 16 ohms ☐ Inputs: Magnetic phono or adapted ceramic phono, tuner, tape auxiliary ☐ Sensitivity: 2.3 mv phono, 250 mv others ☐ Noise: —65 db at 10 mv, mag phono;—80 db others.

New Eico Classic 2536 Stereo FM Receiver

Now... every other stereo receiver seems overpriced

Take a superb stereo tuner, guaranteed stable under all conditions, and sensitive enough to give full stereo separation even on weak, fringe-area signals . . .

Add a virtually distortion-free 36-watt stereo amplifier with remarkable overload and transient characteristics . . .

Mount them on one chassis—effectively separated for the performance benefits of components plus the convenience of a single compact unit. . . . Price this combination at $209.95 factory-wired, and at $154.95 in a new kit pack that makes building a delightful experience—and what do you have? The Classic 2536 Stereo Receiver, star of the new Eico Classic Series, and a component that matches or surpasses the performance of components selling at substantially higher prices. How? Simple. It's pure performance. Stripped of everything but the finest basic circuitry. Examine the specifications yourself. Compare them with those of more expensive units. Listen to the 2536—then to higher priced units. Can you see or hear a difference worth paying for?

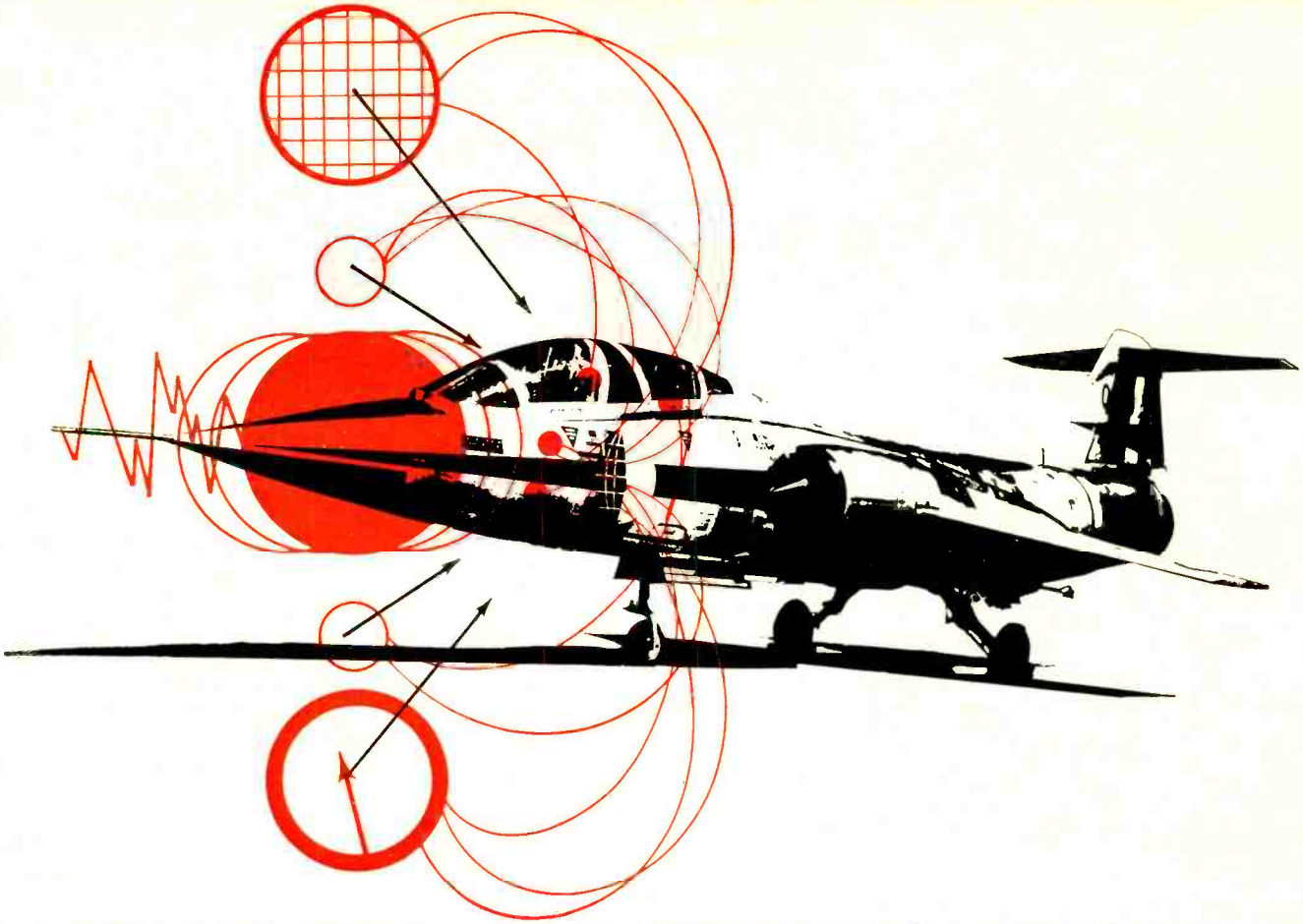
If you're interested in building a fine stereo receiver, take a long look at our new kit pack, too. Note the logical, orderly arrangement of parts. How easily it sets up for work. How easily it closes down between work sessions—with no loose parts to go astray. Thumb through the 2-color Construction Manual. Ever see such graphic diagrams? Every step is clear and unmistakable—and no diagram shows more than 20 steps. Another thing the diagrams show you: how simple the wiring is. No tricky frills; no clutter; no confusion, even around switches and controls. Plenty of space to work in. And Eico has eliminated the most tedious part by pre-mounting jacks, sockets, terminal boards, and transformers.

Does any other kit give you more building ease, or assurance of success than the Eico Classic? See it at your hi-fi dealer. Optional Walnut Cabinet WE-73, $19.95, Metal Cover E-12, $7.50.

EICO ELECTRONIC INSTRUMENT CO. INC.
131-01 39th Avenue, Flushing, N. Y. 11352
Export: Roburn Agencies, Inc., 431 Greenwich St., N. Y. 13

EICO ADD 6% IN WEST

Circle No. 109 on Reader Service Page

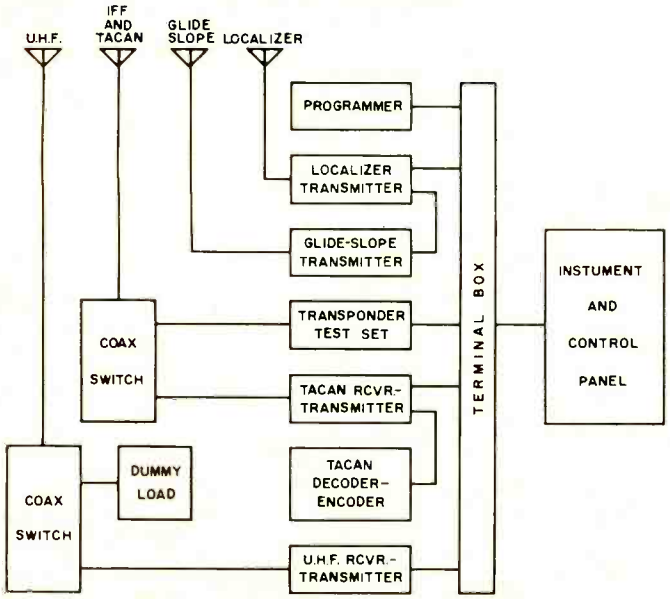


AUTOMATIC ELECTRONIC TESTING

By KEN GILMORE

Many electronic systems that are currently being employed in military aircraft and for missile tracking and guidance are far too sophisticated for human checking and troubleshooting. Hence, other electronic systems are checking out this equipment and locating troubles quickly. Components, semiconductors, and tubes are also being tested automatically.

Fig. 1. Simplified diagram of "RADFAC," Republic Aviation's radiating test facility. In 2-minute test sequence, it checks a plane's u.h.f. gear, its IFF, Tacan, ILS, and automatic pilot.

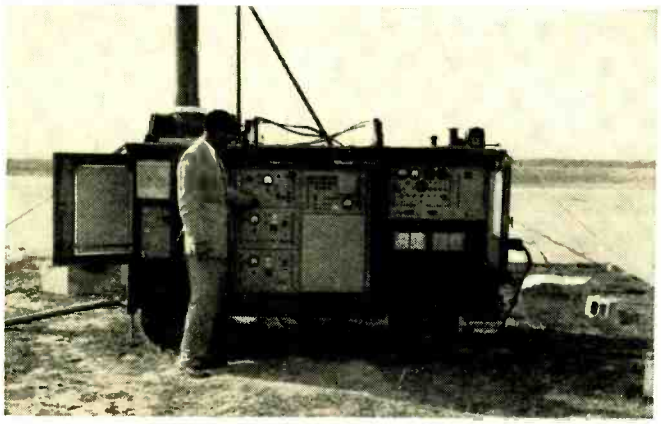


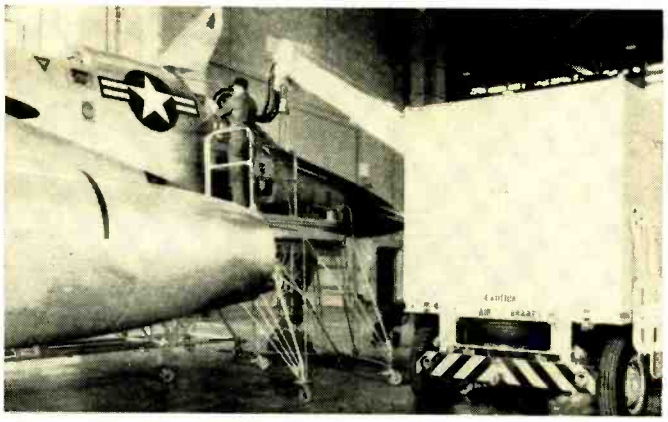
AT Air Force bases around the world these days, fighter pilots taxi out onto the runway, pause before take-off, and press a button on the complex instrument panel. A u.h.f. transmitter in the plane sends out a signal modulated by a 1020-cps tone.

A receiver mounted in an equipment-filled trailer parked near the runway picks up the signal, responds to the 1020-cps tone, and starts a tape recorder. One channel of the tape plays back a series of complex signals designed to put the plane's electronic equipment through a series of performance tests. From the other channel comes a small, calm, feminine voice which whispers instructions into the pilot's ear. As the automatic tester transmits one performance test after another, the girl's voice tells the pilot what indications he should be getting from the meters and signal lights on his electronic equipment, and how he should respond. Within two minutes, the plane's IFF transponder, u.h.f. receiver, ILS display, Tacan system, and autopilot are certified operational, and the pilot takes off.

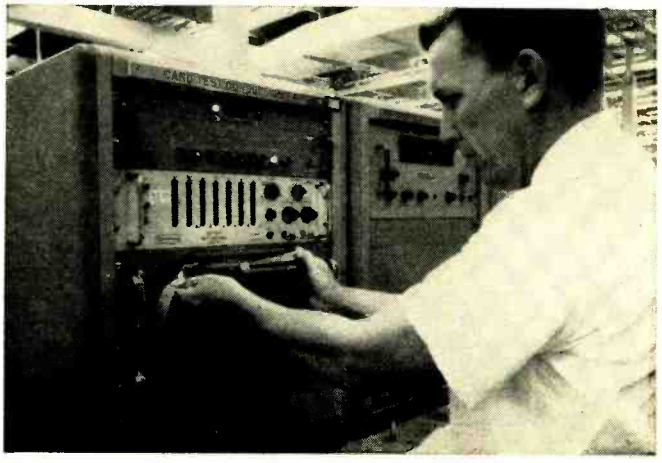
Using conventional instruments and techniques, a skilled team of technicians would take at least an hour to accomplish the same thing in a pre-flight checkout. But *Republic Aviation's* "RADFAC"—*RAD*iating test *FAC*ility—does it all in minutes, accurately and efficiently. See Fig. 1.

Automatic checkout devices such as "RADFAC" are becoming common in today's complex military, space, and in-





(Left) The "RADFAC" system puts a plane's u.h.f. equipment, IFF, Tacan, ILS, and autopilot through a complete operational test procedure in two minutes while the plane is waiting to take off. The unit, which has a 2-mile range, is parked near a runway. Since the test procedures are done by radio, the plane's complete electronic systems, including antennas, are checked out. (Right) The trailer houses an automatic ground check-out system for bombing and navigation equipment of the B-58 jet bomber. Sperry developed the system which can make one automatic measurement every four seconds and complete bombing-navigation checkout in a few hours. This checkout, involving thousands of measurements, previously took days.



(Left) "D-PAT" uses a digital computer with a test program stored on a magnetic memory drum. After going through an extensive automatic testing procedure, the unit flashes repair instructions on a viewing screen, displaying a picture of the malfunctioning assembly with a bright red arrow pointing to the part causing the trouble. (Right) A coded Mylar tape is being inserted into "TAPAT" (Tape Programmed Automatic Tester). The unit cuts the time and cost of inspection of printed circuit cards and allows the tests that are made by the system to be monitored readily by means of non-technical personnel.

dustrial electronics systems. Current installations are simply too big, too complicated, for efficient human checking and troubleshooting.

Sometimes pyramiding complexity and the laws of probability combine to make manual testing completely impractical. A modern supersonic bomber—the B-58, for example—has nearly a million parts in its inconceivably complex communications, navigation, identification, and electronic warfare systems. No part is perfect: each has a probability of failure. The more parts involved in any system, the shorter the average time between systems failures. Electronic designers calculate such probabilities on a statistical basis to determine predicted systems reliability. The resultant figure is the equipment's MTBF—Mean Time Between Failures.

With rigorous reliability testing, engineers have managed to get the MTBF for the electronic systems of the B-58 up to about 10 hours. But manual checkout for the complex system would take days. Failures, in other words, would happen faster than they could be found and corrected manually. Only with high-speed, automatic testing can such a system be kept operational for a long enough period of time to perform its mission properly.

BMEWS Automatic Testing

One of the most striking examples of automatic testing now in operation keeps our Ballistic Missile Early Warning System in operating order. BMEWS is extremely complex. Powerful radars in Thule, Greenland; Clear, Alaska; and Yorkshire, England spread their fan-shaped beams over the North Polar regions to detect any intruder which comes into view over the top of the world. Computers at each installation analyze the radar data and compute speed, bearing, trajectory, predicted point and time of impact of any missile which appears. Each station sends its data to a central computing and display system at North American Air Defense Command headquarters in Colorado Springs. There, additional computers correlate signals from all installations and decide whether targets detected by the radar signal the beginning of an enemy attack or not.

The BMEWS system *must* be in perfect operating condition at all times. Further, crews must *know* that all systems are ready. The sheer complexity of the system rules out manual checking. To do the job, *RCA* has designed and built "CAM"-Checkout and Automatic Monitoring.

"CAM" is set up to perform two functions simultaneously without interfering with the normal operation of the system. Fig. 2 shows the over-all plan. The first job—detecting potential and actual malfunctions and isolating them rapidly so that technicians can make repairs—is done by the Automatic Monitoring Subsystem. The second—checking out the entire system under actual operating conditions—is the duty of the Checkout Subsystem.

The Automatic Monitoring Subsystem does the first job by continuously checking conditions at key points throughout the system. Voltages, r.f. signals, and pulses are compared with stored standards by a series of comparator circuits. A certain circuit, for example, might be designed to operate at 100 volts ± 5%. The automatic monitoring system thres-

hold would then be set at 95 and 105 volts. If the voltage drifts beyond these limits, the monitoring circuit sounds an alarm.

Fig. 3 shows the general plan of the Automatic Monitoring System. When it spots trouble, a light on the control console turns from green to yellow and the alarm sounds. The operator on duty checks the panel to find out which unit is giving the trouble signal. He then selects a special deck of punched cards, corresponding to the trouble circuit, and puts them in a card reader at the left of the control console. The signals generated by the card reader put the faulty section through a fast, detailed, automatic check to locate the component giving the trouble (Fig. 4). The printer unit begins to chatter, and types out a list of check points which fall outside the pre-set tolerance.

This sequential checking capability is a useful tool for routine maintenance, too. Periodically, the machine can be set to print out conditions at every check point. Values or operating conditions which change slowly—over weeks or months—begin to show up even before tolerance limits are reached, so repairs can be made before failure occurs.

To double-check the monitoring system—and prove the equipment under actual conditions—"CAM" provides another completely separate checking system: the Checkout Subsystem. This is, in effect, a giant automatic signal tracer. Heart of the Checkout Subsystem (Fig. 5) is a checkout data processor—a computer which controls the entire process and analyzes the results to see that they meet all standards. The Checkout Subsystem does its job by simulating an actual raid. In operation, a magnetic tape reader feeds two kinds of signals into the data processor. The first is fed to a target simulator which, with the help of an r.f. target generator, injects signals into the radar's receiver which look like real targets on the radar screen. The targets are tagged with special markers so that personnel operating the equipment know that a test is going on. The radar's computing system analyzes the trajectory data, Doppler shift, and other target information which it derives from the false targets, and decides whether the targets are planes, satellites, or missiles. If they are missiles, it calculates the place of origin, point and time of predicted impact, and other data.

Meanwhile, the second category of signals fed into the checkout data processor tells the processor what conclusions the BMEWS system should reach if everything is in a proper operating condition, and if the target information is analyzed accurately. The processor then compares the system's actual conclusions with those it should have reached. Discrepancies are printed out automatically.

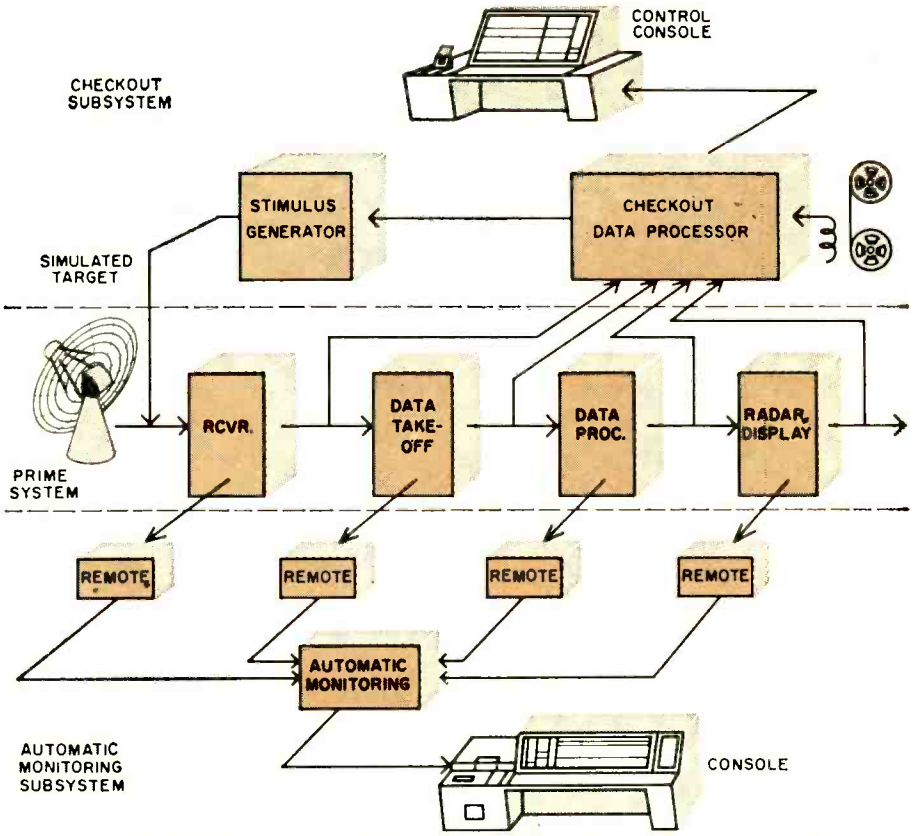


Fig. 2. "CAM" keeps our Ballistic Missile Early Warning System in operation. The Automatic Monitoring Subsystem continuously monitors voltages, currents, frequencies, and other parameters to make sure they remain within predetermined tolerances. The Checkout Subsystem operates as a large signal tracer. It generates false targets which are processed through system; then checks output.

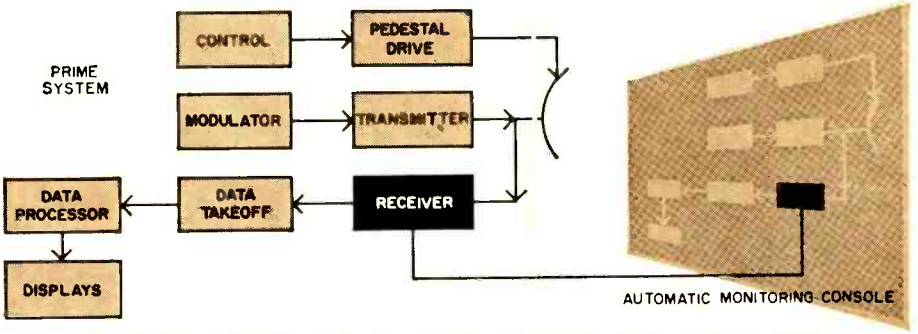
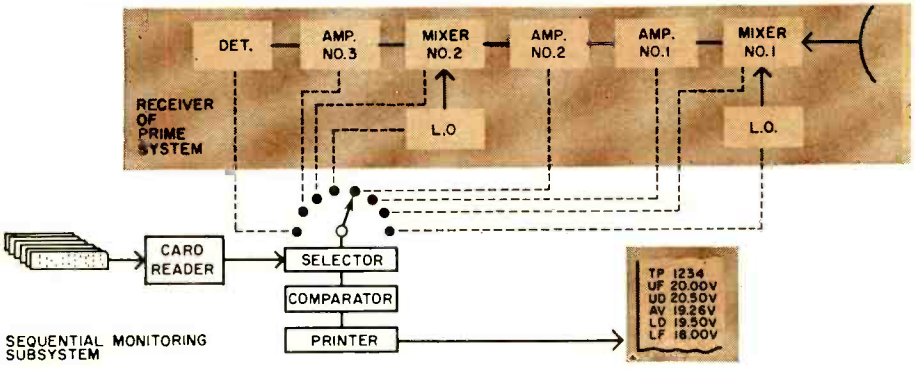
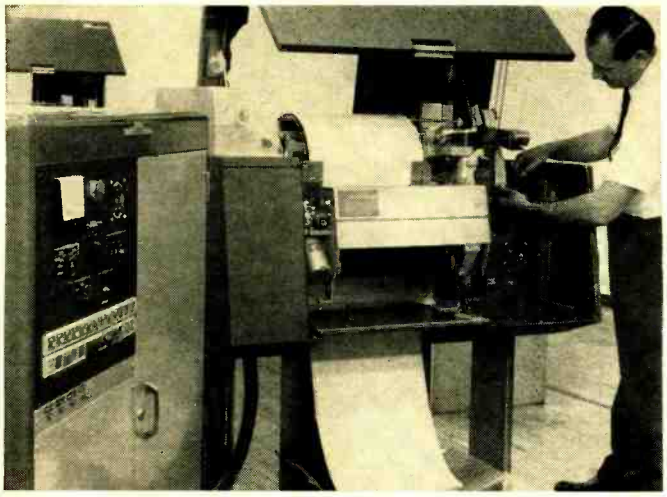
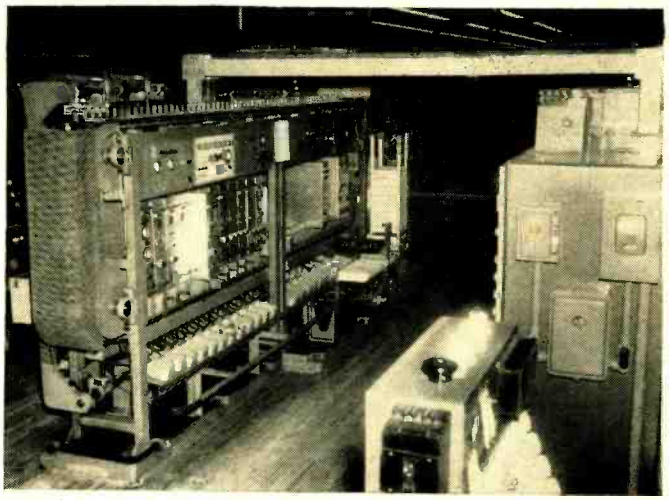


Fig. 3. The automatic monitoring console continuously checks voltages, pulse rates, and other operating conditions. The monitoring link between the receiver and the receiver-testing section of the automatic monitoring console is shown above. Actually, there are links between all components of the radar prime system and the corresponding test circuits of the system's monitoring console.

Fig. 4. If the Automatic Monitoring System spots a voltage, current, or other circuit parameter outside of pre-set tolerances, the operator switches to a sequential monitoring mode. He inserts a deck of punched cards into a reader on the console. These cards, pre-programmed for each individual subsystem, direct the equipment to make a fast, detailed stage-by-stage test of the defective subsystem. Results are printed out on a tape so defective component can be located quickly.







(Left) IBM technician is setting up automatic tester that will be used to check company's high-speed printer. Unit at left runs the test procedure by simulating instructions a computer would normally give the printer. (Right) Sylvania is using this automatic tester for checking tubes off the production line. It runs through tests previously performed by 3 men at twice their speed. The unit checks tubes for shorts, open welds, heater-cathode leakage, plate and screen current, transconductance.

Of course, automatic testing equipment is subject to failure, too, so special circuits are built into "CAM" so that it can keep a continuous watch over its own operations.

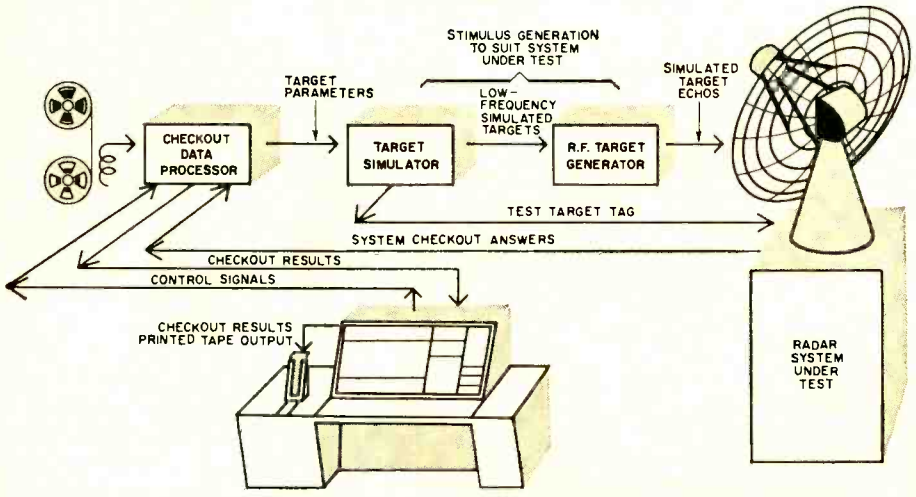
Built-in Testing Systems

Built-in systems designed to guarantee reliability of critical electronic systems are coming into wide use. The "Minuteman" missile, for example, is designed to wait patiently in its silo for years, if necessary, yet be ready to go at any time on 60 seconds' notice. Responsible for maintaining this state of readiness is "Minuteman's" built-in computer.

In the silo, this unit probes the missile's various systems—guidance, gyros, staging, etc.—24 hours a day. If any voltage, current, frequency, or pulse rate drifts beyond pre-set limits, the computer signals a control station many miles away. A pre-recorded tape announces to the duty crew where the trouble is, and teams of technicians rush out to make repairs.

In addition to its constant monitoring, the computer also makes detailed measurements periodically—to check operating efficiency and long-term degradation of components. With the combination of tests, components changing in value are usually detected and replaced long before they actually fail. During the checkout procedure, the computer is also programmed to recalibrate gyros and accelerometers which may have drifted slightly since the last check. Once the missile is fired, the computer switches into its operational mode and takes over the complete guidance and control of the missile.

Fig. 5. The Checkout Subsystem generates false radar targets and inserts them into the radar system at the antenna. When the targets have been analyzed by the radar and its associated processing units, results are fed back to the Checkout Subsystem data processor for evaluation. Results are printed out by control console.



Although the demand for the highest attainable degree of reliability makes automatic testing especially important in military applications, it is by no means limited to defense systems. *Bell Laboratories'* experimental electronic central office which was tested in Morris, Illinois two years ago, was programmed to check itself periodically. The controlling computer automatically switched failing modules out of the circuit and replaced them with spares provided for the purpose. Then an automatic teletypewriter tapped out the location of the faulty module so that it could be replaced.

Manufacturing Operations

Although large, complex installations frequently have self-checking circuits permanently installed to provide continuous troubleshooting, automatic testing is useful in many other kinds of operations, too. Manufacturers, for example, are using automatic machines of many kinds for checking out subassemblies and printed circuit boards. The *Martin Company's* Orlando Division produces printed-circuit subassemblies for "Pershing," "Bullpup," and other missiles. Some 1000 circuit boards, containing up to 100 components each, roll off the production line each day. Manual checking took from 14 to 45 minutes per card, depending on the circuit involved.

Company engineers designed and built an automatic tester which they call "TAPAT" (*TApe Programmed Automatic Tester*). Punched Mylar tape feeds any one of some 35 different test sequences to the tester, depending on the circuit card being tested. The equipment runs up to 32 separate tests in less than two minutes. Another tester periodically checks "TAPAT" to make sure that it is operating properly.

Savings in time and effort are frequently even more dramatic. The *Autonetics Division* of *North American Aviation* found that one circuit board used in an airborne digital computer required 270 tests which took an experienced man some 10 hours. Thirty boards went into each computer, and testing accounted for a considerable part of the cost of the completed unit.

Since the board contained so many circuits, another problem came up. Normally circuit boards can be tested by connecting test instruments to the input and output terminals. But more test points were needed to analyze all of this

(*Continued on page* 82)

CB RANGE NOMOGRAM

By GENE KARLIN/Hammarlund Mfg. Co.

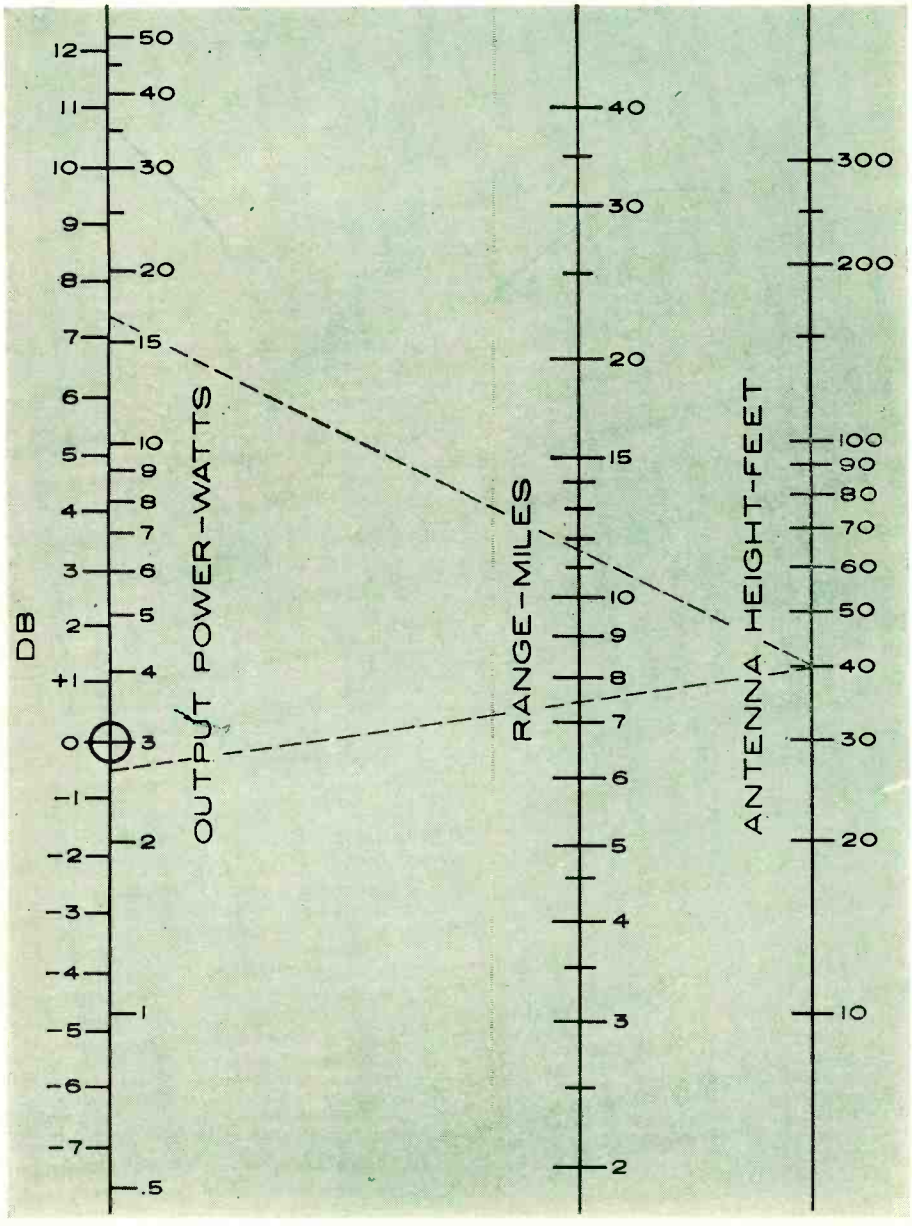
Simple method of approximating useful Citizens Band range for various output powers and antenna heights.

THIS nomogram was constructed to give the CB user a guide in predicting the range that can be expected from his equipment. It is intended only as a guide inasmuch as the actual range experienced may be greater or less depending upon local conditions, the efficiency of the transmitter, the sensitivity of the receiver, and other factors too numerous to cover here.

Certain assumptions were made which simplify the chart considerably. The power output of the transmitter is assumed to be three watts. Some CB transmitters may have higher output but if the power input is held to the five-watt limit, the output power will not exceed 3½ watts except in a very few special cases. Any transmitter that is used over a number of channels may produce only 2½ watts on some channels. This is normal when operating over a frequency range of several channels without retuning the transmitter. Therefore, we assumed that the average CB transmitter produces about 3 watts at the antenna terminals.

The signal strength required for the average CB receiver for good, dependable communications is on the order of 5 μv. Most receivers will operate at lower signal levels however, when used in an automobile, the high noise levels, ignition, etc. will cause considerable loss in sensitivity.

To use the nomogram lay a straightedge from the actual useful power output of the transmitter to the height of the base-station antenna from ground. The distance that will be covered under average conditions will be found where the straightedge crosses the center of the "Range" line.



Some antennas, such as most beams, exhibit an apparent increase in power output or *gain* when compared with a ground-plane antenna. This gain is usually expressed in decibels (db). Where a gain antenna is used, add the db gain to the transmitter power output.

Any transmission line causes some loss of power which must be subtracted from the transmitter power output. For instance RG8/U has a 1-db loss per 100 feet while RG58/U has a 1.8-db loss.

Example

A CB base station has a ground-plane type antenna mounted 40 feet above ground. The transmission line consists of 50 feet of RG8/U representing a loss of .5 db. A straightedge laid between the 40-foot point on the antenna height line and the −0.5 db point on the power line crosses the range line at 7.5 miles.

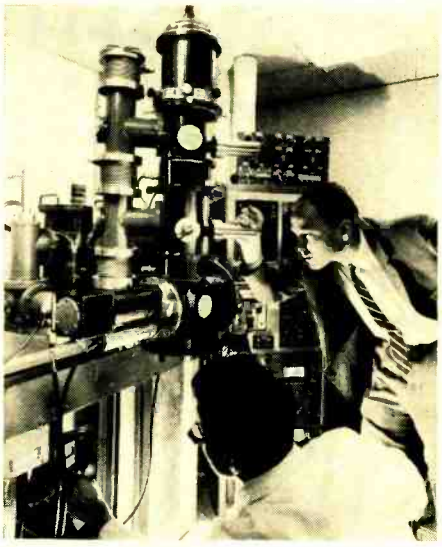
If the antenna is changed to a beam which has a forward gain of 8 db, using the same height and transmission line, what will the increase in range be?

The 8-db gain is added to the −0.5 db from above and produces an effective system gain of 7.5 db. A straightedge laid between 7.5 db and 40 feet shows an expected range of 11.5 miles.

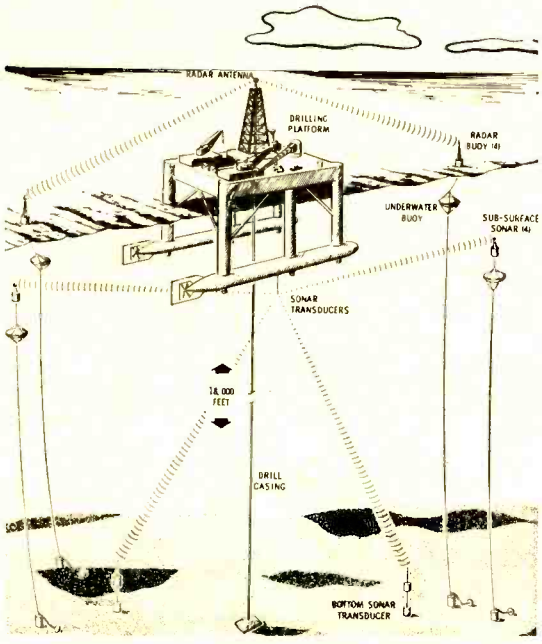
By changing the antenna from a simple ground-plane to a beam, the dependable communications range of the CB system has been extended from 7.5 miles to 11.5 miles.

In the past few years much has been written and discussed about increasing the power of CB transmitters to extend the range. In practice the difference between 3 watts and 3½ watts will be so slight that the average CB user will not be able to tell the difference. Improving the antenna system will produce far more noticeable results. ▲

RECENT DEVELOPMENTS in ELECTRONICS

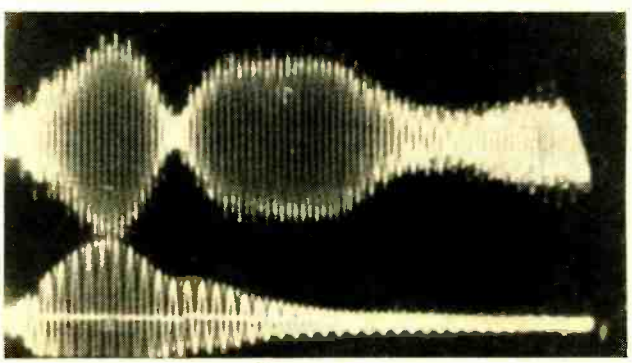


Scanning Electron Microscope. (Above) This instrument is said to be the first successful scanning electron microscope in the United States. The device, developed at Westinghouse Laboratories, "sees" with a thin beam of electrons that repeatedly sweeps across a surface, building up a picture as it goes. Prime use of the instrument has been to study the surface structure of molecular electronic devices.

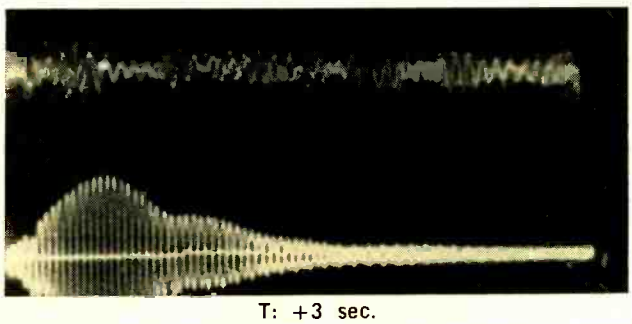


Electronically Positioned "Mohole" Platform. (Above) An artist's conception of Project "Mohole's" drill platform and a portion of its unique positioning system are shown here. This project's purpose is to drill an underwater hole in the earth's crust to the Mohorovic Discontinuity. Bottom sonar, subsurface sonar, and surface radar units provide ranging signals that are processed by computers on the platform and used by six electric engines to drive positioning propellers under the pontoons. The positioning system is being built by Honeywell....

Loran-C Spots Atom Blasts. (Right) Results of a study made by Sperry have revealed that Loran-C, a system that uses low-frequency radio signals as a long-range navigation aid to ships and planes, can be used to monitor high-altitude atomic tests on a world-wide basis. The top waveform in the upper pair shows normal, night-time pattern for Loran-C sky-wave signal at 7 seconds prior to blast. The upper waveform in the lower pair was obtained 3 seconds after the atomic blast. Note that the two lower waveforms in each pair of waveforms, which are ground-wave signals, remain unaffected.

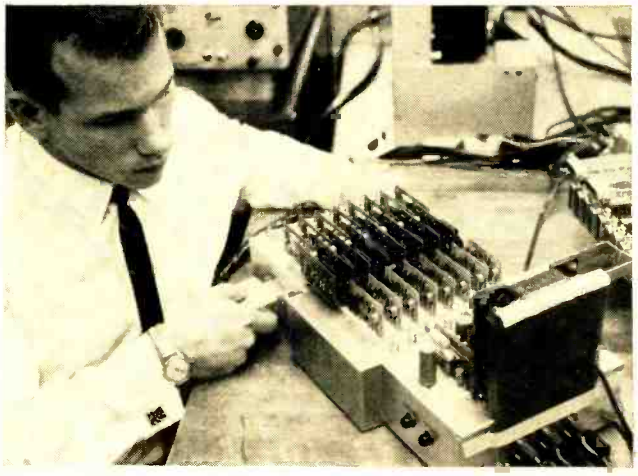


T: −7 sec.

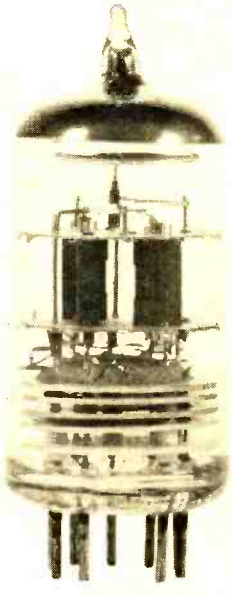


T: +3 sec.

Long-Distance Communications Antenna. (Left) A new antenna that will facilitate long-distance communications with the U.S. Air Force's missile-tracking ships has been designed by ITT Federal Labs. The antenna uses a remotely tunable helical loading coil plus top-hat loading. The fan of wires is a ground plane. Tuning range is 2 to 30 mc. with power-handling capability of over 10 kw. peak envelope power.... **Laser Tracking System.** (Below) An experimental optical-frequency tracking system that tracks laser-illuminated targets is now being tested by Westinghouse. The transmitter, at left, and receiver, at center, are being manually aimed at a target. The two meters that are shown at the lower right corner of the photograph indicate the azimuth and elevation errors.



Tube With Built-in Circuit. (Below) The "Circuitron," a vacuum tube which employs the integrated circuit concept and functions reliably when exposed to nuclear radiation, has been developed by Sylvania. The device incorporates active thermionic components and passive components in a common envelope. Because tubes have demonstrated resistance to high energy and space radiation, "Circuitrons" are designed as modular circuits capable of operating satisfactorily in nuclear environments.

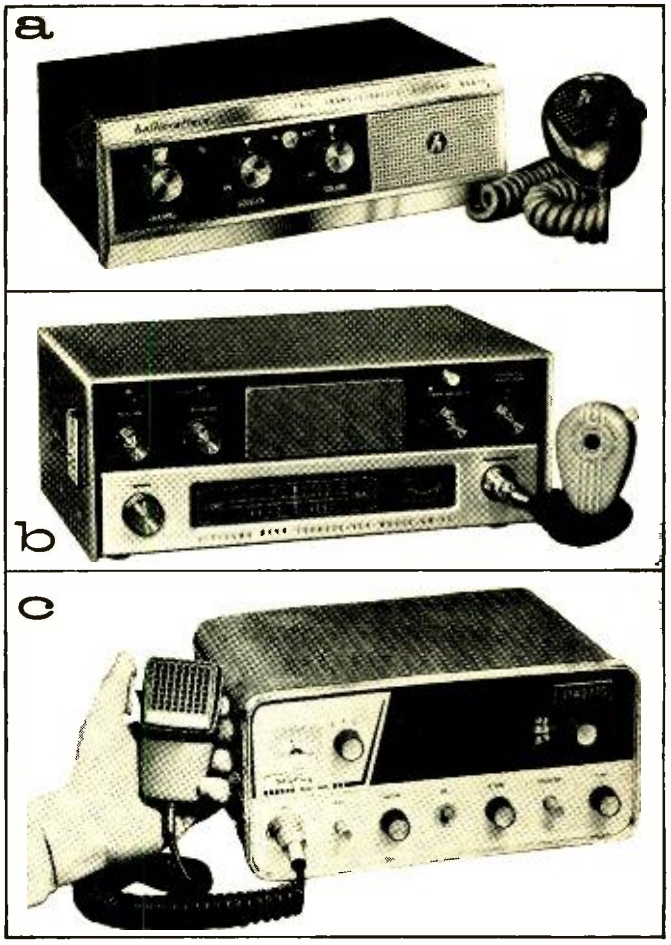


Semi-Automatic Tester. (Above) A National Bureau of Standards engineer is shown inserting the probe of a semi-automatic tester into the self-test receptacle of a fault-location test set. This device, developed under Project FIST (Fault Isolation by Semi-Automatic Techniques), determines whether each module is operating correctly or needs replacement. No settings are needed and modules can therefore be tested in any order desired; only "bulb-changing" level of skill is required. The greatest impact of the troubleshooting system is expected to be in alleviating the shortage of capable electronics technicians. Secondary effects will be a higher level of dependable operation due to better maintenance, reduced numbers of technicians to be trained, and the accompanying possibility of creating a small elite corps of technicians, trained in greater depth. The system is now being developed for use in maintaining a naval radar equipment.

NEW CITIZENS BAND CIRCUITS

By LEN BUCKWALTER

Description of hybrid tube-transistor rig, a transceiver with built-in selective call, and a unit with modified DSB transmission.



INNOVATIONS mark the three CB circuits described this month. *Hallicrafters*, in quest of reduced power drain while preserving full 5-watt r.f. capability, has come up with a tube and transistor unit that combines the best features of both devices. In the new CB-5 transceiver there are 18 transistors and three instant-heating tubes in a circuit that is novel in the field of CB.

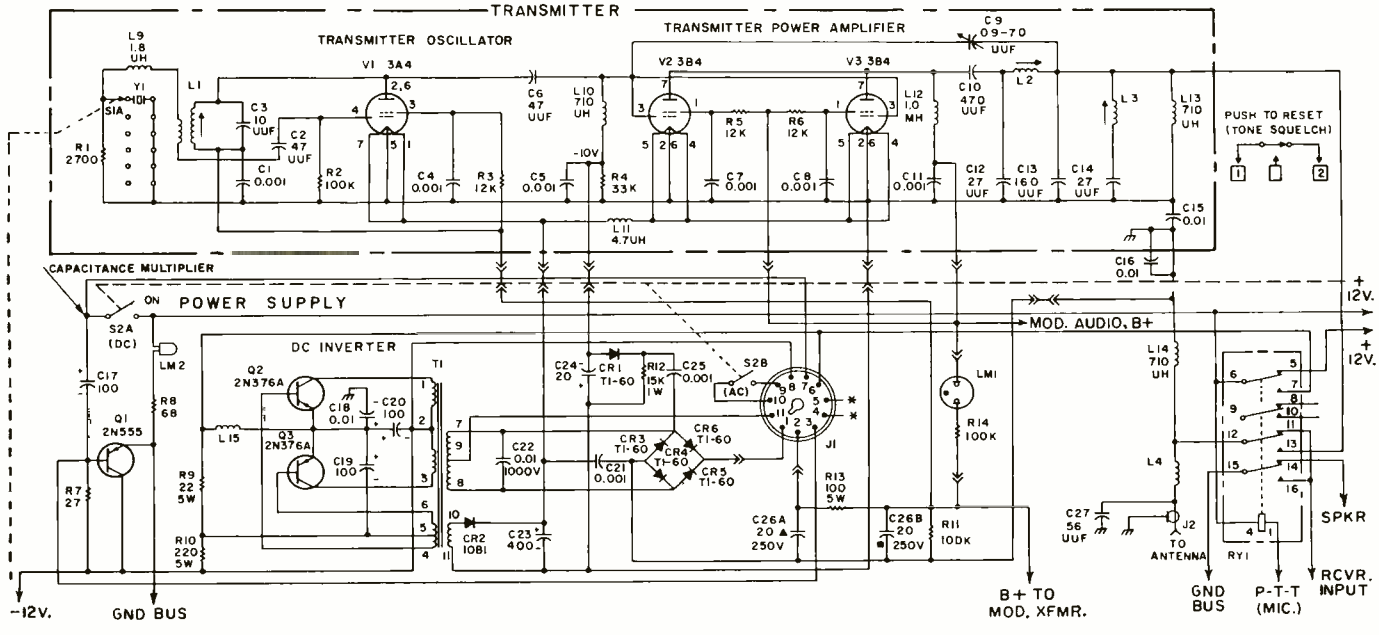
The second circuit, found in the *Heath* GW-42 kit, is indicative of the growing popularity of selective calling. In this new transceiver, the complete facility is built in and requires no external accessories. The third is "Range Gain" by *Regency*, a modified form of double-sideband transmission. It takes a portion of energy normally expended in the steady radio-frequency carrier and injects it into sidebands, which is where the actual modulation is borne.

(a) Hallicrafters CB-5 Transceiver

Exceptionally low power drain is achieved in the new *Hallicrafters*[1] CB-5 transceiver, a unit in the maximum 5-watt r.f. class. The circuit derives its efficiency through a technique uncommon to CB radio—the instant-heating tube. Combined with transistors, it reduces power consumption to a scant 200 ma. for receive and 1.9 amps on transmit. Thus the CB-5 is equally adaptable to operation as a base, mobile, or hand-carried portable. The circuit at first glance is reminiscent of the tube and transistor hybrid of auto radio design. The differences, however, are considerable, as shown in the partial schematic of the CB-5.

To reveal significant circuitry of the unit, only the r.f. section of the transmitter and power supply is given in the diagram. (The portion not shown is an all-transistor receiver of dual-conversion design.) As shown, there are three tubes in the transmitter, *V*1, *V*2, and *V*3. The first is a crystal-controlled oscillator, the remaining two are parallel-connected r.f. amplifiers which develop the needed 5-watt input. The key characteristic of the tubes is their instant-heating ability, evidenced by directly heated filaments. These tubes remain

Fig. 1. Transistors are combined with quick-heating tubes in the hybrid design employed by Hallicrafters.



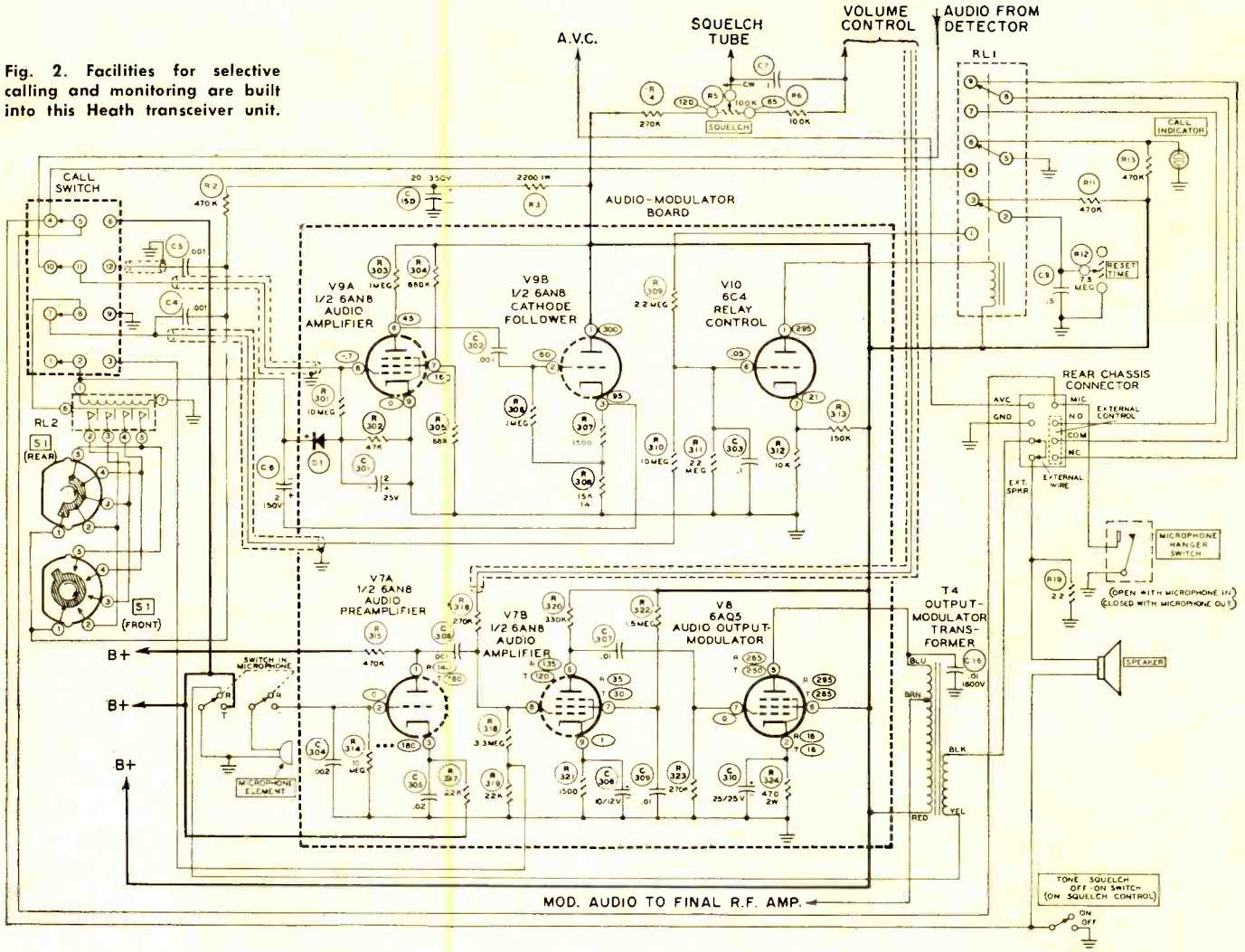


Fig. 2. Facilities for selective calling and monitoring are built into this Heath transceiver unit.

totally dark during receive—only the transistorized receiver is operative.

When the operator depresses the mike push-to-talk button, the tubes energize as follows: The coil of the transmit-receive relay *RY*1, pulls all contacts to the down position for the transmit function. This applies positive battery voltage to the d.c. inverter *via* contacts 6 and 7. As transistors *Q*2 and *Q*3 begin to oscillate in the inverter section, "B+" and filament voltages develop in the secondary windings of the power transformer *T*1.

Note especially that the filament windings of *T*1 (at 10 and 11 on the transformer) have a rectifier-filter network. It aids the instant-heating action of the tubes by applying pure d.c. to the filaments. There is no thermal delay, as in the case of an indirectly heated cathode. Warm-up time is negligible and the operator may talk as soon as the push-to-talk button is depressed.

(b) Heath Built-In Tone Squelch

Included in the GW-42, a recent transceiver by *Heath Co.*[2], are internal facilities for selective calling and monitoring. The system is based on audio-tone coding. Switch-selected from the front panel, one of four available tones may be chosen by the operator. After depressing a "Call" button, the transmitted tone opens up only similarly equipped receivers. A look at the tone-squelch circuitry reveals that most components function for both call and monitor. The key component is a resonant-reed relay whose vibrating elements are known for excellent selectivity in handling audio signals.

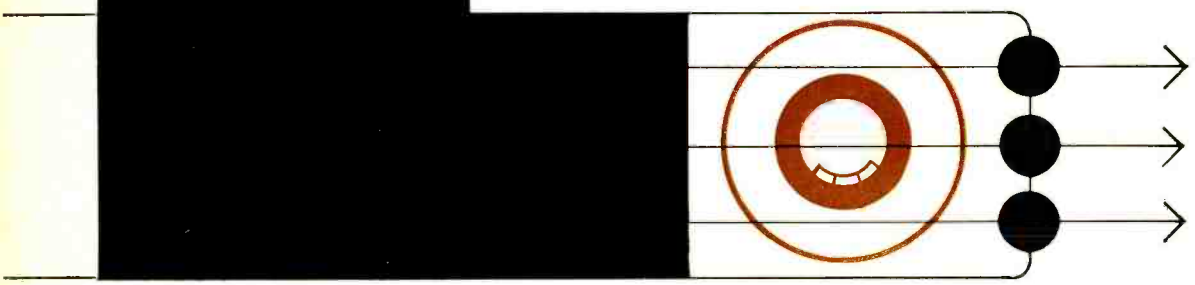
Since the schematic shows various switch positions in the receive, or monitoring, mode we'll consider it first. The tone from a calling unit appears as an audio voltage at the receiver's detector stage (upper right). It is coupled to terminal 10 on the "Call Switch." From there it is impressed on the grid of *V9A* where amplification occurs. The second half of the tube, *V9B*, is a cathode-follower to match the *V9A* impedance to that of the resonant-reed relay coil, *RL*2. If tone energy is on the correct frequency, a corresponding reed on the relay proceeds to vibrate. Movement of the reed transfers pulses of "B+" to a fixed contact on the relay. Fed through the "Call Switch" (terminals 8 and 7), pulses reach the grid of relay control tube *V*10. When they attain sufficient positive potential (by charging *C*303 and overcoming tube bias), *V*10 conducts, energizing relay *RL*1. Contacts on the relay close the speaker circuit, the tone signal becomes audible, and an indicator lamp illuminates.

If the operator does not respond to the call, the circuit automatically resets itself to the monitor condition. This is done by the lowermost contacts on *RL*1 and the time-constant circuit of *R*12 and *C*9. Prior to the call, *C*9 remains across the "B+." But as an incoming tone causes *RL*1 to energize, *C*9 transfers its positive charge to the grid of *V*10, causing the tube to continue conducting after the tone ceases. When the capacitor depletes its charge, depending on the setting of pot *R*12, *V*10 drops out the relay and the circuit is restored to "Monitor," ready for the next call.

The sequence of events for selective calling begins when the operator depresses the "Call Switch." As contacts 11 and 12 close, a transient pulse of voltage derived from "B+" is applied to the grid of *V9A*. Amplification and impedance transformation occur in the manner described earlier for the monitor function. Transient energy reaches the relay coil *RL*2 and the reeds are shocked into vibration. Only the desired reed, however, is (*Continued on page* 84)

UNIQUE COLOR-TV TUBES & SYSTEMS

By LESLIE SOLOMON, Associate Editor



Most color-TV sets use the three-gun, shadow-mask CRT. Here are 11 different approaches to color reception ranging from a new optical projection device, through a 3-color, transparent phosphor tube to a thin tube that may eventually lead to a television set on the wall.

ALMOST without exception, every color-TV set in operation in the United States uses the shadow-mask type of color cathode-ray tube. Operation of this type of tube has been extensively covered over the past few years and should be familiar to the reader.

However, during the past several years, a number of other color-TV reception approaches have been made; some good, some fair, and others doomed from the start. At the present writing, none of these appears to be in a position to challenge the shadow-mask tube as far as commercial production and acceptance are concerned. Most of them are either laboratory curiosities or have just reached the prototype stage.

New approaches to color-TV reception have not been limited to this country alone. Research laboratories in England, Bermuda, and Japan, among others, are still trying to develop new means of generating low-cost, acceptable color pictures for the home consumer.

It appears that the major concern of these researchers is to avoid the use of the three-gun, shadow-mask color tube. They feel that the tube is mechanically overcomplex in the sense that the three guns have to be exactly aligned with the associated shadow mask, that the shadow mask blocks out a good portion of the electron beam thus reducing brightness, that heating of the mask due to electron bombardment produces mechanical distortions that could introduce color errors, that an excessive number of external electronic circuits and magnets are required to properly converge this tube, that external magnetic fields play too much of a role necessitating degaussing, and that generally too much activity must take place outside of the tube for proper color rendition.

In the search for new approaches, the resultant tubes and systems have managed to get away from the shadow mask, but in many cases have only succeeded in replacing one type of problem with another. In some cases, the new problem is electrical in that a complex external circuit is required to operate the "simple" tube, while in other cases, mechanical considerations involve production or packaging nightmares.

However, some of these tubes and systems appear to be on the track of something new and it only remains for them to be manufactured and field tested to learn if they will represent serious competition for the shadow-mask color tube.

The Thintube

The *Kaiser-Aiken* thin cathode-ray tube manufactured by *Video Color Corp.*, represents a radical change in what a cathode-ray tube should look like. Here, the electron gun is placed at the corner of a thin glass box rather than behind the phosphor screen. (See Fig. 1A and front cover).

In operation, the electron gun injects an electron beam along the bottom of the tube and passes it over a row of horizontal deflection plates. When the potential of one or more of these plates is lowered below the nominal 1-kv. operating voltage of the electrodes in that primary area, the beam is deflected upward. It then passes through a transition region whose lenses control its width and shape in a direction perpendicular to the plane of the tube as it is transferred from the low-voltage, horizontal-deflecting region to the high-voltage region behind the phosphor.

Once the beam reaches the region behind the phosphor, it is re-directed by a set of vertical-deflection plates—normally operating at the same voltage as the phosphor screen. These plates run horizontally and are stacked one above the other on the back wall of the tube. When one or more of these deflection plates are reduced in voltage, the beam is deflected. This time, deflection is at right angles to the initial bend, into the phosphor.

Control of the beam impact point is accomplished by sequentially varying the voltage on the various deflection plates. Since all deflection is electrostatic, relatively little power is required although high voltages are involved.

For linear, well-defined pictures at least two adjacent deflection plates must be operated in time overlap—two adjacent plates must cooperate to bend the beam somewhat like push-pull amplifiers in an audio amplifier.

Whenever an electron beam goes from a region of one voltage to another of differing voltage, focusing or defocusing forces come into play. Such a change from one region to another occurs when the beam passes from horizontal to vertical deflection regions. The forces in this case tend to focus the beam strongly in a plane 90° from the phosphor. Uncontrolled, the beam would focus before it reached the bottom of the phosphor screen and diverge widely. The cylindrical lens transition region keeps the beam from focusing prematurely, guiding it from low to high voltage and delivering it to the region behind the phosphor as a thin ribbon beam with parallel edges.

The *Video Color Corporation* of Inglewood, California is starting production of the Thintube and will soon start producing a two-primary-color, two-gun version. At some future date, they hope to have a full three-primary-color version in

operation. Fig. 1B shows how the proposed two-color version operates. Basic operation is similar to the monochrome unit except the color tube will have two guns, one on each side of a thin glass screen. The screen has one primary color on one side and another primary color on the other. The two guns, and the deflection system, are synchronized so that beam landing is identical on both sides of the glass screen. In this way, color registration is perfect and the beams cannot strike the wrong color. They hope to have some two-primary-color, two-gun Thintubes in production in the near future.

As these tubes have high resolution and high brightness, have no internal masking or grid structure, are not subject to normal stray magnetic fields, and are small in size, they are expected to find favor in certain types of video displays.

Banana Tube

An English entry in the race for a new color tube is the Banana tube, so called because of its shape, the result of research conducted at the *Mullard Research Laboratories*, London, England.

Working on the premise that other color tubes require shadow masks, deflecting grids, or other physical elements inside the tube, and that this contributes to an overcomplex mechanical arrangement besides making the electron beam sweep more complex, the *Mullard* researchers decided to use the simplest approach and reduce the tube innards to three color phosphor stripes (red, green, and blue) and one gun.

As shown in Fig. 2A, the three color phosphors are laid parallel to each other in long, thin stripes. The single-gun electron beam is made to start at the far end of the color stripes, wobble across the three stripes as shown by the dotted line until it reaches the area closest to the gun, then rapidly retrace back to the far end. Because such a scan can only reproduce one line of color information, some means must be found to produce the vertical sweep for the raster.

Referring to Fig. 2B, three cylindrical lenses are placed 120° apart on a frame that surrounds the Banana tube. The lens drum rotates about the tube to produce the vertical scan. Because of the optical arrangement, the resultant picture will be somewhat distorted. However, using a cylindrical mirror with a hyperbolic cross-section, the picture presented to the viewing screen appears to be perfectly flat.

Because of the physical arrangement within the Banana tube, the electron beam from the one gun would approach the color phosphors at a shallow angle, particularly at the far end of the tube. This would cause spot elongation and reduction of resolution in the line direction. This problem was overcome by the use of a magnetic field at right angles to the electron beam trajectory plane, increasing in field strength towards the phosphors thus reducing spot size to improve both resolution and focusing capabilities.

Present tubes have displayed about 40 footlamberts at a mean beam current of 400 μa. for average picture material.

It is also possible to add a conventional P4 phosphor stripe to the tube for use as a monochrome picture source.

Because of the mechanical parts involved in the operation of this tube—creating the problem of noise, jitter, flicker, dust accumulation, and mechanical wear—this system may never be used for a mass-produced home receiver. Also, due to high beam loading of the Banana tube, deterioration of the phosphor efficiency takes place more rapidly than is the case with conventional direct-view tubes.

Apple Tube

This tube is an index-controlled display device that uses triplets of color phosphors arranged on the tube face in thin vertical stripes. An indexing phosphor (see Fig. 3), is used to indicate the instantaneous position of the electron beam from the one gun. The phosphor triplets consist of alternate red, blue, and green stripes 0.01-in. wide, separated from each neighbor by a 0.01-in. wide black guard band.

To produce color images, the electron beam is modulated so that to produce a red light, the beam is turned on when it crosses the red phosphor, and off when it is passing over the other phosphors. The same thing happens for green and blue. The amplitude of the signal is controlled by the chrominance information.

The index signal resulting when the electron beam excites an index stripe is collected, amplified, and processed by electronic circuits to keep the signal in register with the color-line structure on the face of the CRT.

Goodman Tube

Developed and named by David M. Goodman of New York University, this single-gun tube is quite conventional looking on the outside. Inside, the tube consists of a single electron gun, an x-ray-sensitive scintillator, and a unique phosphor screen. The details are shown in Fig. 4.

The phosphor screen consists of repeating groups of vertical color stripes with one stripe (for example, red) including an additional special index phosphor that radiates in the invisible portion of the spectrum, all deposited on the internal face of the tube. During scanning, every time the electron

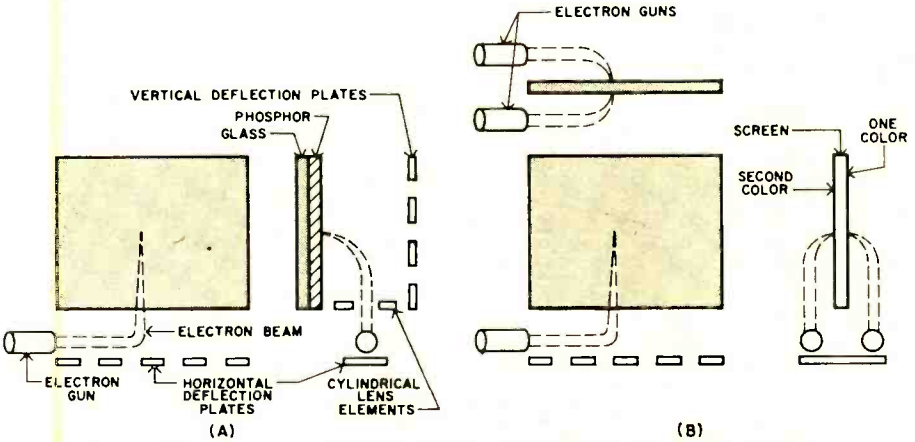
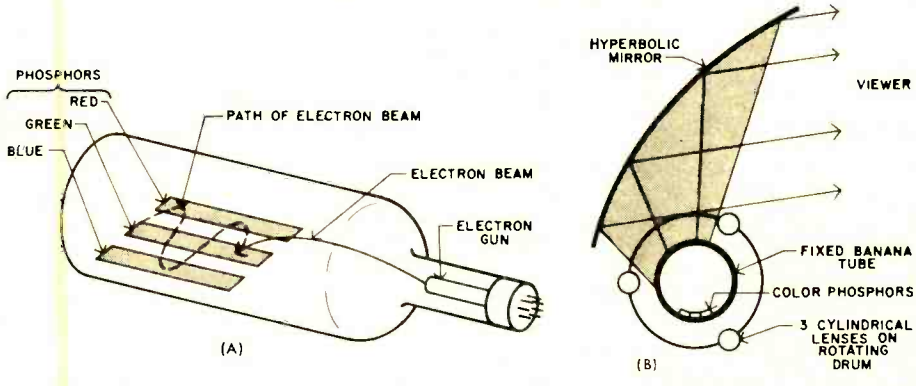


Fig. 1. (A) shows the monochrome version of the Thintube while (B) shows the possible two-color version. Electron gun remains the same size regardless of size of the screen area. This could lead to a flat picture-on-the-wall TV set.

Fig. 2. (A) The Banana tube generates only one line of color. (B) To make a raster, a mechanical arrangement rotates three cylindrical lenses around tube.



beam passes over one of the index stripes, it radiates short bursts of invisible radiation. These radiated bursts then can be used to accurately locate the position of the beam along the target screen. The radiated bursts are picked up by scintillators located near the electron gun. As the x-rays excite the scintillator crystal, it emits a burst of light. This light is passed down a glass light pipe (possibly fiber optics) to the gating circuit. This burst of light is detected by a multiplier phototube and converted into a voltage spike.

In operation, the tube functions as follows: At the start of the raster there is no phosphor excitation. As the electron beam progresses across the screen, it strikes the first index phosphor which radiates the index signal that is picked up by the scintillator, passes down the light pipe, and triggers the voltage pulse. This pulse opens the red gate and passes red information to the electron gun for the period of time that the electron beam is moving across the red phosphor. Since a finite time elapses between excitation of the special phosphor and opening of the red gate, a variable delay is provided so that the red signal is delayed until the beam passes over the red phosphor. Both the blue gate and green

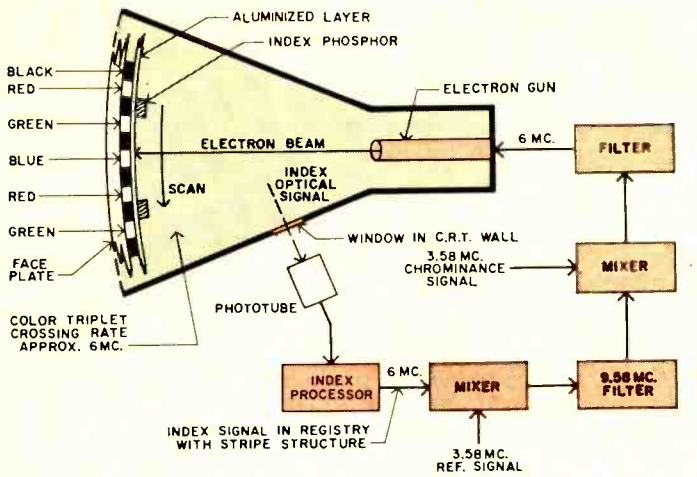


Fig. 3. In the Apple tube, the output from the filter to the electron gun is in register with the stripes but controlled in amplitude and differential phase by chrominance information.

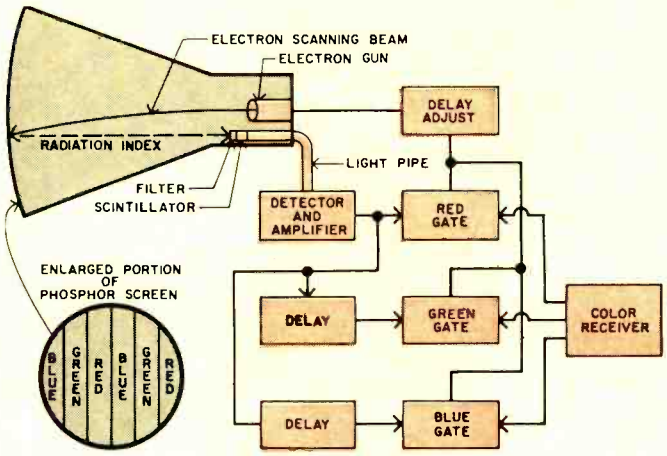


Fig. 4. In the Goodman color tube, burst of x-ray radiation generated as the electron beam passes over certain phosphors is used to keep the beam synchronized with the color stripes.

gate receive the detected light/voltage pulses through differing lengths of time delay. The green phosphor is energized after the red one so that its gate is delayed for the interval of time it takes the electron beam to pass over the red phosphor. The green gate then opens when the electron beam enters the green phosphor. The blue phosphor is next to be energized, so its gating pulse is the longest delayed. Like the green gate, it too only opens when the electron beam is entering the blue phosphor.

Synchronization of the electron beam as it passes across the phosphor screen during a conventional line scan then becomes automatic as the gates are opened only by radiation emitted by the special phosphor as the beam passes over it. Synchronization during the flyback period is unnecessary since the system can operate with a time delay of only 150 nsec.

Although still in the laboratory stage, initial production plans call for 600-line, 75-footlambert, 21-inch round and 23-inch rectangular versions.

Sunstein System

This system is a form of beam indexer that claims to obviate problems with previously known indexing systems.

In an indexing system, as the electron beam is scanned, its location relative to the phosphor stripes is detected by a beam-perception device such as a form of photocell looking at phosphor lines or a pickup from secondary-emission electrodes. The fundamental problem with beam indexing systems is that the derived index signal tends to have errors from the necessary modulation of the beam by the picture information. For example, in a horizontally scanned color system in which the electron beam is modulated to provide an ideal solid color field, the beam is brightened at periodic intervals corresponding to the time at which the beam arrives at the given phosphor lines.

In conventional indexing systems, the index structure is laid down at the same periodicity as the color triplet structure. This leads to the undesirable effect that the time-of-occurrence of each peak in each index cycle is influenced by when the center of the beam passes the center of the index stripes, as well as by modulation of the beam while it passes from stripe to stripe. Therefore, the phase of the derived index signal, which should be totally independent of beam current, and dependent only on spot position relative to the triplet structure, is in fact influenced in substantial measure by the modulation of the electron beam while portraying picture content. This index phase error, in turn, causes phase errors in the reproduced color and can, in principle, even cause oscillations on the cathode-ray tube face, since the color loop is, in reality, a closed loop in the presence of any such crosstalk between beam modulation and phase of the derived pickup signal.

The color phosphors used in the Sunstein system are arranged in vertical stripes across the inside face of the CRT, and they are covered with a conventional aluminized layer. A series of vertical index elements are evenly spaced across the screen on the gun side of the aluminized layer. These index elements are made of a phosphor having a short persistence and a secondary emission different from that of the aluminized layer.

Color contamination by phase error is practically eliminated by spacing the index elements along the scan line so that the index signal detection circuit has an output frequency of three-halves or five-halves times the fundamental color-triplet frequency, for example. When the index signal is smoothed or averaged over a few cycles, it is substantially free of contamination, due to cancellation of the error-producing tendencies with each alternative color triplet.

Because the derived index signal is at a different frequency than the triplet frequency, it must be converted to the triplet frequency before actually being used to control the grid modulation in accordance with color information.

The schematic of the circuit used is shown in Fig. 5. The photoelectric cell detects the index signal and passes it through a gate to an amplifier tuned to one-half triplet frequency. This signal is passed to a frequency doubler that generates triplet frequency. The photocell also drives an am-

plifier at 2.5 times triplet frequency. This signal is limited and, in conjunction with the output from the .5-times triplet frequency amplifier, drives the fractional ratio frequency divider. The output of this circuit is phase locked to the index signal from the limiter so that any changes of phase in the input signal cause corresponding fractional changes of phase of the output signal. An integral frequency divider is used, and a harmonic of the final divided frequency is taken as the smoothed index signal at color triplet frequency. This is used to control the chrominance and Y-signals fed to the grid of the CRT, or can be used to control writing speed.

The "Set" terminal receives a synchronization pulse at the beginning of each scanning line, opening the gate circuit.

When the index signal is derived in the above manner, it has an ambiguity. When the count-down circuit is first started, it can start in any one of three or five possible phases (for three-halves or five-halves systems), and hence its output would not be suitable for indexing unless special steps are taken. A non-ambiguous index signal is made available at the left-hand edge of the picture tube, outside the useful screen area. This signal is either a fundamental triplet frequency or a submultiple of it and is gated through the frequency dividers at the start of each horizontal line to provide initial phasing of the frequency-divider network. Once started, the network remains in step.

Chromatron Tube

Besides the shadow-mask tube, the only other color cathode-ray tube that is close to actual production is the three-gun *Chromatron* tube, developed by the *Chromatic Division* of *Paramount Pictures Corp.* This tube is an offshoot of the original one-gun *Lawrence* tube of many years ago. However, unlike the older *Lawrence* tube, this one uses three electron guns and also does away with the beam-switching grid with its associated r.f. power that characterized the older tube.

The major benefit claimed by the designers of this tube is the fact that this tube has generated in excess of 300 footlamberts highlight brightness in normal operation. (A typical shadow-mask CRT develops 30 to 45 footlamberts highlight brightness.) Such brightness will permit operation in normally lighted rooms besides producing the apparent increase in resolution present in any really bright picture.

Although the color phosphors are laid down as a continuing sequence of red-green-blue vertical stripes, a slender black stripe is laid between each color phosphor to improve the picture contrast.

Three in-line electron guns are used and, in conjunction with the second anode grid, are electron-optically directed to their respective color stripes. The two outer guns have a slight inward tilt so that the three beams converge as a unit on the phosphor screen. A conventional color receiver is used with the chromatic signals passed to the respective electron guns.

The post-deflection focusing second-anode grid is an array of closely spaced parallel taut wires located about ½-inch in front of the phosphors. This grid is operated with about 6 kv. difference between it and the electron guns. Approximately 20 kv. is applied between the second-anode and the final-anode consisting of the Aquadag internal coating and the phosphor aluminizing coating.

Transylume Tube

The idea of using controlled penetration of a series of phosphor layers to produce color changes in cathode-ray tubes is rather old. The problem has been to produce good transparent phosphors. Some of the early suggestions for such tubes did not even recognize that the phosphor layers must be transparent, and after this requirement was recognized, no such films were available. Tubes of this type were displayed several years ago, but the efficiency and range of

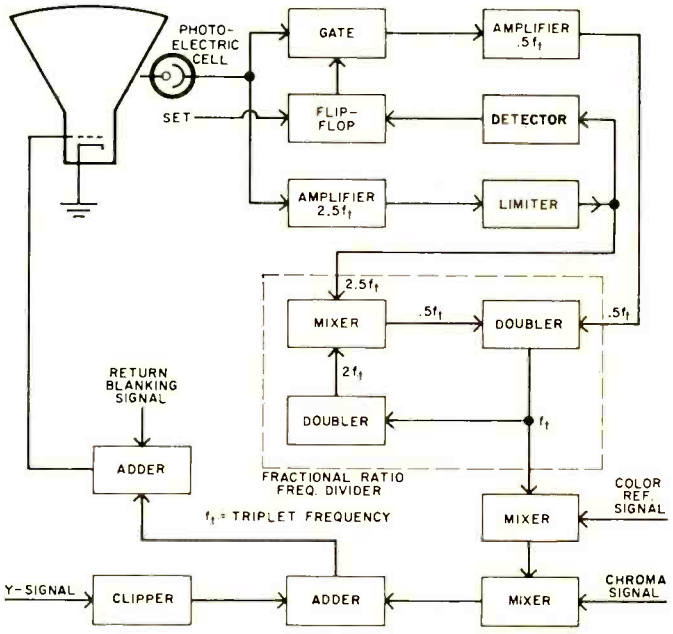


Fig. 5. In the Sunstein system, a fractional ratio frequency divider is used to synchronize the electron beam with color phosphors. Horizontal sync pulse gates system into operation.

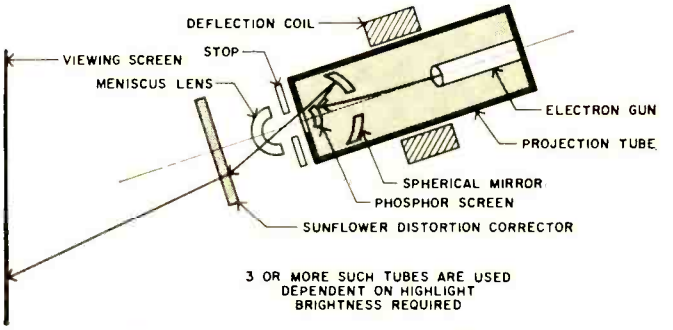


Fig. 6. Typical projection system using Sunflower optics correction. Each projection tube generates a high-intensity beam of one color with the multiple beams registered on the screen.

colors were limited and the results were not very startling.

The current renewed interest in such tubes was stimulated by the work of Dr. Feldman at the U. S. Naval Research Laboratory. He developed a process which, for the first time, made it possible to produce bright, highly transparent phosphors in a good range of colors. A tube using this process is the Transylume tube being developed by the *Panaura Corp.*

Transparent phosphor films are produced by evaporating powdered phosphors and subsequently baking them on a refractory glass substrate. The films have the same basic properties as the phosphor powders, the same emission color, the same constants, and the same efficiency. The differences are entirely optical, arising from the fact that the particles in the film are very small and therefore absorb, reflect, and scatter very little light. On this fact are based the unique properties of the transparent films, their advantages and limitations. When an electron beam strikes a conventional powdered phosphor, the light emitted is scattered among a number of particles, reflected from an aluminum backing, and most of it emerges as a trace considerably broader than the electron beam. When the beam strikes the transparent film, however, the light generated is emitted in all directions, half of it back into the tube, and an additional fraction (at greater than the critical angle) is trapped in the glass. Therefore, only a fraction emerges toward the viewer, but in a trace just as fine as the electron beam. High resolution is accordingly a natural advantage of the transparent films. The ultimate resolution has not been precisely established; 3000 line-pairs has been demonstrated (1000 is the limit with

powdered phosphors) and spots of 3-micron diameter have been measured. This is not the limit, but beyond that measurements are very difficult.

Brightness is reduced by optical losses as previously described, but visibility of the trace is better, under most conditions, than with powdered phosphors. Ambient light is efficiently reflected from a powdered phosphor screen so that in a well-lighted room, the unlighted background of the screen is about as bright as the luminescent trace of the electron beam. With the transparent film, ambient light penetrates the screen and is lost in the interior of the tube. Thus, even though the trace on a transparent screen may be only a fraction as bright as the trace on a powdered screen with aluminum backing, the trace on the transparent screen remains easily visible in the brightest light. Neither a six-foot arc searchlight focused on the tube from six feet away or direct sunlight beaming directly into the tube reduces visibility appreciably.

Evaporated films can be used in any color tube as dots or stripes in whatever geometry is required for existing color tubes with the advantages of resolution and contrast previously described for single-layer films. More unique, however, are the variety of new color systems that can be devised based on tubes in which the screen is composed of multiple layers of transparent films. The color variation depends on the fact that electrons with a particular accelerating voltage all penetrate the luminescent films precisely the same distance, and the depth of penetration varies with voltage by amounts that correspond to reasonable thicknesses of film. Brightness from a particular layer of film therefore increases as voltage is increased to penetrate more of the film. As voltage is increased to the level where electrons penetrate farther than the thickness of a particular film, the light output from that film drops off rapidly. Thus at a relatively low voltage, for example 4 kv., the emission is solely from the top layer of film. At a second voltage, which may be 2 to 4 kv. higher depending on the thickness of the luminescent films, the emission is virtually the pure spectral emission of the second film. At intermediate voltages, the emission is an additive mixture of the two. Thus, if the top layer emits red and the second layer emits green, at intermediate voltages the color emitted changes from red to orange to yellow to green. By the addition of a blue-emitting film, the purple, violet, and blue colors are added in the same way. By use of proper emission colors of the adjacent films, any color mixture can be produced. For example, voltages intermediate between a yellow and blue film will produce white or the proper blue-green and red film will produce white. Myriads of color combinations may thus be obtained because films can be produced in a wide variety of emission colors including the same phosphors widely used in the present shadow-mask tubes.

The intensities of the various traces would normally be adjusted so that when two beams were superimposed, one would dominate, and the colors would not vary appreciably. It is also possible to adjust intensities so that the several colors are additive when superimposed, for example, the trace would be yellow at the point where green and red traces crossed, or alternately if a beam producing green and a beam producing red are kept superimposed, the combined emission could be changed from red through orange and yellow to green by changing the intensity of either beam. In theory, then, a full spectrum of colors can be produced with three guns which are kept superimposed on three layers of film, each of which emits one of the three primary colors. In practice the difficulty of maintaining perfect registration at all points on a large tube is a formidable problem.

A simpler way to produce a full spectrum of color is to modulate the second anode voltage from a single gun. This variety of color tube also works extremely well and produces the same sharp traces and vivid colors. The obvious problem of maintaining the same deflection as the beam voltage changes is easy to solve. The beam is focused on a fine metal mesh mounted just back of the screen and voltage modulated by post acceleration the short distance between the mesh and the screen. Here again the circuitry is very simple, identical with a single-color system, but with the addition of a voltage-modulator synchronized with the color modulation desired. The limitation of this system is the rate at which voltage can be modulated over the range necessary for a full spectrum of colors. A small, simple modulator has been developed which operates well at several hundred kilocycles. Modulation at the rate necessary for the present commercial color-TV signals does not appear feasible; but the existing capability appears to be adequate for a very simple closed-circuit color-TV system. A black-and-white closed-circuit system can be converted to a color system by simply adding a three-color optical filter wheel (in front of the black-and-white camera) synchronized with the voltage modulator in the receiver. Primitive systems of this kind have been demonstrated. Neither the optimum series of phosphor layers for the tubes nor the time constants for the modulation system have been explored in depth, but very early results along this line have been most encouraging.

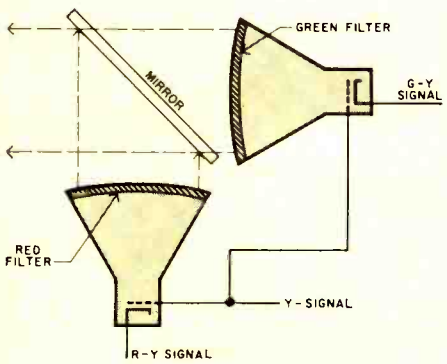


Fig. 7. Two monochrome picture tubes, each with a color filter, take advantage of Land effect to make full-color pictures.

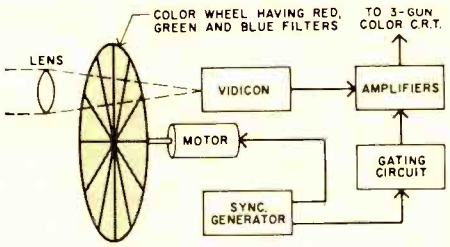


Fig. 8. Gating circuits synchronize the portion of color wheel passing in front of the vidicon with the three-color CRT.

Sunflower Optics

Developed by the *Harries Electronic Corp. Ltd.*, of Devonshire, Bermuda, the Sunflower system is a modified color projection system that uses a new concept in color cathode-ray tubes combined with a new development in optics.

Many attempts have been made to produce a home color projection system. Here, each color signal (red, green, and blue) from the receiver is fed to a projection cathode-ray tube. The three projection tubes, with their associated optics, are arranged so that they register on the viewing screen. Because of the mechanical arrangement necessary, usually two of these projectors are not normal (right angles) to the viewing screen. This usually produces keystone distortion. Also, because of the large numerical aperture required, pincushion distortion usually occurs. When the projection systems are compressed in size for use in a smaller area (such as a table-top viewer) the viewing screen size is greatly reduced and the distortions increase.

Some projection systems pre-distort the cathode-ray tube scanning signals to reduce the keystone distortion. However, these circuits usually use vacuum tubes or transistors making them subject to aging, drift, and other misalignment.

Fig. 6 shows one typical projection tube as used in the *Harries* system. Three projection (*Continued on page 76*)

NEW FACILITIES for WWVB and WWVL

Increased power and range for the National Bureau of Standards' highest-accuracy, low-frequency stations.

NEW facilities, providing greatly increased power and range, were dedicated recently for standard broadcast stations WWVB and WWVL.

These stations, operated by the National Bureau of Standards Boulder Labs near Ft. Collins, Colo., transmit standard frequencies that are received at greater accuracy than those of the NBS high-frequency stations WWV and WWVH. This higher accuracy is required in many satellite and missile programs and for basic research on atmospheric and ionospheric phenomena.

Until recently stations WWVB and WWVL have been used only for experimental low-frequency transmissions. Because of the success of these broadcasts, new facilities were constructed for the two stations and they are being established on a permanent basis. The stations do not replace WWV and WWVH, which are sufficiently accurate for many important applications.

The high-frequency signals from WWV and WWVH are propagated over long distances by alternate reflections between the earth and the ionosphere. Because of constant changes in the ionosphere resulting in changes in the path of the radio waves, there is a loss of accuracy in the signals at the point of reception. To overcome this limitation, WWVB and WWVL are operated in the low- and very-low-frequency bands. Their signals follow the curvature of the earth. As the ionosphere acts as a boundary and not as a reflector, its variations have almost no effect on the travel of the waves; thus the stability of the received signals is increased. The stability of the signals of all Bureau stations is 2 parts in 100 billion at the transmitter. Received signal stability is much less.

Station WWVB operates on 60 kc. with a radiated power of 5 kw. (see Table 1). The signal, as received, is some 100 times more stable than that from WWV and WWVH. This station serves the continental U.S., and it provides more stable coverage at distances up to 2000 miles than does its sister station WWVL.

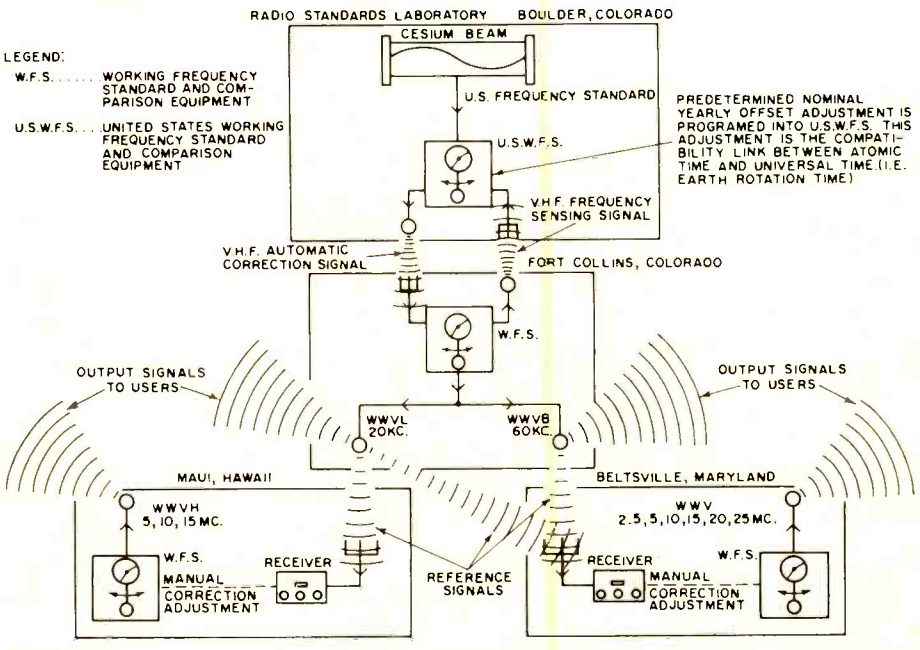
Station WWVL operates at 20 kc. with a radiated power of 1 kw. This signal provides intercontinental reception with a precision of one part in ten billion over one day. Very long distance reception is important to international standardization activities, military bases, and to NASA (which partly supported the construction of the very-low-frequency station).

	WWV	WWVH	WWVB	WWVL
Location	Beltsville, Md.	Maui, Hawaii	Ft. Collins, Colorado	
Frequencies	2.5, 5, 10, 15, 20, 25 mc.	5, 10, 15 mc.	60 kc.	20 kc.
Services				
Standard Radio Frequencies	Yes	Yes	Yes	Yes
Time Signals	Yes	Yes	No*	No*
Standard Audio Frequencies	Yes	Yes	No	No
Standard Musical Pitch	Yes	Yes	No	No
Radio Propagation Forecasts	Yes	Yes	No	No
Geophysical Alerts	Yes	Yes	No	No

*To be added soon.

Table 1. The major characteristics of the standard stations.

Fig. 1. Relationship between the cesium beam frequency standard and the U.S. Working Frequency Standard at NBS Boulder, and the standard-frequency, time broadcasts.



The antenna array for each station consists of four guyed steel towers, arranged in a diamond 1900 feet long and 750 feet wide. A transmitter building is located between the two antennas; a helix house, used for resonance tuning, terminates each antenna.

A high-quality quartz crystal oscillator at the site provides stable carrier frequencies for the transmitters. To insure that the phase of these frequencies agrees with that of the U.S. Working Frequency Standard maintained at NBS Boulder, a servo loop has been established between the site and the Boulder Laboratories (Fig. 1). The carrier phases, as received at Boulder, are compared with the standard by means of phase detectors, any phase difference resulting in error signals. These error signals, along with a servo motor reference phase, modulate a 50-mc. FM telemetering transmitter at Boulder. The FM signals received at Ft. Collins are used to correct phase errors. ▲

CABLE TV: on the move

By CHARLES S. TEPFER

Cable TV systems are not only used in low-signal areas, but also offer several channels of TV signals in areas served by only one or two stations.

WE are still accustomed to thinking of community antenna television systems (CATV) as confined to small towns nestled in the midst of mountains, blocked off from all TV stations. Nothing could be further from the truth. Today, cable vision systems, as they are called by their operators, are spreading to small cities and large towns, which often have one or two local TV broadcasting stations.

In some of the newly served areas there are no local stations, but many inhabitants view one or two channels, more or less satisfactorily, by using high-gain antenna arrays on towers. Cable systems promise these towns 5- to 7-channel TV immediately on hookup, as much choice TV fare as enjoyed by such cities as New York, Chicago, and Los Angeles.

In fact, despite the development of new translators which help existing broadcasting stations extend their coverage, and the coming expansion of u.h.f. TV, community antenna systems are sprouting like summer flowers after the spring rains. More and more people are subscribing to systems already in operation. *Teleprompter Corp.*, operator of 14 CATV systems, reports a 25% increase in subscribers during the past year. Current estimates place the total number of subscribers for all systems in excess of 700,000.

What is the effect on a community when cable TV comes in? Community antenna TV obsoletes towers for individual homes; it presents some TV receiver problems and service headaches; and it stimulates the buying of TV sets and increases the number of viewers.

Service team installs droplines from the main feeder cable.

In Saugerties, N.Y., a medium-size town of 14,000 inhabitants spread out along the Hudson River, the *Vidi-Com Inc.* community antenna company serves 700 homes. Before the arrival of the cable system, most of these 700 had antenna towers to receive channel 6 out of Schenectady, fifty miles north. Some could get, with considerable snow, channels 2, 4, and 5 from New York City, 100 airline miles to the south. What happened in Saugerties when community antenna television came to town in October 1961 could happen in any area.

In the beginning, most local service dealers were suspicious of the outside company that promised good seven-channel TV to anyone in Saugerties. To allay service dealers' hostility, as part of the franchise agreement, the CATV company promised to neither sell nor service TV receivers. This cleared the way for local service technicians and dealers to handle all of the sales and service work that would accrue from the increased television viewing in the area. At this point, the CATV company met informally with local TV dealers, service technicians, and community groups and clubs to acquaint them with what the company planned to do and how, and what problems could be anticipated.

The company then proceeded to install single-channel yagi antennas on Mount Airy and ran the cable down the mountain and into the town. The latest wideband head-end equipment and booster amplifiers with frame-grid tubes were used. This equipment enabled the cable company to receive and distribute all thirteen channels simultaneously. Channels 7 to 13 are converted at the head end to subchannels between 9 and 51 mc. to take the long run into town without excessive attenuation. In town, each subchannel is reconverted to the original frequency to correspond with the channel designation on the TV set tuner. Because these particular booster amplifiers have built-in equalization for the low-band channels, there is no loss in detail due to the long run from the mountain antenna location to town.

The cable running into town is ¾-inch, 72-ohm shielded coaxial tapped for each home with an isolation unit and ¼-inch RG-59U, 72-ohm coaxial, which feeds the individual TV set. The outside isolation network (transformer, resistive, and capacitive types are used) at the tap-off prevents feedback from the TV set into the line and maintains constant impedance along the cable. It also regulates the amount of signal fed to each home.

Once in the house, the RG-59U terminates at a small matching transformer at the TV set's antenna terminals. At these terminals, all responsibility of the community antenna television company ends. No one from the company may service or adjust the TV receiver in any way. If the customer has any service problem at all, he is referred to the local service technicians. The company will install a wall outlet for the antenna or a multi-set coupler if asked to do so, for an extra charge.

Not all community antenna companies operate on a "hands off" franchise relative to TV set sales and service. About fifty percent do not. Many cable companies are organized by TV set dealers who thereby hope to sell more sets in their area, and TV technicians are often among the backers of cable companies. But in many cases, cable vision companies are happy to stay out of the TV sales and service business.

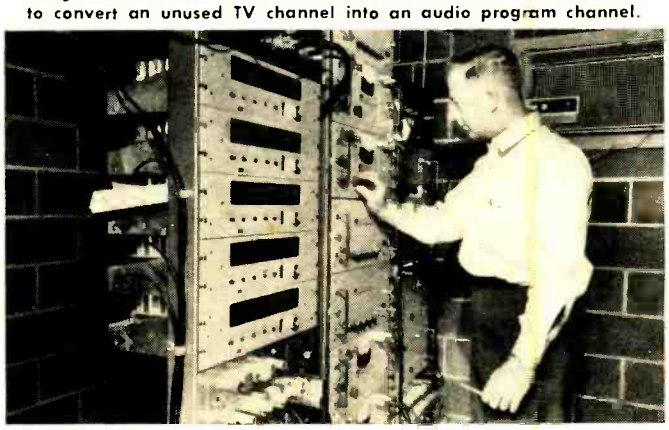
The introduction of cable TV leads to fewer service calls for those sets hooked up to the cable. The average signal strength received in the area by those people who used their own antennas on towers before hooking up to the cable was only a few microvolts. With the cable, these same sets now get about one millivolt on all channels. This means that the r.f. and even the i.f. tubes may get somewhat weak and still not need replacement to give a good picture. This is something that is taken for granted in cities where local channels are strong, but tube emission is critical in deep-fringe areas.

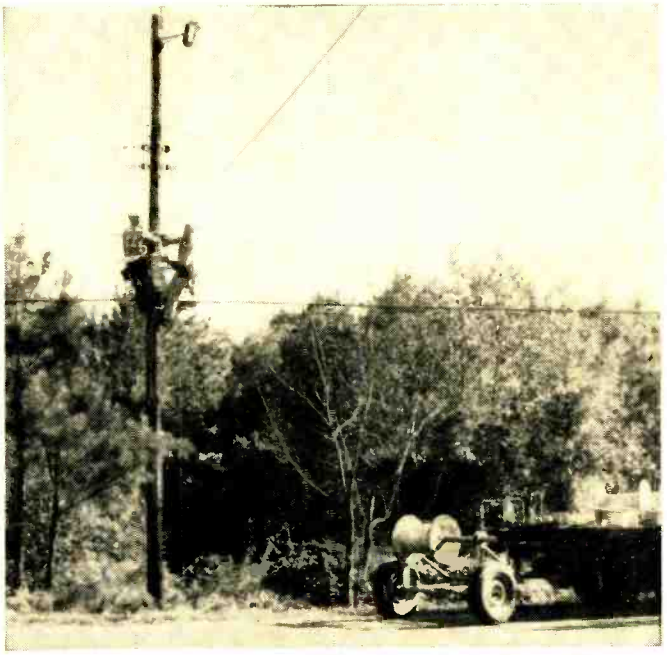
Fewer i.f and r.f. tubes need replacing but alignment has become more important for better set performance because some community antenna systems use narrow-band amplification.

Narrow-band systems have a passband from channels 2 to 6. This means that they can carry five TV channels. Most of the older CATV systems and some of the newer ones use narrow-band equipment to save on cost. Also, wide-band equipment was developed relatively recently. Not only is narrow-band gear cheaper, but fewer booster amplifiers need be used to increase the gain of the signal along the cable, since low-band frequencies do not suffer as much attenuation as those of the high-band. Use of the narrow-band results in adjacent channel operation.

If the cable is to furnish five TV channels confined between 2 and 6, then these channels must be lined up on the TV set tuner at channels 2, 3, 4, 5, and 6, all adjacent channels except for 4 and 5. With most of the less expensive sets, this presents a reception problem. Many low-cost TV receivers do not have an adjacent channel sound trap. In these sets, the sound carrier of the lower channel will beat with the picture carrier of the next higher channel, producing a light herringbone pattern on the TV screen. To alleviate this effect, many of the community antenna systems reduce the sound carrier level about 15 db below the picture carrier. Where this is not done by the cable company, or where the effect in the TV set is still annoying, the i.f. strip can be realigned so as to reduce the sound carrier. This is done by decreasing the width of the i.f. response curve, *i.e.*, peaking it more sharply. This drops the position of the sound carrier on the slope.

Technician adjusts microwave receiver of CATV system. In the foreground are the FM receivers and modulators that are used to convert an unused TV channel into an audio program channel.





Most CATV systems use existing utility poles to hang cable. Here linemen tighten coaxial cable before lashing it down.

Herringbone pattern is caused by sound carrier of next lower channel beating against next higher channel picture carrier.

Unfortunately, this technique also reduces the quality of the picture since it cuts down on the amount of detail. A better method of solving this problem is to install an adjacent-channel sound trap. Some are available from TV receiver manufacturers for their own sets, but these must be installed within the receiver. Somewhat more convenient is a tunable antenna trap, which attaches to the antenna terminals of the TV set. Some of these provide up to 50-db attenuation.

Incidentally, many of the newer sets without traps already have narrow-peaked i.f. stages to get around the adjacent channel interference problem. Even so, a trap may be needed in these receivers if the adjacent channel sound is strong enough.

The most immediate and obvious result of the coming of CATV to a town is the reduction of antenna towers. A large percentage of those families who already have towers, hook up to the cable when antenna repair time rolls around, and dismantle their original installations. What is more, the towers and tall masts serve as (*Continued on page 87*)

LOUDSPEAKERS for TRANSISTOR AMPLIFIERS

By VICTOR BROCINER/H. H. Scott, Inc.

What factors are important in selecting a speaker system for use with a transistor hi-fi amplifier? What are the effects of changing impedance and of improper impedance matching? What about using motional feedback and integrated amplifier-speakers?

SLOWLY, but inevitably, transistor amplifiers are appearing in the hi-fi equipment field. As this process continues, will it be necessary for speaker engineers to design for transistor operation? Will the transistor amplifier open new possibilities not previously attainable with tube amplifiers? Will the speaker and amplifier be wedded because of specialized complementary characteristics? This article will examine these questions and attempt to make the problems more definite, as well as including some of the probable answers to the problems which may arise.

The Amplifier as a Source

An amplifier can be viewed as a "black box" with two output terminals at which an a.c. voltage appears, and having an internal impedance which is essentially a resistance. This resistance usually varies over the audio range because of the variable feedback factor resulting from the loss in transistor gain at high frequencies. The transistors themselves have high output impedances, like power pentodes. The very large amounts of feedback used (as much as 30-40 db or more) reduces this to such a low value that the amplifier can be considered a constant-voltage source; that is, one with nearly zero internal resistance—very much lower than the voice-coil resistance of the speaker that is to be connected.

In selecting a speaker system for a transistor hi-fi amplifier, keep the following important points in mind:

1. The speaker must have the proper impedance value to match the amplifier, otherwise you risk distortion, reduced power, or increased loading that may ruin your transistors.
2. Speaker impedance varies with frequency; minimum impedance should not be less than 75% of rated value.
3. Fuses or other protection should be provided to prevent speaker burnout in case of transistor failure, with direct-coupled output stages, unless a capacitor is used in series with the speaker. Protect transistors from overload due to accidental shorting of speaker terminals.
4. With tweeters, especially electrostatic units, whose impedance falls with frequency, make sure that the minimum value of impedance is not below the minimum load permissible for the amplifier.

The maximum power transfer theorem states that the load must match the source impedance for a generator having a linear current-voltage characteristic over the range of operation. Fig. 1 shows the relationship of load power to load resistance. Consider a 50-watt amplifier operating into an 8-ohm load. This corresponds to 20 volts. If the amplifier has an internal resistance of 1 ohm at the "8-ohm" tap, the open-circuit generator voltage must be $20 \times 9/8 = 22.5$ volts. If this voltage were applied to a 1-ohm load in series with the source resistance of 1 ohm, the maximum power output of 126 watts would be produced. While the *calculation* gives us 126 watts, the amplifier certainly doesn't! With the rated 8-ohm load, we are operating at point A. Fig. 1. With a tube amplifier, for values of load impedance below rated load, distortion rises, since the operating point is chosen for minimum distortion, as shown by the dot-dash line. Fig. 2 shows measured undistorted power output *vs* load resistance for a transistor amplifier without feedback. Here the limiting factor is not distortion but transistor dissipation.

The value of the source resistance of the amplifier, while it certainly affects speaker damping, is unrelated to the fact that a speaker of a given impedance must be connected to the amplifier output taps marked with that impedance. At this value of "matched" load impedance, the amplifier is delivering the highest undistorted power output obtainable without exceeding the power ratings of the output transistors. If a transistor amplifier uses an output transformer or tapped choke, the speaker and amplifier are "matched" just as with a tube amplifier.

One of the attractive features of transistor power stages is that they require low-impedance loads, hence they offer that long-dreamed-of possibility: the elimination of the output transformer.

Fig. 3 indicates the variation of power output with change in load resistance for different d.c. supply voltages for class B operation of a series-connected power output stage in which the saturation resistance of the transistors is assumed to be zero and no emitter resistors are used. A representative figure of 69% has been assumed for efficiency and a reasonable figure is assumed for power-supply regulation, which is the same for the different supplies considered.

Suppose we have a 40-volt supply and require a power

output of 20 watts. The 40-volt curve intersects the 20-watt ordinate (point *A*) at 7.8 ohms. This is a convenient value, since many speakers are made with an impedance of 8 ohms. Now let us consider the requirements for 50 watts output. The required load resistance (point *B*) is 3.1 ohms. In actuality, typical values of saturation and emitter resistance would bring R_L closer to 1.7 ohms. These impedances are inconvenient and would also cause more heating in the amplifier because of lowered efficiency.

If we decide to retain our load impedance of 8 ohms because there is a wide selection of speakers at this impedance, Fig. 3 tells us inexorably that we must increase the supply voltage (point *C*) to 65 volts. Higher voltage transistors and power supplies are more expensive than higher current equivalents, and there is less of a selection of transistor types. It appears that if direct coupling to the speaker is going to be the rule, the amplifier designer will call the tune on speaker impedance, and the speaker manufacturer will dance to it.

The situation is reversed with respect to d.c. unbalance. The speaker will not tolerate the presence of an appreciable d.c. voltage because this would displace the voice coil from its rest position, resulting in reduced power capacity at low frequencies, and increased distortion. The amplifier design must, therefore, provide d.c. isolation or a balanced arrangement to eliminate or minimize this effect. Electrolytic capacitors are used for d.c. isolation because of the very low impedance involved; these must have very high capacitances (1000-2000 μf.).

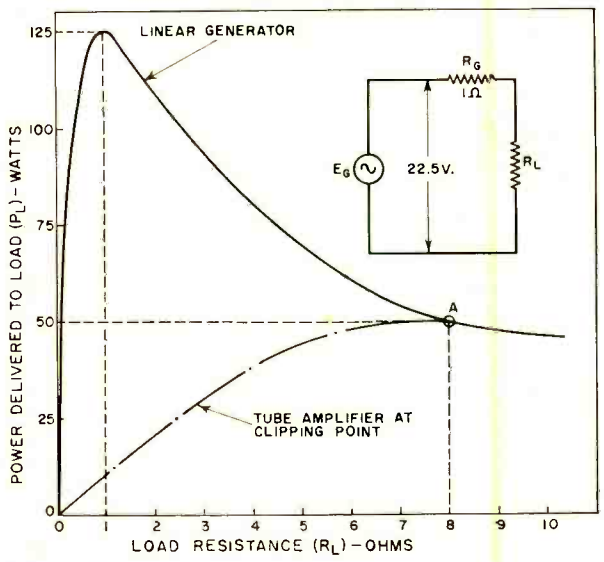
Balanced circuit designs eliminate the need for the coupling capacitor. Unbalance caused by mismatch between transistors is not serious because the idling current is so low in class B operation. Simple servo circuits have been developed to maintain balance automatically. Fuses should be provided to prevent speaker burnout in case of transistor failure.

The Speaker as a Load

The amplifier looks into an impedance which is very different indeed from the simple value of resistance given as the rating of a speaker. The equivalent electrical circuit of a speaker is shown in Fig. 4, together with a graph of the variation of impedance with frequency for a typical speaker in a closed box. The equivalent circuit is far more complicated for a speaker in a vented cabinet, a horn-loaded speaker, or a multiple-speaker system and its dividing network.

The data in Fig. 4 shows that the speaker impedance is resistive and only near its rated value over a limited frequency range. This is nothing new to most readers, and has been tolerated for a good many years with tube amplifiers because

Fig. 1. Variation of power with different load resistors.



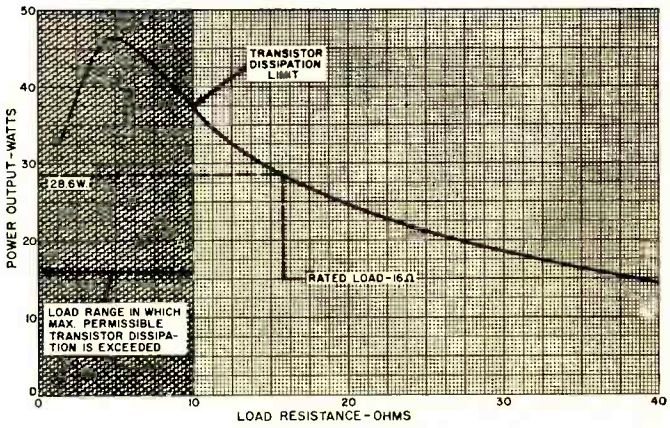


Fig. 2. Measured undistorted output vs load at 1000 cps for transistor power amplifier using an 18-volt regulated supply.

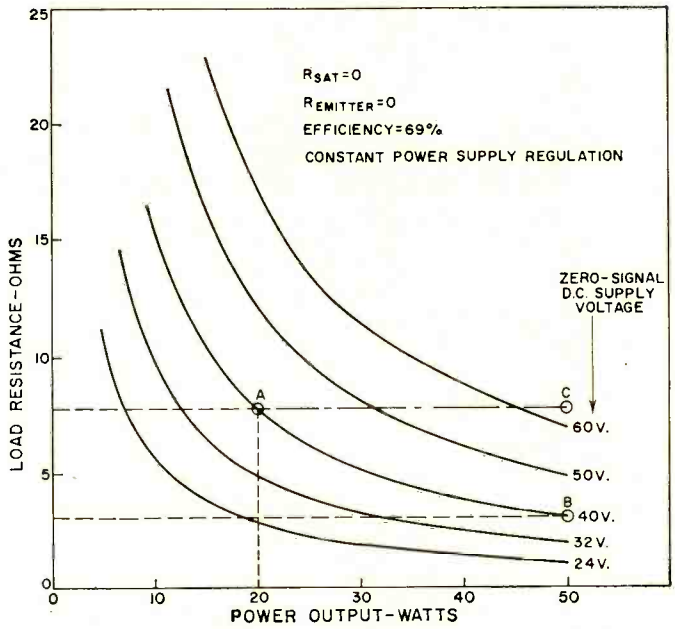


Fig. 3. Performance of a series-connected transistor output stage that is directly coupled to an output load resistor.

variations in load resistance have relatively small effects.

With transistor amplifiers, the situation is different. If we attempted to operate at maximum undistorted output, we would burn out the transistors (Fig. 2). Over the usable part of the curve the maximum undistorted power output is roughly inversely proportional to the load resistance, and the operating point is near the limit of transistor dissipation. A value of impedance below rating in any region of the frequency range results in overload on the transistors. Speaker system designers should pay more attention to maintaining uniform impedance over the frequency range. This problem is not a simple one. While we cannot go into details here, it may be amusing to examine an illustration of the preceding statement. If we pour epoxy cement into the gap of a speaker and let it harden, the speaker will have a perfectly uniform and resistive impedance from d.c. to the region where the voice-coil inductance begins to have an effect, because there will be no motional impedance. (In the remote event that the reader has missed the point: please do not try it.)

Not only must the speaker manufacturer try to keep the impedance constant: he must rate the impedance accurately. Here, the speaker industry has had a tendency to play a sort of inverted numbers game. When speakers are compared in a showroom they are usually switched back and forth without compensating for their different efficiencies. The louder speaker usually sounds more impressive. Now, making a speaker more efficient is expensive. However, there is a

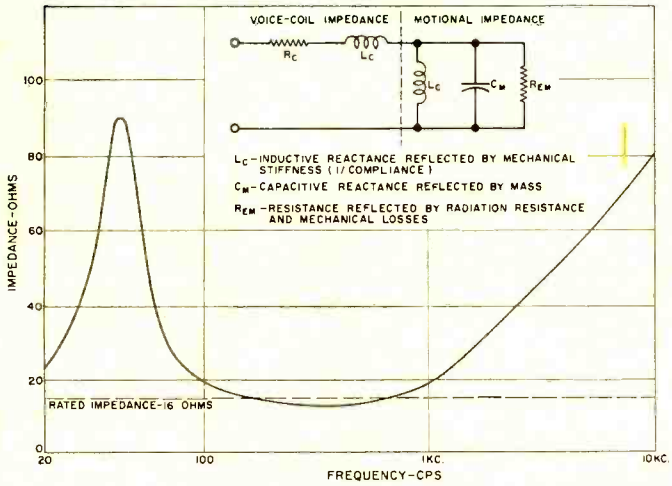


Fig. 4. Equivalent circuit diagram and curve of impedance variation for a typical loudspeaker mounted in closed box.

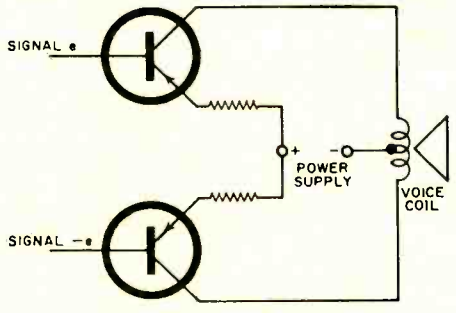
method that costs nothing by which the *apparent* sensitivity can be increased. It is based on the fact that hi-fi amplifiers all use large amounts of negative voltage feedback and consequently appear to be nearly constant-voltage sources. Since $P = E^2/R$, we can increase P by decreasing R. All we need to do is reduce the impedance of our "8-ohm" speaker to 6 ohms, and *voila!* there is about 2 db more output. Also, we are that much closer to overloading the output transistors. In good practice, value of speaker impedance should not be less than 75% of the rated value.

Consider the case of a tweeter having a smooth frequency response curve that slopes downward as the frequency increases. The speaker designer is tempted to use an undersized series capacitor as a high-pass filter, thereby correcting the tilt and incidentally saving the boss some money. A happy solution? Not if the resulting filter-tweeter combination has an impedance of 12 ohms at crossover (say, 2000 cps) and 4 ohms at 20,000 cps, and is rated at 8 ohms. If this tweeter is connected to a transistor amplifier on the basis of this rating, we had better pray that we never encounter program material that has full energy content in the 10,000-20,000 cps region, or we may have to buy a new pair of output transistors. (There are ways of protecting an amplifier against such overloads, and these are used in some commercial units. This protection is important. The situation is made even more critical because of the possible accidental presence of program material above the audible range.) For the same reason, some care needs to be taken when using electrostatic speakers which, being essentially capacitors, decrease in impedance as the frequency increases.

Special Speaker Design

The inconvenience, non-linearity (slight as it is), expense, and the bulk of the electrolytic capacitor used to couple the speaker to a transistor amplifier can be eliminated by using a center-tapped voice coil. Fig. 5 shows an output stage directly connected to such a center-tapped coil. In the schematic, the winding resembles the primary of a conventional output transformer, and this resemblance can lead to the dangerous assumption that its function is analogous. Let us see. If the amplifier operates in class A, the analogy applies fairly well. The quiescent direct currents of the transistors are in opposite directions in the two halves of the voice coil, resulting in cancellation of their ampere-turns and zero displacement of the voice coil. A less happy result is that the I^2R loss in the coil (heat) is considerable and is present continuously, unlike the a.c. signal. No "music power" rating applies to the heat dissipated!

Fig. 5. Use of center-tapped voice-coil speaker.



Because practical transistor output stages are usually operated class B or class AB, the quiescent current is quite small, and the heat dissipation is moderate. However, the d.c. resistance of each half of the voice coil is in series with the "B" supply. The adverse effect on regulation is not negligible, since the d.c. resistance is of the same order of magnitude as the rated impedance (per half-winding).

In class B, each transistor operates over half a cycle only. With transformer coupling, or series push-pull circuits, the current of the transistor that is operating passes through the entire voice coil. With the center-tapped arrangement, the current goes through only half the voice coil. Since, at a given instant, only half the coil is driving the cone, while the acoustic and mechanical load are the same as if all the coil were energized, speaker efficiency is reduced by 50%.

Special Amplifier Designs

Direct coupling between speaker and amplifier involves problems relating to d.c. unbalance and the resulting off-center displacement of the speaker voice coil. It also presents the possibility that failure of one output transistor by short or open circuit can place one-half the d.c. supply voltage across the speaker voice coil, with disastrous results. In one design, a feedback system senses the d.c. unbalance and corrects it.

Transistor output stages using a center-tapped choke offer an excellent solution in terms of low distortion, efficiency, quality, and cost.

Amplifiers using high-frequency carriers modulated in various ways have been built experimentally. Some designs involve the presence, under no-signal conditions, of a high-frequency carrier which is converted into heat in the speaker voice coil. This must be considered in designing the speaker.

Motional Feedback

What prospect can be more delightful than that of including the speaker in the feedback loop to flatten its frequency response and reduce its distortion? Several schemes have been devised.

This discussion has purposely excluded feedback taken from the *acoustic output* of the speaker because, except at low frequencies, it is almost impossible to know what to feed back, with the sound pressure level varying so radically from point-to-point in the environment. The really logical attack is to feed back from the listener's ears (or brain?), but this scheme is not exactly ready to go into production.

Motional feedback involves the utilization of the voltage generated by the velocity of the voice coil. Successfully applied, this would make more linear the relationship between the voice-coil velocity and the signal input to the amplifier. There are several ways to accomplish this. A second voice coil can be wound on an extension of the main voice-coil form, operating in an additional small magnetic structure. The motion of this auxiliary voice coil in the magnetic field generates a voltage that is directly proportional to the velocity of the coil. This voltage is fed back to the input of the amplifier. The speaker is thus included in the feedback loop, and non-linear distortion is reduced. This is the case if the auxiliary voice coil never leaves the gap, if the field is uniform throughout the gap, and if the auxiliary coil is attached to the main voice coil with sufficient rigidity to insure that their velocities are identical. These conditions are not easy to fulfill.

In all motional feedback schemes, there is some phase shift, which varies

(*Continued on page 60*)

By FRED L. MERGNER
Director of Engineering, Fisher Radio Corporation

TRANSISTORS vs TUBES for HI-FI

Additional comments on power-amplifier performance and loudspeaker matching with transistor circuitry.

Editor's Note: Following are some additional thoughts on the two-part article "Transistors for Hi-Fi: Panacea or Pandemonium?" which appeared in our September and October issues. There is much general agreement with the views previously expressed, hence these views are not repeated. On the other hand, Author Mergner has a somewhat different point of view on some of the items covered earlier.

WE feel it would be interesting and beneficial to both present and future users of transistor equipment if the ideas previously advanced were illuminated from a different viewpoint, and if alternative design approaches were considered. We intend to cover in detail only those areas where we differ in opinion with the previous authors. It is generally agreed that where lack of microphonics, quick warm-up, cooler operation, and increased life expectancy are concerned, transistors are superior to tubes.

Size of Transistor Amplifiers

The problem of amplifier size may seem a trivial one, since both audiophile and engineer are more interested in performance than compactness. However, when the problem of amplifier dimensions is thoroughly investigated, it inevitably leads to considerations of circuit design, the key to amplifier performance.

The size of an amplifier depends on the size of the components used, the chassis layout, and particularly, the circuit design. A major factor influencing the size of transistor amplifiers is the need for heat sinks to dissipate the heat generated in the junctions of transistors (mainly in those of the output and driver stages). Depending on the permissible temperature rise and on the location and exposure to the surrounding air, heat sinks for required dissipation will naturally vary greatly in size.

The most influential factor, however, is the circuit itself. One can design transistor amplifiers which, in spite of lower power capabilities than comparable vacuum-tube equipment, still require larger outside dimensions. This might be the case if a designer chooses, for reasons of his own, a design which requires both output and driver transformers, as well as large coupling capacitors in the power-amplifier section. After careful consideration of all the variables, however, we feel there is no reason why transistor amplifiers cannot be made smaller than vacuum-tube equipment with comparable power. The main determinant of amplifier size is circuit design.

Matching to Speakers

One important consideration in the design of transistor amplifiers is the matter of impedance matching. Transistors in power-output stages, whether working in a bridge-type, parallel, or series push-pull configuration, are basically low-impedance devices. Of these, however, only the bridge and series push-pull configurations have characteristic output impedances which are low enough to facilitate direct connection of a speaker to the output terminals of the power amplifier.

The nominal values of impedances of speakers commonly used for high-fidelity reproduction vary between 4 and 16 ohms. Maximum power transfer from the amplifier to the speaker occurs if the speaker impedance is matched to the internal impedance of the source, *i.e.*, the amplifier. With conventional circuits the internal impedance of transistor amplifiers, however, is considerably lower than the lowest speaker impedance of 4 ohms. This mismatch will result in a decrease of available power with increasing load-impedance values. Approximately 30% of the power at a 4-ohm load will be available to 16-ohm speakers.

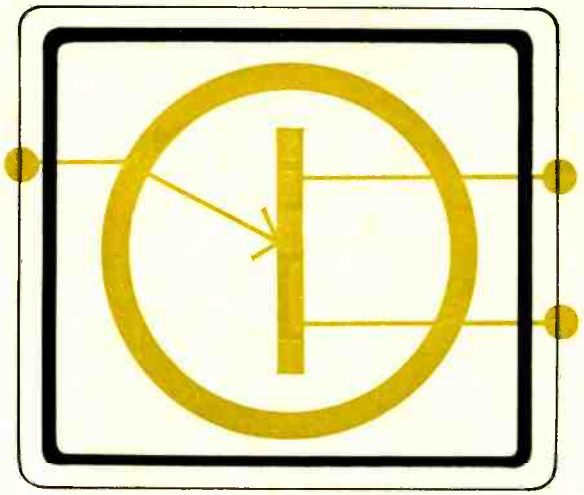
One way of surmounting this difficulty is to use only 4-ohm speakers which, of course, is impractical; another would be matching all speakers to 4 ohms with the help of a transformer. There are, however, more advantageous approaches, such as to increase the internal impedance of the amplifier, which, in turn, will result in a higher optimum load impedance. This can be achieved by the use of four power transistors per channel connected in series. In this case, the additive saturation resistances of the transistors and any external emitter resistors increase the source impedance seen by the speaker. Assuming that the optimum load impedance is now closer to 8 ohms, the mismatch occurring with 16-ohm speakers will not reduce the available power seriously.

This approach will result in two important improvements. First, no output transformer is needed. Furthermore, the use of four power transistors per channel with their higher operating voltages, will provide more power and permit safer operating conditions. This occurs because the working voltages and, consequently, the heat dissipated per transistor is greatly reduced. The power available under these conditions *without* an output transformer is considerably higher at *all* impedances than is the case with a constant transformed load of 4 ohms. The price which would otherwise be paid for the output transformers will compensate for the cost of additional output transistors.

Elimination of Output Transformer

It is well known that the output transformer is the one element in any amplifier which most strongly affects and limits frequency, power, and transient response. Even the less complicated bifilar design required for transistor matching still results in a component which in no way improves a particular amplifier.

For many years designers have tried, with more or less success, to eliminate the problems inherent in output transformers, which are required in tube amplifiers to provide proper matching between tubes and speakers. Their first attempt was to improve the transformer itself, and later to reduce its harmful effects by using unity-coupling, bridge-type, and similar circuits. OTL, or output-transformerless tube circuits proved to be impractical, as even a large number of tubes operating in parallel still (*Continued on page* 80)



THE UNIJUNCTION TRANSISTOR

By DAVID L. PIPPEN
Guidance & Control Labs, White Sands Missile Range

Operation and applications of special semiconductor device with single p-n junction. Used in timing circuits, pulse generators, multivibrators, SCR firing circuits, counters.

EVEN though the unijunction transistor was developed in 1954, the industry is just beginning to utilize the potentialities of this remarkable, single *p-n* junction, semiconductor device.

The external configuration of the unijunction transistor is the same as a conventional two-junction transistor, but its internal construction and electrical characteristics are quite different. When an aluminum contact wire is alloyed to a bar of *n*-type silicon, a unijunction transistor is formed. The base contacts at each end of the bar are ohmic contacts rather than the rectifying contacts found on conventional transistors. The junction of the aluminum wire and the silicon bar does, however, form a rectifying *p-n* junction. Fig. 1A shows the electronic symbol used to designate a unijunction transistor. Fig. 1B is a cross-sectional view of the same transistor, while a representative circuit of a unijunction transistor is given in Fig. 1C.

The resistance between base 1 and base 2 can be measured with a conventional ohmmeter if care is taken to avoid using a meter which would apply excessive voltage across the base junctions. The maximum base-to-base voltage which can be applied across the unijunction transistor bases should not exceed those maximum ratings specified by the manufacturer. The resistance measured will vary from a low of around 4500 ohms up to approximately 12,000 ohms.

In normal operation, base 2 is connected to a positive voltage source and base 1 is connected to ground. With the emitter open-circuited, the device acts as a resistance voltage divider with current flowing through the silicon bar. A fraction of the voltage applied across the bases will appear at the emitter junction. This fraction or the proportional part of the voltage applied across the bases is an important parameter of the device and is called the "intrinsic stand-off ratio." The Greek letter *eta* (η) designates this parameter.

In Fig. 1C, R_{B1} and R_{B2} represent the ohmic resistance of the silicon bar. $D1$ represents the rectifying contact formed by the alloying of the aluminum wire to the silicon bar.

If an externally applied emitter voltage, V_E, is less than the voltage at the junction of R_{B1} and R_{B2} (ηV_{BB}), the junction will be reverse-biased and only a small amount of leakage current will flow. However, should V_E be raised to a value above ηV_{BB}, then the junction will be forward-biased and current will flow. This increase in current flow in the emitter-to-base 1 region consists primarily of minority current carriers injected into the silicon bar. The result of this action is evidenced by the decrease in the resistance of R_{B1} and an increase in emitter current. Since the emitter voltage decreases and, as stated above, the emitter current increases, a negative resistance characteristic is obtained. Fig. 2 gives the emitter characteristics of a Type 2N492 unijunction transistor. The characteristic curves indicate negligible emitter current until the emitter voltage is raised to the peak point or firing potential. From this point until the valley point is reached, emitter current increases as the emitter voltage decreases, therefore, this portion of the curve is characteristic of negative resistance. It should also be noted that for each V_{BB} there is a particular peak point. This is due to a different voltage being developed at the junction of R_{B1} and R_{B2} for each different V_{BB}, thus back-biasing the rectifying junction at different levels in proportion to the V_{BB} used.

Relaxation Oscillator

Now that the operation of the unijunction transistor has been briefly explained, we can consider a few of its many applications. Fig. 3 is a schematic of a simple relaxation oscil-

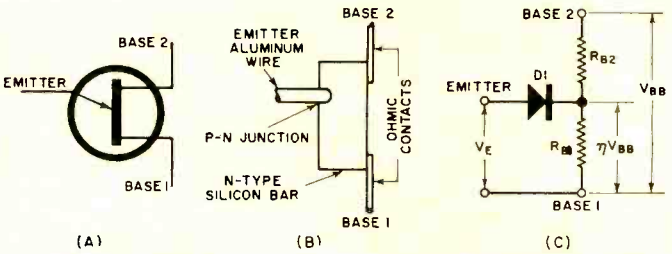
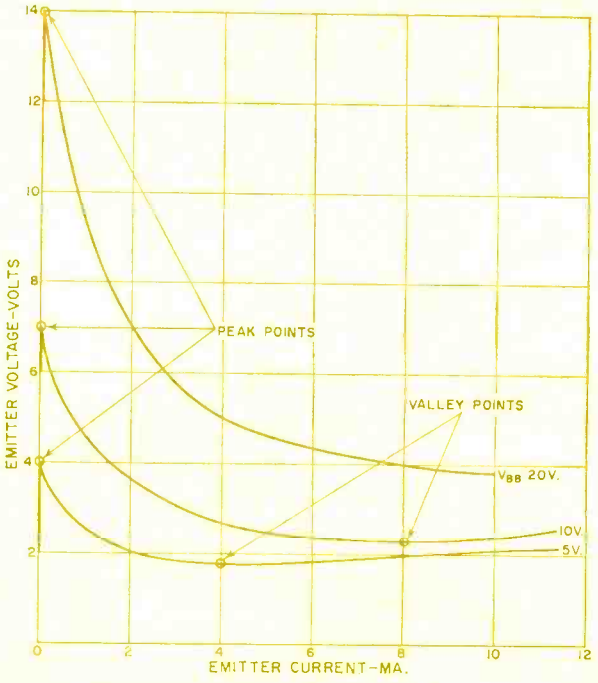


Fig. 1. Symbol, construction, and equivalent circuit of device.

Fig. 2. Emitter characteristics of 2N492 unijunction transistor.



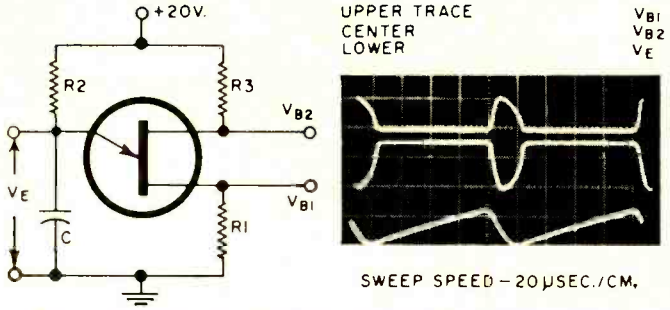


Fig. 3. Schematic and waveforms of simple relaxation oscillator.

lator circuit. When the battery is connected, capacitor C begins to charge at a rate determined by the $R2$-C time constant. When the voltage across C (designated as V_E) reaches the peak point or firing potential of the device, emitter current begins to flow and C discharges rapidly to a value at which emitter current ceases to flow. The cycle then repeats and sustained oscillation is thus accomplished.

This action is represented by the saw-tooth waveform, V_E, given in Fig. 3. This action is much like that associated with silicon controlled rectifiers or thyratrons except when the unijunction emitter voltage is removed, the emitter base current ceases. During the period that emitter current flows, the outputs shown in Fig. 3 will appear at the base monitor points V_{B1} and V_{B2}.

The frequency of oscillation can be approximated from the equation $f = 1/(R2Ck)$, where $k = ln\ (1/[1-\eta])$. Fig. 4 gives the values of k for a wide range of η. The k can be omitted from the formula and the value of $R2$ calculated. This will give a rough value of resistance to which a resistor decade box or potentiometer can be set and then adjusted for the desired frequency of operation. The ratio of $R2$ to C for a particular frequency of operation must fulfill certain requirements in order for the circuit to operate. $R2$ must have a value large enough to limit the current to a safe value yet small enough to allow the peak-point emitter current to flow. These conditions are broad and allow a resistance range for $R2$ of from approximately 2000 ohms to over 1 megohm.

Resistor $R3$ is used for temperature compensation and should be kept small. Typical values for $R3$ range from about 200 to 600 ohms. $R1$ is not necessary and is used in the schematic only to demonstrate the voltage waveshape present at that point. The upper frequency limit of most unijunction types is usually below 1 megacycle. For frequencies above 150 kc., the value of C becomes small and the usual precautions with regard to stray capacitance should be taken.

As an example of the simple design procedure using a Type 2N492, the η spread is from 0.56 to 0.68. If a 1-kc. oscillator is desired, then a 0.2-μf. capacitor and a 10,000-ohm pot placed in the circuit for C and $R2$ would give oscillations close to the desired frequency. The potentiometer would be used as a fine-tuning control to adjust to the exact frequency. It should be mentioned that the recovery time of the circuit (that time for the emitter voltage waveform to fall from its 90% of maximum value to its 10% of maximum value) is principally determined by the value of C. The smaller the value of C, the faster the recovery time. It should be realized, however, that $R1$ could be used to advantage should a long recovery time be desired. For example, if the circuit were used as a pulse generator, the pulse width obtained at base 1 or base 2 could be increased by increasing the value of $R1$. Increasing the resistance of $R1$ increases the discharge time of C.

Demonstration Circuit

For demonstration purposes, the circuit shown in Fig. 5A was set up. The value of C was 0.05 μf. and the value of $R2$ was set at 2500 ohms. $R1$ and $R3$ were 470 ohms each. The waveforms obtained using these circuit values are given in Fig. 5B. (The amplitudes of the three waveforms shown were adjusted to permit all to be viewed on a single exposure.) The frequency of oscillation was approximately 1 kc. and the recovery time was slightly less than 20 μsec. The output pulses obtained at the base monitoring points were approximately 24 μsec. in duration.

C was then reduced to 40 pf. and $R2$ adjusted for as high a frequency as could be obtained. Fig. 5C gives the waveforms at the various points. The emitter waveform shows that the charge time of C was very nearly equal to the recovery time. The resultant output waveshape was a fairly good sinusoid, whose frequency is approximately 250 kc.

The 0.05-μf. capacitor was switched back into the circuit and S1 switched to position 2. This configuration allowed the use of a square-wave generator to supply the emitter voltage. $D1$ was used to prevent C from discharging through the square-wave generator when the square-wave output amplitude was zero. Fig. 5D shows the emitter waveform impressed upon the square-wave input signal. The top trace shows the output obtained at base 2. By *(Continued on page 77)*

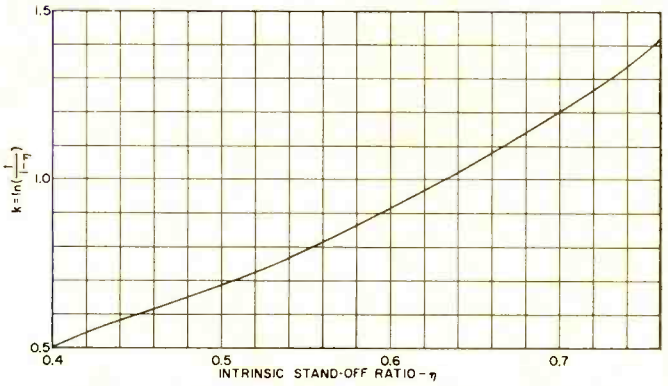
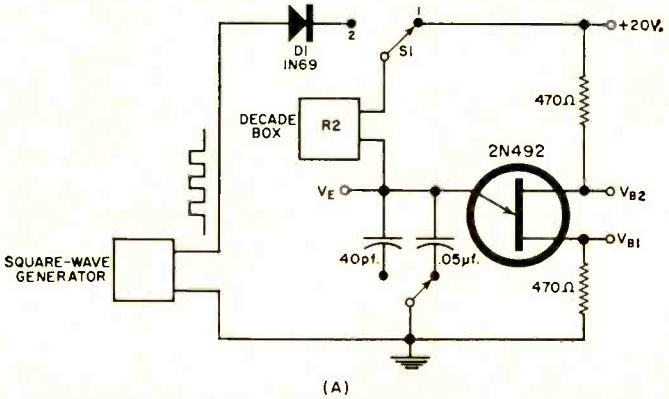
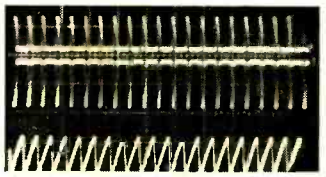


Fig. 4. The values of "k" for various intrinsic stand-off ratios.

Fig. 5. Demonstration circuit, waveforms under various conditions.

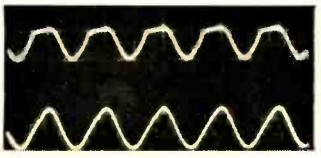


(A)



SWEEP SPEED 200μSEC./CM.
UPPER TRACE – V_{B1}
CENTER ——— V_{B2}
LOWER ——— V_E

(B)

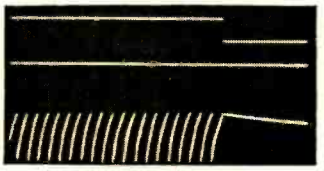


SWEEP SPEED 2μSEC./CM.
UPPER – V_{B2}
LOWER – V_E

(C)

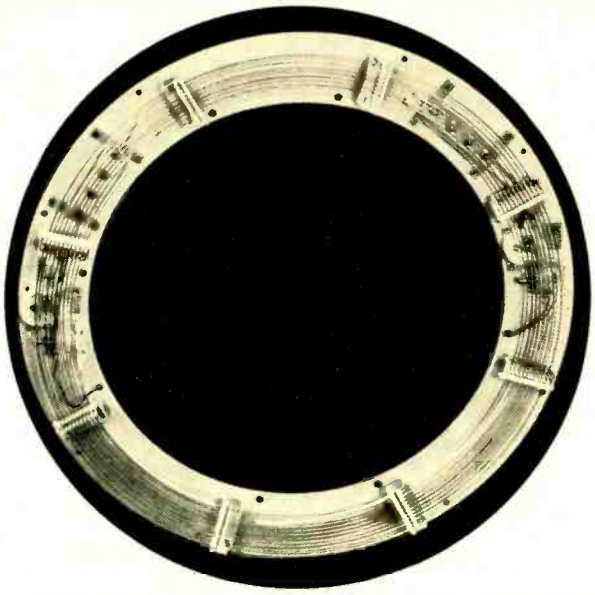
UPPER ——— V_{B2}
SQUARE WAVE – INPUT
STAIRSTEP — V_E

(D)



UPPER TRACE — INPUT
CENTER ——— V_{B2}
LOWER ——— V_E

(E)



Internal view of a typical delay-line package. This particular torsional-mode line has a delay up to 10,000 microseconds.

MAGNETOSTRICTIVE DELAY LINES

By JOHN R. COLLINS

Wire delay lines convert electrical signals into sonic signals then back into electrical signals. Because they can store pulses for a period of time, they are used mainly as memory devices.

ALTHOUGH the great speed at which electrical impulses travel is generally considered an asset, there are occasions when it is desirable to slow them down. In electronic computers, for example, signals are delayed to provide the short-term storage needed for mathematical calculations. In radar and sonar, signals delayed for precise intervals are used for timing circuits and, in the case of certain radars, for blanking out the echoes from stationary objects so that only the moving targets are displayed.

Short delays can be conveniently provided by inserting *LC* networks in the signal path. Since time is needed for a capacitor to charge and discharge through an inductance, the effect is to retard the movement of electrical impulses. This method is not accurate for many purposes and *LC* networks are not often used for time delays greater than 50 μsec. Standard and specially constructed coaxial cables can serve as delay lines but to obtain useful delays, very long sections have to be used.

Magnetostrictive delay lines permit longer delays while preserving the timing accuracy. They are based on the principle of converting electrical energy into ultrasonic energy, transmitting it over a length of wire or rod, and then converting back into electrical energy. Since sound travels much slower than electricity, the result is a time delay that can be precisely regulated by adjusting the distance between the point of transmission and the point of reception of the sound wave. Magnetostrictive delay lines have been designed to provide delays of 10,000 microseconds and with a capacity to store as many as 5000 binary bits.

Magnetostriction

Several metals, principally iron, nickel, cobalt, and their alloys, have the property of changing in length when they are subjected to a magnetic field. This effect is most pronounced in nickel which exhibits a negative magnetostrictive characteristic (*i.e.*, becomes shorter as the magnetic field is increased) as shown in Fig. 1. Note that the change is quite rapid up to about 300 oersteds, after which it tapers off until further increases in field strength have little effect.

The explanation of magnetostriction is based on the reorientation of the crystals making up the material when it is exposed to a magnetic field. Crystals of ferromagnetic materials contain groups of atoms called *domains* which are so aligned that their magnetic fields are parallel. Each domain in a cubic crystal may take any one of six directions within the crystal. If no magnetic field is present, then the 100,000 domains in an average crystal will be randomly oriented and the net magnetic field will be zero.

When an external field is applied to the ferromagnetic material, the domains begin to align themselves in the direction of the field. Those most favorably oriented are the first to line up, but as the field is increased, those less favorably positioned will follow suit. When all the domains are parallel to the external field, the material is saturated.

This realignment of domains causes a contraction of the metal and, in the case of nickel, amounts to about 30 parts in 1 million. For a nickel rod 1 foot long, this would be 3.6 ten-thousandths of an inch. In the case of cobalt, the initial effect is a small contraction followed by expansion as the field is increased.

The changes in length of a magnetostrictive material along the axis of the applied magnetic field when this field is changed is called the Joule effect. The reverse, called the Villari effect, relates to the fact that the magnetization of a magnetostrictive material, in the presence of a field, is altered when an external stress is applied.

In addition to delay lines, magnetostriction is the basis for various electromechanical transducers used in sonar, ultrasonic cleaning equipment, etc. It is also used in band-pass filters, vibration pickups, and strain gages.

Longitudinal Delay Lines

A simple magnetostrictive delay line is shown in Fig. 2. It consists of a nickel wire or rod which has a tightly wrapped transmitting coil at one end and a similar receiving coil at the other. The line is supported by damping pads at each end to prevent unwanted reflections.

When a current pulse is passed through the transmitting coil, the resulting contractions of the nickel bar in the induced magnetic field causes a shock wave to travel down the line at the speed of sound.

When the shock wave reaches the receiving coil, it causes a change in the reluctance of the nickel and hence a change in the external magnetic field. The result is an output voltage at the terminals of the receiving coil when the changing field cuts across the coil.

The waveforms associated with the operation are shown in Fig. 3. When the current is turned on, a shock wave is launched and a voltage with a positive and negative peak will be generated at the output. When the current is turned off and the rod returns to its former length, a second shock wave is launched. However, whereas the first wave was a rarefaction caused by the contraction of the rod, the second is a compression wave caused by its expansion. The result is a double peak in the opposite order—first a negative, then a positive peak.

Fig. 3A shows the waveform produced when the duration T of the input pulse is greater than the time needed for the pulse to traverse one length of the delay line. When T is less than, or equal to, the length of the delay line, the two negative peaks merge to form a single peak as shown in Fig. 3B. This

peak is then amplified and used as the line's output signal.

Torsional Delay Lines

A longitudinal delay line of the type just described produces a delay of about 5 microseconds per inch. Consequently, a 20-inch line would be needed for a 100-microsecond delay. This is about the maximum length used for a longitudinal line. When longer delays are needed, it is usual to use a coiled line, called a torsional delay line. Such a line is shown in the photograph. Torsional lines are energized by a sudden twisting movement at one end. This causes a pulse to travel the length of the coil at about half the velocity of the longitudinal pulse, so that a longer delay per inch is obtained.

The twist is applied by a longitudinal-to-torsional converter, whose principal elements are shown in Fig. 4. The nickel tapes are welded to opposite sides of the transmission wire. The tapes are slipped through coils that are connected together but wound in opposite directions so that when a current pulse passes through them, their magnetic fields will be of opposite polarity. A biasing magnet is placed equidistant from both coils.

In operation, the induced field about the bottom nickel tape is in such a direction as to reinforce the field of the bias magnet. This causes the lower tape to contract and to exert a pulling force on the transmission wire. However, the field of the upper coil tends to counteract the field of the bias magnet. This causes the upper nickel tape to expand and exert a push against the top of the transmission wire.

The result of this push-pull action is a twisting force that is transmitted through the wire. A similar converter at the other end of the transmission wire changes the torque back into an electrical impulse.

For rigidity, the converter components are mounted in a plastic block. Openings are provided so that the nickel tapes can be slipped through the coils. The tapes are usually about 2 mils thick and 10 to 20 mils wide. Their unwelded ends are held firmly in a damping material such as silicone rubber to prevent undesired reflections. Reflections may be further inhibited by using tapes made up of very thin strips which are then separated at the ends with insulating material sandwiched between the layers.

As the nickel tapes are welded to the transmission lines, it is not possible to vary the delay by changing wire length. However, it is customary to make the converter movable so that it can be moved backward or forward on the tapes. This permits minor adjustments to be made in time delay.

The transmission wire itself is usually made of an alloy called *Ni-Span C*, that contains about 42% nickel, 5.5% chromium and 2.2% titanium, the remainder being iron. This alloy maintains a constant length over a wide range of temperature making it possible to construct delay lines that maintain their characteristics from −65 to +105 degrees C.

Advantages and Limitations

Magnetostrictive delay lines provide relatively long delays without deterioration of the signal. The output pulse is as well defined after a delay of several thousand microseconds as after a brief delay of a few microseconds. Furthermore, the bandwidth and bit storage capacity are not affected by the frequency of the input signal as they are in the case of *LC* networks. The temperature characteristics are also much better.

Magnetostrictive lines are compact, have no moving parts, need no servicing, require little associated equipment, no extra power supply, and the energy is confined to the wires. They are often used in small or medium-sized computers instead of magnetic drums or core-memory devices. Because of their small size, ruggedness, and temperature characteristics, they have been especially useful for airborne applications.

Perhaps their greatest limitation is their high energy loss. While it is true that very little energy is lost in the transmission of the shock wave through the line, the input and output transducers are inefficient devices and they consume much energy. When compared with their many advantages, this may be of minor concern.

Such delay lines find great use in radar pulse formation, discrimination, and in electronic data-processing systems. ▲

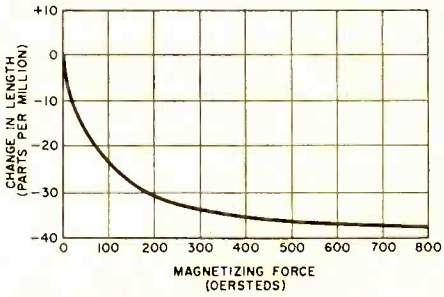


Fig. 1. Change in length with applied magnetic field strength for nickel. Change is quite rapid up to about 300 oersteds.

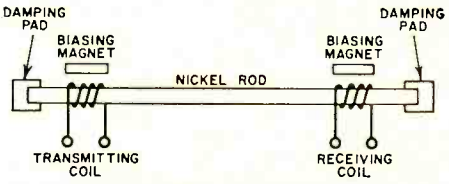


Fig. 2. A simple longitudinal delay line using a nickel rod. Bias magnet at receiver helps to generate output signal, while magnet at transmitter makes the input polarity sensitive.

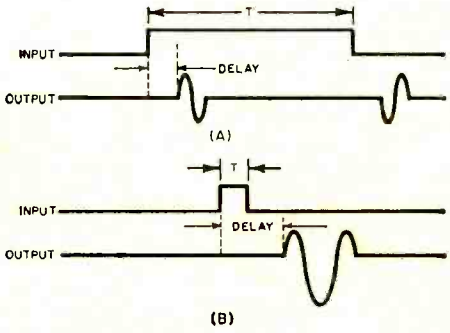
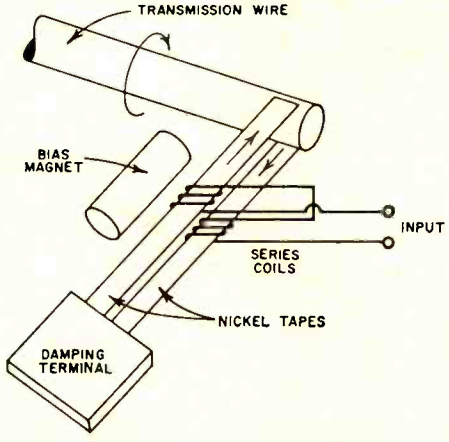


Fig. 3. Input and output pulses associated with operation of a longitudinal line. Long pulse shown at (A), short at (B).

Fig. 4. Elements of longitudinal-to-torsional mode converter.



SIMPLIFIED SOLID-STATE COLOR ORGAN

By DONALD LANCASTER

More economical version of author's earlier design made possible by novel method of firing controlled rectifiers and simpler filters.

THE development of a novel method for firing controlled rectifiers, certain readily available economical components, and a fresh approach to the filter problem makes possible two improved color-organ circuits based on the author's "Solid-State 3-Channel Color Organ" (April 1963). The new circuits provide certain cost and performance advantages over the original unit.

Fig. 1A is the schematic of a "minimum parts" version designed with economy as the principal objective. The unit is suitable for use in conjunction with a display, or as an experimental device, but provides no means for adjusting the color balance or background level. It is designed to be incorporated directly into a display with no connectors or cables required. Power capability is one kilowatt total.

Fig. 1B takes the minimum-parts unit and adds the refinements to give a "deluxe" unit, suited to the needs of even the most critical hi-fi enthusiast or professional bandleader. It provides complete control over both color balance and individual color background level. A noise filter is included to minimize SCR line noise. The unit is fused and switched and designed for operation of a remote display by conventional connectors. Power capability is also one kilowatt total. By changing SCR's and doubling all wire, switch, and fuse ratings, a two-kilowatt control capability may be realized.

As considerable current flows through certain portions of the circuits, requiring heavy gauge wire and cautious common connections, the schematics are drawn using the industrial convention of showing the main current paths as heavy lines and the control circuitry as in a normal schematic.

Minimum-Parts Version

Considering the minimum-parts unit first, the circuit is basically a full-wave unfiltered bridge rectifier driving three lamp loads through series silicon controlled rectifiers (SCR). Each SCR is "told" when in each cycle to turn on by the control circuitry, giving lamp brilliance in proportion to the audio energy present.

Diodes *D1*, *D2*, *D3*, and *D4* are 18-ampere press-fit rectifiers available from *Motorola*, *Delco*, or *Tung-Sol* at very moderate cost. They may be pressed into regular copper tubing (using nothing but a bench vise) to provide both mounting and suitable heat-sinking. Finning is required. Two forward-polarity and two reverse-polarity diodes allow the use of only two heat sinks. The sinks must, of course, be insulated from each other as well as from the case. The SCR's are 3-ampere, 200 p.i.v. rated and are available from *Sarkes Tarzian* or *Texas Instruments*. These are about the most economical SCR's available and will handle loads of between 15 watts minimum and 375 watts maximum with a suitable heat sink. Lower current SCR's are no cheaper than the 3-ampere units, and the lower current diodes are actually more expensive than the ones specified.

The SCR's are controlled by three line-locked neon-bulb saw-tooth oscillators. The time for capacitors to charge to neon breakdown is determined. (*Continued on page 60*)

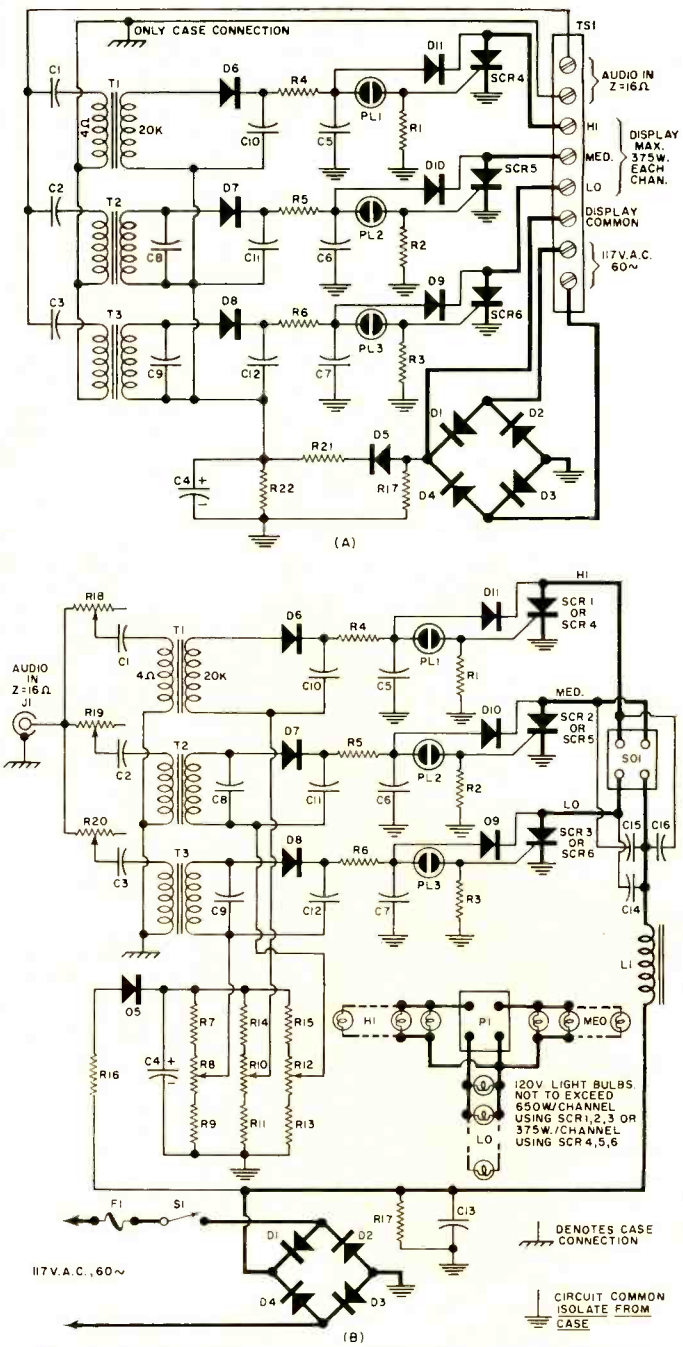
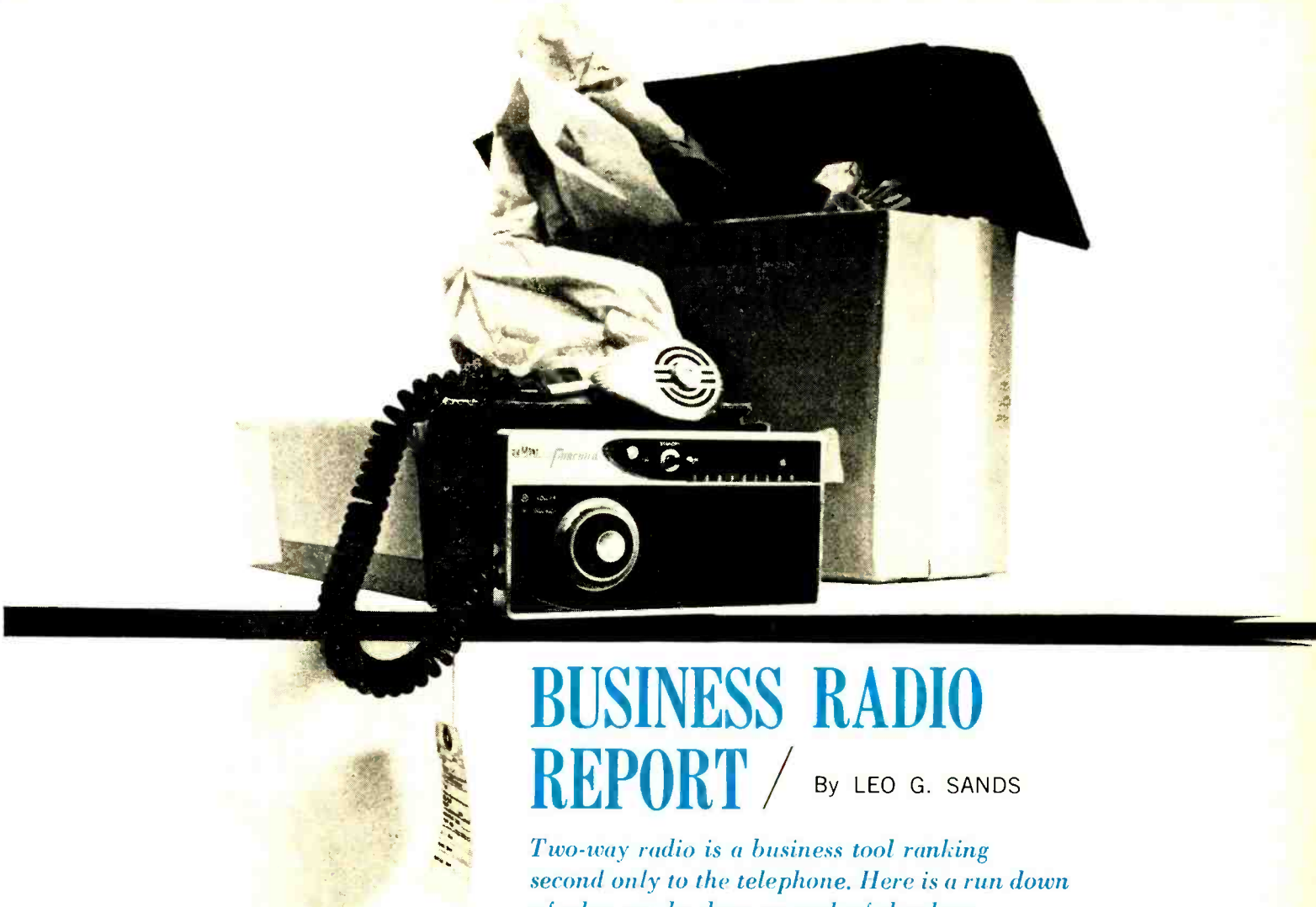


Fig. 1. Circuit of (A) economy and (B) deluxe versions of organ.

R1, R2, R3—1000 ohm, ½ w. res.
R4, R5, R6—100,000 ohm, ½ w. res.
**R7, R9, R11, R13, R14, R15—27,000 ohm, ½ w. res.*
**R8, R10, R12—25,000 ohm linear-taper pot*
**R16—100 ohm, ½ w. res.*
R17—4000 ohm, 5 w. wirewound res.
**R18, R19, R20—50 ohm, 5 w. linear-taper pot*
R21, R22—10,000 ohm, 2 w. res.
C1—10 µf. non-polar. capacitor (Olson Asst. No. AS-552)
C2—25 µf. non-polar. capacitor (see C1)
C3—150 µf. non-polar. capacitor (see C1)
C4—8 µf., 150 v. elec. capacitor
C5, C6, C7—.02 µf. ceramic capacitor
C8—.01 µf. ceramic capacitor
C9, C10—.04 µf. ceramic capacitor
C11—.1 µf. Mylar capacitor
C12—.25 µf. Mylar capacitor
**C13, C14, C15, C16—.01 µf. ceramic capacitor*
PL1, PL2, PL3—NE-2 neon lamp
D1, D2, D3, D4—18-amp. rectifier (Motorola MR3224 and MR3224R. Note: R is a reverse-polarity unit, heat-sink design determines which to use)
D5, D6, D7, D8, D9, D10, D11—750 ma., 200 p.i.v. diode (DI-56.1N2070, or equiv.)
**SCR1, SCR2, SCR3—5-amp, 200 p.i.v. silicon controlled rectifier (Sarkes 5TCRD or TI 2N1774)*
SCR4, SCR5, SCR6—3-amp, 200 p.i.v. silicon controlled rectifier (Sarkes 3TCRD or TI-40A2)
**SI—Heavy-duty switch (10 or 15 amp. Use 15-a, when using SCR1, SCR2, SCR3)*
**F1—8 or 16 amp fuse (use 16-a. with SCR1, SCR2, SCR3)*
T1, T2, T3—Audio output trans. 20,000:4 ohms, 5 w. (Burstein Applebee #13A223)
**L1—22 t. #16 wire on Arnold A-930157-2 core*
**J1—Phono jack*
**SO1—Four-prong socket (Jones S304AB or S404AB when using SCR1, SCR2, SCR3)*
**PL—Four-prong plug (Jones P304CCT or P4043CCT when using SCR1, SCR2, SCR)*
TS1—8-screw terminal strip
**Used only in the deluxe version (Fig. 1B)*



BUSINESS RADIO REPORT

By LEO G. SANDS

Two-way radio is a business tool ranking second only to the telephone. Here is a run down of what can be done on each of the three bands available, equipment costs, range, and methods of increasing effective power.

SMALL business can now use radio for a variety of purposes including two-way mobile communications, teletypewriter and data transmission, remote radio control, telemetry, and transmission of closed-circuit TV.

Hundreds of channels in the h.f., v.h.f., u.h.f., and s.h.f. (microwave) portions of the radio spectrum are now available to business users.

Mobile two-way radio is a business communications tool ranking second only to the telephone. Until recently, use of two-way radio was restricted to public utilities and public safety organizations. Now, any non-alien commercial enterprise is eligible to apply for a license to operate a private two-way mobile radio system.

Classes of Systems

There are several classes of business radio—the Business Radio Service—the Special Industrial Radio Service—the Manufacturers Radio Service—and the very popular class-D Citizens Radio Service.

Business radio is quite different and disassociated from the Citizens Radio Service (CB). While CB was intended to serve the needs of small business, it has definite limitations and, in some areas, the band is so congested as to limit its usefulness as a business tool.

Business radio systems operate on a specifically assigned channel in any of three bands, unlike conventional CB stations which may operate on any channel in the band. Nearly all business radio systems employ FM, whereas all CB stations must use AM. There is no limit on the height of business radio antennas, except when a hazard to aircraft exists, unlike CB station antenna height which is limited to 20 feet above its mounting surface or structure. Business radio stations may employ as much as 600 watts of transmitter power, while CB stations are limited to 5 watts input power.

Business Aspect

Business radio is big business. Based on the station licenses and mobile units authorized during a single typical week, annual sales volume of two-way mobile radio equipment to business radio users alone is in the vicinity of almost $75,000,000 annually. The projection indicates that some 16,000 two-way mobile radio systems employing 150,000 mobile units will be installed during the year ahead by businesses eligible for licenses in the Business, Manufacturers, and Special Industrial Radio Services. This does not include systems to be installed by police and fire departments, railroads, taxicab companies, truckers, bus lines, power companies, pipe lines, and other right-of-way industries.

To the radio service industry, this means an annual income of about $2,250,000 for equipment installation and an increase of annual revenues for equipment servicing in excess of $10,000,000.

The number of systems and mobile units authorized during a single typical week in the Business, Manufacturers, and Special Industrial Radio Services indicate that of the total number of mobile units authorized, 48.1% were high band (150-174 mc.) 43.3% were low-band (25-50 mc.), and 8.6% were u.h.f. band (450-470 mc.) types. In the listing of u.h.f. band systems and mobiles, those authorized as class-A CB stations were included in Business Radio Service figures, since all

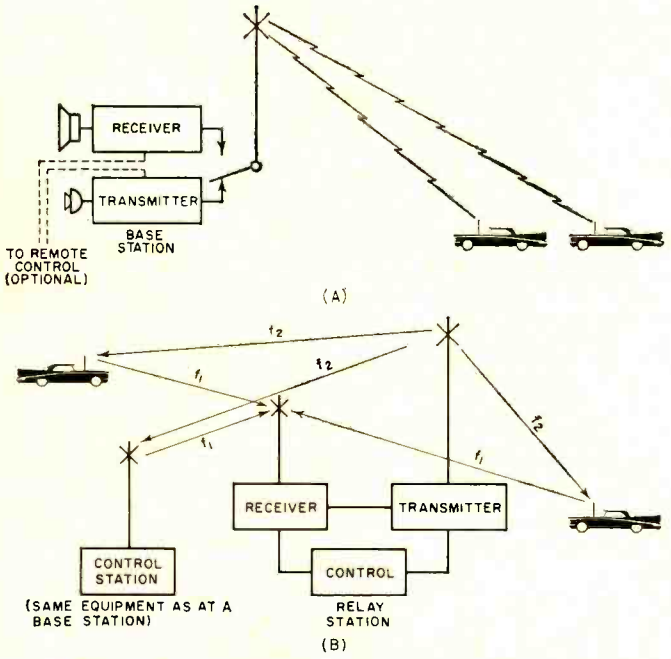


Fig. 1. The typical mobile radio system such as shown in (A) is used in all three business radio bands. However, the mobile relay system shown in (B) is far use in the u.h.f. band only.

were eligible in the latter service. Class-A CB is related to ordinary class-D CB only in that licenses are processed by the same FCC section.

The popularity of the three bands in terms of systems is approximately 42% low band, 48% high band and 10% u.h.f. band. The average number of mobile units authorized per system is 14 with 15 in the typical Special Industrial Service, 8.4 in the typical Business Radio Service and 20 in the typical Manufacturers Radio Service.

Band Use

The low band is used primarily by those who have need for communicating over a relatively long distance, such as an entire country or along highways. The high band is intended for coverage of an urban area. The u.h.f. band basically provides local coverage but, when used with a mobile relay station, considerable coverage can be realized. Typical ranges in the three bands are listed in Table 1.

Equipment for the low band is comparable in price to high-band equipment, ranging from about $300 to $900 per mobile unit. U.h.f. band equipment costs more, starting at about $550 for a mobile unit.

Quarter-wave mobile antennas range in length from six inches in the u.h.f. band, 18 inches in the high band, to nine feet in the low band. Base station antennas are in the same proportion. However, some of the new high-gain antennas for use in the high and u.h.f. bands are comparable in size to some low-band antennas.

While AM can be used, FM equipment is used almost exclusively on all of the channels in all three bands, except on 27.235, 27.245, 27.255, 27.265, and 27.275 mc. These five channels are for narrow-band transmissions only, with band occupancy limited to 8 kc., precluding use of FM, but favorable for use of AM or SSB (single sideband).

Narrow-band FM (± 5 kc. deviation) is used in the low and high bands, and wide-band (± 15 kc. deviation) is used in the u.h.f. band. Wide-band performance is superior, but narrow-band operation is required on the low and high bands to allow room for more channels.

All of the channels in the three bands can be used by mobile units. Most can be used by base stations. A few can be used by operational fixed stations for point-to-point communication.

Transmitter power is limited to 3 watts on several channels which are intended for intra-plant and other short-range systems. On some channels, up to 600 watts of transmitter power can be used, although use of this much power is seldom justified economically, or actually required for operational purposes. Transmitter power is rated in terms of input to the final r.f. power amplifier stage.

Typical Systems

A typical system consists of a base station and several mobile units. In some systems, there is no base station and communication is maintained only between mobile units. The communicating range between a base station and mobile units depends mainly upon antenna height and effective radiated power as is indicated in Tables 1 and 2.

Mobile-to-mobile range is considerably less than the base-to-mobile range because neither antenna has a height much in excess of 10 feet.

When extensive mobile-to-mobile range is required, a mobile relay station may be used—but it must operate in the u.h.f. band. Fig. 1 shows various system combinations.

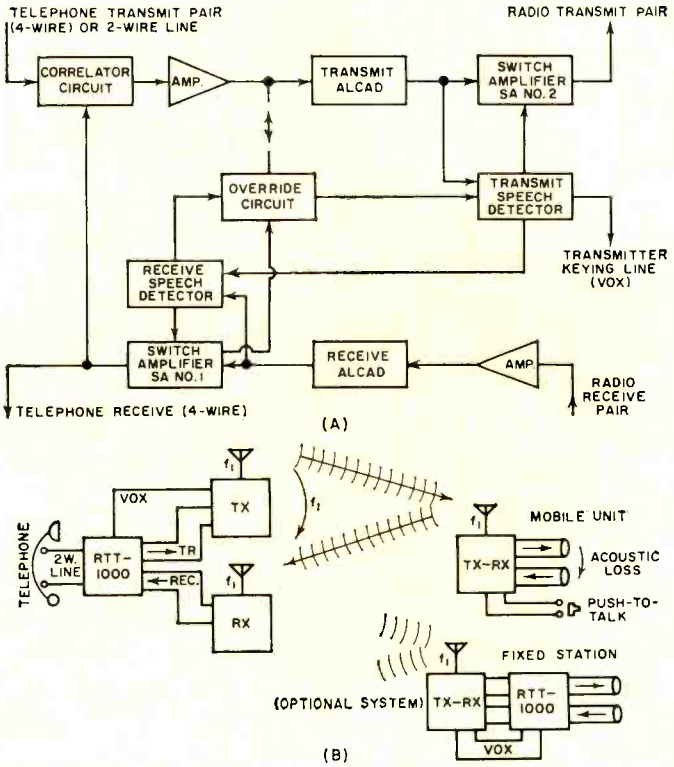


Fig. 2. The block diagram of a commercial radio-telephone terminal (A) showing connections to both radio and telephone lines. (ALCAD means automatic level control and adjust device.) (B) shows its application in a mobile or fixed system.

While mobile relay systems have range advantages, they are also subject to more interference than conventional systems, particularly in populous areas.

When two or more neighboring mobile systems share a channel, tone squelch is sometimes used to silence mobile receivers until their particular base station goes on the air.

When tone squelch is used, the receiver remains muted until a radio signal is picked up which is modulated by a tone burst to initiate communications, or a continuous tone to initiate and maintain communications. Each station employs a tone generator that is automatically actuated when the transmitter is turned on—and a tone decoder to keep the receiver muted until a tone of appropriate frequency is intercepted. Different tones are used by different mobile systems so that they cannot unlock each other's receivers.

Tone squelch can be added to any make of mobile radio equipment as an inboard or outboard accessory.

Some systems employ selective calling to silence all mobile receivers until the base station operator dials, or pushes a button, to alert the desired mobile unit. As in the case of tone squelch, selective calling can be added to any mobile system.

In addition to mobile communications, businesses may use two-way radio for voice communication between fixed points. Such operation is permitted on 27.235, 27.245, 27.255, 27.265 and 27.275 mc. in the low band, using up to 30 watts of transmitter power. There is no antenna height limit.

The frequencies 27.51, 27.53, 33.14 and 35.02 mc. in the low band, and 154.570 and 157.600 mc. in the high band, as well as the 10 low-power Industrial channels in the u.h.f. band, can also be used for fixed communications provided interference is not caused to mobile systems. Transmitter power on these channels is limited to 3 watts and the center of the radiating portion of the antenna must be within 25 feet of the transmitter.

The entire 72-76 mc. band is also available to businesses for fixed point-to-point communication, with power up to 500 watts, in areas remote from TV stations operating on channels 4 or 5. There are 80 channels in this band on which wide-band FM (± 15 kc.) transmission is permitted. All of the 48 class-A CB channels in the u.h.f. band can be used for point-to-point communications. Power limit in this band is 60 watts.

Point-to-point communication can be useful to many businesses. It can be used in lieu of telephone service and can be economically justified when the distance between points is great enough to offset telephone toll charges.

The base station of a private mobile system and the fixed stations of a private point-to-point radio link cannot ordinarily be directly interconnected to a telephone system owned by a telephone company. Interconnection with a private telephone system is of course permitted, except in the case of CB stations which cannot be used to extend any other type of communications system.

Interconnections

Recently, there have been instances where base stations have been interconnected with PBX (private branch exchange) facilities owned by telephone companies. This enables mobile units to communicate directly through any telephone extension within the PBX system. However, communication cannot be extended to telephones which can be reached only through telephone company toll and exchange facilities, unless specific arrangements to do so have been made with the telephone company.

When a base station or fixed station is interconnected with a telephone system, a special type of radio/telephone terminal unit is required. Fig. 2 is a block diagram of the *Philco* RTT-1000 radio/telephone terminal unit designed for this purpose. It automatically turns the base station transmitter on and off without requiring push-to-talk operation at the extension telephones. Mobile units, of course, continue to use push-to-talk operation.

A radio/telephone terminal unit has been developed by *Secode Corporation* to extend dial telephone service to mobile units. Any telephone within the PBX system can be dialed by a mobile unit, and mobile units can be dialed from any extension telephone.

All of the channels in the low, high and u.h.f. bands, except 27.235, 27.245, 27.255, 27.265 and 27.275 mc., are intended primarily for voice communication. On these five channels, any type of emission can be used as long as bandwidth is limited to 8 kc. On all other channels, FM is mainly used, but AM or SSB can be used if so desired.

Non-Vocal Transmissions

Other types of emission, such as teletypewriter, data, telemetry and control signals, may be authorized on voice communication channels by the FCC upon a satisfactory showing of need therefore. If approved, the station license will indicate the technical limits authorized.

Without having to make a special showing of need, according to Sec. 11.554 of FCC Rules and Regulations, teletypewriter messages and digital data, as well as facsimile, can be transmitted on 27.235, 27.245, 27.255, 27.265 and 27.275 mc. Since 30 watts of transmitter power, and use of directional antennas, are permitted, distances of 50 miles or more can be spanned with reasonably high antennas.

To transmit teletypewriter code or serial digital data (d.c. pulses), a transmitter may be employed whose frequency is shifted (FSK) slightly as it is keyed. The receiver must be equipped with an FSK converter which delivers d.c. impulses. Or, the output of an AM (on-off-keyed) or FSK (frequency-shift keyed) tone generator can be used to modulate an AM transmitter. At the receiver, an AM or FSK tone receiver converts the coded tone signals back into d.c. pulses to actuate the teletypewriter machine or data input device. A simple system is shown in Fig. 3.

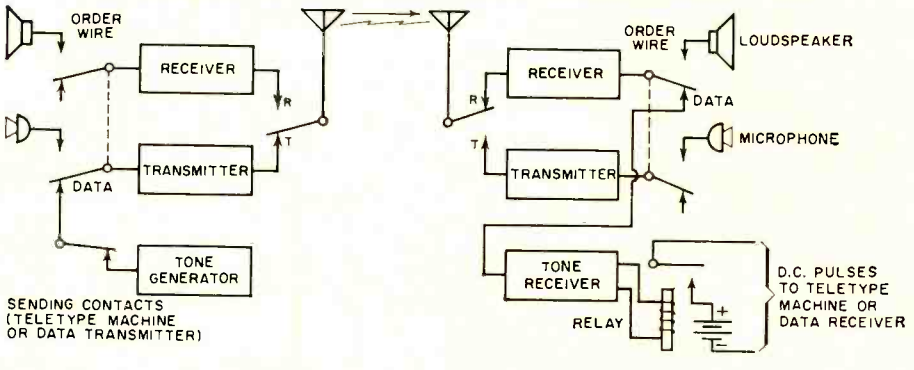
Facsimile is transmitted as an audio tone of varying frequency over an AM transmitter (on these channels), in the same manner as voice transmission.

Telemetry and remote radio control can be used by business on some of the channels. These include 27.235, 27.245, 27.255, 27.265, and 27.275 mc. which are business channels. The transmitter can be automatically actuated with no operator present. The class-C CB channels, 26.995, 27.045, 27.095, 27.145, 27.195 and 27.255 mc., can also be used, but the transmitter must be under the control of an operator. The low-power Industrial low- and high-band channels (27.51,

Antenna Height (ft.)	15-w. (e.r.p.)			30-w. (e.r.p.)			60-w. (e.r.p.)			250-w. (e.r.p.)		
	Low	High	U.h.f.	Low	High	U.h.f.	Low	High	U.h.f.	Low	High	U.h.f.
20	15	9	6	20	12	8	20	13	9	30	20	12
50	20	13	9	25	16	10	30	20	12	40	25	16
100	30	20	12	35	22	14	40	25	16	50	32	20
200	40	25	16	45	28	18	50	32	20	60	38	22
500	50	32	20	60	38	22	65	40	25	70	45	30

Table 1. Reliable range in miles is a function of the height of the antenna in feet above the surrounding ground, the effective radiated power of the transmitter (including any antenna gain), and which of the three bands is being used.

Fig. 3. A radio system can be used for other-than-voice operation. Here, a combination teletypewriter and data transmission system can be switched into the voice transmitter and data information can be transmitted in either direction.



27.53, 33.14, 35.02, 154.570 and 154.600 mc.), as well as the 10 low power channels in the u.h.f. band are available for this purpose if the applicant can make a satisfactory showing of need and that interference to mobile users will not occur.

The FCC has recently opened the 88-108 mc. FM broadcast band to radio telemetry on an unlicensed basis. Transmitter radiation is restricted to 50 microvolts per meter at a distance of 50 feet. Equipment for this band is not yet available but should be in the near future.

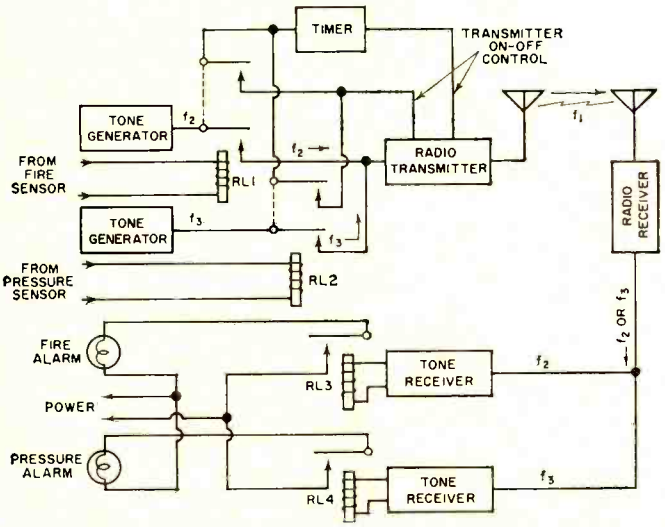


Fig. 4. An automatic radio monitor can be used to telemeter many remote functions to a base station. When one of these sensors is activated, a relay operates to turn on an automatic timer that cycles the transmitter in required intervals.

Antenna Gain (db)	Transmitter Power Output (Watts)			
	15	30	60	250
Unity	15	30	60	250
3 db	30	60	120	500
6 db	60	120	240	1000

Table 2. A gain antenna can be used to increase the effective radiated power of a transmitter. Such antennas consume no electrical power yet can multiply transmitter power rapidly.

Power companies, pipe lines and petroleum processors can use their voice radio channels on a secondary basis to transmit alarm and control signals on a restricted basis.

Telemetry

Radio telemetry has many potential business applications. A warehouse, for example, can be equipped with sensors to detect unlawful entry, fire, or change in water pressure. As shown in Fig. 4, the sensors would actuate tone generators, whose frequency identifies the location and nature of the off-normal condition, and a radio transmitter modulated by the tones. The modulated tones would be picked up by a radio receiver and fed into tone receivers and indicators to identify the locations and nature of the troubles. Such a system could also transmit signals at intervals which indicate the state of an existing condition, such as cold storage area temperature.

Remote radio control can be used for such purposes as turning lights on and off at a parking lot, storage yard, warehouse, or store from a moving car or fixed point.

Microwave Bands

The microwave bands are also available to businesses, and private microwave systems may be operated in certain of these bands. Those eligible for station licenses in the Special Industrial or Manufacturers Radio Service can operate microwave systems in any of these bands. Those eligible only in the Business Radio Service may operate private microwave systems only at frequencies above 10,000 mc.

Microwave systems operated in the bands below 10,000 mc. may be used for multi-channel voice communications and transmission of teletypewriter, data, telemetry, and control signals. Above 10,000 mc., sufficient bandwidth is available for transmission of closed-circuit TV signals.

Band Selection

To select the band on which to operate a proposed business radio system, the range requirements should be established first. (See Table 1.) Maximum range is generally achieved in the low band, but skip interference from distant stations on the same channel occurs at times. Ignition interference is more severe than in the other bands.

For most purposes, the high band offers reasonable range with virtual freedom from skip interference and ignition noise is seldom a serious problem. While the u.h.f. band has the shortest range, noise is virtually absent and there are more channels to choose from.

While a channel in any of the three bands can be chosen at random, it is better to determine which, if any, are not in use in your area. This can be determined by referring to the Radio Registry No. 1 covering the Special Industrial Radio Service or Radio Registry No. 3 covering the Business and Manufacturers Radio Services. Both of these registries are available at $7 each from *Radio Magazines, Inc.* P.O. Box 629, Mineola, N.Y.

These directories list the licenses, locations of station, number of mobile units and operating frequencies. Naturally, new stations have come on the air since the directories were compiled, but you will get a pretty good idea of which channels are least congested.

Business radio equipment is sold through independent local dealers and distributors by most manufacturers, and on a direct factory-to-user basis by others. Sellers of business radio equipment are usually listed in telephone directory Yellow Pages under the heading "Radio Communication Equipment and Systems."

Portable Equipment

To provide communication between a man on foot and either a mobile or base station, a large variety of battery-operated, two-way radio equipment is presently available. Although restricted in power output because of battery weight, these units can be used to provide communications up to several miles under the right terrain conditions.

To increase communications range during long periods of field operation where a portable unit is required, it is possible to connect the portable unit to a conventional full-scale, tower-mounted antenna.

Present Situation

All of the radio facilities available to business are only beginning to be utilized. There were 48,692 Business, 29,780 Special Industrial, and 868 Manufacturers Radio Service stations authorized as of June 1, 1963. Each station license usually covers several mobile units. But, expansion of use of radio by business is accelerating. Applications for licenses in the Business Radio Service rose from 1868 in March to 1999 in April and 2115 in May, an increase of about 7% per month. Other industrial license applications rose from 2318 in March to 2683 in April and to 2918 in May, an average increase of better than 10% per month. Each application may represent a large number of mobile units.

Expansion rate is expected to continue to rise as more new, lower-priced radio communications equipment reaches the market and with the steadily rising increase in the number of dealers selling two-way radio equipment. ▲

McCormick Place uses Belden Cable exclusively for its 5-Channel Sound System

Belden sound and audio cables are engineered for the highest efficiency and quiet performance. According to Bill Cummings, Production Coordinator for Boom Electric, Sound Engineers for the McCormick Place, "In a job the size of McCormick Place, with a 5-channel sound system, we depend on suppliers who give us excellent service. Belden is that kind of supplier. Belden's one length per spool takes the guesswork out of pulling cable. We know exactly how far we can go without splicing. Their color coding stability and uniform physical characteristics from spool to spool are tops. For these and many other reasons, Belden continues to be our Number 1 wire and cable source."

Belden offers the most complete line of microphone, sound, and audio cables in the widest range of sizes and insulations. Many of these cables feature exclusive Beldfoil* shielding which reduces cable diameters and eliminates crosstalk. Ask your electronics distributor for complete specifications, or write for Catalog 863.

Belden 51-pair cable. Vinyl insulated conductors cabled in pairs with overall *Beldfoil* aluminum—Mylar† shield, chrome vinyl jacket. Trade No. 8751

McCormick Place, one of the largest and most complete convention centers, is located on Chicago's beautiful lakefront. Audiences in its impressive theatre enjoy stereo-like sound. Its 5-channel sound system includes speakers located strategically on either side of the theatre as well as in the center. As performers move across the stage, multiple microphone installations transmit the voice movement to corresponding speakers.

Looking over part of the large Belden wired console in the McCormick sound control booth are two of Belden's Men-on-the-Go—Charlie Schreyack, District Sales Manager, and Howard Baron, Belden Territory Salesman. With Charlie and Howard are Bill Cummings, Production Coordinator for Boom Electric, and Monte Fassnacht, McCormick's Director of Theatrical Services.

Better Built—Better Buy—Belden

Belden
WIREMAKER FOR INDUSTRY
SINCE 1902 — CHICAGO

power supply cords • cord sets and portable cordage • electrical household cords • magnet wire • lead wire • automotive wire and cable • aircraft wires • welding cable

*Belden trademark—Reg. U.S. Pat. Off.
†duPont trademark

8-7-3

SCR TESTER

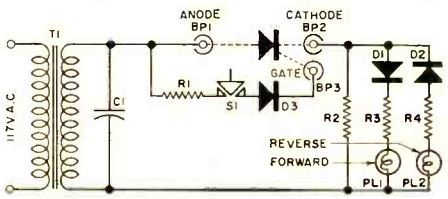
By T. E. HOPKINS / Sr. Application Engr., Westinghouse Electric Corp.

You can't test an SCR with an ohmmeter. The test set covered in this article will and, as an added bonus, test conventional rectifiers too.

INCREASING commercial and domestic use of silicon controlled rectifiers in such popular devices as light dimmers, power tool speed control, etc., as well as the continued and growing industrial use of these versatile devices creates a need for a simple, quick, and reliable method of checking the condition of those suspected of being faulty.

An SCR is a four-layer semiconductor device with two main conducting terminals and a gate, or trigger, terminal. It contains junctions that are intended to block all current in a reverse direction, block current flow in the forward direction under normal or ungated conditions, and allow forward current flow when the gate is energized or triggered. Thus, it is possible for an SCR to break down in either the forward or reverse direction or both. It is also possible for the gate connection to become either shorted or open. Therefore, it is not possible to determine the condition of an SCR by simple ohmmeter tests as may be done with a rectifier or even to some extent with a transistor. The device described in this article will test both forward and reverse breakdown and gate operation.

Such a device is shown schematically in Fig. 1 and physically in Fig. 2. Operation is as follows. Transformer *T1* provides a 25-v., r.m.s. source of a.c. to the circuit. This voltage is alternately applied in the forward and reverse directions across the anode-cathode connections of the SCR. If initial breakdown is present in either direction, current will flow in that particular direction and the current will be detected by either the



R1—100 ohm, 1 w. res.
R2—50 ohm, 10 w. res.
R3,R4—75 ohm, 5 w. res.
C1—.05 μf., 200 v. capacitor
D1,D2,D3—100 v., 1.6 a. silicon rectifier (1N1218)
PL1—#47 indicator lamp (Dialco 81410-112 (green) or equiv.)
PL2—#47 indicator lamp (Dialco 81410-111 (red) or equiv.)
S1—Normally open push-button switch
T1—Fil. trans. 25.2 v. @ 1 amp. sec. (Stancor P-6469 or equiv.)
BP1,BP2,BP3—Binding post (Johnson 111-101, 111-102, 111-103 or equiv.)

Fig. 1. Schematic and parts list for the SCR tester. Lamps indicate SCR condition.

"Forward" or "Reverse" indicator lamps. Thus, lighting of the "Forward" lamp as soon as the SCR is connected into the circuit indicates failure of the forward blocking junction. Lighting of the "Reverse" lamp at any time indicates breakdown of the reverse blocking junction. If neither lamp lights when the SCR is connected into the circuit, the "Test" push-button is operated applying a source voltage to the gate.

The "Forward" lamp should light under these circumstances if the SCR is good. If this lamp does not light when the button is depressed, the gate is either open or shorted.

This unit can also be used to test ordinary rectifiers by connecting them across the "Anode" and "Cathode" terminal posts. With the rectifier properly connected, a good one will light the "Forward" indicator lamp, an open one will keep both lamps off, while a shorted one will make both lamps come on.

If a more quantitative test is desired, a d.c. oscilloscope may be used with the tester to read approximate values of gate triggering voltage and current.

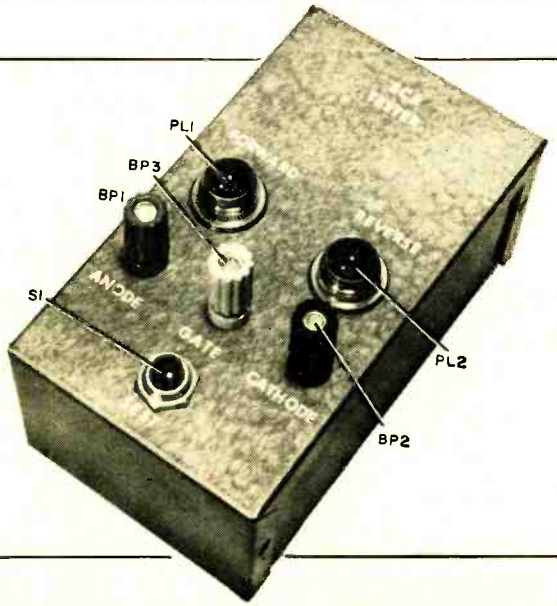
To read gate triggering voltage, set the oscilloscope controls to 60-cps line synchronization and the vertical sensitivity to 4 or 5 volts d.c. full-scale deflection. Connect the scope *plus* lead to the "Gate" terminal and the *minus* lead to the "Cathode" terminal. Depress the "Test" button and observe the most positive deflection. This will be the approximate gate triggering voltage.

To read gate triggering current, set the scope as above and connect the leads across "Anode" (+) and "Gate" (−). Depress the "Test" button and observe the most positive scope deflection. The gate triggering current will be 10 ma. per volt of this deflection.

Since the peak anode current of an SCR in this test circuit is about .6 ampere, the forward drop at this current can be checked by connecting the scope from "Anode" to "Cathode" and reading the peak forward drop.

In each of the above readings, a sharp spike may be observed at the beginning of each trace. This should be ignored in reading the values.

The tester applies about 35 v. peak anode volts to the SCR so that higher voltage capabilities of the unit are not indicated. Also, with very small SCR's, heat sinking may be necessary. ▲



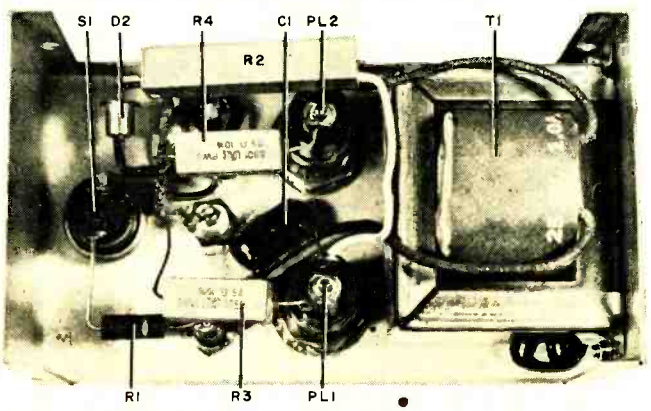


Fig. 2. The front panel and bottom views of the finished SCR and rectifier tester. Indicator lamps show the SCR condition.

JOHN FRYE

What are the advantages and disadvantages of diversifying as against being a specialist in one branch of electronics?

DIVERSIFY OR SPECIALIZE?

"BEN Franklin was right!" Barney announced as he entered the service shop rubbing his cold hands briskly together to warm them.

"Right about what?" Mac, his employer, wanted to know. "Wise old Ben said a lot of things, and he made a habit of being right. Which one of Poor Richard's sayings did you have in mind?"

"He said a man could get used to anything—even hanging. I was reminded of this by the thought that just about this time of year folks around here get used to winter. We've had time enough to forget what warmth and sunshine and green grass and leafy trees and blue skies are like. We've grown accustomed to walking stiff-legged on icy sidewalks, to grinding the starter of a cold motor, to using the brake pedal gingerly to keep from skidding, to feeling awkward and bundled up in heavy clothing, and to being half-frozen a good part of the time."

"Man! You're in a rare mood this morning. Did you and Margie have a spat last night, or have you been hitting that Florida real estate literature again?"

"Neither one. I'm just a little sick of gray skies, of street salt eating up the body of my car, and of climbing frosty antenna towers. Maybe we ought to specialize in some nice, comfortable, lucrative branch of electronic service. Did you ever give any thought to that?"

"Frankly, I've been giving a good bit of thought to it lately," Mac admitted. "When I first started in this game, you had to diversify to pay the rent. There simply weren't enough radios needing repair to keep a shop going. I was not a bit too proud to fix a toaster, put a new cord on an electric iron, or replace a three-way switch in a floor lamp. Gradually, though, the number of radios increased and became more complicated; and electric phonographs, public-address systems, and auto radios came on the market. A good service technician could keep busy working on these.

"But then along came FM radio, mobile communications equipment, TV, color-TV, hi-fidelity sound systems, transistor radios, tape recorders, industrial electronics, garage-door openers, electric-eye devices, communications receivers, CB transceivers, and a host of other electronic gadgets such as intercoms, movie-projector amplifiers, and electronic toys. In practically every one of these fields, improvements came thick and fast. If a technician did not need to eat or sleep and could devote the time thus saved to continual reading and study, I don't believe he could keep abreast of all the crowding innovations in all these fields. If he does sleep and eat, he can't hope to stay on top of all of them. Some specialization is necessary."

"You're talking about the individual technician. A shop could service all these different fields if it had enough specialist technicians," Barney pointed out.

"True. In the medical field such a 'shop' with a stable of specialists would be called a 'clinic.' Incidentally, medicine has seen a terrific increase in specialization in the last twenty-five years. For that matter, automobile service is also becoming pretty specialized. In this town we have one shop that does nothing but carburetor and ignition work, one that does nothing but install mufflers, another that works only on transmissions, still another that confines itself to body work, and finally a tire store that specializes in tires, wheel alignment, and brakes."

"Yep, I guess we're in the age of specialization, and electronic service is going to have to tag along," Barney said. "There was a kind of tacit admission of this last summer when a service literature publishing firm that had been covering tube radios, auto radios, transistor radios, Citizens Band radios, TV, tape recorders, and radio-phono sets announced that henceforth only TV, tube radio, and radio-phono sets would be covered in the regular subscription service. The other four categories are now covered in individual specialized volumes that can be purchased separately if desired."

"I agree that the trend is toward specialization," Mac said, "but we must not get carried away and forget that there are still some pretty potent arguments in favor of doing several different kinds of service. For one thing, diversification provides a much wider base from which to draw business. This has several advantages. It tends to level off seasonal fluctuations: when TV service falls off in the summer, antenna tower erection picks up, and *vice versa*. More important, diversification lessens the chance of the specialist's being left stranded high and dry by a new development or a sudden change in the service situation in his community. I well remember in the early days when some technicians haughtily refused to work on a.c.-d.c. 'cracker-box' radios and concentrated entirely on console radio receivers. Then one day there were no more console radios. A more recent example is the bleak prospect now facing the boys who have done very well concentrating on antennas and antenna-tower installation in this ultra-fringe area. Now that cable-TV is to go into operation here in a month or so, their business is certain to drop sharply to a small fraction of what it was."

"Another advantage of diversification is the way it permits one job to lead to another," Barney suggested. "I seldom go on a TV call without the customer asking me to look at a radio, record-player, garage-door opener, hi-fi, etc. The customer *expects* an electronics technician to be able to repair any kind of electronic equipment. Refusal to do so must be accompanied by a pretty convincing argument if the customer is to retain his faith in the technician's ability even in that technician's specialized field."

"I can't argue with that. And we must not overlook the effect diversification has on the technician himself. It presents him with a very strong challenge. When he stands up and offers 'to take on all comers with tubes or transistors in 'em,' he's sticking his neck way out. He must study like crazy to maintain even a nodding acquaintance with what is going on in all phases of electronics. If he is able to keep his wife, his health, and his sanity through all this, he should emerge a very strong technician indeed, one whose broad knowledge of electronics will present him with many job opportunities, especially in the administrative field, denied to technicians with a deeper but narrower

grasp of a single aspect of electronics."

"Yeah, but I gotta hunch an ordinary individual would have to spread his knowledge so thin to cover the tremendous field of electronics that his superficial theory would be of little value in practical service work," Barney objected. "When you're working on modern electronic equipment, whether it be a color-TV receiver or an electronic-welder control in a factory, you've gotta know *exactly* what you're doing. There is no place for general theory of operation. Each circuit has its own peculiarities, and you must be thoroughly familiar with these circuits if you're to service them quickly, properly, and efficiently."

"I must agree," Mac admitted; "and we can't overlook the fact the diversified shop has to invest a young fortune in equipment. Each branch of service work requires its own specialized tools and service instruments. Color-TV and mobile communication equipment servicing are good examples. Both require expensive, precision-type instruments and special hand tools and service aids; yet the equipment needed for one kind of service is, with a few exceptions, useless in the other kind of work. The specialist can make a great saving in the amount of money he needs to invest in service equipment."

"A fellow must remember, too, the specialist is, or should be, an expert in his own field. As such, he can command a better hourly rate for his work than can a general technician. When your general practitioner sends you to a specialist, you're braced to pay the specialist considerably more for his time than you paid the home doctor; and it's the same way in electronics."

"You slid over an important point," Mac interrupted. "You don't become a specialist simply by refusing to do various types of electronic service. Specializing carries with it the obligation to be good—much better than average—at your specialty. If you specialize, you should select a field or fields that you really like and then work hard at it until you know practically everything there is to know about that area of electronics. But it's actually easier to learn to do one thing superlatively well than it is to learn to do ten things reasonably well.

"So far we've been talking about specializing in certain kinds of electronic service, but a shop here in town has specialized in a slightly different fashion. This store sells and services radios, TV, and home appliances. It services all makes of radios and appliances, but its TV service is restricted to the brand of sets sold by the store. In fact, the store will not service that brand if the owner lives in town but bought the set somewhere else. It will, though, service the set if the owner had the brand set when he moved to town. This policy is to discourage the 'smart boys' who want to buy their sets wholesale and still get excellent service.

"I've watched this arrangement work out extremely well. The store has grown from a hole-in-the-wall to being the most successful shop of its kind in the city, and it calls itself 'The store service built.' In this case, the boast is justified. People who purchased TV sets from the store have received excellent service. As you well know, a technician who works with only one brand of receiver becomes very good at servicing a comparatively few chassis. All their quirks are familiar to him. Furthermore, he is not too rushed to give good and prompt service. People soon found this out for themselves, and they bought that brand of receiver mostly to get the good service that went along with it. What's more, they bought radios and stoves and refrigerators and washing machines from the same store because of the confidence inspired by the TV service."

"Then I gather you feel this way: increasing complexity and rapid expansion of the electronic field is forcing practically all technicians into some degree of specialization. It's simply a question of how much. In some cases, the technician may have the drive to do the extra study and work that will permit him to cover several fields. Doing so will provide him with more job opportunities and will keep him informed on what is going on in electronics; but if he tries to cover too many fields, he cannot hope to master any of them.

"On the other hand, specializing in too narrow a field carries with it the danger of having the ground cut from under you by a technical innovation or a change in consumer interest. The specialist, though, can concentrate his effort along lines in which he has a genuine interest and he is more inclined to like what he does. The specialist can really master his chosen field, and he can command a better rate of pay because of this mastery. He does not have to invest as much money in equipment. There's just one thing. I never quite liked that classic definition of a specialist."

"What definition is that?" Mac asked.

"'A specialist,'" Barney quoted, "'is a person who knows more and more about less and less.'" ▲

CONTEST COMPUTING

"RANK in order of importance, 5 of the 12 numerically listed features of an *Onan* generator that customers like best." This was the contest that George Woodruff, an engineer with Space Technology Labs., entered. George primed his TRW230 computer to write every possible five-digit permutation of the numbers 1 through 12. Total computer time 104 seconds, total number of answers 95,040 covering every possible answer. George won. ▲

Simplified Color Organ

(*Continued from page 50*)

by a d.c. voltage consisting of two components: one proportional to an audio-filter output voltage and one constant offsetting voltage used to determine the minimum background lamp level. The capacitor is discharged every time the SCR fires and every time the line voltage approaches zero, and thus the cycle repeats. The more voltage, the faster the charge. This causes the SCR to fire (turn on) earlier in the cycle and the lamps to receive more power.

A typical oscillator consists of *R*1, *R*4, *C*5, and *PL*1 and is line-locked by *D*11 and *R*17. The offsetting voltage consists of the voltage divider, rectifier and filter combination *D*5, *R*21, *R*22, and *C*4. The ratio of *R*21 to *R*22 determines the background level, which should be either just off or just on, depending on user preference. This offsetting voltage is required to prevent a dead-space effect that would flatly ignore music below a certain critical level.

All that remains is the filter circuitry, which must sort out the high, medium, and low frequencies and provide a high-voltage rectified and filtered d.c. output in proportion to the audio input. In addition, isolation between the circuit proper and the audio input must be made since the common is hot. It is all done with three speaker output transformers. The primaries are series-resonated and the secondaries are parallel-resonated with suitable capacitors thus providing the desired filter response. The voltage is stepped up by the 71:1 turns ratio and the "*Q*" of the resonant circuits.

Unless the exact transformer specified in the parts list is used, the capacitor values will have to be altered to provide proper filter characteristics. The capacitors must be non-polar. One source for such capacitors is indicated in the parts list. Ordinary polarized electrolytics can also be used. In this case, two back-to-back connected capacitors, each having twice the capacity shown, must be used. The secondary of *T*1 resonates with its own stray capacity. Filter output is rectified and filtered to provide the proportional d.c. control voltages.

"Deluxe" Version

Most of the modifications made to the "economy" model to produce the "deluxe" version are obvious. Plugs, a switch, and fusing are added. Variable controls are added in series with the individual filters to provide color balance and to adjust the colors to suit a particular musical selection. Resistors *R*8, *R*10, and *R*12 are used to adjust the background level while inductor *L*1 and capacitors *C*13, *C*14, *C*15, and *C*16 comprise the noise filtering arrangement.

A word on power capability. Those who want lots of power will be happy to note that the control capability of this circuit can be increased without bound. A word of caution: 15 amperes is a lot of current through an electronic circuit, let alone the normal, possibly already overloaded 15-ampere house circuit. By replacing the 3-amp SCR's with 5-amp units, and designing the circuit with No. 14 wire (including the display cable), a 2-kilowatt rating may be achieved. Fan cooling is recommended at this higher rating.

Still more power? Use the 3-amp SCR's as gate switches on the *Westinghouse* or *International Rectifier* monster 225-ampere SCR's! ▲

Speakers for Transistor Amps

(*Continued from page 44*)

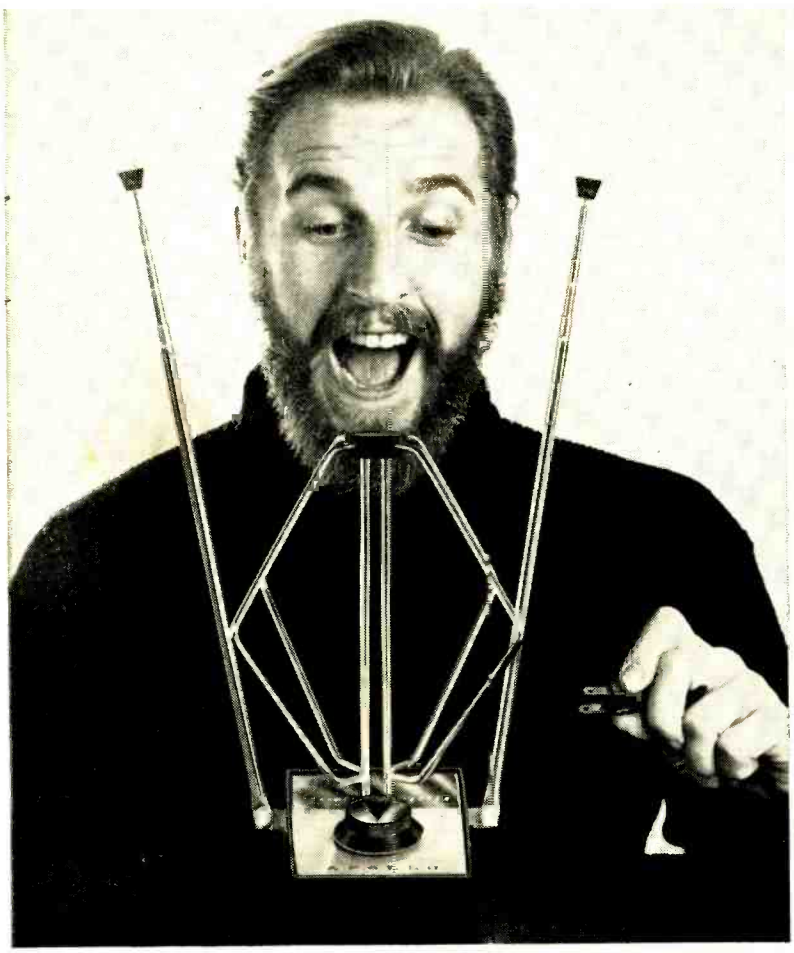
with frequency, between the speaker driving voltage and the feedback voltage, which aggravates the stability problem and the system designer. This can be minimized by restricting the frequency range over which a given speaker is used, and designing a two- or three-way system.

There is an even more cogent reason for doing this. The reader may have noticed that we have been referring to the velocity of the *voice coil*, and not that of the cone. This has not been fortuitous. As long as the cone moves essentially as a unit (ideal piston action) and as long as its mechanical connection to the voice-coil form is, in effect, perfectly rigid, the voice coil and cone velocities are identical. These conditions may apply in a woofer up to something like 500 cps. Above the piston range, the motion of the cone becomes very complicated. It "breaks up" into zones, with different sections moving at different velocities and even in different directions. The resulting irregularities in frequency response cannot be controlled by anything one does to the voice-coil velocity. Fortunately, there is less need for feedback at higher frequencies because in a well-designed speaker the excursions are relatively small except at low frequencies, and non-linearity is less of a problem.

The stability problem is less difficult for the amplifier designer to solve if he knows the exact characteristics of the speaker load on the amplifier; a motional feedback amplifier-speaker combination really needs to be designed as a system. The speaker and amplifier should be designed as mates. This was done in the *Integrand* transistor-amplifier system which appeared briefly some years ago.

Combining the speaker and the amplifier in one unit is an idea that is receiving renewed attention. The word

LOOK! ALL PROFIT AND NO WORK!



Transistor-Powered Apollo, model 3721

Transistor-Powered FM/Stereo, model 3731

A new TV indoor antenna guaranteed to work up to 45 miles clear out!

Bet you thought the "15-to-60 mile" reception area was the private preserve of outdoor antennas only; that nobody, but nobody, had yet conceived an indoor antenna powerful enough to break the suburban picture-and-sound barrier!

Well, Channel Master **has!** And it creates a brand-new market. We've combined the world's most advanced indoor TV antenna and a super-effective built-in hidden amplifier. Result? The Apollo!—a transistor-powered indoor antenna that, for sheer TV pull-in power, surpasses every other indoor antenna ever created. What other indoor antenna guarantees to bring in a picture clear, sharp, and ghost-free—from 15 to 50 miles out.

And talk about adaptability: the Apollo's "Miraclick" Switch gives the viewer exactly the right amount of power his area requires. The "Miraclick" electronically adjusts the antenna to weak or strong signal areas. And a built-in FM Trap cuts out FM overloading in strong signal areas. **Fair-traded at $29.95.**

A new FM/stereo indoor antenna guaranteed to work up to 60 miles clear out!

Channel Master's transistor-powered FM/Stereo indoor antenna alone does for FM what the Apollo does for TV. Works from 15 to 60 miles out. (And offsets signal loss inherent in the multiplex circuit). **Fair-traded at $19.95.**

You're in a new business! Both these powerhouse antennas are smart, modern showpieces. Eye-catchingly packaged for easy selling, too. Together, they push the indoor antenna market back to a brand-new frontier. Even if you don't know the first thing about antennas (of any kind)—and have never before cared to become involved with them—the high sales possibilities of these two should be enough to change your mind.

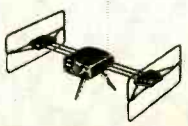
Think of it! All profit (very high) and no work (no rooftop installation). You're really in business! Matter of fact, it's no trade secret that each antenna in Channel Master's complete indoor antenna line is the best in its category at its price.

Call your Channel Master distributor for full details on our indoor antenna **free premium** promotion!

Also available! Top quality non-amplified indoor antennas.

Model 3720.

Model 3730.



Model 3900, Model 3901.

Model 3718.

IF PRODUCT OR PERFORMANCE DEFECTIVE ★ Good Housekeeping GUARANTEES REPLACEMENT OR REFUND TO CONSUMER

...Only from

CHANNEL MASTER

ELLENVILLE, N.Y.

"renewed" may surprise some readers, but the fact is that one of the very early commercially produced dynamic speakers (the *Radiola* Model 104 loudspeaker with built-in amplifier produced in 1926) was just such a unit, using tubes, of course. Transistor amplifiers make the idea more attractive because of their low standby power consumption, physical ruggedness, and greater flexibility as to shape factor, compared to tubes. The speaker is permanently connected to the amplifier, eliminating the danger of accidentally short-circuiting the amplifier output terminals and ruining the output transistors. It is advantageous to have the amplifier neatly tucked out of sight as part of the speaker cabinet assembly.

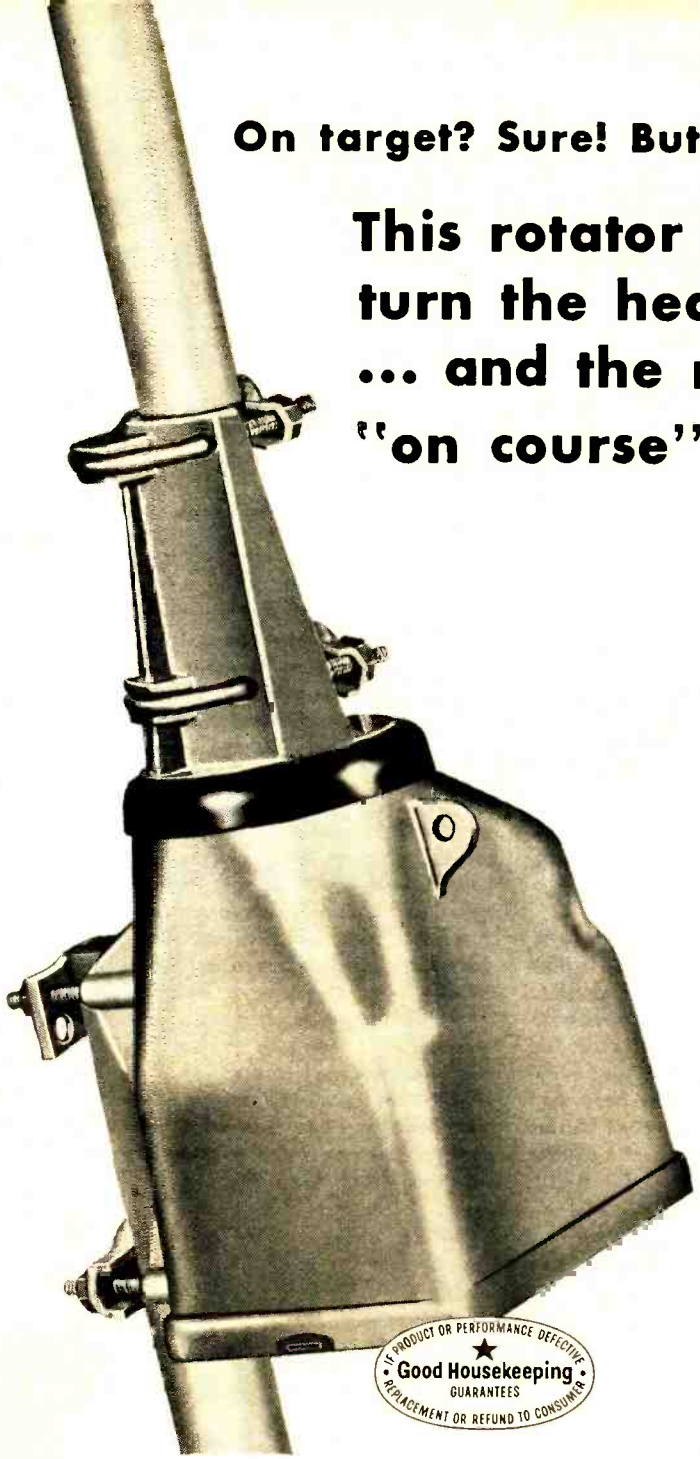
The integrated design eliminates the need for the designer to match the amplifier to a variety of speaker impedances. It permits some frequency equalization in the amplifier to compensate speaker deficiencies. The damping factor of the amplifier can be made the correct value for optimum bass response of the speaker. The feedback stability margin can be made great since the load on the amplifier is known.

On the other hand, each integrated speaker-amplifier usually requires its own power supply, while a dual-channel power amplifier requires only one. The power supplies must either be switched on and off from the tuner-preamplifier, requiring more wiring, or left on continuously—which reduces the life of the transistors, especially because of the longer exposure to line transients.

There is also the factor of hum. A hum level that is unnoticeable when one is using hi-fi equipment can be annoying in quiet surroundings when the equipment is ostensibly turned off. Slight clicks and noises due to line surges or other kinds of transient pickup may be rather disturbing when emitted by "non-operating" equipment. It is rather amusing that speaker manufacturers, after being plagued for years by occasional unhappy customers who complain that "the speaker hums" are now seriously contemplating speakers that really do so.

The connection between the tuner-preamplifier will no longer be a simple zipcord or 300-ohm flat-ribbon TV antenna lead; it must be shielded cable. This is not quite so easy to conceal.

The integrated speaker-amplifier also bucks the trend toward tuner-preamplifier—power-amplifier combination units. In fact, unless this trend is reversed, the owner of such speaker systems will have a rather limited choice of tuner-preamplifiers. Whether the improved performance claimed for the integrated units is justified in terms of what one hears, in relation to the increased cost, will be decided—as usual, by the final arbiter—the customer. ▲



On target? Sure! But more than that—

This rotator alone has the power to turn the heaviest antenna array easily ... and the ruggedness to keep it "on course" in foulest weather.

Most any good rotator can hit the target in fair weather!

(Channel Master Tenn-A-Liner Rotators offer a degree of pinpoint accuracy pretty close to perfect).

But in installing a rotator, ask yourself this: How will it do in foul weather? Stand up -- or act up? Will it turn a heavy antenna load without trouble? And keep the antenna on the beam?

THE FACTS are as follows: Channel Master rotators (manual or automatic) have the greatest turning power of any TV-FM rotator in existence. Thanks to their built-in, friction-free, ball thrust bearing (nobody else has it), these rotators alone have the power to easily turn the heaviest fringe-area antennas. They've proved they can even "crack through" an ice-loaded antenna installation weighing over 329 pounds. Also, because higher voltage is delivered to the motor, you can use longer leads. And still maintain peak torque.

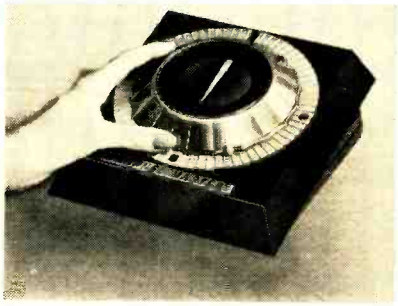
CHANNEL MASTER rotators, furthermore, are made to operate under a 70 mile gale wind. And to back up all this rugged, foolproof performance, only Channel Master Tenn-A-Liner Rotators give your customers a 90 day "Instant Replacement" Warranty. (After 90 days, parts or the complete unit can be replaced at extremely low pro-rated prices).

Priced to let you meet competition head-on, too. And to give you top profit as well. Do yourself, and your customers, a good turn. Install Channel Master Rotators next time.

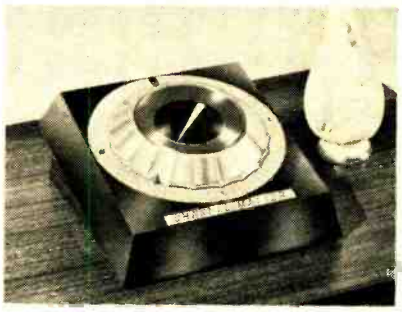
CHANNEL MASTER Rotators

"More accurate by design ... more distinctive in design"

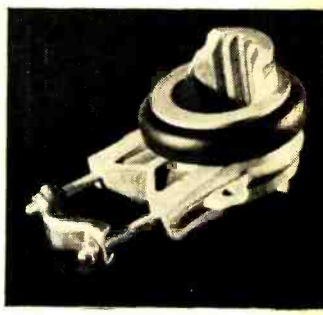
COMPASS TENN-A-LINER (Model 9520). Non-automatic. Fingertip control. Accurate repeatability. Continuous instant direction indication. Pushbutton Switch ends reception interference caused by wind vibration.



AUTOMATIC TENN-A-LINER (Model 9524). Most accurate in the world. Aims antenna within one degree of precise transmitter location. Increments are not limited to 10 to 15 degree segments.



NEW! GEMINI (Model 9527). World's first all-in-one Automatic Rotator with built-in amplifier. Combines Tenn-A-Liner with famous Telstor transistorized booster-coupler. Fast, profitable, 2-in-1 installation. Only 1 unit on mast -- 1 housing on set -- 1 transmission line. Built-in "FM Trap".

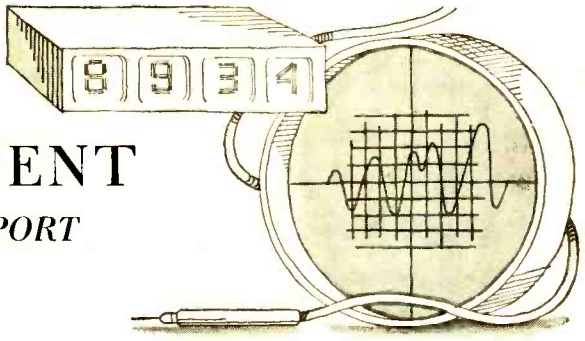


ROTATOR ALIGNMENT BEARING (Model 9523). Provides added rough-weather protection by stabilizing antenna on giant fringe-area antenna arrays.

CHANNEL MASTER CORP., ELLENVILLE, N.Y.

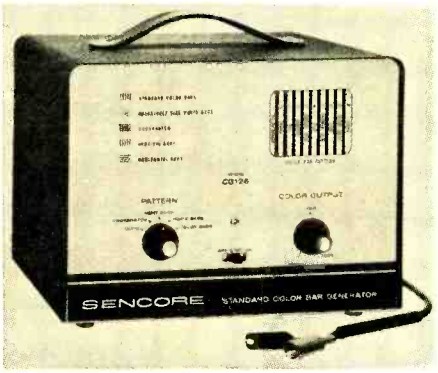
TEST EQUIPMENT

PRODUCT REPORT



Sencore CG126 Color-Bar Generator

For copy of manufacturer's brochure, circle No. 45 on coupon (page 15).



FOR the service technician just getting into color-TV work or for the man who wants an inexpensive bar generator without having to spend hundreds of dollars, *Sencore* has come out with a basic version of their more elaborate generator reported on here last October. This new unit, the Model CG126, sells for $99.50, about half the cost of the company's Model CA122. Although some of the features and flexibility had to be sacrificed, this present generator produces all the test patterns required for color-circuit and convergence adjustments. Also, the unit is compact enough (11″ x 8″ x 6″) and light enough in weight (under 10 lbs.) so that it can be carried into the customer's home for servicing of the color set.

The color bars produced by the instrument are generated by the offset-subcarrier method. In this method, a crystal oscillator (±.001%) in the unit operates at a frequency that is below that of the color subcarrier by the amount of the line frequency. As a result of the beat note produced, there is a complete phase change of 360 degrees for each horizontal line of sweep. Hence, a complete rainbow of colors is produced during each line. If we gate the oscillator at a frequency 12 times higher than the horizontal sweep frequency, color bars are produced that are 30 degrees apart in phase. One of these bars occurs at the time of the horizontal sync pulse and another is used as the color sync burst. Hence, the remaining ten bars of color are visible on the color picture tube.

In addition to this color-bar pattern, which is similar to the pattern recommended and used in *RCA* service data, four other patterns are generated. One of these is a white-dot pattern, with adjustable dot size. Second is a cross-hatch pattern consisting of 10 vertical lines and 14 horizontal lines. Third is a pattern consisting of the vertical lines alone, and fourth is a pattern with the horizontal lines alone. These patterns are used to make convergence adjustments on color sets and for linearity, height, and width adjustments on both color and monochrome receivers.

All bar, dot, and line signals are produced by modulating a built-in r.f. oscillator with the proper video signals. This oscillator is factory-adjusted to channel 4. Hence, the technician simply connects the output leads of the generator to the color set's antenna terminals, switches the set to channel 4, selects the desired pattern on the generator, and proceeds with his adjustments. In the event that channel 4 is in use in a given location, the generator's oscillator trimmer may be readjusted to either channel 3 or 5.

Every effort has been made by the manufacturer to make the generator simple to use and maintain, and highly stable in operation. For example, the timer circuits are tightly controlled by a 189-kc. crystal oscillator. The timer circuitry is quite simple, employing only four frequency-divider stages and these can be readily readjusted, if required, with the aid of an operating TV set.

An important and useful section in the instruction manual deals with the actual use of the unit in some typical color-TV receivers and the techniques for making the adjustments properly. ▲

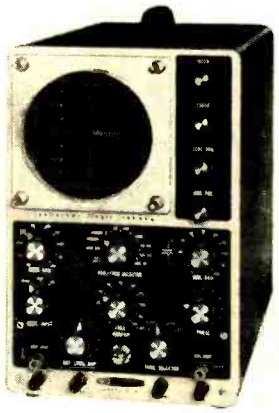
B & K Model 360 V.O.M.

For copy of manufacturer's brochure, circle No. 46 on coupon (page 15).

The *B & K* 360 is a 20,000-ohm/volt d.c. and 5,000-ohm/volt a.c. volt-ohm-milliammeter with the usual ranges that has several important and unusual features. Foremost is the use of a single-scale display that changes automatically in step with operation of the range

for a perfect diagnosis

call in these Heathkit specialists!



With this superb trio on your test bench you can tackle any FM or TV service problem with complete confidence! Heathkit test instruments are recognized nationwide for their high quality and performance at low cost. Compare Heathkit features and specifications . . . you, too, will find them your best buy in dependable testing facilities.

TV Alignment Generator

• All the essential generator facilities you need for fast, easy, and accurate alignment of FM & TV sets • Complete FM & TV coverage —3.6 to 220 mc • Stable, all-electronic sweep circuit for consistent, reliable results • Smooth control of signal output allows alignment of high gain stages without danger of overloading • Built-in crystal and variable marker oscillators (4.5 mc crystal included) • Retrace blanking • Phasing control • Variable sweep width—0 to as high as 42 mc • A favorite among service technicians everywhere!

Kit IG-52 . . . . 14 lbs. $67.95

SPECIFICATIONS—Output impedance: 50 ohms terminated at both ends of cable. **Sweep deviation:** Continuously variable from 0-4 mc lowest max. deviation to 0-42 mc highest max. deviation (depending on base frequency.) **Marker crystal:** 4.5 mc and multiples thereof. **Variable:** 19 mc to 60 mc on fundamentals, 57 mc to 180 mc on harmonics. **External marker terminals:** Provided on panel. **Attenuators:** Step-switch controls sweep and marker oscillators together, plus variable controls for each output. **Blanking:** Converts return trace into Zero reference line, phasing control also provided. **Cables:** 3 supplied, output, scope horizontal, scope vertical. **Power requirements:** 105-125 VAC, 60 cycles, 50 watts. **Dimensions:** 13" W x 8½" H x 7" D.

Color Bar & Dot Generator

• Unmatched in the industry for performance, quality and value! • Carefully designed throughout for accuracy and stability • Produces six different patterns for convergence, color and linearity picture adjustments on color or black & white TV sets • Crystal-controlled sync pulses lock patterns firmly on screen . . . no jitter or crawl . . . no sync leads needed • Requires only connection to the antenna terminals of TV set • The 10 color bars allow AFC, phase and matrix alignment of color sets and adjustable video output permits checks of color hue and sync at different signal levels • Your best buy in a color service instrument!

Kit IG-62 . . . . 13 lbs. $64.95

SPECIFICATIONS—RF output frequency range: TV channels 2 through 6. **Output voltage:** Variable from 100 to 100,000 microvolts. **Sound carrier:** Crystal controlled, unmodulated, 4.5 mc away from picture carrier; off-on switch provided. **Video output:** Positive or negative output variable from 0-10 volts peak-to-peak open circuit. **Modulation:** White dot pattern, cross hatch pattern, horizontal bars, vertical bars, 10 vertical color bars, shading bar pattern. **Tube complement:** 6-12AT7, 4-12AU7, 1-6BQ7, 1-6CS6, 1-0B2. **Power requirements:** 117 VAC, 50/60 cycles, 70 watts. **Dimensions:** 13" W x 8½" H x 7" D.

Wide Band 5" Oscilloscope

• Professional styling and features at low cost • Full 5 mc bandwidth for color TV servicing • Heath patented sweep circuit—10 cps to 500 kc • Push-pull vertical & horizontal output amplifiers • Positive trace position controls • Peak-to-peak calibration reference voltage • 3-step frequency compensated vertical input attenuator • Automatic sync circuit • Z-axis input • 5UP1 CR tube • 2 circuit boards & wiring harness for fast, easy assembly • A superbly engineered instrument loaded with extras.

Kit IO-12 . . . . 24 lbs. $76.95

SPECIFICATIONS—(Vertical) Sensitivity: 0.025 volts RMS per inch at 1 kc. **Frequency response (referred to 1 kc level):** ± 1 db 8 cps to 2.5 mc; + 1.5 to −5db, 3 cps to 5 mc; response at 3.58 mc, −2.2 db. **Rise time:** 0.08 microseconds or less. **Input impedance:** (AT 1 KC) 2.7 megohms at X1; 3.3 megohms at X10 and X100. **(Horizontal Channel) Sensitivity:** 0.3 volts RMS per inch at 1 kc. **Frequency response:** ± 1 db 1 cps to 200 kc; ± 3 db 1 cps to 400 kc. **Input impedance:** 4.9 megohms at 1 kc. **Sweep generator:** Range—10 cps to 500 kc in five steps, variable, plus any 2 switch-selected preset sweep frequencies in this range. **Synchronizing:** automatic lock-in circuit using self-limiting synchronizing cathode follower. **Power requirements:** 105-125 volts 50/60 cycles AC at 80 watts; fused. **Dimensions:** 14¼" H x 8⅝" W x 16" D.

FREE 1964 CATALOG

See these and over 250 other exciting Heathkits available in easy-to-build kit form. Save 50% or more by doing the easy assembly yourself! Send for your free catalog today!

HEATHKIT by Daystrom

HEATH COMPANY

Dept. 15, Benton Harbor, Mich. 49023

☐ Enclosed is $_____, plus postage. Please send model (s) _____.

☐ Please send my Free 1964 Heathkit Catalog.

Name_____

Address_____

City_____ State_____ Zip_____

TE-120

switch. Hence, instead of the usual multi-scale meter found in most v.o.m.'s, only a single scale is visible at any time, and this is the scale required for the particular setting of the range switch. This permits accurate voltage measurements to be made by relatively unskilled personnel, or allows the skilled technician or engineer to take measurements with greater speed while completely eliminating the possibility of recording readings from the wrong scale.

A simple mechanical arrangement accomplishes the scale changes required. A large beveled gear on the shaft of the range switch engages gear teeth on the edge of a white, high-impact plastic drum on which the meter's 18 basic scales are printed (see photo). When the range switch is rotated to any position, the proper meter scale is automatically moved into place behind the front-panel window of the meter. Hence, the

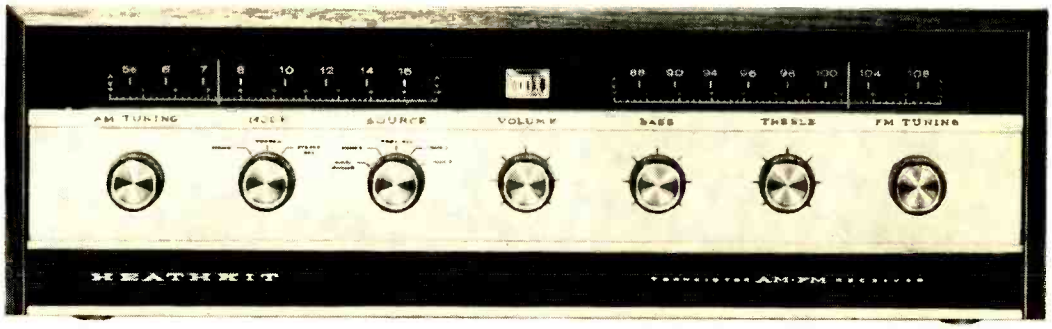
position of the pointer can be read without ambiguity.

Not content with the scales built into the instrument, the manufacturer supplies 18 additional scales printed on plastic sheets. Each of these scales can be inserted into the window opening on the front of the v.o.m., thereby retaining the single-scale display feature. These supplementary scales are used for measuring capacity, low-voltage (250 mv.) d.c., decibels, audio power, and peak-to-peak voltages.

The meter movement itself is protected against burn-out; it will withstand overloads well in excess of one hundred times without damage. This is accomplished by the use of a crystal diode across the movement. The diode is connected in the forward-biased direction, but with normal voltage drops across

what's new at Heathkit?

me!



Thirteen years ago we introduced the "Williamson Type Amplifier Kit". It represented a breakthrough in "do-it-yourself" high fidelity. For the first time a truly high fidelity amplifier was made available in kit form at an "easy-to-afford" price. The old WA-1 and its successors including the famous W-5 provided high fidelity listening pleasure to hundreds of thousands of music lovers across the nation. Ever since, Heath's history has been one of major advances in the hi-fi/stereo field. And now today, another first from Heathkit! Heath's newest . . . an all-transistor Stereo Receiver Kit, incorporating the latest in solid-state circuitry, at a price far below similar units . . . only $195.00!

Now in one compact unit! . . . two 20-watt power amplifiers, two separate preamplifiers, plus wide-band AM, FM, FM stereo . . . all superbly engineered to give you the clean, uncompromising realism of "transistor sound". All with transistor circuitry . . . a total of 43 transistors and 18 diodes . . . to give you the coolest, fastest, most-reliable operation possible! All handsomely housed in a single, smart-looking walnut cabinet with a striking extruded gold-anodized aluminum front panel . . . fashioned in Heathkit's modern low-silhouette styling! This is the beautiful new AR-13. This is the first all-transistor, all-mode stereo receiver in kit form! Compact in size, compact in price!

Many advanced features have been incorporated to make possible the advanced performance of the AR-13. You'll like the way this unit *automatically* switches to stereo, and the stereo indicator light silently verifies that stereo is being received. For all-around versatility there are three stereo inputs (mag. phono and two auxiliary) plus two filtered tape recorder outputs for direct "off-the-air" beat-free recordings. Dual-tandem controls provide the convenience of simultaneous adjustment of volume, bass, and treble of both channels. Balancing of both channels is accomplished by a separate control. The AM tuner features a high-gain RF stage.

Other quality features include an FM local-distance switch to prevent overloading in strong signal areas; a squelch control to eliminate between-station noise; AFC for drift-free reception; heavy die-cast flywheel for accurate, effortless tuning; pin-point tuning meter; and external antenna terminals for long-distance reception. For added convenience the secondary controls are "out-of-the-way" under the hinged lower front panel to prevent accidental system changes. The slide-rule AM and FM dial is fully lighted.

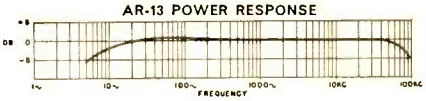
An exciting challenge for the more experienced kit-builder. Takes approximately 35 hours to assemble. The "front-end" and AM-FM I.F. strip are already preassembled and prealigned to aid construction.

Compare the new AR-13 Stereo Receiver with similar units. You'll agree that for advanced features, advanced solid-state engineering, advanced styling, and money-saving *price*, no unit matches the AR-13. Start enjoying the "transistor sound" of tomorrow, *today*, by ordering the AR-13 now!

Kit AR-13 . . . 30 lbs. $195.00

SPECIFICATIONS — Amplifier: Power output per channel (Heath Rating): 20 watts /8 ohm load, 13.5 watts /16 ohm load, 9 watts /4 ohm load. (IHFM Music Power Rating): 33 watts /8 ohm load, 18 watts /16 ohm load, 16 watts /4 ohm load @ 0.7% THD. 1 KC. **Power response:** ± 1 db from 15 cps to 30 KC @ rated output; ± 3 db from 10 cps to 60 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 @ 20 KC, 60 db @ 1 KC. 40 db @ 20 cps. **Input sensitivity** (for 20 watts output per channel, 8 ohm load): Mag. phono, 6 MV; Aux. 1, .25 v; Aux. 2, .25 v. **Input impedance:** Mag. phono, 35 K ohm; Aux. 1, 100 K ohm; Aux. 2, 100 K ohm. **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 (all inputs except Aux. 2); Push-Pull ON/OFF Switch. **FM: Tuning range:** 88 mc to 108 mc. **IF Frequency:** 10.7 mc. **Antenna:** 300 ohm balanced (internal for local reception.) **Quieting sensitivity:** 2½ uv for 20 db of quieting, 3½ uv for 30 db of quieting. **Bandwidth:** 250 KC @ 6 db down (full quieting.) **Image rejection:** 30 db. **IF Rejection:** 70 db. **AM Suppression:** 33 db. **Harmonic distortion:** Less than 1%. **Multiplex: Bandpass:** ± ¼ db, 50 to 53,000 cps. **Channel separation:** 30 db, 50 to 2,000 cps; 25 db @ 10 KC. **19 KC Suppression:** 50 db down, from output @ 1 KC. **38 KC Suppression:** 45 db down, from output @ 1 KC. **SCA Rejection:** 30 db. **AM: Tuning range:** 535 to 1620 KC. **IF Frequency:** 455 kc. **Sensitivity:** 1400 KC, 3.5 uv; 1000 KC, 5 uv; 600 KC, 10 uv—standard IRE dummy antenna. **Bandwidth:** 8 KC @ 6 db down. **Image rejection:** 30 db @ 600 KC. **IF Rejection:** 45 db @ 600 KC. **Harmonic distortion:** Less than 1%. **Overall dimensions:** 17" L x 5⅜" H x 14¾" D.

AR-13 POWER RESPONSE



FREE 1964 CATALOG

See these and over 250 other exciting Heathkits available in easy-to-build kit form. Save 50% or more by doing the easy assembly yourself! Send for your free catalog today!

HEATHKIT by Daystrom

HEATH COMPANY

Dept. 15, Benton Harbor, Mich. 49023

☐ Enclosed is $195.00, plus postage. Please send model no. AR-13.

☐ Please send my Free copy of the 1964 Heathkit Catalog.

Name_____

Address_____

City_____ State_____ Zip_____

HF-155

the movement, the diode does not yet conduct. With higher current through the meter and a rise in voltage of over several tenths of a volt, the diode conducts and shunts the excessive current around the movement.

Another interesting feature of the Model 360 is the use of a push-pull switch on the ohms-adjust rheostat. When the knob is pulled out, a short is placed across the input of the instrument. Hence, the meter can be zeroed readily without having to short the input leads. This feature is especially convenient when switching from one resistance range to another; the test leads need not be removed from the component being checked.

The accuracy of the instrument is within 3% of full scale on all d.c. ranges, and 5% on all a.c. ranges. One-percent or better multiplier and shunt resistors are used. The meter itself has an anti-parallax mirror for highest reading accuracy. Standard ¾-inch spacing of the test-lead jacks enable the user to employ *General Radio* type connectors if desired.

The instrument is available at $59.95, including batteries and test leads. ▲

Panco Resistance Calibrator

For copy of manufacturer's brochure, circle No. 47 on coupon (page 15).

THE simplest way of checking the accuracy of the resistance scales of v.o.m.'s or v.t.v.m.'s is to measure a number of known, accurate resistors. Laboratory standard resistors or decade boxes can be used for this purpose, but the former are expensive and the latter usually provide too many check points, and these do not have a sufficient spread in resistance values to cover all ranges of the ohmmeter being checked. For example, no single decade box covers from 1 ohm through 100 megohms.

The *Panco* Resistance Calibrator, with its 9 switched resistors, makes it simple to check the ohmmeter function quickly and easily. The resistors used are: 1, 10, 100, 1000, 10,000, 100,000

ohms, 1, 10, 100 megohms. In addition, the calibrator switch has one open-circuit and one short-circuit position. This means that the ohmmeter leads need not be removed from the unit's binding posts in order to short the leads and reset the zero adjustment on the ohmmeter when changing range.

Three versions of the calibrator are available. Model RFC-363 uses 1% resistors; Model RCB-663 uses 0.1% resistors; and Model RCA-763 uses 0.05% resistors. The 1% version is designed for use with ordinary v.o.m.'s and v.t.v.m.'s. The higher accuracy models may be used for calibration of bridges and digital ohmmeters and also where small resistance changes must be measured with extreme accuracy.

To keep leakage resistance high, the calibrator is housed in a Bakelite case and uses a switch with ceramic insulation. The case size is 3¾" x 6¼" x 3". Prices range from $17.50 for the 1% version to $37.50 for the 0.05% version of the calibrator. ▲

Hi-Fi Test Report

(*Continued from page* 20)

cps. Normally, in close talking there is some accentuation of bass response, which would make the effective response somewhat flatter. We were unable to measure it under a true close-talking condition.

Listening to a recording made with the mike confirmed that it has excellent characteristics for communication service. The sound was pleasant and natural without excessive crispness or the nasal sound sometimes produced by communications microphones. It was possible to use it in close proximity to a loudspeaker without feedback, by utilizing its cardioid response to reject direct pickup from the speaker.

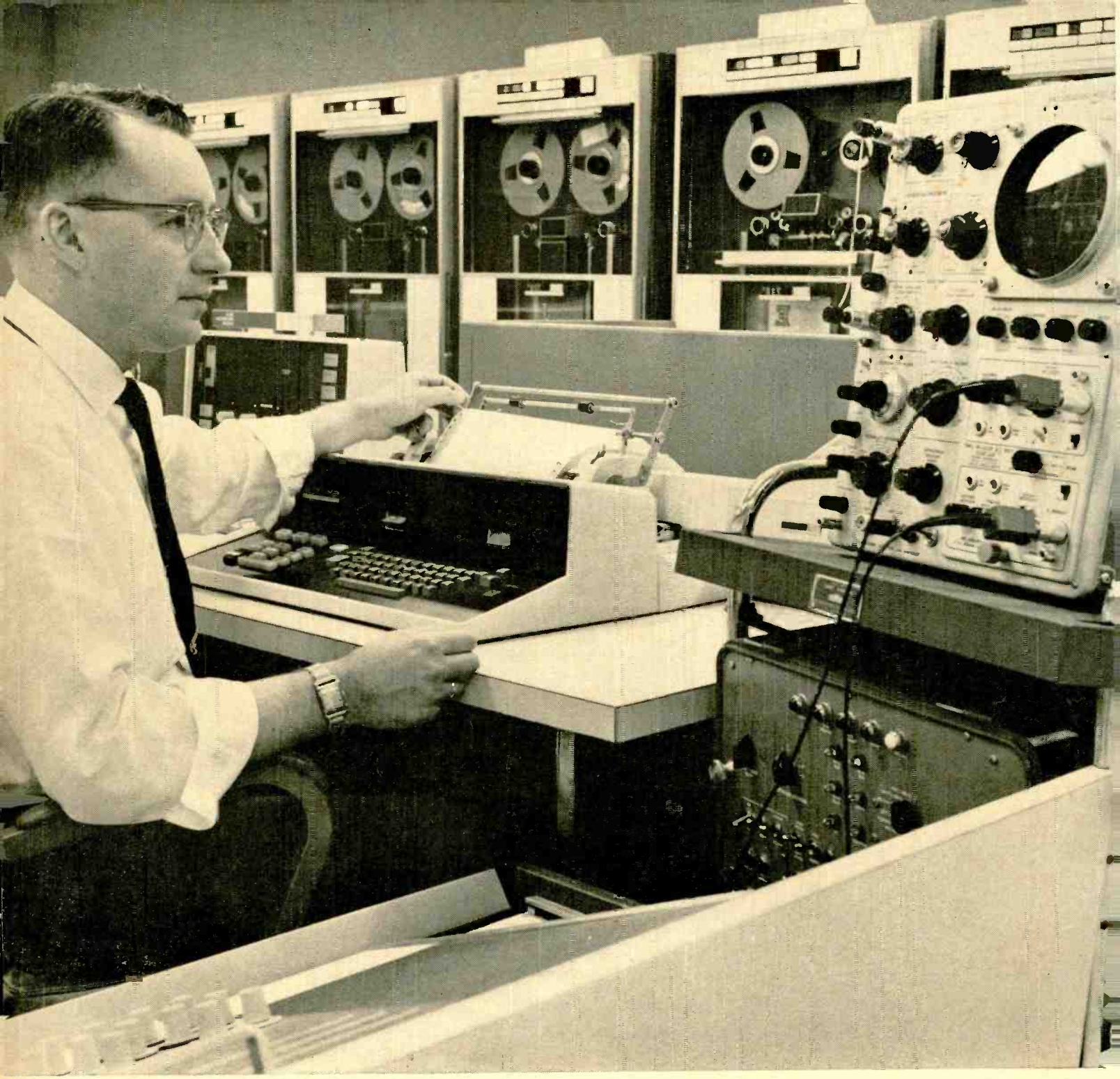
The Model 717, selling for $12.00, should be a good choice for amateur and commercial mobile service, particularly under high ambient noise conditions. ▲

REPAIRING ELECTROLYTICS

By ELWOOD C. THOMPSON

MANY discarded and junk-box electrolytics having broken leads too short to be soldered can be salvaged in the following manner.

If the lead has been broken off right at the retaining rivet, pry up the edge of the rivet from where the lead enters to a point 180 degrees around. Then, very carefully force a half-turn of the broken lead from under the pried-up section of the rivet, thus providing a short stub to which an extension can be soldered. Be sure and leave a full half-turn of the old lead clamped under the rivet for contact. ▲



Why Fred got a better job . . .

I laughed when Fred Williams, my old high school buddy and fellow worker, told me he was taking a Cleveland Institute Home Study course in electronics. But when our boss made him Senior Electronic Technician, it made me stop and think. Sure I'm glad Fred got the break . . . but why him . . . and not me? What's he got that I don't. There was only one answer . . . his Cleveland Institute Diploma and his First Class FCC License!

After congratulating Fred on his promotion, I asked him what gives. "I'm going to turn $15 into $15,000," he said. "My tuition at Cleveland Institute was only $15 a month. But, my new job pays me $15 *a week* more . . . that's $780 more a year! In twenty years . . . even if I don't get another penny increase . . . I will have earned $15,600 more! It's that simple. I have a plan . . . and it works!"

What a return on his investment! Fred should have been elected most likely to succeed . . . he's on the right track. So am I *now*. I sent for my three *free* books a couple of months ago, and I'm well on my way to Fred's level. How about you? Will you be ready like Fred was when opportunity knocks? Take my advice and carefully read the important information on the opposite page. Then check your area of most interest on the postage-free reply card and drop it in the mail *today*. Find out how you can move up in electronics too.

How You Can Succeed In Electronics

. . . Select Your Future From Five Career Programs

The "right" course for your career

Cleveland Institute offers not one, but five different and up-to-date Electronics Home Study Programs. Look them over. Pick the one that is "right" for you. Then mark your selection on the reply card and send it to us. In a few days you will have complete details . . . without obligation.

1. Electronics Technology

   A comprehensive program covering Automation, Communications, Computers, Industrial Controls, Television, Transistors, and preparation for a 1st Class FCC License.

2. First Class FCC License

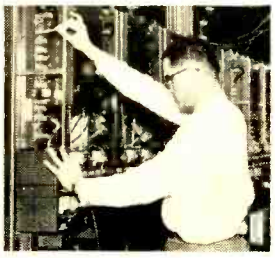
   If you want a 1st Class FCC ticket *quickly*, this streamlined program will do the trick and enable you to maintain and service all types of transmitting equipment.

3. Broadcast Engineering

   Here's an excellent studio engineering program which will get you a 1st Class FCC License and teach you all about Program Transmission and Broadcast Transmitters.

4. Electronic Communications

   Mobile Radio, Microwave, and 2nd Class FCC preparation are just a few of the topics covered in this "compact" program . . . Carrier Telephony too, if you so desire.



5. Industrial Electronics & Automation

   This exciting program includes many important subjects such as Computers, Electronic Heating and Welding, Industrial Controls, Servomechanisms, and Solid State Devices.

An FCC License . . . or your money back!

In addition to providing you with comprehensive training in the area indicated, programs 1, 2, 3, and 4 will prepare you for a Commercial FCC License. In fact, we're so certain of their effectiveness, we make this *exclusive* offer:

> The training programs described will prepare you for the FCC License specified. Should you fail to pass the FCC examination after completing the course, we will refund *all* tuition payments. You get an FCC License . . . or your money back!

Cleveland Institute's new "Check-Point Plan" helps you learn faster and better

Cleveland Institute uses the new programmed learning approach. This "Check-Point Plan" presents facts and concepts in small, easy-to-understand bits . . . reinforces them with clear explanations and examples. Students learn more thoroughly and faster through this modern, simplified method. You too will absorb . . . retain . . . advance *at your own pace.*

Job placement service . . . another CIE extra to help you get ahead in electronics

Once enrolled with CIE, you will get a bi-monthly listing of the many high-paying interesting jobs available with top companies throughout the country. Many Cleveland Institute students and graduates hold such jobs with leading companies like these: American Airlines, American Telephone and Telegraph, General Electric, General Telephone and Electronics, IBM, Motorola, North American Aviation, New York Central Railroad, Raytheon, RCA and Westinghouse.

Electronics is a fast moving, dynamic industry . . . Cleveland Institute keeps you current

The Electron Bulletin is CIE's bi-monthly digest of new developments in the world's fastest growing industry. As a CIE student, you will get a free copy throughout your training to keep you up-to-date on Masers, Lasers, Solid State Devices, and other new inventions.

Full accreditation . . . your assurance of competence and integrity

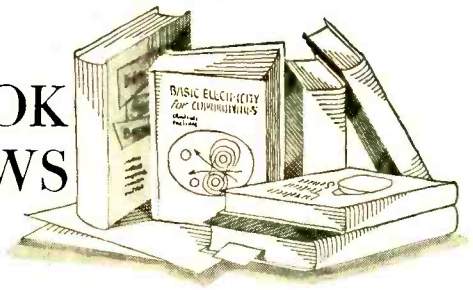
Cleveland Institute of Electronics is accredited by the Accrediting Commission of the National Home Study Council. You can be assured of competent electronics training by a staff of skilled electronics instructors.

Your Future In Electronics Is Up To You. Make It A Brighter One. Mail Reply Card Today.

Cleveland Institute of Electronics

Dept. EW-85, 1776 E. 17th St., Cleveland 14, Ohio

BOOK REVIEWS



"KNOW YOUR VOM-VTVM" by Joseph A. Risse. Published by *Howard W. Sams & Co., Inc.* 139 pages. Price $2.50.

This is a comprehensive treatment of two of the most widely used test instruments, the volt-ohm-milliammeter and the vacuum-tube voltmeter.

In this non-mathematical exposition, the author discusses the design principles and operation of the units beginning with the different types of meter movements, shunts, multipliers, switches, and rectifiers as well as meter-protection circuits.

The internal and external features of typical v.o.m.'s and v.t.v.m.'s are described, including the functions and characteristics of all the important components. The book also covers testing, troubleshooting, repair, and maintenance on these instruments.

* * *

"THE CRISIS WE FACE: AUTOMATION AND THE COLD WAR" by George Steele & Paul Kircher. Published by *McGraw-Hill Book Company, Inc.* 220 pages. Price $2.65. Soft bound.

This is a sobering analysis of our position with regards to military automation as well as the status of business automation with respect to rising European production. While much current talk is about the effects of automation on employment, the authors are more concerned with our military and business postures.

The text is divided into eight chapters covering an introduction to the subject of automation; antecedents; problems of management; problems of design; solutions to management problems; long-range technical problems; education for management; research, design, and maintenance of automation; and an analysis of our defence.

Since all of these matters affect or will affect every U.S. citizen, this book is recommended to all thinking Americans.

* * *

"COMMUNICATIONS EQUIPMENT SCHEMATIC MANUAL" compiled and published by *Howard W. Sams & Co., Inc.* 128 pages. Price $3.95.

This volume not only provides a representative selection of schematic diagrams for the most widely used two-way radio sets but includes text sections describing operating principles, troubleshooting, alignment, and maintenance practices.

The equipment described and the companion text material covers units to operate in the 145-170 mc. portion of the spectrum. Citizens Band and business radio equipment in the 25-50 mc. and 450-470 mc. bands is not included.

* * *

"THE CENTURY OF SCIENCE" by Watson Davis. Published by *Duell, Sloan and Pearce.* 305 pages. Price $5.95.

The author of this volume has spent an entire lifetime making science understandable to the layman. As a developer of science clubs and conductor of the annual science talent search among high-school seniors, he has devoted his energies to instilling a sense of pride in scientific achievements in his fellow Americans.

This volume is a still further attempt to interest his fellow citizens in the amazing strides science has taken in the twentieth century. He covers atoms, geology, communications, the automotive age, aviation, rockets and space, chemistry, electronics—machines and automation, food and agriculture,

health and medicine, sex and genetics, the population explosion, civilizations and peoples, the mind and emotions, human talent, research, and the future. Over 200 photographs have been included.

* * *

"SERVICING FM-STEREO RECEIVERS" by Edward M. Noll. Published by *Howard W. Sams & Co., Inc.* 128 pages. Price $2.50.

While this may appear to be a rather specialized topic on which to devote an entire book, the ever-growing popularity of FM-stereo has put equipment in the hands of so many non-technically oriented music lovers that technicians are receiving an unprecedented number of calls for service.

This is a detailed exposition which starts with a thorough explanation of FM-stereo signal fundamentals, then goes on to a discussion of receiver and adapter circuitry, servicing and alignment procedures, components, installation problems, FM antennas, and needed test equipment.

* * *

"RCA TUNNEL DIODE MANUAL" compiled and published by Semiconductor and Materials Division, *RCA*, Somerville, N.J. 152 pages. Price $1.50.

This handy volume is divided into nine chapters which deal, progressively, with the latest switching and microwave applications for tunnel diodes and tunnel rectifiers. Of interest primarily to circuit design engineers, but also helpful to the student, teacher, and experimenter, the text explains in detail microwave capabilities of the tunnel diode in oscillator, amplifier, and converter applications.

There is a 7-page technical data section which gives ratings and characteristics for more than forty of the firm's germanium and gallium arsenide tunnel diodes and rectifiers.

* * *

"PRACTICAL TV TUNER REPAIRS" by Robert G. Middleton. Published by *Howard W. Sams & Co., Inc.* 126 pages. Price $2.50.

Written for the practicing service technician, this volume explains how to identify and correct many tuner troubles. The author outlines complete step-by-step techniques for isolating troubles to specific circuits and components—with check charts and illustrations to help the technician along.

The text progresses from how to determine whether or not the tuner is at fault to how to perform the various tests to isolate tuner troubles. The book is divided into seven chapters covering troubleshooting r.f. tuners, elusive tuner troubles, evaluation of test data, tuner replacement, tuner test and alignment setups, job reports, and r.f. alignment techniques. ▲

Unique Color-TV Tubes & Systems

(*Continued from page 38*)

tubes, each generating one color, are used. Adding a second red projector (making a total of 4 light sources) approximately doubles the luminance. The modulated electron beam from the gun is focused through a hole in the spherical mirror onto the one-color phosphor. The phosphor is 0.5 x 0.7 inch in size and is mounted on a metal supporting structure whose 9½ square inches of radiating surface acts as a heat sink. The phosphor surface and the associated spherical mirror are pre-focused and mechanically mounted within the cathode-ray tube. The tube is electrostatically focused and magnetically deflected and is approximately one foot long and about 2½-inches in diameter.

The new optical portion of this projection system is an injection-molded, faceted plastic plate, called a "Sunflower," that is used as an optical distortion corrector. The Sunflower corrects keystone, pincushion, and other distortions of the projected images and insures correct registration on the viewing screen. As shown in Fig. 6, the Sunflower is positioned between the projection tube and the viewing screen. Once adjusted, the multiple projection systems are mechanically locked in place and require no further adjustment.

The Sunflower operation depends on the fact that any principal ray of light from a projector can be bent and its point of contact with the viewing screen corrected by various refracting surfaces in the light path. By using various refracting angles for a number of facets scattered about the Sunflower, it is possible for the principal rays from the projectors to fall within a 0.3-mm. diameter circle on a 23.6-inch diagonal viewing screen. Resolution of the prototype projection system, using a 23.6-inch diagonal viewing screen, is in excess of 500 lines, falling to about 300 lines in the extreme corners.

Because of the extreme optical control of registration, it is only necessary to mechanically secure the various items of the projection system in a rigid cradle. Raster size and rotary alignment of the raster is performed by placement and adjustment of the magnetic deflection coils. Electrical shift voltages within the circuit are used for fine adjustment of raster position.

The operating circuits that drive the projection system are essentially the same as any other color receiver.

One planned table projection system has internal dimensions of 20 inches front-to-back, is 34 inches wide, and 19 inches high. Weight of the prototype system is 38 pounds.

Two Tubes—Land Color

Shortly after Edwin Land propounded his two-color theory of color perception, a number of electronic laboratories went to work in an attempt to develop a TV system using his findings.

Although some undisclosed practical work is going on in this country, researchers at the Television and Electronics College, Tokyo, Japan have released information on their two-color system.

In Land's original color experiments, he found that a red-and-white combination could be used to reproduce just about all the colors needed for a passable full-color photograph. However, this system had some difficulty in reproducing certain blues and greens. During the course of experiments at the Japanese college, a number of colors were tested and finally a combination of red-orange and blue-green was found capable of reproducing the widest gamut of useful colors.

As shown in Fig. 7, a pair of conventional monochrome cathode-ray tubes is mounted at 90° to each other with a half-silvered mirror mounted at 45° to the mounting axis. The two tubes are mechanically arranged so that their pictures will be exactly registered. One tube has a blue-green filter covering its screen area while the other uses a red-orange filter.

The G-Y chromatic signal is fed to the green-filtered tube while the R-Y signal is fed to the red-filtered one. The Y (luminance) signal is fed to both control grids in parallel.

Because the tubes are mounted at right angles to each other, it makes for an awkward cabinet of large proportions. Also, this mechanical arrangement produces an uncomfortable tunnel-like viewing effect.

Japanese Color Wheel

At first glance, the *Mitsubishi Electric* color system, shown in Fig. 8, appears to look like the old *CBS* non-compatible color-wheel system. Unlike that system, however, this Japanese approach uses a single vidicon with a synchronized color wheel having red, green, and blue filters passing in sequence (rotating) in front of it and a conventional three-gun color tube in the monitor. This system was developed for industrial closed-circuit use.

As shown in Fig. 8, a synchronizing generator keeps the color wheel in step and simultaneously operates a gating circuit to pass only the electrical signal representing that color to the monitor three-gun color tube.

Use of a conventional monochrome vidicon greatly reduces the price of the television camera.

Japanese Tubes

One unknown in this area is the direction to be taken by Japanese manufacturers when they decide to enter the color TV field in a big way. Certain Japanese manufacturers have developed small versions of the shadow-mask tube (*Toshiba*, for example, has a 14- and 16-inch version) while others are testing small versions of the one-gun Lawrence tube (*Sony*, for example, has mentioned a 9-inch version). The Japanese are known to be working on other types of color tubes.

Electroluminescent Panels

One other novel approach to halftone picture display is the use of electroluminescent panels. Although at present in the laboratory stage and as yet limited to a monochrome display of alpha-numeric characters, future research may produce a high definition display and, very likely, a color version.

Electroluminescent panels are solid-state devices that do not use electron bombardment, or emission, but depend wholly on the electronic process occurring within certain materials.

Destriau, in 1936, observed the emission of light from a specially prepared zinc sulphide phosphor suspended in an insulating oil and subjected to an intense alternating electric field by capacitor-like electrodes. Today, the phosphor powder is embedded either in a solid organic such as plastic or an inorganic material such as glass. Thin films of tin oxide or metal are used to provide transparent electrically conductive electrodes. Such cells can be made with a base of glass, metal, or flexible or rigid plastic and are often sold as night lights in most hardware stores.

By providing mutually perpendicular sets of parallel conducting strips on opposite surfaces of an electroluminescent layer and applying a voltage between any pair, the phosphor area at the intersection will light up. Laboratory experiments have shown that it is possible to reproduce halftone images at low light levels. Some EL phosphors also exhibit a change in emission color as the frequency of the applied voltage is varied.

Although considerable progress has been made in the generation of images with scanned electroluminescent arrays, many problems remain to be solved if resolution comparable to present commercial television is to be achieved. The *Electro-Optics Division* of *Belock Instrument Corp.*, is presently working on a high-resolution EL panel using a novel fabrication technique of closely spaced insulated wires, formed into a matrix, and used to excite the phosphor. When the wires are sequentially excited, a bar scan is produced across the EL panel. ▲

Unijunction Transistor

(*Continued from page* 47)

varying the amplitude of the input square wave and/or varying the resistance of the decade box, the unijunction transistor could be made to fire on every input pulse or any number of input pulses. The value of the unijunction transistor as a frequency divider is quite apparent.

The resistance was then set to a value where the oscillator would oscillate at approximately 600 cps at a particular V_E. The square-wave generator was then adjusted to an output frequency of 10 cps at an amplitude equal to the V_E used to obtain the 600-cps oscillation. The output, as shown in Fig. 5E, was observed on the oscilloscope. The output obtained from the base monitoring points did not appear on the photograph due to their short duration at the slow sweep speed used on the scope. Evenly spaced pulses in groups of any desired number were obtainable. This example points out the possible use of the device as a pulse generator.

Special Marker Generator

As a practical example, a need existed whereby the group of five pulses could be extracted from the pulse train given in Fig. 6, so as to give a single marker pulse output for each group. The intermediate pulses were not used in this application and therefore were not to show up in the output.

First thoughts were turned toward a combination of timing and logic circuit which would give the required marker. It was soon realized that this approach would take considerably more time to design and construct than was allowed.

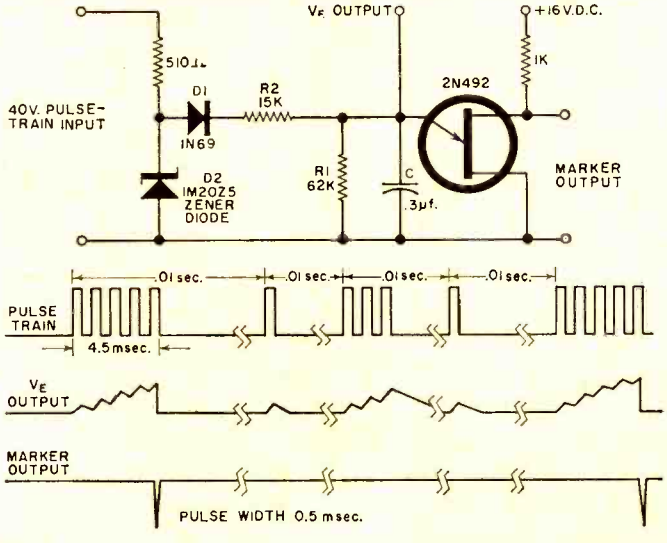
Utilizing a unijunction transistor simplified the circuit, as shown in Fig. 6. The pulse train was applied at the input as shown. The first pulse of the group of five pulses was limited to a constant amplitude by the zener diode $D2$ and simultaneously forward-biased $D1$. Capacitor C charged through $R2$ for the duration of the first pulse. At the end of the first pulse, the charge of C back-biased $D1$ and therefore C could discharge only slightly through $R1$, since the unijunction's firing potential had not yet been reached.

In the same manner the remaining pulses of the group additively charged C until during the fifth pulse, when the firing potential was reached. At this time the unijunction conducted and allowed the capacitor to discharge. This discharge provided the required pulse at the market output, as shown in Fig. 6. The next pulse charged C to a fraction of the firing potential but discharged through $R1$ before the group of three pulses arrived. The group of three pulses additively charged C, but not to sufficient magnitude to fire the unijunction. This charge also bled down to a low value before the next single pulse arrived. This action, as just described, enabled a marker pulse to be produced only for each group of five input pulses. It can now be realized that the simplicity of the design required to do this seemingly difficult job is entirely due to the unique characteristics of the unijunction transistor.

The unijunction transistor can be used in many applications—including timing devices, multivibrators, pulse generators, silicon controlled rectifier firing circuits, saw-tooth generators, time-delay circuits, ring counters, and voltage-sensing circuits. Advantages of the unijunction transistor include its low cost (ranging from $3 to $10), excellent linearity, stability, and simplicity of circuit design. The circuits utilizing this device are stable over a wide range of temperature coefficients.

It is a unique device that may let you meet your circuit requirements easier and with less effort than would otherwise be possible. ▲

Fig. 6. One marker pulse is produced for each train of five pulses.



TELEVISION SERVICING—SOVIET STYLE

By THEODORE M. HANNAH

A shortage of technicians, the quota system for service shops, and lack of replacement parts make owning a TV set in the Soviet Union a frustrating experience for the average comrade.

"WE saved our money for two years and finally bought a TV set. But it worked for no more than an hour, and it's been out of order ever since."

This letter, recently published in the Soviet press, is only one of many that complain of the poor quality of Russian TV sets. The problem has reached such proportions that even Premier Khrushchev has spoken out on the subject. At the Communist Party Congress of last year Khrushchev said:

"Or take the Neman-3 brand of television sets produced at the Minsk radio plant, directed by Comrade Shapoval. I would like to quote from a letter sent to Comrade Shapoval by Comrade Krasnova in Riga, Latvia, who bought a Neman-3 television set:

" 'For a long time I could not get a television set. But, thanks to the concern of the state, my dream came true and I was able to buy a set on the installment plan. I paid 293 rubles for it and skimped on many things to do so. I bought a Neman-3 set of your manufacture on February 3, 1962. On February 28, it stopped working and my trials began. The set is still not working. I would like to know whether, in putting out such an expensive product at your plant, you are really completely indifferent to those persons to whom you bring disillusionment instead of joy and satisfaction. I am not writing this letter casually; since acquiring the set which you manufactured I have obtained my entertainment not from the set but from the television repair shop.'

"You can imagine, of course, what entertainment it is to deal with a television repair shop! The factory director should burn with shame after having received such a letter. One must put an end to such outrageous things, comrades! The people who babble about how our products must be the best in the world while themselves turning out shoddy goods should not be allowed, as the saying goes, within cannon-shot of the management of enterprises!"

If there is anything the Russians complain of more than the quality of their TV sets, it is the quality of TV service. They say it is slow, often incompetent, and usually overpriced. Why should this be so? The Russians have been producing TV sets for a number of years (there are about 9 million sets now in use) and the sets are generally of good design, yet the twin problems of poor sets and poor service continue to plague both the Soviet TV industry and the 40 million Russians who watch television.

Service and Service Troubles

Just as all Soviet TV sets are produced in state-owned plants, so are they serviced in state-owned shops. To see what these shops are like and how they operate, let's take a look at television servicing in Moscow. Each part of the city and each suburb is served by a particular service shop. (It appears that you have no choice but to deal with the shop in your part of town.) These shops, which are identified only by number ("Television Repair Shop No. 72"), are administered, equipped, and stocked (at a 10% discount) by the Television Trust of the Ministry of Communications. The Trust employs about 2400 persons, and they are responsible for the installation and maintenance of Moscow's 1,250,000 TV sets. Of the 2400 employees, about 1300 do TV service work.

Everything in the Soviet economy is planned, and television servicing is no exception. The government, operating through the Trust, assigns "norms" (quotas) to each shop. A shop's profit (if any) depends upon how well it fulfills its quota, and fulfilling the quota depends on how many service calls are made and on how many rubles' worth of service is sold. Service shops are under considerable pressure to meet their quotas, and this pressure contributes to poor quality service work.

Why is Soviet TV service so bad? There are three main reasons: the quota system encourages slipshod work and repeated callbacks, there is a shortage of trained service technicians; and there is a chronic shortage of needed replacement parts.

Taking the last reason first, it has been estimated that 70% of all repairs involve the replacement of the same few components (two high-voltage rectifier tubes and one horizontal output tube, horizontal output transformers, and a few parts in the sweep circuits). In spite of the demand for these components, or perhaps *because* of it, there is a continual, acute shortage of these parts, particularly the tubes. It is not unusual for a set to be inoperative for months because of the lack of a horizontal output tube or transformer. The same is true of picture tubes. One Moscow shop has about 3000 sets awaiting a particular 12-inch tube; some of these sets have been in the shop for six months or more! Other shops are so overcrowded with sets that they can accept no more service business.

The television factories and the service shops blame the tube plants for not producing enough tubes. In 1962, for example, 13 million receiving tubes and 482,000 picture tubes were to have been produced for replacement use, but actual production was 11 million and 350,000 respectively. The tube plants are also criticized for producing inferior tubes, many of which fail within a very short time.

One way to alleviate the shortage of picture tubes is to rebuild the old ones, and this is now being done in a number of cities. Only 14-inch and larger tubes are rebuilt; the rebuilding of smaller sizes is not economically feasible. Cost of a rebuilt tube is about one-third that of a new one.

The procedure for getting TV service goes something like this: you go personally to the shop serving your neighborhood, a repair order is made out, and about a week later a service technician arrives to check your set. If it has to go to the shop *you* take it there and when it is repaired *you* pick it up and bring it home. If this sounds like an inconvenience to the customer, it is, and the Russians now seem to be aware that it is. Some shops, for example, are now providing evening service (until 9 p.m.) two nights a week. They will also take service requests by telephone and will deliver the set after it is repaired. (It is not clear who takes the set *to* the shop.) This kind of service is available only in major cities; elsewhere TV service of any kind is very limited.

Although the Television Trust recommends that shops loan the customer a good set while his is being repaired, it appears that this is seldom done.

The six-month warranty that all Soviet TV sets carry is often cited as a reason for the production of poor quality sets. Under this system, the factories pay "warranty repair shops" 8 rubles for service required on each set during the first six months. To cover the cost, the plants automatically add 8 rubles to the selling price of each set produced. (The official

exchange rate is 1.11 rubles to the dollar. For convenience, all costs mentioned in this article will be expressed in terms of dollars at the ratio of one ruble to one dollar.) This warranty doesn't mean that the factory guarantees the set for six months; it means only that the factory guarantees to underwrite the cost of repairs for six months.

The press often charges that this practice encourages factories to produce inferior sets. Another criticism is that the average repair cost is not $8, but $6, thus an unearned $2 profit to the shop, paid for by the customer when he buys the set. (Steps have been taken recently to bring the factory pre-payment more in line with actual costs.) In any case, the warranty system, in effect, transfers responsibility for final testing and adjustment from the factory to the service shops, and again it is the set owner who suffers. Despite its many defects, there is now some talk of extending the set warranty period to 12 months.

Replacing Defective Sets

During the warranty period the owner of an especially troublesome set can exchange it for another set, but only under certain conditions. If the set has three times required the replacement of major components, it can be returned. The same privilege does not, however, apply in the case of minor repairs, no matter how many of them there may have been. One service technician suggested that shops be allowed to exchange sets after the third service call, regardless of the nature of the trouble. He saw this as a way of forcing the factories to turn out better sets.

A recent survey showed that the percentage of late-model sets requiring service during warranty ranging from 60.1% for one model up to 87.6% for another model. Some of the older sets—those made 5 or 6 years ago—do, however, have better repair records. Russians still speak longingly of one very reliable 7-inch set first produced about 15 years ago. "If only we could get sets like that today!"

It has been suggested that special shops be set up in the larger cities to handle "tough dog" repairs sent to them by the regular shops, but so far it appears that this is only at the suggestion stage.

American-style service contracts have also been proposed. It is argued that, in addition to improving service, such contracts would have two very desirable side effects—they would eliminate the part-time service technician and would discourage the practice of tipping for service.

It is often said that too many different models of sets are produced and that some of them are rushed into production without adequate testing. It has been charged that the 59 different models produced thus far (12 of them in 1962) are entirely too many, that "each new model is worse than the one before," and the result is generally poor service from all sets.

Like the United States, the Soviet Union has its share of television "do-it-yourself-ers." They, however, face much more serious problems in repairing their own sets than do Americans. First, the Russians are usually not free to install their own sets. This is the responsibility of the service shops. Even though installation normally involves only connecting the set to a master antenna (most TV sets are in apartments), the customer must have the job done by the service shop. Since this usually involves a wait of about two weeks, it too becomes a cause of complaints. (Once the set is installed, the owner pays a 15-cent monthly charge for use of the antenna.) Then there is the problem of getting replacement parts. In the large cities it is only very difficult to get parts; outside the large cities it is almost impossible.

Despite these obstacles, many Russians do repair their own sets. A popular booklet called "Learn to Repair Your Own TV Set" describes not only how to make the usual minor repairs (tube replacement, adjustments, etc.) but also some fairly major ones—replacement of flybacks, for example.

In at least one respect, Russian television technicians are much like their American counterparts: they are both subjected to the same kind of customer abuse, as the following letter illustrates:

"The technician arrived, blew some dust out of the set, installed a new fuse (borrowed from my supply), soldered something to a contact under the set, then charged me $2. A week later the set was again out of order."

Whether or not the technician was at fault in this particular case, all Russian TV technicians come under considerable criticism from both the public and the press. The public claims that technicians are slow, incompetent, and sometimes dishonest. The press agrees, but says that the fault lies with the system rather than with the technicians.

Technicians and Their Pay

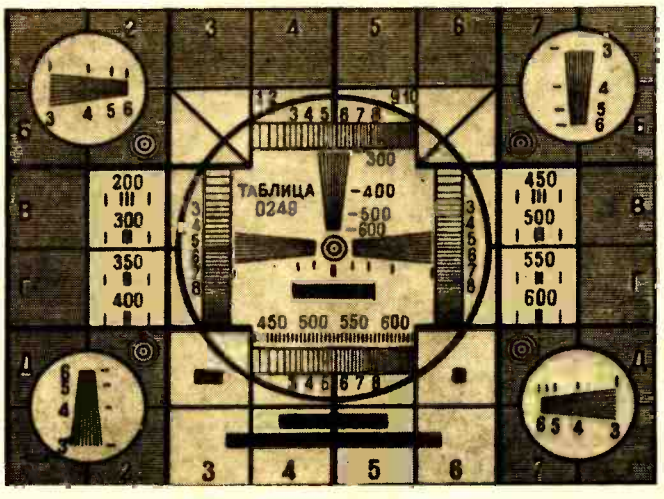
It is claimed that TV servicemen are not properly trained. As proof, the press cites the case of the Moscow Television Trust. Of the approximately 1300 technicians employed in Moscow, only one has an engineering degree, 63 are graduates of electronics schools, and over 900 have only a sixth- or eighth-grade education (these are called the Russian equivalent of "screwdriver mechanics"). The reason for the shortage of trained men is that the electronics schools simply do not graduate enough of them.

How is the technician paid? Like the shop he works in, he is on the quota system. His work is planned in terms of "norm-hours," and his pay is based on the number, difficulty, and cost of the service jobs he completes. The technician himself determines the degree of difficulty of the particular job. (There are three degrees based on the time required to complete the repair.) The technician thus is his own norm-setter, norm-fulfiller, and cashier—particularly on home service calls. If he fills his quota 100%, he gets a 10% bonus. If he exceeds 100%, he gets a 25% bonus. For reaching 125% of the norm, he receives a bonus equal to half his regular pay (providing there have been no valid complaints from his customers). This system, of course, puts the emphasis on number of sets repaired, not on quality of the work.

It has been suggested that, in the interest of quality service, pay should not *increase* with each service call but rather should *decrease*. The technician would, in other words, be paid according to the condition of the sets and antennas in his service district—the better their condition (thus the fewer the service calls), the higher the pay.

In practice, a technician must make 8 calls per day to qualify for bonus pay. Even if the calls are all reasonably close together, he will have no more than 25 minutes per call. If he encounters anything more than routine, minor trouble, the quota system encourages him to send the set to the shop. This adds to the shop's workload and, instead of the pre-

Soviet TV test pattern. (Courtesy: "Tekhnika Televideniya")



scribed 5 days in the shop, the set may be there for 30 days or even a longer period of time.

In some cases, less-than-honest technicians charge for work not done and then are paid again during callbacks, at which time they do the work they should have done on the first call. This practice also permits the technician to get one call closer to the quota qualifying him for bonus pay.

Still another disadvantage of the Soviet television servicing system is that no two service districts are alike. One will have a preponderance of the older, more reliable sets while another will have more of the newer, less reliable receivers. And one technician may be responsible for hundreds of sets while another is responsible for thousands. To correct this situation, Soviet officials believe that service should somehow be equalized and that technicians should receive equal amounts of pay for equal work performed.

Service Charges

First of all, an understanding of Soviet prices requires an understanding of Soviet wages. The average Russian worker earns about $80 a month. To earn enough to buy the cheapest TV set now produced (a 14-inch model selling for $168), a Russian must work for about two months. In comparison, an American worker (average pay, $2.40 per hour) must work for less than 2 weeks in order to buy a set selling for about the same price (a 19-inch portable costing $165). To pay for the installation of a new 17-inch picture tube (total cost, $38.80), a Russian must work for almost two weeks. An American would work two days to earn the same amount of money. These figures are from the U.S. Department of Labor.

Some typical Russian service charges are: basic charge for a service call, $1.20; cost of an 807 horizontal output tube, $1.50; cost of replacing a tube (not charged for when there are no other repairs), 10 cents; cost of typical 17-inch picture tube, $35.80; installing a new picture tube, $1.80; cost of deflection yoke, $5.00; installing the new deflection yoke, $1.40; and cleaning safety glass, $1.30.

As a model of what television service *can* be, Russians point to the example of Poland. There each TV sales outlet has its own service shop, new sets are delivered within two hours, a technician installs and checks the set, supplies a voltage regulator and antenna if needed, and asks the owner whether he would like to have regular service on his set. If the answer is "Yes," the technician returns twice a month to check the set. Is it any wonder that the Russians ask, "Why is it that *we* can't get that kind of service?" ▲

Transistors vs Tubes

(*Continued from page* 45)

requires impedances many times higher than those presented by common speakers.

Transistors provide, for the first time, a practical means of achieving OTL circuits. It is for this reason that we feel the few minor design difficulties associated with this approach should be overcome rather than again resorting to the use of a matching transformer.

Power and Transient Response

Two properties affected by the use of an output transformer stand out: these are power and transient response. First, let us consider power *vs* frequency response. Core size, and related to it, primary inductance, affect the low-end performance; leakage inductance and winding capacitance affect the high end of the frequency spectrum. Transistor output stages without transformers will definitely permit a wider power response, as these restrictions are eliminated.

Power response, however, is only one important criterion. Stability is another. Modern amplifiers depend on large amounts of feedback to achieve acceptable final performance figures with regard to distortion, frequency response, and damping factor. Whether the voltage feedback from output to input is derived from the secondary or the primary of the output transformer is of no significance since, in the case of a well-designed bifilar auto-transformer, both are practically identical.

To avoid d.c. flow through the transformer windings, the output stage must be either d.c.-balanced with respect to ground or a coupling capacitor must be used. Feedback voltages may be derived from the junction of the coupling capacitor and transformer. The impedance of both elements, whose reactive components change in opposite directions with a change in frequency, creates a phase shift of the feedback voltage at the very extremes of the frequency spectrum. This necessarily will result in problems with regard to stability. Elimination of the output transformer and coupling capacitor removes these problems.

In addition, it should be remembered that coupling capacitors must be designed to withstand the high a.c. currents encountered when working into low impedances. With a 4-ohm speaker, for instance, and 40 watts of power, a capacitor would be required to handle up to 3.2 amps. Only very large and expensive units are capable of sustaining these currents over long periods.

A point of disagreement, and one not restricted to transistor circuits, is the significance of transient response. Transient response is determined by feeding

square waves of various repetition rates through the amplifier and examining the output waveforms. These give a useful indication of amplifier stability, quickly revealing any instability within the circuit.

As long as no new frequencies are created, the phase relationship of sine components in the square wave is of minor importance to the listener. In contrast to this, however, the ringing effects that may be visible on pulse output waveforms are a form of distortion that *can* be heard. They result from an undesirable characteristic of the amplifier, which produces damped oscillations within the circuit. These oscillations, like the products of IM distortion, are harmonically *unrelated* to the input signal.

It is here that the frequency response of the amplifier becames important. A roll-off at either end of the audio spectrum *inside the feedback loop* of the amplifier is bound to result in natural modes of excitation which will produce the form of ringing distortion discussed above. Only when the frequency response of the power amplifier extends far enough beyond the audible spectrum can this distortion be rendered insignificant.

As pointed out in the earlier article, the program material from any source is restricted to frequencies from 20 to 20,000 cps, or less. To eliminate distortion products or overload conditions outside this range, the response to these undesired frequencies should be greatly attenuated. It should be emphasized, however, that roll-off filters required for this purpose must be inserted within the preamplifier section and *not* within the power amplifier's feedback loop. If this is not done, the kind of instability discussed above will certainly result.

There was one important point that was omitted from the previous article; namely, the higher price of good-quality hi-fi transistor equipment. It is our confident belief that the advantages offered by transistors, as well as the gradual reduction in transistor cost, which will come with increased production quantity and efficiency, will continue to make transistors a potent force in high fidelity, even after their novelty has worn off. ▲

DEFENSE ELECTRONICS CENTER QUALIFICATION TESTS

THE Defense Electronics Supply Center is establishing Qualified Products Lists for fixed, glass-dielectric capacitors under specification MIL-C-23269A (Aug. 22, 1963). Companies which have products meeting the requirements of this specification are urged to contact the Center, Atten: DESC-EQ, 1507 Wilmington Pike, Dayton, Ohio 45420, for an opportunity to have their products tested and approved for the Lists. ▲

Automatic Testing

(*Continued from page 28*)

board's circuits thoroughly. Designers produced a jig in which some 100 sharp, precisely placed, spring-loaded test probes make contact with all necessary points in the circuit when the circuit board and jig are pressed together.

Automatic test procedures save money because they do more work more accurately in less time. And since the machines are usually simple to operate, manufacturers can frequently use less highly trained employees for routine testing. In many procedures, an operator simply loads circuit boards or other parts to be tested into a hopper, then removes the passed and rejected units from their respective bins. *Hughes Aircraft*, for example, has developed a machine called "D-PAT" (*D*rum *P*rogrammed *A*utomatic *T*ester) which does everything but make the repairs. A magnetic memory disc, whirling at 2300 rpm, runs the tester through a pre-programmed sequence, and equipment measurements are compared with standards stored on the drum. When a reading beyond the accepted deviation comes up, "D-PAT" shuts down, reaches into a stored library of 35-mm. slides, and projects the proper one on a translucent screen. The picture seen by the operator shows the defective part with a red arrow pointing to the precise trouble area.

When a company is set up for a mass production run, it frequently builds an automatic testing machine designed specifically to check out the single type of equipment to be produced. But in the case of much military or space gear, only a few units are produced, and the cost of a special machine would be prohibitive. Yet the complexity of the machine and the need for ultimate reliability demand automatic testing.

A number of versatile devices have been built to meet this need. *RCA*'s "DEE," for example, is being built on the "erector set" principle. ("DEE" stands for *D*igital *E*valuation *E*quipment: it is considered poor form in the automatic testing industry to build a piece of equipment without figuring out an acronym for it.) The user puts together any combination of some 108 different basic modules to come up with the testing capability he needs. When the job is over, the equipment can be arranged in different order for the next job.

Checking Components

Automatic testing machines are doing their most vital jobs in checking out complex systems and complicated subassemblies where human testing is costly, inefficient, or impossible. But today, robot testers are even being put to work checking individual components as they come off the industrial production lines. Traditionally, parts such as resistors were frequently sampled, rather than individually tested. Now automatic units can check every unit off the line, helping manufacturers increase reliability and save money at the same time.

Diodes taped into a ladder feed through an automatic tester built by *Contronics, Inc.* of Boston, for example, and are checked, in a fraction of a second, for saturation, reverse leakage, recovery time, and other parameters. When a unit fails any part of the test, an automatically actuated pair of knives cuts the sub-standard unit from the tape and a blast of air blows it into a reject bin. Good units—still taped together—are reeled in on a take-up spool. The machine checks its own calibration against self-contained mercury cells between each diode test. Any variation shuts down the machine.

Automatic production tests not only reject sub-standard units, they also help manufacturers keep quality high. A new vacuum-tube tester now used by *Sylvania*, for example, records data from each tube it tests. If values begin to change over a period of time—if transconductance creeps slightly lower or grid leakage higher—engineers check the production equipment, see what is causing the problem, and correct it before it gets bad enough to cause rejects.

One kind of automatic testing is even available to service technicians in the form of punch-card-controlled tube checkers. Instead of setting the various knobs to supply the proper voltages and load for the tube test, the operator simply slips a card corresponding to the tube type under test into the machine. Contact fingers close through the card's holes and automatically set up the proper test conditions.

More Sophisticated Devices

Although automatic electronic testing has reached a high degree of refinement, engineers are now looking to even more sophisticated devices. Current equipment, for example, is usually a compromise. A tester can be built to monitor a relatively few points in a piece of equipment and point out sections in which failures occur. Such devices are relatively simple to build and incorporate into operating units. But the precise component which has failed must be located by conventional techniques. In other cases, highly complex checking procedures are devised which can pinpoint the exact component which has failed. But this requires an extremely complicated network of testing cables and an involved, expensive test device which has an elaborate testing routine. Some large, complex systems require as many as 12,000 connections between the

operating unit and the checking device that is used.

In the future, engineers hope to get the advantages of both simple test procedures and complex diagnosis by using more advanced programming for the testing computer. With sufficiently sophisticated techniques, a computer might be able to sample a relatively few points in equipment, then perform a complex analysis of the combination of conditions it found. It might pinpoint the precise bad component by deduction, rather than by elaborate checking of thousands of different points.

Future systems may also be able to predict the remaining useful life of any piece of equipment by analyzing its operations and calculating probable costs of maintenance over a long period of time as opposed to the replacement costs.

The most all-encompassing systems, though, will probably come in space. There, automatic testers which can not only detect trouble, but make elaborate repairs as well, will help to keep future unmanned equipment operating continuously and reliably for a good many years in outer space. ▲

TUBES CLUE TO AIR CRASHES

By PATRICK HALLIDAY

ALL over the world, whenever an aircraft crashes, painstaking investigations by skilled teams have to be carried out to pinpoint the exact cause of the accident. Once the fault – whether of equipment or crew – has been traced, steps can be taken to prevent further accidents arising from the same or similar cause.

One of the most valuable sources of clues is the radio, navigational, and other electronic equipment. The investigators seek to discover whether all such equipment was functioning correctly at the moment of impact.

For many years, accident reports have usually included such details as the frequencies and channels to which the equipment was tuned—this can often be determined even where the units are badly smashed up. Accidents have been traced to bearings being taken on the wrong radio beacon stations and similar unfortunate mistakes—rare as these mistakes are.

But even the most careful examination of the tangled remains of electronic equipment may fail to provide the answer to one most important question. Was it working immediately before the crash? It would be of tremendous value if the investigators could be sure that no electronic failure had helped to cause the crash.

Recently, scientists at the British Royal Aircraft Establishment – a large government research center – have evolved a new technique which allows investigators to state with some certainty that at least the heaters of the tubes in the equipment were powered right up to the moment of impact.

The remains of the heaters or filaments of tubes whose envelopes have been smashed are carefully examined for signs of oxidation.

A heater which is hot at the instant when the tube envelope is broken shows clear traces of oxidation. Conversely, if the heater was cold at the time when air reached it, there will be no such oxidation, and it can be deduced that the equipment was not working at the time of impact.

Similarly the tungsten filaments of miniature indicator lamps have been found to show clear signs of stretching if the glass bulb breaks when the lamp is lit, but not when the lamp is off. Indications of such filament distortion persist even after severe fire damage.

Further evidence of the functioning or non-functioning of the equipment at the time of the crash is often supplied where the tube grid supports are made of copper. Discoloration of the copper will indicate that both high and low voltage was still connected when the tube envelope broke.

Other useful clues can be garnered from careful examination of meter needles and other indicators which often continue to show the reading at the moment of the crash, even when the instrument is badly damaged.

Now scientists at the Royal Aircraft Establishment are seeking ways of determining the status of transistor and semiconductor circuits on impact. So far this problem has not been solved but if no solution is forthcoming special filaments in glass envelopes may be incorporated in fully transistorized equipment for the sole purpose of providing the sought-after clues.

Another more elaborate technique which has been recommended for passenger-carrying aircraft is the installation of magnetic-tape instrument recorders which could be salvaged and would contain a record of the important instrument readings throughout the flight.

The findings of the electronics detectives are thus added to the reports of those seeking traces of mechanical failures. Such work is contributing to increased safety in the air. ▲

New CB Circuits

(*Continued from page 33*)

connected to the "B+" by tone-selector switch S1. The moving reed acts like a variable capacitor (with the fixed contact) to set up small voltage fluctuations at the tone frequency along the applied "B+" leg. This energy is coupled through capacitor C5, terminals 12 and 11 of the "Call Switch," and to the grid of amplifier *V9A*. Since the signal through the tube is returned to the relay coil, a positive feedback path is established and the tone signal is sustained. Note that tone is picked up by terminal 3 on the "Call Switch" and sent to the audio section for modulation.

(c) Regency Double-Sideband

Transmitters utilizing a form of double-sideband are introduced to the CB field in *Regency's*[3] "Range Gain" transceivers. The design objective is to take a portion of r.f. power normally wasted

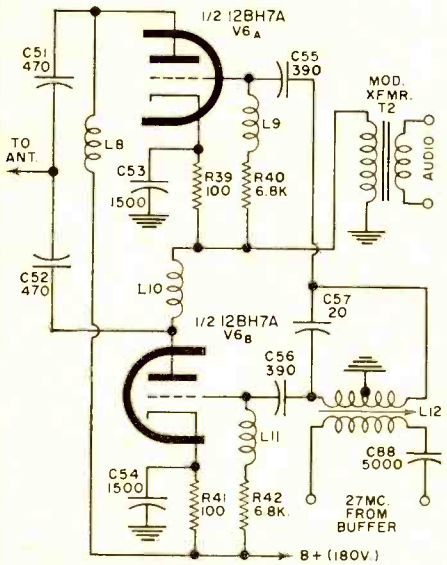


Fig. 3. Unusual final used in Regency rig.

in the carrier signal and inject it into the sidebands—the actual bearers of intelligence. With the technique employed by *Regency*, the result is an approximate doubling of "talk power." This power increase, however, remains within existing FCC regulations. And the system is compatible, that is, any CB receiver may reproduce the signal without adapters or modifications.

The chief difference between the "Range Gain" transceiver and sets of conventional design is in the final r.f. amplifier. In place of the usual single-ended stage, there are two tubes, shown in the schematic as the two halves of *V6* (a 12BH7A). It's helpful in tracing the circuit to first observe its operation as a basic double-sideband generator.

The desired channel signal, on 27 mc., is introduced to the final r.f. stage through buffer coil *L12*. Notice that the secondary winding of the coil is center-tapped to ground. This applies r.f. energy in *push-pull* to the final grids. If normal amplification were to occur through the tubes, output r.f. would be nearly zero. This is due to the *parallel* connection of the tube plates. The circuit operating in this mode may be considered a balanced modulator; steady r.f. input is purposely cancelled in the output. But the balanced condition changes with the introduction of audio from the modulator—applied by transformer *T2* to the cathode of *V6A* and the plate of *V6B*. The net result is an unbalancing of the tubes at an audio rate. Let's assume that audio from *T2* is instantaneously positive-going. Since it causes the cathode of *V6A* to go positive, that tube's amplification drops. Stated another way, the tube grid is made relatively more negative. An opposite condition occurs in the lower tube, *V6B*. Positive voltage from the modulator increases its amplification and r.f. current flows. Each of these events will reverse as audio swings negative.

What has been described is a standard means for obtaining double-sideband output. The audio signal may be considered a switching medium to vary r.f. amplitude in step with the voice. During steady carrier conditions, *i.e.*, no modulation, no r.f. output results. The lack of a carrier in no way hinders the transmission of sidebands, but it does present a problem at the receiver of a standard CB set. During the detection process, a source of steady r.f. is needed to mix with the sidebands and produce audio (the reverse of what occurs in the transmitter). This introduces the circuit technique used by *Regency* to inject sufficient steady carrier into the transmitted signal for driving receiver detectors.

If the "B+" supply is traced from its starting point at the lower right of the schematic, it will be seen that the circuit is not perfectly symmetrical. Note that the positive d.c. potential is applied to the *cathode* of *V6B* and the *plate* of *V6A*. Thus, the top tube, *V6A*, will always conduct some steady r.f. power; there is a consistent unbalance between output tubes. The lower section, on the other hand, only conducts during positive modulation peaks (which may reach several hundred volts). The amount of unbalance, or "offset," determines how much carrier appears in the output. In this case, *Regency* elected to keep the carrier approximately 6 db down, a value adequate to drive a receiver detector. The offset relationship persists during modulation and the suppressed level of the carrier is preserved. ▲

REFERENCES

1. Hallicrafters, 5th & Kostner Aves., Chicago 24, Ill.
2. Heath Company, Benton Harbor, Mich.
3. Regency Electronics Inc., 7900 Pendleton Pike, Indianapolis 26, Ind.

POSITIVE-GROUND TRANSISTOR IGNITION SYSTEM

By WILLIAM H. THORNTON
Head, Dept. of Electronics, Technical Institute, Old Dominion College

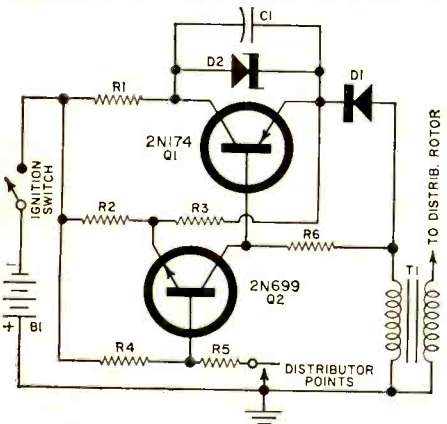
Construction of simple circuit that does not require installation of any special insulated breaker points.

WHILE several circuits have been designed to transistorize the automobile ignition system, most are limited to cars having a negative-ground electrical system. These can be adapted to positive-ground systems only by the installation of insulated distributor points, which are not easy to obtain. The circuit illustrated in Fig. 1 was developed to make possible the transistorization of the positive-ground cars without the need for special insulated points. The circuit makes use of an inexpensive medium-power *n-p-n* silicon transistor to gate or control the high-power *p-n-p* transistor, which serves to switch the current in the primary coil circuit. This reduces the distributor-point current to a small value and makes the point circuit resistive. The waveforms observed are shown in Fig. 2.

Circuit Description

Since the circuit is subjected to two entirely different sets of conditions, depending upon whether the distributor points are open or closed, the operation may be most easily understood by considering these conditions separately.

Fig. 1. Circuit diagram of system described.



R1—.7 ohm, 50 to 100 w. in 12-v. systems (.2 ohm, 25 w. in 6-v. systems)
R2—10 ohm, 5 w. in 12-v. systems (2 ohm, 2 w. in 6-v. systems)
R3—500 ohm, 5 w. in 12-v. systems (50 ohm, 5 w. in 6-v. systems)
R4—3000 ohm, 2 w. res.
R5—200 ohm, 2 w. res.
R6—50 ohm, 2 w. res.
C1—200 pf., 500 v. capacitor
T1—Automobile ignition coil (Mallory F-12T or equiv.)
B1—6- or 12-volt auto battery
D1—10 amp silicon rectifier
D2—60 v., 1 w. zener diode
Q1—2N174 transistor or equiv.
Q2—2N699 transistor or equiv.

Referring to Fig. 1, first assume that the distributor points are closed. The emitter of *Q*2 is returned to the negative terminal of the battery through *R*2, and the base is connected through *R*5 and the distributor points to ground (the positive battery terminal). Since this is a forward-bias condition for the *n-p-n* transistor, there will be a base current of about 30 ma. (which is the only current drawn by the points), and a collector current of about 500 ma. Although this is quite a large current, a saturated condition exists due to the relatively large base current and the collector-to-emitter voltage is low. The power dissipation is well within the 2-watt rated maximum for this particular transistor.

The collector-to-emitter circuit of *Q*2 acts as a low resistance path between the base of *Q*1 and the negative terminal of the battery. This saturates *Q*1 and, under these conditions, this transistor is equivalent to a closed switch that does the work of the distributor points in the conventional ignition system. The primary-coil current, about 9 amperes, will produce the corresponding magnetic field in *T*1. It should be noted that although the collector current of *Q*1 is high, it flows only while the transistor is saturated; therefore, the power dissipation is quite low, much less than the maximum rating for transistor *Q*1 (up to 150 watts, depending upon the method of cooling).

With the distributor points open, *Q*2 is reverse-biased and cut off by the potential across *R*2, thus removing the forward bias from *Q*1. This will now be cut off by the reverse bias supplied by the drop across *D*1. The reverse bias for both transistors is developed by the small current drain through *D*1, *R*3, and *R*2 in series.

Transition Between States

When the points are closed, the forward-biased *Q*1 appears as a closed switch and allows a current to build up in the primary circuit. The rise of this current is exponential and is determined by the 1-mhy. inductance of the primary winding and the total circuit resistance of about 1 ohm. These values result in a time constant of about 1 msec. and will, therefore, allow the current to reach its full value of 9 amperes in approximately 5 msec., or 8 amperes in about 2 msec. This is important since it shows that the ignition coil current of an eight-cylinder engine will reach more than 85% of its maximum value before the points open at a speed of 5000 rpm. (For a 4- or 6-cylinder engine, this figure would be even higher than the 85% value.)

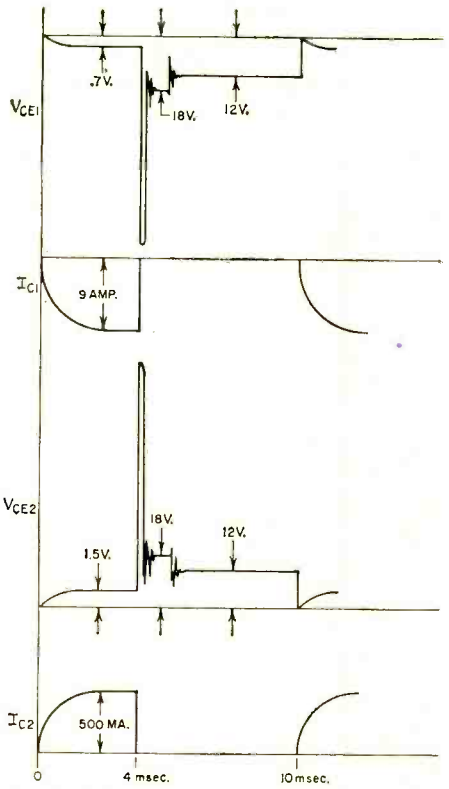
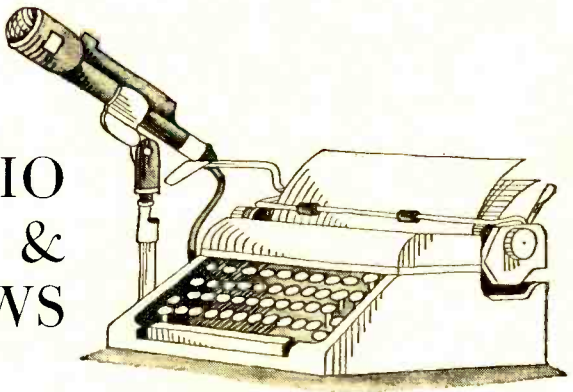


Fig. 2. Collector-to-emitter voltages and collector currents of transistors Q1 and Q2 respectively. Waveforms were obtained with a 4-cylinder engine running at 3000 rpm.

Opening the points will interrupt this current, inducing a high-voltage pulse in the secondary winding which will be fed to the spark plugs. There will also be a relatively high voltage induced in the primary of *T*1, of such a polarity as to maintain the current through the collector circuit of *Q*1. This voltage, if it is allowed to rise too high, may damage the transistor. The zener diode *D*2 and capacitor *C*1 are placed across the collector-to-emitter terminals of *Q*1 to prevent this. The zener diode acts as a relief circuit, conducting when the voltage rises to about 60 volts, and the capacitor is used to effectively absorb any short voltage spikes.

The components in the author's model were mounted on a simple aluminum plate and located in front of the radiator to take advantage of the fan for cooling. However, since the power dissipation is low, it is doubtful if this would be necessary.

The system has been in use for some time and the results have been very satisfactory, producing a smoother running engine and along with somewhat improved gas mileage. ▲



RADIO & TV NEWS

LOOKING at the latest models of TV sets, radios, and hearing aids, there is no doubt that the consumer electronics industry is thinking small. TV sets in particular have come a long way as witnessed by the 5- and 6-inch models that can be found around today. Hearing aids have been reduced to the point where they are all contained within the ear.

Most of the small size comes from the use of semiconductors and printed-circuit boards. However, in the near future there may be an impetus given to smallness in the shape of "spin off" from the nation's space efforts.

Many new and improved electronic components are necessitated by the various complex experiments carried out by satellites, and when coupled with their necessary reliability, may make some drastic changes in consumer electronics.

Size, for example, may be even further reduced. Space people really think small. For example; in 1958 it was possible to package 100,000 items in a cubic foot of space. Today using integrated circuits, it is possible to package 10,000,000 parts per cubic foot of space and with the advent of molecular circuits, this figure could really go much higher.

At the same time, costs are going down. In 1963, the cost of an integrated circuit ran about $1 per element and it has been estimated that in 1973, the cost will have been reduced to about 5¢ per element.

It appears that once output devices, such as speakers and TV picture tubes, tuning and volume control devices, and power sources are made proportionally smaller, then consumer electronic devices will reach their ultimate small size.

Color Sales Boom

The current upsurge in color-TV set sales will continue to gain momentum next year, and in 1965 should surpass the $1-billion annual retail going rate of the black-and-white receiver industry, according to Raymond W. Saxon, President of *RCA Sales Corporation*.

Mr. Saxon also said that the color-TV receiver market will achieve retail sales of over $40-million this year and he also predicted that it will increase to at least $750-million in 1964.

A major crossover point for his company will be reached in 1964 when the retail dollar volume of *RCA*'s color set sales will surpass the combined total of the remainder of their home instrument business including black-and-white TV, radio, stereo phonographs, and tape cartridge recorders.

First Year of Pay TV

"The first year of subscription TV has been encouraging and enlightening," said Thomas F. O'Neil, Chairman of the Board of *General Tire and Rubber Co.*, concerning the country's only pay-TV project now being conducted in the Hartford, Connecticut area by *RKO General Phonovision Co.*

Applications from new subscribers have increased and the system is now serving over 3000 homes in the area. Mr. O'Neil emphasized that the purpose of the Hartford experiment was not to get the greatest number of subscribers, but to maintain a large enough sample for eventual evaluation of pay TV.

On the subject of motion picture programming, Mr. O'Neil expressed gratification with the cooperation given the project by most major film distributors. They have been supplying a substantial number of first subsequent run films, exhibited same day and date as Hartford theaters. The only exceptions have been *Universal* and *20th Century Fox*.

All films are shown unedited and free from commercial interruptions. The cost to subscribers is in the $1 to $1.25 range. In the sports field, the pay-TV system covered 75 live sports events during the first year. These ranged across several sports and the Patterson-Liston fight was watched by 80% of all viewers who paid a price of $3 per home.

In the Hartford experiment, picture and sound are sent out scrambled and a decoding device is needed with home TV sets to clear up both picture and sound when a correct number is dialed on the decoding instrument. Subscribers are billed monthly by a tape that prints a record of every program seen and its price. The tape is mailed to the station along with the fee for the programs viewed. Most programs are in the $1 to $1.50 range and subscribers pay no minimum fee. ▲

Cable TV: On the Move

(*Continued from page* 41)

a continual cause of concern during storm seasons and many homeowners carry insurance on them, which they would just as soon forego. While there will always be those who prefer to get their TV with a high-gain antenna and tower, even if the installation costs as much as $200, many set owners will choose a cable hookup charge of about $20 and a monthly fee of about $4.50. In fact, in an effort to get more customers, or subscribers, for their cable, many CATV operators work out a cooperative arrangement with many TV dealers allowing the latter to offer free cable hookup to buyers of TV sets. The cable company is happy to forego all or part of the installation fee in favor of getting the monthly fee.

Color TV

The coming of color TV has added impetus to the conversion of many areas to cable coverage. Now that color TV sets have broken through the $500 barrier, there is renewed interest in outlying areas in getting TV in full color. Since cable systems assure adequate signal strength for sharp pictures with good contrast, this also means good color reception. Individual high-gain installations on the other hand, cannot always offer good color. Some amount of snow can be tolerated in black-and-white reception, and usually is, in deep fringe areas. It cuts down on picture resolution but may be no worse than looking at a slightly out-of-focus snapshot. On color, however, the situation is far more critical. The snow is vari-colored, and watching a weak picture is like viewing a tickertape parade covered with colored confetti. Not only is there lack of resolution and detail, but the natural colors are completely obliterated. Few viewers who have spent the premium price for color TV sets will resist the cable.

FM Channels

An added source of entertainment for subscribers comes from the FM radio reception brought into TV homes in many cable areas. For this purpose, unused TV channel space is used with special FM tuner-modulator equipment at the head end of the system. The FM is tuned in on the TV receiver or external speaker. Most CATV systems furnish one or two FM music channels, some more.

Besides the TV channels, some CATV systems sell a music service consisting of long-playing tape music systems fed to FM transmitters operating within the conventional FM band. The subscriber then hooks a conventional FM receiver to the cable system to use this service.

More and more cable systems are serving as broadcasters too, for their captive audiences. Some have film facilities for transmitting movies on an unused channel with interspersed commercials for local businesses. Others have complete camera systems for originating live productions. Many of these cameras are of the compact closed-circuit TV design. Partly because of these broadcasting activities of CATV operators, partly because a cable system can be thought of as a common carrier crossing state lines (as when they are picking up broadcasts from stations in one state for viewing in another state), the FCC has been seeking regulatory powers over community antenna systems. A recent court decision upheld the FCC's right to regulate the microwave relay systems used by several large CATV operators to carry signals over very great distances. There is some feeling that the FCC will use this decision to extend its regulatory powers to cover all community antenna operations. Nevertheless, CATV is expanding. Recently, a large system was opened in Wilmington, North Carolina to serve an area with over 65,000 people. Cable vision people say this is only the beginning of the big push to put small cities all over the country on cables for more and better television. ▲

Exclusive with **RCA** ...

AUTOTEXT®

the faster, easier way toward a career in electronics

Amazing home training method makes learning almost automatic

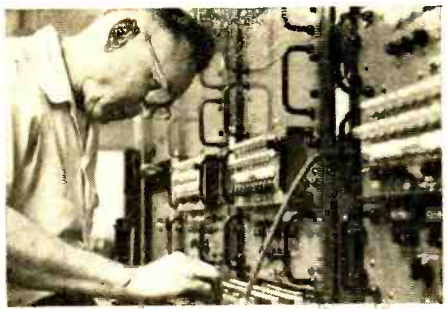
Exclusive with RCA. "AUTOTEXT" the revolutionary home training method introduced by RCA Institutes, Inc., is stirring the interest of thousands. Every day, "AUTOTEXT" is helping people like yourself join the thousands of other successful electronic students who are working toward profitable careers right now! This faster, easier way to learn electronics uses the latest scientific development in the field of home training—and "AUTOTEXT" is exclusive with RCA.

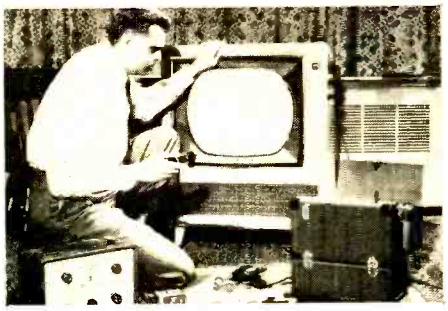
New trend in education. This exciting new trend in education represents a significant advance in teaching electronics. People who have been interested in careers in electronics in the past, but have had difficulty with conventional home training methods, can now begin to master the fundamental principles of electronics almost automatically. Tested in schools throughout the country, checked out and proved with thousands of students, programmed instruction is helping people learn more quickly and with less effort.

Prove it to yourself now! If you have a natural inclination or interest in the exciting field of electronics, that's all you need. RCA "AUTOTEXT" will help you do the rest. And the future is unlimited. Jobs are available for qualified technicians in Space Electronics, Communications, TV, Computer Programming, Automation, and many other electronic fields. The important thing is to get started now!

Complete course available. Right now, RCA Institutes offers you a complete Home Training Course ("Introduction to Electronics") using the "AUTOTEXT" method. You get a complete set of theory lessons, service practice lessons, experiment lessons, and all the kits you need. And most important, "AUTOTEXT" takes most of the effort out of learning the all-important groundwork of the electronics field.

FREE OFFER! We'll send you complete information on amazing new RCA "Autotext" along with a FREE SAMPLE of a lesson to prove to you how easy it is to learn this new way. Send the attached postage-paid card and check "Autotext".





Wide choice of Home Training courses in Electronics:

- Autotext
  Introduction to Electronics
- TV Servicing
- Color TV
- Communications Electronics
- FCC License Preparation
- Mobile Communications
- Automation Electronics
- Electronic Fundamentals
  (also available in Spanish)
- Computer Programming
- Transistors
- Electronic Drafting
- Industrial Electronics
  Automatic Controls
  Industrial Applications
  Nuclear Instrumentation
  Digital Techniques

RCA Institutes Home Training Courses are complete step by step easy-to-understand units. You get prime quality equipment in the kits furnished to you, and all of it is top grade. It's yours to keep and use on the job.

Liberal Tuition Plan. RCA Institutes Home Training Courses are available under a liberal tuition plan that affords you the most economical possible method of home training. You pay for lessons only as you order them. If, for any reason, you should wish to interrupt your training, you can do so and you will not owe a cent until you resume the course. No long-term obligations!

Set Your Own Pace. RCA Institutes Home Training takes into consideration your own ability, finances and time. You learn at your own speed, in the most effective manner, with personalized instruction every step of the way. You get theory, experiment, and service practice beginning with the very first lesson. All lessons are profusely illustrated—a complete training package in every way.

CLASSROOM TRAINING

RCA Institutes Resident Schools in New York City, and RCA Technical Institute in Cherry Hill near Camden, N. J., offer classroom training that will prepare you to work in rewarding research and production positions in many fields of electronics. No previous technical training required for admission. You are eligible even if you haven't completed high school.

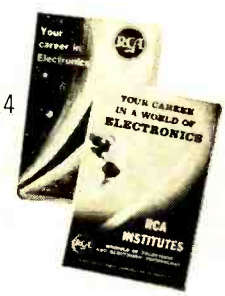
Free Placement Service. RCA Institutes Resident School graduates are now employed in important jobs at military installations, with important companies such as IBM, Bell Telephone Labs, General Electric, RCA, in radio and TV stations and in communications systems all over the country. Many other graduates have opened their own businesses. A recent New York Resident School class had 92% of the graduates who used the FREE Placement Service accepted by leading electronics companies, and had their jobs waiting for them on the day they graduated!

Coeducational Day and Evening Courses are available at Resident Schools. You can prepare for a career in electronics while continuing your normal, full-time or part-time employment. Regular classes start four times a year.

SEND POSTCARD FOR FREE ILLUSTRATED BOOK TODAY! SPECIFY "AUTOTEXT", HOME STUDY OR CLASSROOM TRAINING.

RCA INSTITUTES, INC. Dept. EW-14

A Service of Radio Corporation of America,
350 West 4th St., New York, N.Y. 10014



The Most Trusted Name in Electronics

NEW PRODUCTS

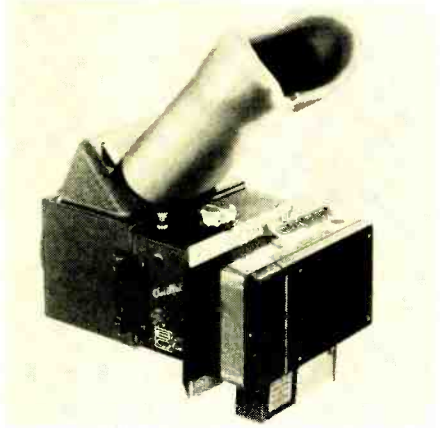
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 15.

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

FILM-PACK SCOPE CAMERAS

1 **Beattie-Coleman, Inc.** is now offering two new oscilloscope cameras that utilize the new **Polaroid** film packs. Designated the "Mark II" and "K-5" Oscillotrons, they feature faster magazine loading and easier developing.

Removal of the exposed film is accomplished without opening the camera back, hard-pulling,



or tearing of the film thus reducing strain on the camera mount. Developing is done outside the camera in 10 seconds.

An adapter which permits use of the new film pack with the company's existing Oscillotrons is also available.

DELUXE TUBE TESTER

2 **Seco Electronics, Inc.** has announced the Model 107B deluxe tube tester which reads all test results on one meter and one scale. This technique eliminates the transposition errors occurring with closely packed multiple scales. The wide meter sweep increases the accuracy of the readings.

Two socket systems are used to test TV, radio, industrial, and foreign tube types. No set-up data is required with the 40 pre-wired sockets accommodating 63 basic arrangements for testing thousands of tube types. The separate plug-in chassis has eight sockets which connect to 14 lever-type pin selectors for testing tubes element by element.

U.H.F. CONVERTERS

3 **Channel Master Corp.** has introduced a new line of u.h.f. converters which will adapt any v.h.f. set to all-channel capability. The "Vu-Con" Model 6700 is designed to provide top power reception of all 70 u.h.f. channels in fringe areas. It also prevents picture overloading where strong signals are present.

The Model 6701 is a moderately priced unit specified for use in weak signal areas while the Model 6702 is designed specifically for metropolitan and strong-signal areas. Two additional units, Models 6703 and 6704, are converters designed to cover only translator channels 70-83.

LIGHTWEIGHT BLOWER

4 **Rotron Manufacturing Company, Inc.** has recently introduced a new lightweight blower especially designed for spot cooling in radio transmitters, power supplies, instrumentation, TV, tape recorders, and similar units.

Known as the "Nugget Blower," Model CA-2, the new unit delivers 15 cubic-feet/minute by means of a new aerodynamic "Centraxial" wheel made of plastic. The unit measures 3-19/32" x 4-1/32" x 2-1/4" and weighs only 0.6 pound. It is designed to operate from 117 volts a.c., 50-60 cps, single-phase and consumes 7 watts at 3200 rpm. A 230-volt a.c. unit is also available.

"EXPERIMENTER" CONTROLS

5 **General Electric Company** is now marketing a new "Experimenter Line" of 15 different types of electronic control devices.

With each of the individually packaged devices comes schematic diagrams for building suggested electronic gadgets ranging from burglar alarms to slave photoflash circuits. Where necessary, hardware items are included in the package.

TELEVISION ANALYST

6 **B&K Manufacturing Company** has added the compact Model 1074 to its line of Analysts for black-and-white and color TV applications.

It provides a complete TV signal-generating source providing a visual check on the screen to signal-trace and troubleshoot any stage throughout the video, audio, r.f., i.f., sync, and sweep sections.

The instrument provides dot pattern, crosshatch, vertical lines, horizontal lines, burst signal, and individual colors one at a time on the TV set. Color phase angles are maintained in accordance with NTSC specificatioos.

LOW-VOLTAGE IGNITION SYSTEM

7 **Breeze Corporations, Inc.** has announced the development of a low-voltage transistorized ignition system for automobiles, trucks, tractors, and boat engines. Prior to this development transistorized ignition at high voltage—20,000 volts—has beco used in racing and sports cars. The new unit, employing special semicooductor sparkplugs, operates at 700 to 1000 volts.

The system will be offered to both OEM and replacement markets.

SOLDERING PISTOL

8 **Anaconda Wire and Cable Company,** which developed a new ultra-high-temperature magnet wire for space applications, has announced its first commercial application in a new soldering pistol which is smaller, lighter, and more efficient than conventional soldering guns.

The new magnet wire is an integral part of the new soldering pistol being marketed by **Wen Products, Inc.** The 1200F magnet wire gives the pistol a 30-watt running input which results in 100-watt heat volume.

SOLID-STATE COUNTERS

9 **Hewlett-Packard Company** has available two new electronic counters capable of counting rates of up to 20 mc. and 50 mc.

Both counters measure frequency, period, multiple period average, ratio, and multiples of

ratio. The Model 5242L has a maximum counting rate of 20 mc. while the Model 5244L will count to 50 mc. Readout is an in-line display of 7 rectangular digital display tubes, with positioned decimal and illuminated "units of measure."

The internal quartz-crystal time base has a drift of less than ± 2 parts in 10^7 per month. Both counters have readout storage for a continuous display of the most recent measurement.

DELAY-LINE KITS

10 **Bel Fuse Inc.** is now offering delay-line laboratory kits in the nanosecond range. Each kit includes a variable delay line and provides complete delay time flexibility within the specified range. The units included in these kits have excellent environment, rise time, bandpass, and transmission fidelity characteristics. They are suitable for printed-circuit or chassis mounting.

Kit-1000 offers continuous delays in increments of less than 1 nanosecond from 0-1000 nsec. Kit-2500 offers continuous delay in increments of less than 1 nanosecond from 0-2500 nsec.

TRANSISTOR IGNITION SYSTEM

11 **Gavin Instruments, Inc.** has introduced a new low-cost transistor ignition system featuring a twin-transistor and twin-diode circuit. The system is compatible with all 6- and 12-volt negative-ground engines in cars, boats, or trucks.

The Model A-4 comes complete with **Delco** heat sink and molded ceramic ballast resistor. It can be installed in a few minutes as it requires no replacement of the original induction coil.

COLOR CAMERA TUBE

12 **North American Philips Company** has developed a new television camera tube called the "Plumbicon" which is said to produce unusually uniform color pictures free from dark "halos," color shadows, and blurring.

A feature of the new tube is low dark current by which a very uniform picture is obtained. Its low noise level is especially advantageous for video tape recordings while its linear light trans-

fer characteristic is of importance for use in a color camera. The spectral response curve of the new tube is said to coincide more closely with human vision than other tubes currently in use.

POCKET PYROMETER

13 **Electronic Development Laboratories** has designed a pocket-sized pyrometer, which measures 4" x 4½" x 2", to be used in the plant or in the field.

Known as "Pocket-Probe," the unit features a large scale, automatic temperature compensation.

red pointer, fast-acting thermocouple, two-foot cable from pyrometer to probe, replaceable thermocouples, and brazed or welded connections.

The instrument is available in any temperature range with a surface probe, needle probe, or roller-contact unit. Standard accuracy is 2%, with 1% accuracy available as required.

REGULATED SUPPLY

14 **Kepco, Inc.** is marketing an automatic voltage-current crossover regulated power supply as the Model CK 2-8M. Designed especially for tunnel diode and thermoelectric cooling units and other devices having similar power requirements, the unit features dual bridge regulation (one for voltage and one for current), 10-turn potentiometers for both voltage and current, automatic crossover with automatic voltage-current crossover indication, and signalling.

Remote programming and error sensing connections are also provided on a rear terminal strip. Other specifications include: 0 to 2 volts and 0 to 8 amperes continuously adjustable, no voltage overshoot, and 500-volt isolation.

SOLID-STATE V.O.M.

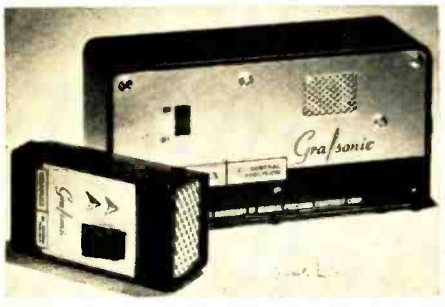
15 **Keinath Instrument Company** has recently introduced the "K-Mag 600," a shock-proof and burn-out-proof instrument for production line and laboratory testing. Measurement functions include a.c.-d.c. volts, a.c.-d.c. amps, and ohms. Accuracy is guaranteed to ±1% on all d.c. functions and ±2% on all a.c. functions.

All circuitry in the instrument is solid-state and there are no reeds, choppers, or vacuum tubes. Readout is on a multi-scale taut-band meter with mirror scale plate and 100 graduations.

REMOTE PROJECTOR CONTROL

16 **Graflex, Inc.** has developed a cordless remote control for use with slide and filmstrip projectors at distances up to 40 feet. Known as the "Grafsonic," the unit consists of two parts: the transmitter which is a cordless, matchbox size push-button device and the receiver control unit which attaches to the projector.

The remote-control unit is designed to oper-



ate with most of the popular projectors on the market today.

"INSTANT" LABELS

17 **Duramatic Company** is now offering a new hand embossing tool for "on-the-spot" production of identification labels for all types of electronic and radio equipment.

Called the "Duratyper," the tool produces raised letters on adhesive-backed labels. Each letter or number is simply and quickly dialed and a lever pressed to permanently emboss a highly visible character on contrasting colored plastic tape.

HIGH-VOLTAGE SR ASSEMBLIES

18 **Syntron Company** has announced a new line of high-voltage silicon rectifier assemblies designated the MB Series.

These assemblies offer a direct replacement for mercury vapor tube rectifiers with the superior characteristics of silicon, including the voltage transient protection provided by the company's avalanche diode.

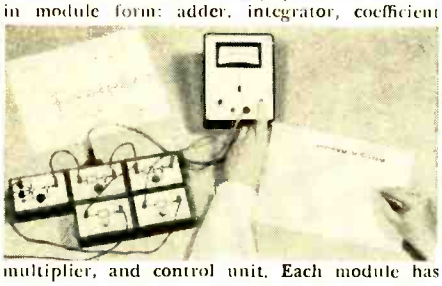
With peak reverse voltage ratings as high as 15,000 volts and average d.c. output current ratings up to 1.75 ampere, the new series will replace the following tube types: 872A, 8008, and 575A.

Housed in an epoxy sealed, phenolic tube, the new series provides long life, no warm-up time, minimum heat generation, and rugged construction.

PERSONAL ANALOG COMPUTER

19 **Pastoriza Electronics, Inc.** has developed a compact Personal Analog Computer (PAC) as a training aid for college instructors to use as a means of showing their beginning mathematics and dynamics students the physical response of systems.

Transistorized and battery powered, PAC is in module form: adder, integrator, coefficient



multiplier, and control unit. Each module has a graphic panel face which indicates its mathematical operation. Panels are white and take crayon easily for marking purposes.

The units are physically and electrically connected by four gold-plated connectors which carry power and control signals.

The manufacturer issues a monthly newsletter "The Dynamic Analyzer" to keep owners of the equipment up to date on new ideas, progress, and the results obtained by other users.

PHOTOCHOPPER KIT

20 **Instruments and Communications, Inc.** is marketing a photochopper in kit form for experimental prototype or educational applications.

The kit includes all parts and instructions for easy, accurate assembly. It provides a selected pair of photoresistors, a neon lamp, electrostatic shielding, a specially constructed metal mounting block, low thermal solder, and mounting hardware.

The illustrated instruction manual shows how the kits may be assembled and used singly or in pairs for series, shunt, series-shunt, or floating modulators and demodulators.

HI-FI — AUDIO PRODUCTS

TIE-CLASP MICROPHONE

21 **Craig-Panorama** has available a miniature magnetic-type microphone which, although designed for use with the firm's miniature tape recorders, will fit any standard tape recorder.

The Model MM-1 "Tie-Mike" measures ¾" long x ½" wide x ¼" high. It is soldered to a 1½" long spring-clip tie-tack for concealed recording.

TV AND MUSIC OUTLET SYSTEM

22 **Winegard Company** has just announced a new home entertainment outlet system, known as the Audio-Pix, for TV, FM, and hi-fi.

The special coupler serves as a TV or FM antenna distribution system and at the same time permits piped in hi-fi system sound.

One wire is used to carry TV, FM, and hi-fi to the outlets. Kit includes a special coupler, an attachment for the FM or hi-fi, a portable extension speaker, four plug-in outlets, and 100 feet of twin lead. A transistorized version for weak signal areas is also available.

NOISELESS WIRELESS INTERCOM

23 **Vocaline Company of America, Inc.** has just announced a noiseless, wireless intercom that completely eliminates buzz and noise on power lines caused by electrical appliances and fluorescent lights.

Model CC-100 has excellent sensitivity, and employs a patented squelch circuit. Each unit is controlled independently and can be plugged in to any a.c. electrical outlet. No ground wires nor connecting leads are required. A special "talk lock" position enables the user to station the units as "ears," serving the purpose of a baby sitter, receptionist, or other room requiring surveillance.

TELEPHONE AMPLIFIER

24 **Gilwin Corporation** is now marketing a new telephone amplifier which enables the user to speak or listen from anywhere in the room with both hands free.

Slightly larger than a pack of cigarettes, the unit has no wires, no plug-ins, and is fully transistorized and automatic. When not in use, it can be stored in a drawer or carried in a pocket.

100-WATT STEREO AMP

25 **Allied Radio Corporation** has added the "Knight" KN-999 100-watt stereo amplifier to its line of assembled hi-fi products.

This all-transistor unit provides 50 watts per channel, or 35 watts per channel continuous sine wave. Frequency response is 20-25,000 cps ± ½

db; harmonic distortion is 1% at full rated output. There are 13 front-panel controls and 2 rear-panel controls.

The unit measures 4½" x 13⅜" x 12¾". A metal case or walnut wood cabinet are available to house the new amplifier.

FM-STEREO BOOSTER

26 **Blonder-Tongue Laboratories, Inc.** has recently introduced a new indoor FM booster which is said to provide an eightfold increase in

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION. (ACT OF OCTOBER 23, 1962; SECTION 4369, TITLE 39, UNITED STATES CODE.)

1. Date of filing: Oct. 1, 1963. 2. Title of publication: Electronics World. 3. Frequency of issue: monthly. 4. Location of known office of publication: 1 Park Avenue, New York, New York 10016. 5. Location of the headquarters or general business offices of the publishers: 1 Park Avenue, New York, New York 10016.

6. Names and addresses of publisher, editor, and managing editor: Publisher, Ziff-Davis Publishing Company, 1 Park Avenue, New York, N.Y. 10016; Editor, William A. Stocklin, 1 Park Avenue, New York, New York 10016; Managing editor: —

7. Owner: Ziff-Davis Publishing Co., Estate of William B. Ziff, A. M. Ziff, 1 Park Avenue, New York, N.Y. 10016.

8. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: None.

9. Paragraphs 7 and 8 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. Names and addresses of individuals who are stockholders of a corporation which itself is a stockholder or holder of bonds, mortgages or other securities of the publishing corporation have been included in paragraphs 7 and 8 when the interests of such individuals are equivalent to 1 percent or more of the total amount of the stock or securities of the publishing corporation.

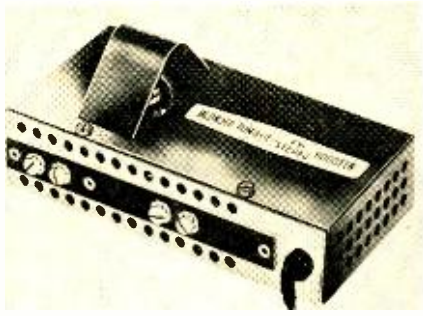
10. Average No. copies each issue during preceding 12 months — A. Total No. copies printed: 259,475; B. Paid circulation: 1. To term subscribers by mail, carrier delivery or by other means: 138,093; 2. Sales through agents, news dealers, or otherwise: 61,278; C. Free distribution (including samples) by mail, carrier delivery, or by other means: 4,287; D. Total No. of copies distributed: 203,658. Single issue nearest to filing date— A. Total No. copies printed: 251,907; B. Paid circulation: 1. To term subscribers by mail, carrier delivery or by other means: 135,000; 2. Sales through agents, news dealers, or otherwise: 59,790; C. Free distribution (including samples) by mail, carrier delivery, or by other means: 4,338; D. Total No. copies distributed: 199,128.

I certify that the statements made by me above are correct and complete.

M. T. BIRMINGHAM, JR., business manager

signal strength. Called "Stereobooster," the new Model FMB has a power gain of 18 db.

The unit is said to be especially effective with older tuners that do not have sensitive front



ends. It can be easily installed near the receiver by means of its patented stripless screws.

FM-STEREO TUNER/AMP

27 **Bell Sound Division** has just introduced a deluxe, transistor FM-stereo tuner/amplifier unit as the first in a new line of transistorized hi-fi equipment.

The "Imperial 1000" is an 80-watt unit which has a frequency response of 9-85,000 cps. IM distortion is less than 0.7% and harmonic distortion less than 0.25%. Tuner sensitivity is 0.48 μv. @ 75 ohms.

The new tuner features a fully silver-plated chassis, four-gang tuner, special harmonic-cancelling balanced-detector design, special limiters,

and the use of four nuvistors in the r.f. section.

The "Imperial 1000" is of modular design permitting the user to purchase the amplifier portion initially and add the tuner section at a later date if desired.

MONO FM RECEIVER

28 **Eico Electronic Instrument Co. Inc.** has added the Model 2715 18-watt FM receiver to its "Classic Series" of audio equipment.

The amplifier section provides 18 watts IHF music power and 14 watts continuous; IM distortion is 2% at 14 watts; frequency response is 15-40,000 cps ± 1 db; and inputs for phono (ceramic) and tape. The receiver uses 10 tubes and measures 5⅝" x 15⅞" x 11⅜". It is available only in wired form.

RECEIVER/PAGING SYSTEM

29 **Harman-Kardon, Inc.'s** Commercial Sound Division has introduced a combination background-music receiver and paging system for business and home use.

The Model FA-10C incorporates a high-fidelity FM tuner and 10-watt amplifier with provision for microphone and any type phonograph and

tape recorder. A "Music-Mic" mode switch is included to permit the interruption of music in order to make announcements.

The audio-control amplifier offers a complete choice of music inputs: crystal or ceramic phonograph, tape recorder, magnetic phonograph cartridge, tape playback head, and built-in FM tuner. Frequency response is 20-40,000 cps ± 1 db. Certified output power is 10 watts minimum at 1000 cps with only 1% total harmonic distortion.

Both 25- and 70.7-volt outputs are available in addition to speaker voice-coil impedances.

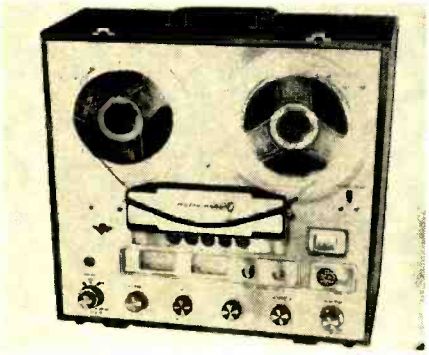
MICROPHONE/STAND

30 **Sonotone Corporation** is now offering the "Ceramike-Pak," a combination package which contains either the company's Model "CM-10A" or "CM-11A" microphones with matching table stands.

Both of the microphones can be used for tape recording, with home movie equipment, p.a. systems, for conference pickups, or in audio-visual labs.

STEREO TAPE RECORDER

31 **Viking of Minneapolis** is in production on the "Retro-Matic 220," a two-speed, quarter-track stereo tape recorder that features two-directional playback. The capstan is placed between two playback heads so that the tape is pulled over the head in both forward or reverse playback. Automatic-reverse playback is controlled by a timed, silence-sensing device which detects the end of a program, reverses the reel motion, and switches playback heads. The silence-sensing threshold is adjustable. The automatic-reverse features can also be switched to push-button-controlled playback.



The integrated stereo amplifier delivers 6 watts per channel and provides 20-25,000 cps frequency response for record-playback at 7.5 ips.

MONO RECORDER

32 **Superscope Inc.** has added the **Sony** Model 102, a lightweight, compact two-track mono recorder to its line of tape machines being distributed in the U.S.

The Model 102 features tape speeds of 7.5 and 3.75 ips and handles a full 7" reel. Frequency response is 50-12,000 cps @ 7.5 ips.

The unit includes mike and line mixing, vu meter for recording-level indication, pause control with lock position, automatic tape lifters, and built-in power amplifier/speaker. The record button may be locked in the "on" position for using the recorder as a p.a. system or for presetting record level.

HOME INTERCOM SYSTEM

33 **Bogen Communications Division** is marketing a new deluxe home intercom system which has been named "Communo-Phone."

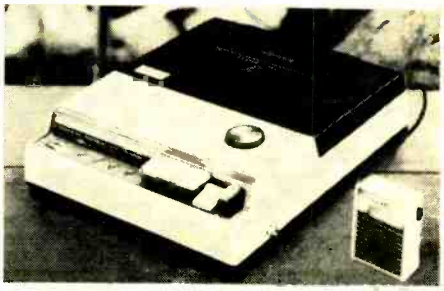
This transistorized system provides fingertip controls to answer the doorbell, monitor the children's playroom, and talk between rooms, terrace, and garage. The unit can also distribute music throughout the house and voice calls will automatically override the background music.

The system is made up of the Model HCM-9 control station, Model HCA-1 amplifier, Model HCR-1 remote station, and Model HCR-2 remote station. Any combination of control stations and remotes up to a total of nine may be used with only a single amplifier required.

TRANSISTORIZED TAPE RECORDER

34 **Channel Master Corp.** has introduced a six-transistor portable tape recorder as the Model 6545.

Featuring simple push-button operation, the recorder operates on six "C" cells and plays tape



at two speeds (1⅞ and 3¾ ips) on its 3¼" reel. The unit has a capstan drive mechanism for stabilized speed.

The recorder comes complete with leather carrying case, remote-control push-button, private earphone, recording cable, telephone pickup cord, dynamic microphone, and special footage indicator. Optional extras include an a.c. adapter, footswitch, and tie-clip microphone.

TRANSISTOR STEREO AMP

35 **Lafayette Radio Electronics Corporation** is currently introducing the Model LA-200, a 44-watt transistorized stereo amplifier.

The LA-200 is a complete stereo preamp and dual-channel amplifier on a single chassis. The circuit is transformerless for low distortion and good transient response. A fast-acting relay protects the output transistors from overloads or shorts in the speaker line.

IHF music power rating is 44 watts, 22 watts per channel; frequency response is 20-20,000 cps ± 1 db; harmonic distortion is 1%; and hum and noise —74 db tuner, —54 db magnetic phono. There are five pairs of inputs.

The amplifier is housed in a brown textured metal case with gold finished aluminum panel and knobs. It measures 13" x 4-3/16" x 9".

CB-HAM-COMMUNICATIONS

AIRCRAFT MONITOR

36 **Regency Electronics** has added a new aircraft monitor receiver to its "Monitoradio" line of equipment.

The new unit covers v.h.f. navigation and communications frequencies assigned to private aircraft with over-all frequency coverage of 108-132 mc. The superheterodyne circuit is temperature compensated. Sensitivity is 2 μv. and audio output is .8 watt. A 4" speaker provides adequate output for monitoring purposes. The monitor has a built-in antenna but provision is made for an external antenna if required.

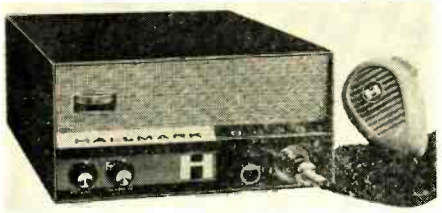
Power consumption is 30 watts at 117 volts a.c.

TWO-WAY RADIO UNIT

37 **Hallmark Instruments** has entered the industrial two-way radio field with its Model

3000, a unit with a plate input power of 30 watts, a range of up to 50 miles, and operation in the 25-50 mc. band.

FCC type-approved for industrial service, the new unit can be used by anyone engaged in business, including farmers and ranchers. The circuit features an improved noise limiter and



squelch for quiet standby operation and speech limiting for maximum transmit modulation.

The unit is being offered in 117-volt a.c. and 12-volt d.c. models for mobile operation.

HAND-HELD TRANSCEIVER

38 **Channel Master Corporation** is now marketing a 10-transistor, 100-mw. hand-held transceiver which operates in the Citizens Band but requires no license.

The Model 6552 has a range of up to 5 miles under very favorable conditions and features a 10-section telescoping antenna which extends to 50 inches. The units, sold by the pair, are housed in modern-designed cabinets and have leather carrying cases for easy portability.

90-WATT RADIOTELEPHONE

39 **Simpson Electronics, Inc.** has introduced the Model 90, a 90-watt radiotelephone which features eight channels plus the broadcast band and is capable of covering a range of more than 75 miles.

The circuit includes adjustable squelch for quiet standby operation and a noise limiter to reduce atmospheric and ignition noises. The unit is housed in a sturdy aluminum cabinet that is "Chromicoated" for added protection. It features a front-panel speaker and simplified finger-tip controls for error-free operation.

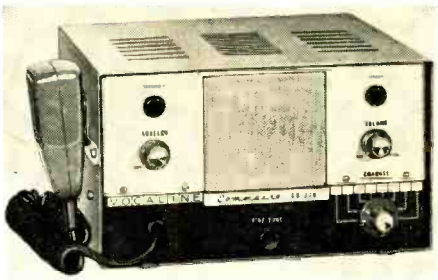
CB TRANSCEIVER

40 **Vocaline Company of America, Inc.** has announced the availability of the "Commaire ED-278," a CB transceiver which transmits and receives on eight bands and can operate on the 10-meter amateur band as well.

The transmitter, which will modulate 100% under all conditions, features a red panel lamp which indicates transmit operation when the microphone button is depressed. The microphone provided with the unit is a new design which helps remove extraneous background noises.

The receiver is a dual-conversion superhet with sensitivity better than 0.1 μv. for 10 db signal-to-noise ratio.

Output is 3.2 watts, 100% modulation capa-



bility. The unit is housed in a two-tone grey metal cabinet which measures 10" x 9½" x 5½".

NEW "HANDIE-TALKIES"

41 **Motorola Overseas Corporation** has introduced a new line of fully transistorized portable two-way radios, the PT series of "Handie-Talkie" FM units.

Designed for use by personnel on foot to coordinate emergency and routine activities, the radios can be used to establish contact with other portable units, mobile radios, and base stations.

The new radio line includes 5- and 1.4-watt models operating on v.h.f. low-band frequencies in the 25- to 54-mc. range, and 3- and 1.4-watt units for use on v.h.f. high-band channels in the 144 to 174-mc. band.

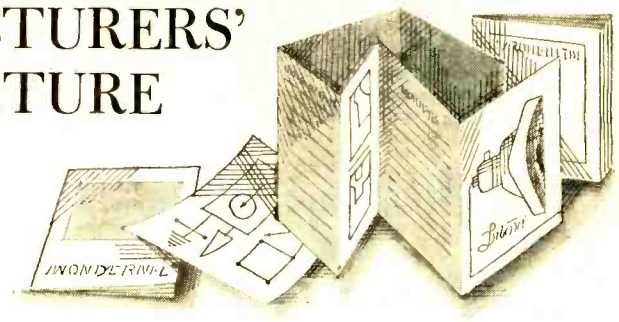
These newly designed models are equipped with standard hand-operated microphones and built-in speakers yet weigh only 6 pounds. Power is supplied by a battery pack of 11 industrial-type "D" cells. The radios can also be powered by a single rechargeable nickel-cadmium battery.

CB WALKIE-TALKIE

42 **Lafayette Radio Electronics Corporation** is now offering a completely wired, three-transistor "walkie-talkie," the Model HA-70.

This hand-held unit measures 5" x 2½" x 1½" and comes complete with 9-volt battery and plastic carrying case. The circuit is superregenerative with crystal control built-in on transmit. Effective range is up to ¼ mile and no license is required for operation. ▲

MANUFACTURERS' LITERATURE



SPACERS & STAND-OFFS

48 **Amatom Electronic Hardware Co., Inc.** has issued a 72-page reference manual covering an extensive line of spacers and stand-offs. The complete line is covered in a series of detailed dimensional drawings and tables. The manual also includes charts of tolerances, specifications, and instructions for ordering variations and specials as well as standard products.

BETTER TV RECEPTION HINTS

49 **Jerrold Electronics Corporation's** Distributor Division has issued an 8-page booklet "TV-FM Reception Aids for the Home" which describes the company's line of mast-mounted TV preamplifiers, u.h.f. converters, amplified TV couplers, splitters, extenders, multi-set couplers, mixing networks, filters, traps, matching transformers, isolation networks, TV-FM broadband amplifier, and an indoor antenna.

TV TAPE RECORDER USERS

50 **Ampex Corporation** has issued a directory listing over 1150 "Videotape" television recorders in service throughout the world. Location and number of units at each location are listed for broadcast television stations as well as educational, military, medical, and industrial installations.

ELECTRONIC TEST INSTRUMENTS

51 **Hewlett-Packard Company** has issued a 26-page short-form catalogue designed to provide quick reference to over 600 electronic test instruments, made by **Boonton Radio Company, Dymec Division of HP, Harrison Laboratories, Hewlett-Packard Co., F. L. Moseley Co.** and **Sanborn Company.**

Typical instruments listed include oscilloscopes, voltmeters, oscillators, signal generators, power supplies, electronic counters, pulse generators, microwave equipment, event recorders, strip-chart recorders, X-Y recorders, impedance measuring instruments, and equipment for digital data acquisition and r.f. measurement/control.

WHEATSTONE-BRIDGE NOMOGRAM

52 **R-Tronics, Inc.** has published a nomogram which speeds accurate computation of deviation from null for Wheatstone and Kelvin bridges. The nomogram translates error voltage in an unbalanced bridge into percentage deviation to obtain accurate resistance measurements and determine the value of the unknown resistance.

The nomogram includes a treatment of basic formulas, derivation, and a sample problem.

SYNCHRONOUS DETECTION SYSTEMS

53 **Triconix, Inc.** has published a 17-page application handbook on synchronous detection systems. The handbook contains a number of illustrations and describes the use of synchronous detection techniques in electron spin resonance spectrometry, radio astronomy, automatic frequency control of klystron oscillators, and detection of narrow-band signals buried in noise.

SATELLITE WIRE DATA

54 **Boston Insulated Wire & Cable Co.** has published a 6-page brochure on the electrical performance of wire during irradiation. The publication describes three styles of miniature, lightweight wires which are radiation resistant to 10^{10} nvt. Temperature tests from +1000 to −320 degrees F, flexing and dielectric tests are shown, together with tables and charts.

CONSTRUCTION PROJECTS

55 **Henry Francis Parks Laboratory** is offering copies of its catalogue which lists 150 projects for which schematics and parts lists are available. The projects are classified as to "very easy," "moderately difficult," and "extremely difficult" with further indication as to whether they are vacuum tube, transistor and/or semiconductor, or electro-mechanical.

The projects themselves range from an electronic organ through various types of test equipment to gear for amateur and CB service.

PRINTED-WIRING HANDBOOK

56 **Methode Electronics, Inc.** has just published a 48-page handbook "Second Generation Printed Wiring," covering multi-layer, flexible, and weldable pre-fab circuits.

In 14 chapters, the book covers generic types of flexible and multi-layer wiring, processing limitations, materials for flexible circuitry, interconnection techniques, performance characteristics as well as a handy chapter on how to solicit quotations on engineering information on flexible weldable or multi-layer circuits. The handbook is illustrated.

ELECTRONICS WORLD
P.O. BOX 7842, Philadelphia 1, Pa.

TOTAL NO. OF REQUESTS

Please send me copies of the literature whose code numbers I have circled.
(Your requests will be forwarded to the manufacturers who will be glad to fill them promptly.)

48 49 50 51 52 53 54 55 56 57 58 59 60 61

NAME (PRINT CLEARLY)_____

ADDRESS_____

CITY_____ **ZONE**____ **STATE**_____

COMPANY_____ **TITLE**_____

VOID AFTER JANUARY 31, 1964 1

ACCESSORIES & ANTENNAS

57 **Mosley Electronics, Inc.** has issued a four-page data sheet covering its line of audio accessories and antennas for the Citizens Band service.

Included are pictures and information on various types of audio switch plates, attenuator plates with speaker jacks, three-position speaker switches, plus a number of beam antennas.

RECORD-PLAYER BOOKLET

58 **Acoustic Research, Inc.** is offering copies of an 8-page reprint of an article "What the Consumer Should Know About Record Players" written by E. Villchur. The article describes methods of evaluating record players outside the laboratory and discusses some of the Old Wives' Tales that exist about turntables and arms. It also includes brief instructions on record care.

BOOKLET ON COMPACTRONS

59 **General Electric Company's** Tube Department has issued a 20-page brochure entitled "Compactrons—An Inside-out Success Story" which covers functional application, construction, reliability, and costs.

Examples are drawn from television, radio, and communications and illustrated with block diagrams. Pictures of many equipments using some of the 65 types of compactrons are included.

COMMUNICATIONS EQUIPMENT

60 **Motorola Overseas Corporation** has issued a 16-page, two-color catalogue covering its complete line of radio communications equipment.

The catalogue illustrates and provides general specifications for two-way radio, portable, and pocket radio equipment including "Handie-Talkie" 33-ounce transistorized and the just introduced PT series all-transistor "Handie-Talkie" with up to 5 watts r.f. output, base station equipment, antennas, railroad radio equipment, microwave components, single-sideband and closed-circuit TV equipment, measuring and test equipment, and crystal filters.

MINIATURE CAPACITOR DATA

61 **Industrial Condenser Corporation** is now offering copies of its Catalogue No. 1195 covering a complete line of miniaturized "Silverfilm" capacitors. The units are self-healing when subjected to over-potentials and offer extra high resistance to short-circuiting under these circumstances. A wide variety of case sizes and shapes, with or without mounting brackets, is available.

AMATEUR TOWER HANDBOOK

Rohn Manufacturing Co., Box 2000, Peoria, Illinois has published a new "Engineering Data and Specifications Handbook" containing amateur radio tower istallation information for all operators. In addition to presenting its entire line of amateur radio towers and accessories, the book provides a wealth of valuable information on towers, including complete engineering drawings and data, and guy charts.

A record section provides space for listing contacts in the U.S. and abroad. Future schedules and log sheets are included. The book is spiral bound with a flexible cover. It sells for $1.25 a copy and can be obtained by writing the company direct. ▲

PHOTO CREDITS

Page	Credit
26 (top left)	Republic Aviation Corp.
26 (top right)	Sperry Rand Corp.
26 (bottom left)	Hughes Aircraft Co.
26 (bottom right)	Martin Company
28 (left)	IBM
28 (right)	Sylvania Electric Products Inc.
30 (left)	Minneapolis-Honeywell
30 (top right)	Westinghouse Electric Corp.
30 (bottom right)	Sperry Gyroscope Co.
31 (top left)	ITT Federal Labs.
31 (top right)	Westinghouse Electric Corp.
31 (bottom left)	Sylvania Electric Products Inc.
31 (bottom right)	National Bureau of Standards
40, 41	Jerrold Electronics Corp.
48	Ferranti Electric Co.

THE CONFUSED FUSE

By A. W. EDWARDS

SEVERAL years ago, we experienced some difficulties with one of the radio navigation stations which were under our maintenance program. This was an A-N type radio beam transmitter, an important navigation aid, which would suddenly go off the air at irregular and unpredictable times. Almost always, the trouble was the same: one of the fuses—a three-ampere unit—had blown. Upon replacing this fuse, service was restored, and there was no visible evidence of any malfunction.

After this happened several times—and it was always that same small fuse—we devoted some time to checking all the components in the load circuit. The circuit was measured and found to be proper. No amount of shaking or jarring of wiring and components could cause any fault, or induce the fuse to go out. It began to "bug" those of us who took pride in our troubleshooting ability.

One day we arrived at the station just in time to see it go off the air. Sure enough, it was the same fuse. Upon removing the bad fuse we noted that it was unusually warm—too hot to hold tightly, in fact. Quickly we cut off the power to the distribution box and removed the fuse panel cover. The bus to the empty fuse socket was touched and found to also be quite hot.

It took only a few seconds to deduce that the evil gremlin that had been plaguing us was a *slightly loose* screw terminal connection at the fuse bus. The resistance of this loose connection was sufficient to allow considerable heat to be developed at the junction. The heavy bus began to accumulate this heat, aided by the dead air space behind the fuse panel cover. Eventually the heat in the fusible link that was developed by normal current flow, in combination with the ordinary heat developed by the I^2R action at the screw connection, caused the fuse to behave as it was designed to do: to melt at a certain temperature.

Previously, of course, the fuse had cooled down long before the technician could arrive at the remote location, and would be cool to the touch, as would be expected. The trouble was permanently repaired by tightening the loose terminal screw. Inspection of all such power wiring connections became a routine part of our maintenance checks from that time on. ▲

ELECTRONICS MARKET PLACE

RATE: 60¢ per word. Minimum 10 words. March issue closes January 5th. Send order and remittance to: ELECTRONICS WORLD, One Park Ave., N. Y. C. 16, N. Y.

FOR SALE

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Nahant, Mass.

INVESTIGATORS, free brochure, latest subminiature electronic listening devices, Ace Electronics, 11500J NW 7th Ave., Miami 50, Florida.

MILITARY Discount—Name Brands Free Recording Tape and Stereo Handbook. Include Rank and Serial Number. Electronics International, Inc., Box 3066, Charlottesville, Virginia.

Save dollars on radio, TV-tubes, parts at less than manufacturer's cost. 100% guaranteed. No rebrands, pulls. Request Bargain Bulletin. United Radio 1000-W, Newark, N.J.

CANADIANS—Giant Surplus Bargain Packed Catalogs. Electronics, Hi-Fi, Shortwave, Amateur, Citizens Radio. Rush $1.00 (Refunded). ETCO. Dept. Z, 464 McGill, Montreal, Canada.

TRANSISTORIZED Products importers catalog, $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

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.

SAVE Money—Free catalog: Photography, Tape Recorder, Hi Fidelity. Electronics tools, Wholesale Radio & Camera Company, Box 3085, Phila. 50, Pennsylvania.

SUPERSENSITIVE Listening-In-Device picks up any telephone conversation in vicinity. No connection to telephone necessary. Easily concealed. $2.98 complete. Consolidated Acoustics, M1302 Washington St., Hoboken, N.J.

OHM'S law never forgotten with copyrighted tool. $2.00 Postpaid. Beck Radio, 6323 South Dale Mabry, Tampa, Florida 33611.

RESISTORS precision carbon-deposit. Guaranteed 1% accuracy. ½ watt 8¢. 1 watt 12¢ 2 watt 15¢. Rock Distributing Co., 902 Corwin Road, Rochester 10, New York.

DIAGRAMS for repairing Radios $1.00. Television $2.50. Give make model. Diagram Service, Box 1151 E, Manchester, Connecticut 06042.

TRANSISTOR Ignition coils, components, kits. Advice Free. Anderson Engineering, Wrentham 5, Mass.

GREATEST Buys! Electronic surplus list 10¢ Western Electric Mercury Wetted Relay SPST 5 AMP Contacts, Only $2.95 Postage Paid 2 for $5. ($15. Value) Fertik's 9th Tioga, Phila. 40, Pennsylvania.

CB transmitters $6.00. Other bargains, send 10¢ for list. Vanguard, 190-48—99th Ave., Hollis 23, N.Y.

DIAGRAMS, service material, Radio, Television. $1.00. Supreme Publications, 1760 Balsam, Highland Park, Illinois 60035

TRANSFORMERS, new plate and filament customized to your specifications at production prices. F.O.B. Los Angeles-Specialty Engineering, 9007 Avalon Blvd.

ELECTRONICS ENGINEERING AND INSTRUCTION

FCC LICENSE in six weeks. First class radio telephone. Results guaranteed. Elkins Radio School, 2603C, Inwood, Dallas, Texas.

HIGHLY-effective home study review for FCC commercial phone exams. Free literature! Wallace Cook, Box 10634, Jackson 9, Miss.

USED Correspondence Courses and Books sold and rented. Money back guarantee. Catalog free. (Courses Bought.) Lee Mountain, Pisgah, Alabama.

NOTICE: International School of Electronics, 1024 Dupont Circle Building, Washington, D. C., 20036, U.S.A.

ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start February, September. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana.

ENGINEERING and Art Degrees earned through home study. Electronics, mechanical, liberal arts, major accounting. When writing specify course desired. Pacific International College of Arts & Sciences, primarily a correspondence school. Resident classes also available. 5719-C Santa Monica Blvd., Hollywood 38, California.

RADIO course only $14.95. Includes all tubes, parts, tools, instructions. Write for full information. Progressive "Edu-Kits" Inc., Dept. 94E, Hewlett, N.Y.

MATHEMATICS. Electronics. Pay as you learn. Free brochure. Indiana Home Study, 64 Hemenway Road, Framingham, Massachusetts 01706.

TUBES

TUBES—TV, Radio, Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality, Top Name Brands Only. Write For Free Catalog or Call Walker 5-7000, Barry Electronics, 512 Broadway, New York N.Y. 10012

TOP Brand Tubes at Terrific Savings. If you need new radio, television or special purpose electron tubes, you'll want our free catalog. Metropolitan, 443 Park Avenue South. New York 16, N.Y., MU 6-2835.

NAME Brand Tubes-Tremendous Discounts catalogue free. Hamel Electronics, Box 473, West Hartford 7, Conn.

BEFORE you buy receiving tubes, test equipment, Hi-fi components, kits, parts, etc. . . . send for your giant free Zalytron current catalog, featuring Standard brand tubes; RCA, GE, etc.—all brand new premium quality individually boxed. One year guarantee—all at biggest discounts in America! We serve professional servicemen, hobbyists, experimenters, engineers, technicians. Why pay more? Zalytron Tube Corp., 461 Jericho Turnpike, Mineola, N. Y.

$30.00 value—7" TV test picture tube, perfect for 70° and 90° sets, built-in ion trap—your cost $6.99. Tubes—new, jobber-boxed RCA, G.E. etc.—65% off list prices. Special: Tube #6146—$2.95 each. Send your order. We pay postage (you save 4%). Immediate delivery. Write for Free Catalog listing thousands of parts, phono needles, tubes, etc. Arcturus Electronics Corp., Dept. ZD, 502 22nd St., Union City, New Jersey.

WANTED

QUICKSILVER. Platinum, Silver, Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Mass.

CASH Paid! Sell your surplus electronic tubes. Want unused, Clean radio and TV receiving, transmitting special purpose. Magnetrons, Klystrons, broadcast types. Want military and commercial lab/test equipment. Want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics, 512 Broadway, New York, New York 10012 (Walker 5-7000).

ARMY Sets or Parts—GRC—PRC—FRR/URR—TCC—SB—SCR—Send Listings—Quick Cash. Anker Electronics, 1617 So. Main St., Box 26, Wilkes-Barre, Pa.

GET Top Dollar for Radio, Television and special purpose tubes. Tell us what you have. Metropolitan Overseas Supply Corp., 443 Park Ave. South, N.Y. 16, N.Y., Tel. MU 6-2835.

TAPE AND RECORDERS

TAPE Recorders, HI-FI Components. Sleep Learning Equipment. Tapes. Unusual Values. Free Catalog. Dressner, 1523 EW Jericho Turnpike, New Hyde Park 10, N.Y.

RENT Stereo Tapes—over 2,500 Different—all major labels—free brochure. Stereo-Parti, 1616—E. W. Terrace Way, Santa Rosa, California.

SELF-Hypnosis. New concept teaches you quickly by tape or LP-record. Free literature. McKinley Publishers, Dept. T6. Box 3038. San Bernardino, California.

SAVE 30-60% Stereo music on tape. Free bargain catalog/blank tape/recorders/norelco speakers. Saxitone, 1776 Columbia Road, Washington, D.C.

TAPE Recorder Sale. Latest models $10.00 above cost. Arkay Sales, 22-21 Riverside Avenue, Medford 55, Massachusetts.

1961 Ampex 601-2 Stereo Recorder with accessories. Charles Goodman, 10 Woolson Street, Mattapan, Mass. 02126.

HIGH-FIDELITY

HI-FI Components, tape recorders at guaranteed "We Will Not Be Undersold" prices. All brands in stock. 15-day money back guarantee. 2 year warranty. Write your requirements for quotation. No Catalog. Hi-Fidelity Center 1797L 1st Ave., New York 28, N.Y.

DISGUSTED with "Hi" Hi-Fi Prices? Unusual Discounts On Your High Fidelity Requirements. Write. Key Electronics, 120 Liberty St., New York 6, N. Y. DI6-4191.

WRITE for lowest quotations, components, recorders. No Catalogs Hi-Fidelity Supply, 2817-GC Third, New York City 55.

LOW, LOW quotes: all components and recorders. Hi-Fi, Ros'yn 9. Penna.

"FM/Q" Metropolitan Broadband Antenna, the finest compact yagi made, completely rustproof, only $14.95 prepaid. FM Book with station directory 30¢. FM/Q, Wethersfield, Connecticut.

ATTACH Adaptor to conventional Stereo Amplifier. Add two Speaker Cabinets. Witness full natural sound reproduced with full incremental locations. Unit encapsulated. Guaranteed. $39.95 Prepaid USA. Stereosphere, Box 3009, Dept. EW, Huntsville, Alabama, 35811.

REPAIRS AND SERVICING

TV Tuners Rebuilt and Aligned per manufacturers specification. Only $9.50. Any Make UHF or VHF. We ship COD Ninety day written guarantee. Ship complete with tubes or write for free mailing kit and dealer brochure. JW Electronics, Box 51B. Bloomington, Indiana.

METERS—Multimeters Repaired and Calibrated. Free estimates—Catalog. Bigelow Electronics, Box 71-F, Bluffton, Ohio.

TV Tuners Rebuilt and Aligned to Specifications. Guaranteed All Makes. One Price. $9.50 Complete. Plus Shipping. Valley Tuners, 5641-B Cahuenga, North Hollywood, Calif.

FAMOUS BC-645 TRANSCEIVER

BRAND NEW! 15 Tubes 435 to 500 MC

Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
Shipping weight 25 lbs. **SPECIAL!...** **$19.50**

PE-101C Dynamotor, 12/24V input	$7.95
UHF Antenna Assembly	2.45
Complete Set of 10 Plugs	5.50
Control Box	2.25

SPECIAL "PACKAGE" OFFER

BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW While Stocks Last **$29.50**

EE8 FIELD PHONES, Checked out, perfect working order. Complete with all parts. Excellent Cond. Each **$12.95**

BC-604 TRANSMITTER Companion unit to 21-27.9 Mc FM BC603 Receiver. Complete with all tubes. BRAND NEW **$10.95**

ARB/CRV 46151 NAVY AIRCRAFT RADIO RECEIVER 190 to 9050 Kc in four bands. 6-tube super communications receiver with local and remote tuning; band change. Complete with tubes and dynamotor. LIKE NEW **$39.50**

RA62 AC POWER SUPPLY FOR SCR522 Transceiver. Like New **$42.50**

BC-652A RECEIVER

Hot Special! 2000 to 6000 Kc AM Receiver, 2-band, complete with all tubes, 200 Kc Xtal Calibrators, and 12 V Dynamotor. Fine for 80-meter Ham band, Marine, etc. Provides for CW, MVC, AVC, Speaker Jack and two Headphone Jacks. Shpg. Wt. 50 lbs. Brand New, only **$39.50**

AN/APR-4 RECEIVER only. 38 to 4000 Mc in 5 tuning unit ranges. High precision lab instrument. Input 115 V 60 cy. Like New **$89.50**

Tuning Units TN16, 17, 18 each	$39.50
Tuning Unit TN19. Brand New	$89.50
Tuning Unit TN54	$149.50

BC-348 SUPERHET RECEIVER 200 to 500 Kc and 1.5 to 1800 Mc. Voice, Tone, CW. Self-contained dynamotor for 24 V DC. Exc. Used, Checked out. . . **$89.50**
AC Power Supply **$14.50**

234-258 MC RECEIVER AN/ARR-2

BRAND NEW 11-tube UHF Tunable Receiver with schematic. Only a few at this low price!
Complete with tubes **$8.88**

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$29.50**

Type	DYNAMOTOR VALUES: Input	Output		Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V	.05A	2.45	4.45
DM-33A	28V 5A	575V	.16A		
	28V 7A	540V	.25A	2.95	4.45
DM-34D	12V 2A	220V	.080A	4.15	5.50
DM-36	28V 1.4A	220V	.080A	1.95	2.95
DM-43	28V 23A	925V	.220A		
		460V	.185A	—	7.95
DM-53A	28V 1.4A	220V	.080A	3.75	5.45
PE-73C	28V 20A	1000V	.350A	8.95	14.95
PE-86	28V 1.25A	250V	.050A	2.75	3.85

DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each **$3.25**

MICROPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
T-17D	Carbon Hand Mike	$4.45	$7.95
RS-38	Navy Type Carbon Hand Mike	3.95	5.75

HEADPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
HS-23	High Impedance	$2.79	$4.95
HS-33	Low Impedance	3.15	5.45
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16/U	High Imp. (2 units)	3.75	7.95
TELEPHONICS—600 ohm Low Impedance HEAD SETS. BRAND NEW. PER PAIR			$3.95
CD-307A Cords, with PL55 plug and JK26 Jack			.99
Earphone Cushions for above—pair			.50

2 VOLT BATTERY "PACKAGE"

1—2V. 20 Amp. Hr. Willard Storage Battery, Model #20-2. 3" x 4" x 5⅛" high. **$2.79**
1—2V. 7 prong Synchronous Plug-In Vibrator. . . **1.49**
1—Quart Bottle Electrolyte (for 2 cells) **1.45**
ALL BRAND NEW! Combination Price **$5.45**

WILLARD 6-VOLT MIDGET STORAGE BATTERY

3 Amp. Hour. **BRAND NEW.** 3⅝" x 1-13/16" x 3⅜". Uses Standard Electrolyte . . . . . Only **$2.95**

IMPORTERS—EXPORTERS of ELECTRONIC EQUIPMENT

We specialize in the export of military surplus electronic equipment:

- **All at LOWEST PREVAILING PRICES.**
- **In addition to items shown on this page, we have in stock or can obtain for export customers, military electronic equipment made for World War II, Korean War, and later.**

  Many thousands of items in our huge warehouse.
- **IF YOU DON'T SEE WHAT YOU WANT HERE, WRITE US YOUR NEEDS. LET US QUOTE ON ANY GOV'T SURPLUS ELECTRONIC EQUIPMENT YOU SEE ADVERTISED ANYWHERE. INQUIRIES WELCOMED.**
- **All packing and shipping is made directly from our own warehouse in NYC to give you substantial savings in handling costs!**

AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$79.50 EXC. USED

complete with Tubes

Famous Collins Autotune Aircraft Transmitter. AM CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90% class "B." A Real "HOT" Ham buy at our low price!
AN/ART-13 XMTR. as above. **In LIKE NEW condition.** with all tubes and crystal **$89.50**

0-16 Low Freq. Osc. Coil for ART-13	7.95
24V Dynamotor for ART-13	11.95

We carry a complete line of spare parts for above.

ELECTRONIC SURPLUS HEADQUARTERS!

G & G Radio maintains one of the largest stocks of Government Electronic Surplus Equipment in America! If the item you need is not shown here—if you see it listed elsewhere—write or call today for our LOW, LOW PRICE and Speedy Delivery FROM STOCK!

BC-617 FM RECEIVER & Selector. Frequency range 30 to 40 Mc. 10 channels tone selector actuates relay circuits. Coaxial antenna input, squelch circuit, audio control output jack. Complete with 15 tubes and 24 Volt Dynamotor. Size 11"x8"x20". NEW **$24.50**

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 MC	12.45	17.95
BC-455	Receiver 6-9 MC	11.50	13.95
1.5 to 3 MC. Receiver Brand New			$17.95

110 Volt AC Power Supply Kit for all 274-N and ARC-5 Receivers. Complete with metal case, instructions . . . . . **$.8.95**
Factory Wired, tested, ready to operate . **$12.50**
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only . . . . . **49¢**

2.1 to 3 Mc Transmitter. Brand New	$12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal. BRAND NEW	$9.75
Like New	$7.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal. BRAND NEW	$10.95
Like New	$7.95
BC-696 TRANSMITTER 3-4 Mc Complete with All Tubes & Crystal. Like New	$11.95
BC-456 Modulator . . . . . USED 3.45 NEW	5.95

ALL ACCESSORIES AVAILABLE FOR ABOVE

TG-34A CODE KEYER

Self-contained automatic unit, reproduces code practice signals recorded on paper tape. By use of built-in speaker, provides code-practice signals to one or more persons at speeds from 5 to 25 WPM.

Like New, Tested **$29.50**

Set of 15 Reels, Army Code Practice Lessons, BRAND NEW, original packing . . . . . **P.U.R.**

SCHEMATIC DIAGRAMS For most equipment on this page, each **65¢**

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50¢ Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change.

G & G RADIO SUPPLY CO.
Telephone: CO 7-4605
77 Leonard St. New York 13, N. Y.

ARC-3 RECEIVER!

Complete with All Tubes Exc. Used **$21.50**
Like NEW $33.50
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 preselected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.
110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested 19.95

ARC-3 TRANSMITTER

Companion unit for above tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6, Exc. Used . . . . . Only **$18.95**
Like new condition $28.50
ARC-3 PUSHBUTTON CONTROL BOX $5.95

LORAN APN-4
FINE QUALITY NAVIGATIONAL EQUIPMENT

Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.

INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes, Exc. Used. **$69.50**

NEW! APN-4A Receiver-Indicator as above, changed to operate same as APN4-B for improved performance . . . . . NEW **$88.50**
Shock Mount for above **$2.95**

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC. OUTPUT: 115 V AC, 800 cycles. Like New **$22.50**

12-Volt Inverter Power Supply for above APN-4. Like New. P.U.R.
We carry a complete line of replacement parts and accessories for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR

Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition **$79.50**

Used, with all parts, less tubes, crystal and visor . . . . . Special **$29.50**

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. Like New **$22.50**

12-V. **Power Supply** for APN-9, like New P.U.R.
Shock Mount for above **$2.95**
Circuit diagram and connecting plugs available.
We carry a complete line of replacement parts and accessories for above.

LORAN APN/4 OSCILLOSCOPE

Easily converted for use on radio-TV service bench. LIKE NEW! Supplied with 5" Scope, type 5CPI only **$14.95**

APN-12 3-INCH SCOPE

Has vertical and horizontal sweep with focus and intensity controls, coaxial antenna changeover motor. Complete with 11 tubes and 3JP1 CR Tube. For 115 V. 400 cycle AC and 24 V DC. Circuit diagram included. LIKE NEW. **$14.95**

TS-100AP 'SCOPE

EXC. USED **(worth $750)**
OUR LOW PRICE
Brand New $69.50 **$39.50**

Can be used with linear sweep or general purpose test scope. Cables included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.

LM FREQUENCY METER

Crystal calibrated modulated, Heterodyne, 125 Kc to 20,000 Kc With Calibration book **$69.50**
Complete, Like New

BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. **BRAND NEW. OUR LOW PRICE.** . **$12.88**

BC-221 FREQUENCY METER

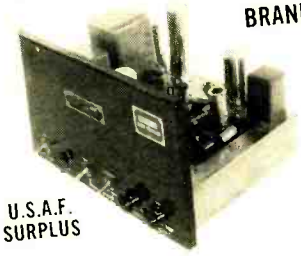
SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book. Crystal, and all tubes. **CHECKED OUT!**
Unmodulated **$79.50** Modulated . . . . . P.U.R.

BC-221 1000 Kc Crystal Brand New **$8.95**

ROTH

AUDIO AMPLIFIER

BRAND NEW



U.S.A.F. SURPLUS

ORIGINAL CARTONS

Ready to operate from 110 Volt, 60 cycle A.C. Conservatively rated at 5 watts, but capable of 10-12 watts peak power.

Input transformer 500 ohms C.T. Output transformer 8 ohms, 50-5000 C.P.S.

Features five-tube printed circuit board, with premium type tubes as follows: 3—5751 (12AX7); 1—12AT7W; 1—6AQ5. Power supply uses 5Y3W tube. RETAIL VALUE OF TUBES ALONE: $18.25!

Attractive blue-enameled front panel is 13" x 7¾", has on-off switch, pilot lite, volume control, sensitivity control, calibration switch & alarm switch. A.F. used amplifier as an aircraft approach alarm. Sensitivity control is set to trip a plate relay when a given sound level is exceeded. This relay can be used to operate a bell, light or motor. This amplifier is suitable as a preamp for low level magnetic phono pickup, tape recorder heads, microphone etc., and adaptable to such uses as hi-fi phonograph amp, intercom amp, burglar alarm, P.A. system, or booster amp. Shipped express or truck, freight collect.

PRICE: $14.95

fob Syracuse, N.Y.

Coaxial Antenna Relay

With simple modification, assembly makes two coaxial relays. (Modification instructions are furnished.) Unit contains two "Advance" or "Bernier" relays with "N" connections. Coil operates 60-100 VDC at 10 MA. These relays similar to "Advance" CB series except with "N" connectors.

$5.95

Comparator CM-23/GR

Used to switch two antenna inputs to one receiver. Contains two coaxial ant. relays (see above adv.), 30 cy. band-pass filter, regulated power supply etc. Tubes: 6SN7 (5), OB2 (2), 5Y3, 6AU6, 6BA6. Like new condition. Circuit diagram with each unit. Shipped express or truck, freight collect.

$8.95

VARIACS

General Radio (No Dials)

W20—20 amp—115V, 60 cy	22.95
V20—20 amp—115V, 60 cy	22.95
W5—6 amp—115V, 60 cy	11.95
W2—2.4 amp—115V, 60 cy	6.95
V2—2 amp—115V, 60 cy	6.45
M-5—5 amp—115V, 350 cy	3.95
M-2—2 amp—115V, 350 cy	2.95

(Latter two will operate on 60 cy. with 60V max input)

Superior Powerstat (with dials)
Type 20—3 amp—115V, 60 cy ... 7.95
Type 10—1.25 amp—115V, 60 cy.. 4.95

CAPACITORS

Mallory & Sangamo—Computor Grade Electrolytics

MFD	Volts DC	Price
8000	55	1.25
3500	55	.75
2500	80	.75
1500	100	.75
1260	200	.75
750	100	.75
500	200	.75
400	350	.75
180	350	.75

SPECIAL! 8000 MFD—3 for $3.00. All others 3 for 2.00.

GE PYRANOL CAPACITORS

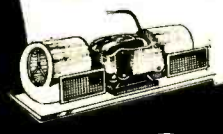
MFD	Volts 60 CY.	Volts DC	Price
10	660	1500	1.25
8	660	1500	1.25
4.5	1000	3000	1.25
3	1000	3000	1.25

SPECIAL! All above—3 for $3.00

Twin Blower

Housed in an 8" x 8" x 28" metal case with provision for filters. Motor rated at ⅛ H.P., 208 V, 60 cy., 1 ph. Will operate excellently on 120V, 60 cy output. Approx. 300 cu. ft. of air per minute. Intake 3¼", Outlet 2½" x 4". Shipped express or truck, freight collect.

$4.95 ea.



WESTINGHOUSE SILICON RECTIFIER BRIDGE

35 amp—150 PIV (4-1N1185) ..... $9.95 ea.

GERMANIUM RECTIFIER BRIDGE

5 amp GE—200 PIV 4 cell ..... $3.50 ea.

PLUG-IN POWER SUPPLY

Using Octal plug. Input 6.3 V, AC. Output regulated 145V. 15-20 MADC

$4.50 ea.

ORDERS 20 LBS. OR MORE SHIPPED FREIGHT COLLECT. FOR SMALL SHIPMENTS PLEASE ADD 75¢ TO COVER PARCEL POST CHARGES.

ROTH STEEL CORP.

127 Oakwood Ave. Syracuse, N.Y. GR5-8431 B. REIBEN

HELP WANTED

EARN Extra money selling advertising book matches. Free Samples furnished. Matchcorp, Dept. MD-13, Chicago 32, Ill.

WANTED Men with experience in Communications, Telephone PBX, Carriers, VHF Radio & Microwave, Openings in Chicago Present Time. Must have second or first class radio telephone Commercial License. Good salary and benefits. Contact Mr. M. W. Minear, 500 W. Madison St., Rm. 436, Chicago, Ill.

RECORDS

RARE 78's. State Category. Write Record-Lists, P.O. Box 2122, Riverside, Calif.

EDUCATIONAL OPPORTUNITIES

LEARN While Asleep, hypnotize with your recorder, phonograph. Astonishing details, sensational catalog free! Sleep-Learning Association, Box 24-ZD, Olympia, Washington.

LEARN while asleep. Remarkable, scientific. 92% effective. Details free. ASR Foundation, Box 721, Dept. e.g., Lexington, Kentucky.

EMPLOYMENT INFORMATION

FOREIGN Employment. Construction, other work projects. Good paying overseas jobs with extra, travel expenses. Write only: Foreign Service Bureau, Dept. D, Bradenton Beach, Florida

EMPLOYMENT Resumes. Earn more by presenting yourself to prospective employers more effectively. Send only $2.00 (cash or money order) for complete Resume Writing Instructions, including sample and instructions for letter of transmittal. J. Ross, 63-61 Yellowstone Blvd., Forest Hills 75, New York, Dept. 6J-EW.

PATENTS

INVENTIONS: Ideas developed for Cash Royalty sales. Raymond Lee, 2104G Bush Building, New York City 36.

GOVERNMENT SURPLUS

JEEPS $111.68, Boats $6.18, Airplanes, Electronics Equipment, Typewriters, thousands more, typically at up to 98% savings. Complete information $1.00. Surplus Service, Box 820, Holland 11, Michigan.

JEEPS—$89.64, Typewriters—$4.15, Receivers—$5.65, Televisions, Oscilloscopes, Multimeters, Typical Government Surplus Prices. Exciting Details Free. Enterprises, Box 402-B6, Jamaica 30, New York.

JEEPS $178, Airplanes $159, Boats $7.88, generators, $2.68, typewriters $8.79, are typical government surplus sale prices. Buy 10,001 items wholesale direct. Full details, 607 locations, procedure only $1.00. Surplus, Box 177-C1, Abbottstown, Penna.

BOOKS

AUTHORS! Learn how to have your book published, promoted, distributed. FREE booklet "ZD," Vantage, 120 West 31 St., New York 1

WANTED: Short stories, books, articles, plays of all descriptions for sale to publishers, producers. Free literature! Literary Agent Mead, Dept. 39A, 915 Broadway, N. Y. C. 10.

PUBLISH your book! Join our successful authors: publicity advertising promotion, beautiful books. All subjects invited. Send for free appraisal and detailed booklet. Carlton Press, Dept. ZDA, 84 Fifth Avenue, N.Y.C. 11.

PHOTOGRAPHY — FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth" one reel, 8mm $7.50; 16mm $14.95. International W, Greenvale, Long Island, New York.

SCIENCE Bargains—Request Free Giant Catalog "CJ"—144 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts, War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

PHOTOGRAPHERS Earn Part Time, Write: PCI Dept. 470, Arlington 10, Va.

STAMPS AND COINS

UNSELECTED World Stamps dating from 1913. Over 200 for $3.00, 500; $5.00. Accredited Press, Lawrence 3, New York.

BUSINESS OPPORTUNITIES

MISCELLANEOUS

SURPLUS BC-969A

To the Editors:

I would like to get in touch with someone who has, or has had, a BC-969A, 15 to 150 kc. surplus v.l.f. radio. I am interested in its size, weight, and general description. I don't need the schematic diagram, but I would like to know more about it other than the fact that it's an 11-tube, 3-band superhet using a separate power supply.

C. R. French
460 Huron Avenue
Louisville, Kentucky 40209

° ° °

NORELCO PROJECTION TV

To the Editors:

On page 68 of the October 1963 issue, in the "Radio and TV News" column, you say, "... large and cumbersome home projection television sets, like the dinosaur . . . mysteriously vanished from the scene."

If any of my fellow readers have one of these sets, particularly the *Norelco* add-on wall-projection unit, in his attic, I'd appreciate it if he would drop me a line.

Herman E. London
Audio-Visual Coordinator
Hunter College
695 Park Avenue
New York 21, N.Y.

ELECTRONICS WORLD JANUARY 1964

ADVERTISERS INDEX

Printed in U.S.A.

CIRCLE NO. 141 ON READER SERVICE PAGE →

TRIPLETT

EXTRA QUALITY IS HIDDEN*

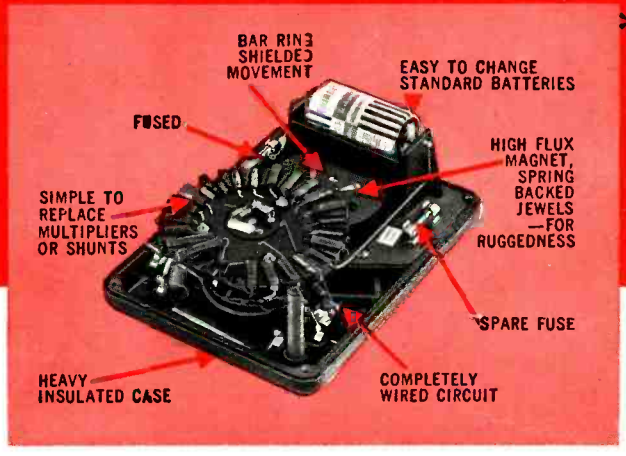
MODEL 630 V-O-M

PRICE† $49.50

Standard Of The Industry

USES UNLIMITED:

- Field Engineers
- Application Engineers
- Electrical, Radio, TV, and Appliance Servicemen
- Electrical Contractors
- Factory Maintenance Men
- Industria Electronic Maintenance Technicians
- Home Owners, Hobbyists



FACTS MAKE FEATURES:

1. Popular streamlined tester with long meter scales arranged for easy reading. Fuse protected.
2. Single control knob selects any of 32 ranges—less chance of incorrect settings and burnouts.
3. Four resistance ranges—from .1 ohm reads direct; 4½ ohm center scale; high 100 megohms.

Attention to detail makes the Triplett Model 630 V-O-M a lifetime investment. It has an outstanding ohm scale; four ranges—low readings .1 ohm, high 100 megs. Fuse affords extra protection to the resistors in the ohmmeter circuit, especially the XI setting, should too high a voltage be applied. Accuracy 3% DC to 1200V. Heavy molded case for high impact, fully insulated.

†630A same as 630 plus 1½% accuracy and mirror scale only $59.50

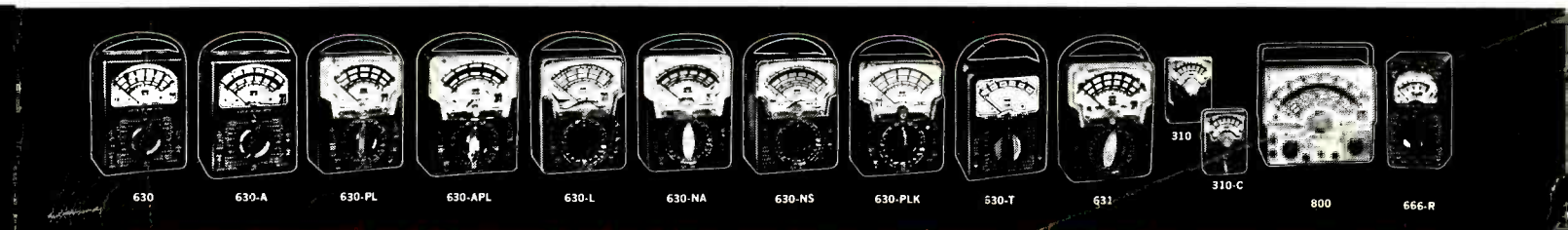
RANGES

DC VOLTS	0-3-12-60-300-1,200-6,000 at 20,000 ohms per volt.
AC VOLTS	0-3-12-60-300-1,200-6000 at 5,000 ohms per volt.
OHMS	0-1,000-10,000.
MEGOHMS	0-1-100.
DC MICRO-AMPERES	0-60 at 250 millivolts.
DC MILLI-AMPERES	0-1.2-12-120 at 250 millivolts.
DC AMPERES	0-12.

DB: —20 to +77 (600 ohm line at 1 MW).

OUTPUT VOLTS: 0-3-12-60-300-1,200; jack with condenser in series with AC ranges.

TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO



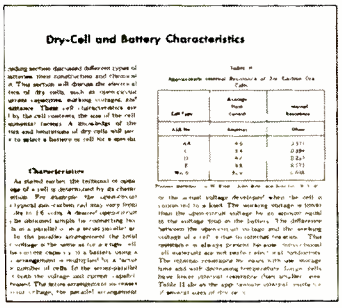
THE WORLD'S MOST COMPLETE LINE OF V-O-M'S. AVAILABLE FROM YOUR TRIPLETT DISTRIBUTOR'S STOCK

If you design or work with battery-operated equipment ...

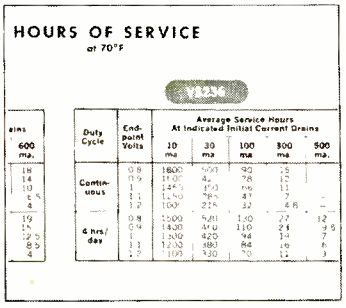
THIS IS THE BOOK YOU NEED

RCA's comprehensive new 64-page battery manual is an invaluable reference source for anyone designing or working with battery-operated circuits, whether for industrial, consumer or hobby applications.

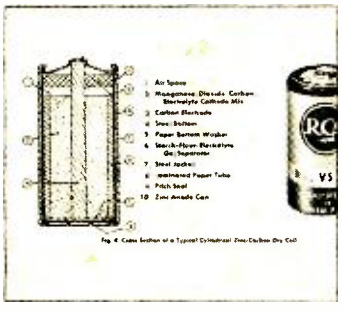
WHAT IT GIVES YOU:



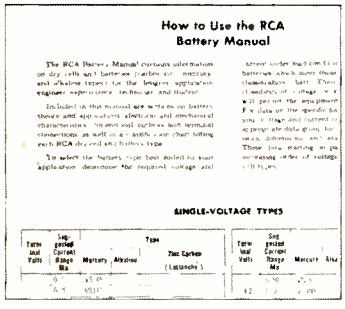
Battery principles and characteristics ... Page 12



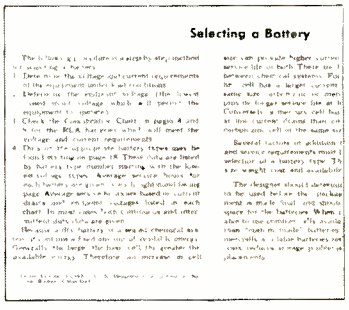
Average service hours (in tabular form) ... Page 25



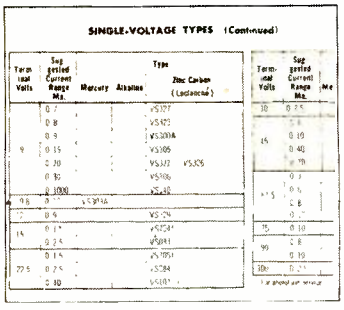
Battery construction ... Page 10



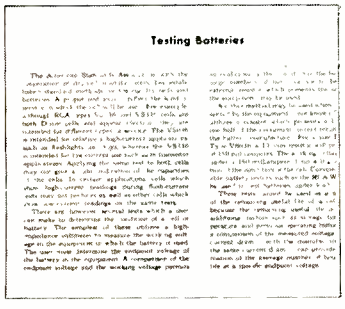
Comprehensive classification chart ... Page 4



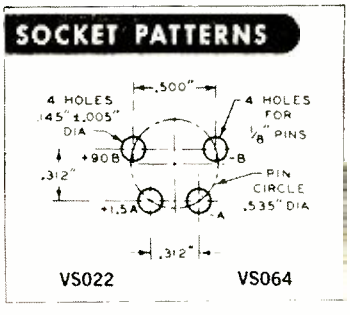
Battery selection guide ... Page 16



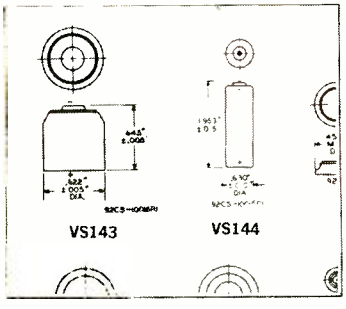
Recommended current ranges ... Page 5



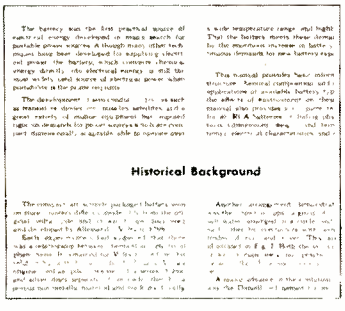
Test procedures for different types ... Page 15



Terminal and socket connections ... Page 56



Dimensional outlines, sizes, weights ... Page 18



Battery development ... Page 6

FREE ON REQUEST

Write RCA, Dept. 451, Harrison, N.J.
Offer ends March 28, 1964.

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N. J.

The Most Trusted Name in Electronics