ELEMENTARY
ELECTRONICS

7 SELECTED PROJECTS

897

A 75c RADIO-TV EXPERIMENTER HANDBOOK

SUMMER 1964

BASIC TEST EQUIPMENT FOR YOUR WORKBENCH!

How to Put Together a Hi-Fi System!

HOW TO GET STARTED IN HAM AND CB!

Special Sections on Electronic Theory!

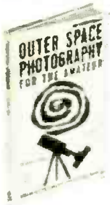
BUILD THIS $15 BATTERY TESTER IN 4 HOURS

AMERICA'S BEST PHOTO BOOKS

25 LOOTENS ON PHOTOGRAPHIC ENLARGING AND PRINT QUALITY
by J. Ghislain Lootens $4.95
Truly a classic. Called "The finest book on the subject."

242 124 WAYS YOU CAN TEST CAMERAS, LENSES AND EQUIPMENT
by Herbert Keppler $2.50
You'll never get stuck if you know what makes photo equipment tick.

56 OUTER SPACE PHOTOGRAPHY FOR THE AMATEUR (New Edition)
by Dr. Henry Paul $2.50



Fascinating astronomical pictures you can learn to take without expensive equipment.

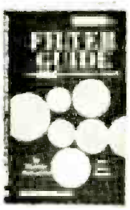
168 35mm NEGS and PRINTS: AND HOW TO GET THE MOST FROM THEM
by Y. E. Satow $2.50
Shows you the special techniques involved in handling 35mm darkroom problems.

175 AVAILABLE LIGHT PHOTOGRAPHY
by H. M. Kinzer $1.95
Get professional results even in poor light conditions using these simple methods.

589 BABY AND CHILD PHOTOGRAPHY
by Burt Murphy $1.95
Follow this method for photographs you will treasure forever.

78 FILTER GUIDE
by Rothschild and Wright $2.50

How filters can be used for creative and corrective photography.



275 HOW TO MAKE MONEY IN PHOTOGRAPHY
by Eugene Hanson $1.95
Paperback edition of a $4.95 bestseller called the most helpful on the subjct.

180 WEDDING AND PARTY PHOTOGRAPHY
by Barney Stein $1.95
A pro gives expert instruction on catching those once-in-a-lifetime moments.

164 CREATIVE CAMERA TECHNIQUES
by Burt Murphy $1.95
Learn to develop a style of your own by examining the components of creative work.

81 LENSES: HOW TO CHOOSE AND USE THEM
by Ted Russell $2.50
Learn what lenses can do and how they do it. Which lenses best serve your needs.

177 PHOTOGRAPHY THROUGH MONOCULARS, BINOCULARS AND TELESCOPES
by Joseph D. Cooper $1.95
This book will open up many new fields, expand the range of your camera more than tenfold.

143 PRACTICAL PORTRAIT PHOTOGRAPHY FOR HOME AND STUDIO
by Abel & Falk $6.95
Handle every type of portrait with the ease and results of a pro.

POCKET COMPANION SERIES

$1.95 each

The handiest camera books published. Contain more useful information than any other books of the same size. Beautifully bound in flexible simulated leather. And convenient—the spiral binding enables the pages to lie flat when holding the book in one hand. Each book contains accurate 18% reflectance gray card so you can get right exposure any time, every time.

202 MINOX POCKET COMPANION
292 ARGUS POCKET COMPANION
285 PENTAX POCKET COMPANION
291 RETINA REFLEX POCKET COMP.
287 CONTAFLEX POCKET COMPANION
298 NIKON F-NIKKOREX F POCKET COMPANION

131 THE NUDE
by De Dienes $4.95
Hollywood's famous photographer presents another 91 memorable treatments, each a masterpiece of artistic sensitivity.

49 FLOYD'S PHOTO TIPS
by Wayne Floyd $2.50
A photo whiz who knows a thousand-and-one money-saving tricks, little-known professional practices invaluable to every amateur.

172 NUDE, FIGURE AND GLAMOUR PHOTOGRAPHY
by Burt Murphy $1.95
A penetrating discussion of the art of photographing nude and semi-clothed figures with photographs by Jack Andersson.

264 MAKING SLIDE DUPLICATES, TITLES AND FILMSTRIPS
by Norman Rothschild $1.95
The most complete guide to equipment and techniques ever.

588 PETER GOWLAND'S GUIDE TO ELECTRONIC FLASH (New Edition)
by Peter Gowland $1.95
How to use speedlights for professional results.

186 AVAILABLE LIGHT AND YOUR CAMERA
by George Wright $5.00
Ten experts combine to explain the methods used by professionals in difficult situations where no supplementary lighting is used. Revised, second edition.

272 THE AMATEUR'S 8MM MOVIE GUIDE
by Sid Norinsky $1.95
A concise guide to planning, shooting and editing home movies. Learn about pan shots, angles, closeups, continuity.

672 IMPROVED 35MM TECHNIQUES
by Paul Jonas $1.95
How to avoid the usual pit falls and errors in 35mm photography. Good advice and concrete suggestions on specific situations.

228 EXPERIMENTAL AND TRICK PHOTOGRAPHY
by Paul Duckworth $1.95
Get "kookie" effects with simple house hold props and astound your friends.

256 COMPLETE GUIDE TO KODACHROME II
by Patricia Caulfield $1.95
How to get the most out of this new color film.

294 THE ABC'S OF LIGHTING
by Lou Jacobs, Jr. $2.50

Beginning or advanced amateur, you will find how to master all situations.

282 MANUAL OF DARKROOM PROCEDURES AND TECHNIQUES
by Paul Jonas $1.95
Get first-class results every time by following these time-tested methods of a working pro.

64 CLOSE-UP PHOTOGRAPHY WITH YOUR CAMERA
by Harold Martin $2.50
Shows how to get results with simple equipment from the first roll of film.

284 ZOOM LENS GUIDE
by Myron A. Matzkin $1.95
Examines zoom lenses for all cameras, movie and still. How they work, how and when to use them.

Camera Guides & Manuals

457	THE LEICA WAY	$6.90
194	MAMIYA C-2, C-3 CAMERA GUIDE	$1.95
613	MINOLTA MANUAL	$3.95
329	OFFICIAL NIKON F & NIKKOREX F MANUAL	$2.50
198	OLYMPUS CAMERA GUIDE	$1.95
189	CANON, CANONET, CANONFLEX MANUAL	$3.95
141	EXAKTA-EXA GUIDE	$1.95
281	KODAK AUTOMATIC CAMERA GUIDE	$1.95
201	VOIGTLANDER BESSAMATIC GUIDE	$1.95
238	YASHICA PENTAMATIC GUIDE	$1.95
614	HASSELBLAD PHOTOGRAPHY	$3.95
647	KONICA POCKET HANDBOOK	$3.50
74	LEICA MANUAL	$6.95
269	PENTAX AND SINGLE-LENS	$2.50

SCIENCE & MECHANICS BOOK LIBRARY, Dept. 697
P.O. Box 96, Madison Square Station
New York, N. Y., 10010 Amt. Enclosed $____

Kindly send me the books whose numbers I have circled below and for which I have enclosed the payment indicated above.

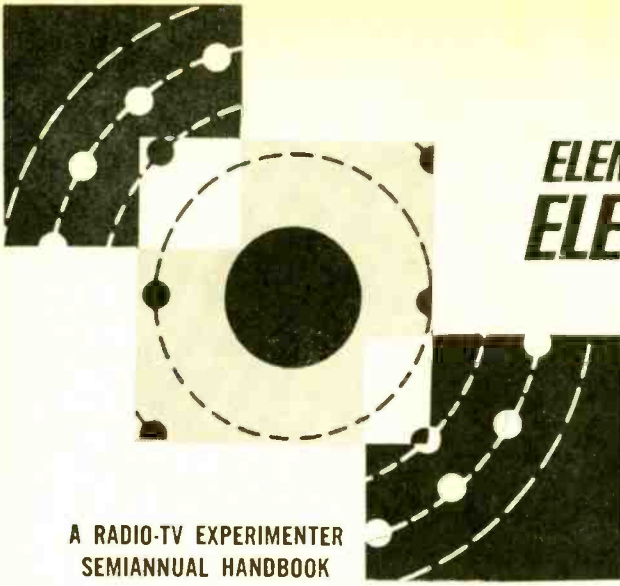
25 242 56 168 175 589 78 275 180 164 81 177 143 131
49 172 202 292 285 291 287 298 264 588 186 272 672
228 256 294 282 64 284 248 372 457 194 613 329 198
189 141 281 201 238 614 647 74 269

NAME ____________________
PLEASE PRINT

ADDRESS ____________________

CITY __________ STATE ______ ZIP # ______

New York City residents: Add 4% sales tax. All books will be sent postpaid. Money refunded if books are returned within ten days.



ELEMENTARY ELECTRONICS

A RADIO-TV EXPERIMENTER
SEMIANNUAL HANDBOOK

summer, 1964

29 working with electronic tools and parts

35 basic electricity

51 introduction to vacuum tube theory

59 dry cells and batteries

67 basic test equipment

77 getting started in amateur radio

87 getting started in CB radio

91 putting together a hi-fi system

101 how to service home entertainment equipment

109 construction projects

Elementary Electronics

No. 697 Summer 1964 Edition

Editor
JULIAN M. SIENKIEWICZ
WA2CQL, 2W5115

Art Editor
EUGENE F. LANDINO

Art Director
SID GREIFF

Associate Art Director
ANTHONY MACCARRONE

Art Associates
ALBERT DE QUERQUIS
GREGORY CHISLOVSKY

Editorial Production Manager
P. D. URBAIN

Production Assistants
BETTY SCHNEIDER
CAROL CRISERA
STEVE WEISMAN

Production Director
LEONARD F. PINTO

Assistant Advertising Director
JOHN McGUIRE

Advertising Production Manager
CARL BARTEE

Assistant Advertising Production Manager
RENEE BENNETT

Circulation Promotion Manager
STEWART S. JURIST

Cover Art Director
FRANK A. TAGGART

Managing Editor, S&M Handbooks
JOE DAFFRON

President and Publisher
B. G. DAVIS

Executive Vice President and Assistant Publisher
JOEL DAVIS

Vice President and Editorial Director
HERB LEAVY

ELEMENTARY ELECTRONICS (No. 697) is published by SCIENCE & MECHANICS PUBLISHING CO., a subsidiary of Davis Publications, Inc. Editorial, business and subscription offices: 505 Park Ave., New York, N. Y. 10022. Advertising offices: New York, 505 Park Ave., PL-2-6200; Chicago: 520 N. Michigan Ave., 527-0330; Los Angeles: 6363 Wilshire Blvd., 653-5037.

ask me another

By Leo G. Sands

Elementary Electronics brings the know-how of an electronics expert to its readers. *Leo G. Sands*, columnist for *Radio-TV Experimenter,* will be happy to answer your question. Just type or print your unsolved problem on the back of a 4¢ postal card and send it to "Ask Me Another," *Elementary Electronics*, 505 Park Avenue, New York, New York 10022. Leo will try to answer all your questions in the available space in up coming issues of *Radio-TV Experimenter* or a future edition of *Elementary Electronics*. Sorry, Leo will be unable to answer your questions by mail.

Question: I notice that most experts have a very high opinion of acoustic suspension speakers like the AR and KLH; but they sound dull and dry to me as compared with several others. I really favor another speaker but on the other hand I don't like to go against the judgment of so many people who ought to know. What do you say?

E. G., Aiken, S. C.

Answer: The obvious answer is to go ahead and buy the speaker you like and the devil take the experts; after all it's you, not they, who's going to be listening to it.

On the other hand, there is this to be said for the experts—a lot of the best things in life take getting used to—like very-dry, very-pale sherry, caviar, camembert cheese, yenidge tobacco, and black-eyed peas, not to mention snails, whether French or Chinese, and abstract art. The tastes of experts and connoisseurs are always more highly developed and sophisticated than those of the newcomer to any field. Specifically, in the case of speakers, the expert usually listens for sharp definition and the ability to reproduce the finest detail of music. The dullness and dryness you mention is evidence of a fine transient response which reveals the fine detail. On the other hand the brightness you like evidences some hangover which, though it may produce a livier, more reverberant and possibly even a more pleasant sound, tends to obscure the finer details of music.

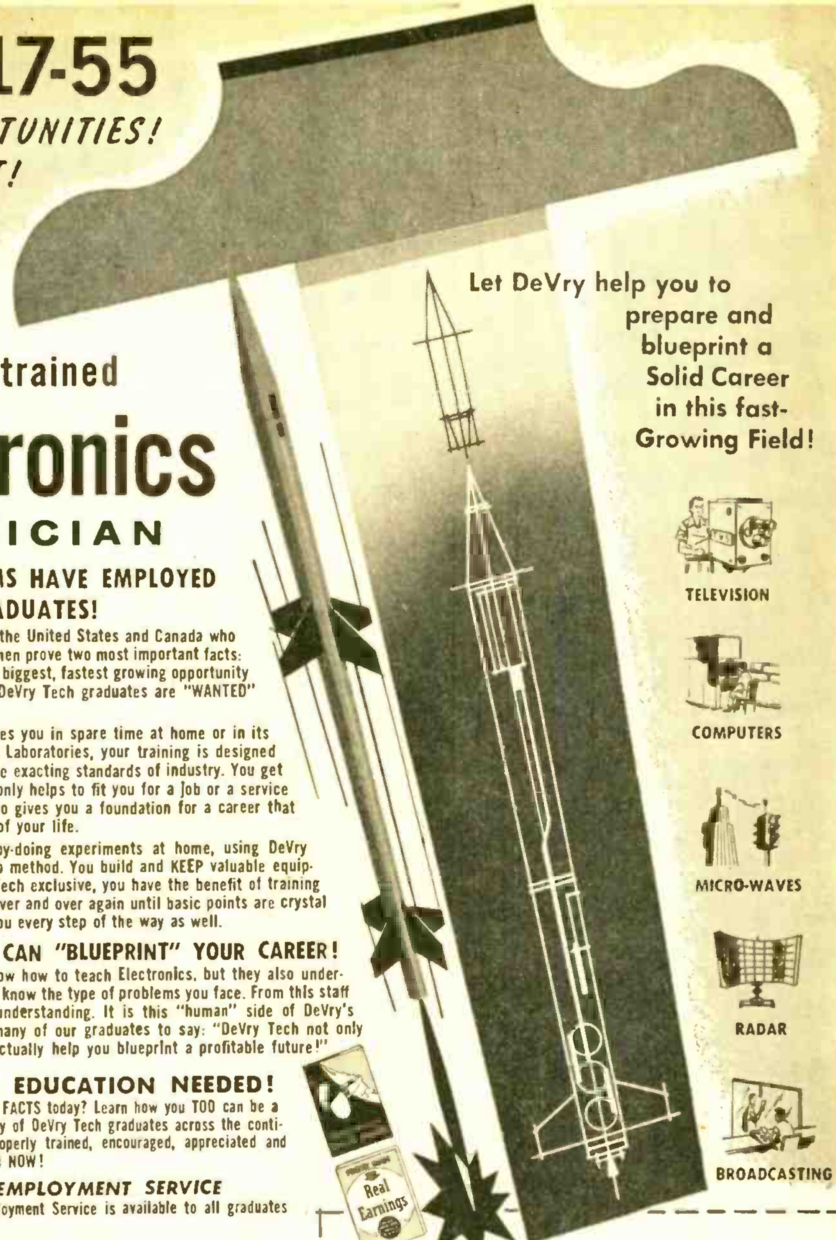
Men 17-55

JOB OPPORTUNITIES!
EXCITEMENT!
MONEY!

All this can be Yours as a trained

Electronics

TECHNICIAN



OVER 6,000 FIRMS HAVE EMPLOYED DeVRY TECH GRADUATES!

Thousands of companies in the United States and Canada who have employed DeVry Tech men prove two most important facts: (1) Electronics is one of the biggest, fastest growing opportunity fields of our time; and (2) DeVry Tech graduates are "WANTED" MEN.

Whether DeVry Tech prepares you in spare time at home or in its modern Chicago or Toronto Laboratories, your training is designed to get you ready to meet the exacting standards of industry. You get practical training that not only helps to fit you for a job or a service shop of your own — but also gives you a foundation for a career that can be profitable the rest of your life.

You work over 300 learn-by-doing experiments at home, using DeVry Tech's exclusive Electro-Lab method. You build and KEEP valuable equipment. With another DeVry Tech exclusive, you have the benefit of training movies that you can show over and over again until basic points are crystal clear. Special texts guide you every step of the way as well.

HOW DeVRY TECH CAN "BLUEPRINT" YOUR CAREER!

DeVry's faculty not only know how to teach Electronics, but they also understand men. They most likely know the type of problems you face. From this staff you get help, advice and understanding. It is this "human" side of DeVry's program that has caused many of our graduates to say: "DeVry Tech not only trains you for a job, they actually help you blueprint a profitable future!"

NO ADVANCED EDUCATION NEEDED!

Why don't you write for FREE FACTS today? Learn how you TOO can be a member of the great fraternity of DeVry Tech graduates across the continent . . . men who were properly trained, encouraged, appreciated and understood! SEND IN COUPON NOW!

EFFECTIVE EMPLOYMENT SERVICE

DeVry Tech's effective Employment Service is available to all graduates without additional cost.

2 FREE BOOKLETS! Send Coupon Today!

"One of North America's Foremost Electronics Training Centers"

DeVry TECHNICAL INSTITUTE

Accredited Member of National Home Study Council

CHICAGO • TORONTO

DeVRY TECHNICAL INSTITUTE
4141 Belmont Ave., Chicago, Ill. 60641, Dept. EE-1-U

Please give me your two free booklets, "Pocket Guide to Real Earnings" and "Electronics in Space Travel"; also include details on how to prepare for a career in Electronics. I am interested in the following opportunity fields (check one or more):

- ☐ Space & Missile Electronics
- ☐ Television and Radio
- ☐ Microwaves
- ☐ Radar
- ☐ Automation Electronics
- ☐ Communications
- ☐ Computers
- ☐ Broadcasting
- ☐ Industrial Electronics
- ☐ Electronic Control

Name________ Age____

Address________ Apt.____

City________ Zone____ State____

☐ Check here if you are under 16 years of age.

Canadian residents: Write DeVry Tech of Canada, Ltd.
2075-A 970 Lawrence Avenue West, Toronto 19, Ontario

BECOME A RADIO

Build 20 Radio and Electronic Circuits at Home

ALL GUARANTEED TO WORK!

YOU DON'T HAVE TO SPEND HUNDREDS OF DOLLARS FOR A RADIO COURSE

The "Edu-Kit" offers you an outstanding PRACTICAL HOME RADIO COURSE at a rock-bottom price. Our Kit is designed to train Radio & Electronics Technicians, making use of the most modern methods of home training. You will learn radio theory, construction practice and servicing. THIS IS A COMPLETE RADIO COURSE IN EVERY DETAIL.

You will learn how to build radios, using regular schematics; how to wire and solder in a professional manner; how to service radios. You will work with the standard type of punched metal chassis as well as the latest development of Printed Circuit chassis.

You will learn the basic principles of radio. You will construct, study and work with RF and AF amplifiers and oscillators, detectors, rectifiers, test equipment. You will learn and practice code, using the Progressive Code Oscillator. You will learn and practice trouble-shooting, using the Progressive Signal Tracer, Progressive Signal Injector, Progressive Dynamic Radio & Electronics Tester, Square Wave Generator and the accompanying instructional material.

You will receive training for the Novice, Technician and General Classes of F.C.C. Radio Amateur Licenses. You will build Receiver, Transmitter, Square Wave Generator, Code Oscillator, Signal Tracer and Signal Injector circuits, and learn how to operate them. You will receive an excellent background for television, Hi-Fi and Electronics.

Absolutely no previous knowledge of radio or science is required. The "Edu-Kit" is the product of many years of teaching and engineering experience. The "Edu-Kit" will provide you with a basic education in Electronics and Radio, worth many times the complete price of $26.95. The Signal Tracer alone is worth more than the price of the entire Kit.

THE KIT FOR EVERYONE

You do not need the slightest background in radio or science. Whether you are interested in Radio & Electronics because you want an interesting hobby, a well paying business or a job with a future, you will find the "Edu-Kit" a worth-while investment.

Many thousands of individuals of all ages and backgrounds have successfully used the "Edu-Kit" in more than 79 countries of the world. The "Edu-Kit" has been carefully designed, step by step, so that you cannot make a mistake. The "Edu-Kit" allows you to teach yourself at your own rate. No instructor is necessary.

PROGRESSIVE TEACHING METHOD

The Progressive Radio "Edu-Kit" is the foremost educational radio kit in the world, and is universally accepted as the standard in the field of electronics training. The "Edu-Kit" uses the modern educational principle of "Learn by Doing." Therefore you construct, learn schematics, study theory, practice trouble-shooting—all in a closely integrated program designed to provide an easily-learned, thorough and interesting background in radio.

You begin by examining the various radio parts of the "Edu-Kit." You then learn the function, theory and wiring of these parts. Then you build a simple radio. With this first set you will enjoy listening to regular broadcast stations, learn theory, practice testing and trouble-shooting. Then you build a more advanced radio, learn more advanced theory and techniques. Gradually, in a progressive manner, and at your own rate, you will find yourself constructing more advanced multi-tube radio circuits, and doing work like a professional Radio Technician.

Included in the "Edu-Kit" course are Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector circuits. These are not unprofessional "breadboard" experiments, but genuine radio circuits, constructed by means of professional wiring and soldering on metal chassis, plus, the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

THE "EDU-KIT" IS COMPLETE

You will receive all parts and instructions necessary to build 20 different radio and electronics circuits, each guaranteed to operate. Our Kits contain tubes, tube sockets, variable, electrolytic, mica, ceramic and paper dielectric condensers, resistors, tie strips, coils, hardware, tubing, punched metal chassis, Instruction Manuals, hook-up wire, solder, selenium rectifiers, volume controls and switches, etc.

In addition, you receive Printed Circuit materials, Including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code Instructions and the Progressive Code Oscillator, in addition to F.C.C.-type Questions and Answers for Radio Amateur License training. You will also receive lessons for servicing with the Progressive Signal Tracer and the Progressive Signal Injector, a High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club, Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep.

SERVICING LESSONS

You will learn trouble-shooting and servicing in a progressive manner. You will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn how to use the professional Signal Tracer, the unique Signal Injector and the dynamic Radio & Electronics Tester. While you are learning in this practical way, you will be able to do many a repair job for your friends and neighbors, and charge fees which will far exceed the price of the "Edu-Kit." Our Consultation Service will help you with any technical problems you may have.

J. Stataitis, of 25 Poplar Pl., Waterbury, Conn., writes: "I have repaired several sets for my friends, and made money. The "Edu-Kit" paid for itself, I was ready to spend $240 for a Course, but I found your ad and sent for your Kit."

FROM OUR MAIL BAG

Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is really swell, and finds the trouble, if there is any to be found."

PRINTED CIRCUITRY

At no increase in price, the "Edu-Kit" now induces Printed Circuitry. You build a Printed Circuit Signal Injector, a unique serving instrument that can detect many Radio and TV troubles. This revolutionary new technique of radio construction is now becoming popular in commercial radio and TV sets.

A Printed Circuit is a special insulated chassis on which has been deposited a conducting material which takes the place of wiring. The various parts are merely plugged in and soldered to terminals.

Printed Circuitry is the basis of modern Automation Electronics. A knowledge of this subject is a necessity today for anyone interested in Electronics.

NOW! TRAIN AT HOME IN RADIO AND ELECTRONICS

ORDER DIRECT FROM AD . . . . USE COUPON ON NEXT PAGE

USE COUPON ON NEXT PAGE

RECEIVE FREE BONUS RESISTOR AND CONDENSER KITS

TECHNICIAN *for only* $26.95

THE NEW IMPROVED DELUXE

Progressive Radio "Edu-Kit"®

is now ready

Reg. U.S. Pat. Off.

NOW INCLUDES

★ 12 RECEIVERS
★ 3 TRANSMITTERS
★ SQ. WAVE GENERATOR
★ AMPLIFIER
★ SIGNAL TRACER
★ SIGNAL INJECTOR
★ CODE OSCILLATOR

PRACTICAL HOME RADIO COURSE

only **$26.95**

SCHOOL INQUIRIES INVITED

Unconditional Money-Back Guarantee

The Progressive Radio "Edu-Kit" has been sold to many thousands of individuals, schools and organizations, public and private, throughout the world. It is recognized internationally as the ideal radio course.

By popular demand, the Progressive Radio "Edu-Kit" is now available in Spanish as well as English.

It is understood and agreed that should the Progressive Radio "Edu-Kit" be returned to Progressive "Edu-Kits" Inc. for any reason whatever, the purchase price will be refunded in full, without quibble or question, and without delay.

The high recognition which Progressive "Edu-Kits" Inc. has earned through its many years of service to the public is due to its unconditional insistence upon the maintenance of perfect engineering, the highest instructional standards, and 100% adherence to its Unconditional Money-Back Guarantee. As a result, we do not have a single dissatisfied customer throughout the entire world.

TRAINING ELECTRONICS TECHNICIANS SINCE 1946

FREE EXTRAS

- SET OF TOOLS
- SOLDERING IRON
- ELECTRONICS TESTER
- PLIERS-CUTTERS
- ALIGNMENT TOOL
- WRENCH SET
- VALUABLE DISCOUNT CARD
- CERTIFICATE OF MERIT
- TESTER INSTRUCTION MANUAL
- HIGH FIDELITY GUIDE • QUIZZES
- TELEVISION BOOK • RADIO TROUBLE-SHOOTING BOOK
- MEMBERSHIP IN RADIO-TV CLUB: CONSULTATION SERVICE • FCC AMATEUR LICENSE TRAINING
- PRINTED CIRCUITRY

You Will Find That The Progressive Radio "Edu-Kit" Is Perfect

• • • FOR anyone who wishes to learn more about radio construction, theory and servicing.
• • • FOR anyone who is looking for an interesting hobby.
• • • FOR anyone who would like to learn radio but does not have time to attend regular school hours.
• • • FOR anyone who wants to start studying for a high-paying radio job.
• • • FOR anyone who wishes to start in Television.

WORTH $7.00

☐ Send "Edu-Kit" postpaid. I enclose full payment of $26.95.
☐ Send "Edu-Kit" C.O.D. I will pay $26.95 plus postage.
☐ Rush me FREE descriptive literature concerning "Edu-Kit."

Name ....

Address ....

....

PROGRESSIVE "EDU-KITS" INC.
1186 Broadway, Dept. 502DJ, Hewlett, N. Y.

ask me another

Your choice should be based not so much on the word of experts or your own off-the-cuff judgment or preference, but on how you want to enjoy the music or sound that comes from the hi-fi. If you want the maximum detail, choose as the experts choose because that's their criterion; but if your interest in music is casual, or more emotional than analytical, choose the speaker that sounds best and produces the highest emotional appeal to you. But remember, you too may like caviar, camembert, or black-eyed peas if you permit yourself to acquire a taste for them.

Question: During a recent snow storm radio reception was interrupted by snow on the antenna, which caused the radio to sound like continuous bolts of lightning and it stopped when the snow stopped. Can you tell me why this occurred?

JS, Albion, Mich.

Answer: This phenomenon is a case of *precipitation static*. It also occurs sometimes during a rain storm. Apparently the flakes of snow or drops of rain originate in a cloud heavily charged with static electricity and carry a considerable charge with them. When the snow flakes or rain drops reach an antenna system that is grounded, the charge is discharged through a short arc between flake and antenna. Thus hundreds of miniature *lightning bolts* occur and produce the interference you noted.

Question: What are the highest paid jobs in the field of electronics?

JW, Woodbury, Conn.

Answer: The Chief Engineer of a sizeable electronic company can command between $15,000 and 25,000. Graduate engineers of proven ability can expect to earn $12,000 to 15,000. Technicians without engineering degrees but outstanding ability can earn as much as $10,000 to 12,000.

Question: I'm getting severe interference in my shortwave radio from fluorescent light —at least, the interference stops when I put the light out. Can I do something about this?

RS, Hamburg, N. Y.

Answer: The simplest and most effective solution is to keep the fluorescent lights off when you're doing serious listening on the radio. While it is possible to "filter" out this type of interference, it can be very stubborn and may require pretty elaborate measures, and may not be fully effective even then.

Question: What is a "trap antenna" and how does it work?

EK, Wichita, Kansas

Answer: Antennas are most efficient when they are resonant at the operating frequency. A dipole, for example, is several times more efficient at the frequency at which its length is equal to a half-wavelength, than at other frequencies. If we want to have equal efficiency at several different frequencies we really need to have several dipoles of different lengths; and, in the past, it was common to combine two dipoles of different lengths to make a "double doublet" or several dipoles to make a "multiple dipole" or "spiderweb" antenna.

A few years ago a clever method was developed by which a single dipole antenna could, in effect, look like two or more dipoles of different length to incoming signals. For example, in Fig. 1 we have in a dipole about 75 feet long tuned to the 6 mc. or 49-meter short-wave band. We would like to cover the 9.5 mc. or 31-meter band. This would take a dipole about 48 feet long. We

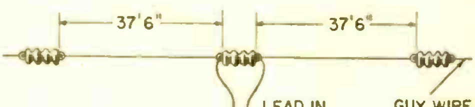


Fig. 1

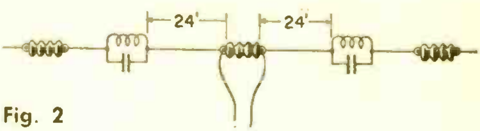
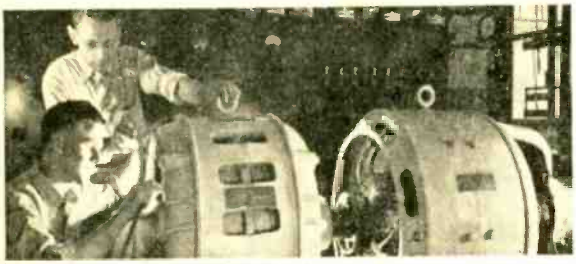


Fig. 2

can make the 75-foot dipole look like 48 feet to a 9.5 signal by cutting it at points 24 feet on each side of center and inserting parallel tuned coil-capacitor tanks tuned to resonance at 9.5 mc. at these points, as is shown in Fig. 2. A parallel-tuned circuit presents an extremely high impedance to any signal whose frequency is the same as the resonant frequency of the tuned circuit. In fact, the tuned circuit or "trap" looks very much like an insulator at 9.5 mc., and hence the antenna seems only 48 ft. long and is therefore resonant at 9.5 mc. The trap is virtually a short circuit at 6 mc. and therefore does not affect the performance in the 49-meter band. We can shorten the antenna

Learn ELECTRONICS in Classrooms and Labs of COYNE ELECTRONICS INSTITUTE

PARTICIPATING RESEARCH SCHOOL



ELECTRICITY·ELECTRONICS: Motors, Generators, Computer Circuitry, Appliances, Automatic Electronic Control Units, Refrigeration and Air Conditioning.

TELEVISION·ELECTRONICS: TV Receivers—Black and White and Color AM-FM and Auto Radios, Transistors, Printed Circuits Test Equipment, Closed Circuit TV.

Now is the time to train for a top-pay job in electronics. When you train at Coyne, you work on the same type of equipment you will work on outside in industry. You will be getting your training at one of the largest and best equipped schools in the country. During the past 65 years, we have put thousands of ambitious men on the road to security and personal independence in the fast-growing field of Electronics. No previous experience needed. No advanced education required.

START NOW—PAY LATER. Liberal Finance and Payment Plans. Part-time employment help for students. Mail coupon now for FREE copy of "Your Opportunities in Electronics." *No salesman will visit.* Send coupon, postcard or letter right away . . . before you forget.

MAIL COUPON OR WRITE TO ADDRESS BELOW

COYNE ELECTRONICS INSTITUTE*
Dept. 84-W
1501 W. Congress Pkwy., Chicago, Ill. 60607

Name ____________
Address ____________
City ____________ State ____________
Age ____________ Phone ____________

*Chartered as an Educational Institution Not for Profit

COYNE offers LOW COST TELEVISION RADIO - COLOR TV Training in Spare Time AT HOME

—*PLUS* Two Weeks Personal Training in our Chicago Shop-Labs—FREE of any extra Tuition!

Coyne—and only Coyne—can make you such a sensational offer. No increase in cost of home training, but as soon as you graduate you are qualified to spend two weeks in Chicago, working on actual projects, getting personal instruction—without one cent of extra tuition. Like getting a post-graduate course free. This offer may be withdrawn at any time, but those who inquire about Coyne's home training now will be guaranteed two weeks of shop training at Coyne's expense for resident tuition. Send name for FREE BOOK.

Now, you can quit *wishing* you had a profitable Radio-TV Service Business of your own. Now, you can quit *dreaming* about a big pay job in Television—and *do something* to make your dreams come true. Start your basic training at home in spare time. We train you to do the work, *and* show you how to get the work to do —even while you are learning. No costly "put together" kits to pay for. Lowest tuition—low monthly payments. Free employment service to graduates. Send name for all facts. No salesman will call.

Founded 1899

The largest, oldest, best equipped resident school of its kind.

COYNE ELECTRONICS INSTITUTE

Chartered as an Educational Institution Not For Profit
1501 West Congress Parkway, Dept. B4-H4 Chicago 60607

Send Name for FREE BOOK. No salesman will call

COYNE ELECTRONICS INSTITUTE
HOME TRAINING DIVISION, Dept. B4-H4
1501 W. Congress, Chicago 60607

Please mail free book and offer of two weeks personal training in Chicago without extra tuition for home study graduates. Explain low monthly payments.

Name ____________
Address ____________
City & State ____________

to around 31 feet to make it resonant in the 19-meter band by inserting another pair of traps resonant at 19-meters about 15.5 ft. on each side of the dipole center; and additional traps can be inserted at other intervals to cover any desired combination of bands.

Because they reduce the number of antennas needed, trap antennas have become very popular in amateur radio. Even Yagi beam antennas have been adapted for two or three band service by the use of "traps." Trap antennas are available also to cover the various short-wave broadcast bands. While trap antennas are not quite as good as individual antennas would be, they do provide high efficiency economically.

Question: Are the surplus crystals that sell for 50 cents any good?

JE, Perry, Okla.

Answer: I have bought dozens and found them all active. If the frequency is useful to you, or you can grind or etch them, to a useful frequency, they are a good buy.

Question: Most of the radio stations in Cleveland have their transmitters from 3 to 6 miles from my home, and they come in so powerfully and so broadly on my 11-transistor Japanese radio that it is next to impossible to hear out of town stations. My radio dealer tells me that the only sure way of getting other stations is to move to some town farther away from the transmitters. Have you any idea what I can do without moving?

RJG, Parma, Ohio.

Answer: He's right about moving being the only *sure* way, especially if you're determined to keep the transistor radio. Close proximity to high powered transmitters raises problems with any receiver, but transistor types usually are much more troubled than old-fashioned tube types. On the other hand, the 5-tube AC-DC type radio isn't likely to improve matters much. The only hope I can offer is to try a first class general coverage communications receiver by Hammarlung, Hallicrafters or National. Some of the older models, 5, 10 or 15 years old can be bought for between 50 and 100 dollars *reconditioned* from distributors who specialize in selling amateur equipment.

Question: How can I change a broadcast-band radio so it will tune to 500 kc.?

CY, Huntington, W. Va.

Answer: Most BC radios can be moved down to 500 kc. by adding between 50 and 75 pf of capacitance across the RF and oscillator tuning capacitors. The inexpensive 5 to 80 pf mica compression trimmers will do the job. Of course this will mess up the tuning and calibration, and cut out some stations on the high end of the band. A neater way would be to use a simple transistor converter like the one I described in the Winter issue of RADIO-TV EXPERIMENTER on page 31. One of the very inexpensive BC604 crystals in the range between 370 and 450 kc. could be used. Pick a spot between 870 and 950 kc. where there is no broadcast station, choose a crystal whose frequency when added to 500 comes close to this.

Question: Some FM stations we receive come in sharp and clear but some come in with considerable distortion. My serviceman says it is the fault of the station; but when I called up the station they said it was the fault of my tuner. Which is it and what can I do about it?

L.D.M., Chicago, Ill.

Answer: Probably both. In FM broadcasting the higher the modulation (or loudness) the greater the deviation and hence the greater the bandwidth of the transmitted signal. If the receiver has a wide enough bandpass to accept the wide deviation, there will be no distortion; but if the receiver bandpass is narrower than the deviation of the signal, there will be distortion.

A deviation of 75 kc. is allowed for FM broadcasting. Theoretically, the receiver should have a bandpass of 250 kc. to receive a fully modulated monophonic signal and more for a stereo signal. Few tuners have that wide a bandpass because it is difficult to achieve it and at the same time obtain enough sensitivity and selectivity. Ordinarily a bandpass of 175 to 200 kc. is wide enough to provide an acceptably low level of distortion because in the case of most stations, particularly those transmitting "good music" type programs, the maximum deviation occurs only on occasional peaks and at the very highest frequencies only.

However, some stations, especially those broadcasting pop type programs tend to push their modulation very close to the limit a very high percentage of the time by

ask me another

the use of compression and limiting amplifiers. Hence, their *average* modulation level tends to approach the maximum permissible level and when the signal is received on the typical tuner the result is *distortion*. Instead of occurring merely on occasional momentary peaks, distortion now occurs a very considerable percentage of the time and is, of course, very noticeable.

There are tuners capable of handling this extreme type of modulation with a minimum of distortion—notably the *Dynatuner*, the *Knight* and *Sherwood* tuners with "dynamic sideband regulation." Actually, however, it is very probable that even with these tuners the reception will be distorted because many of the pop records played by these stations have inherently high distortion, and compression and limiting are accompanied by a certain amount of distortion. The best solution to the problem, then, is simply to tune right past such stations and listen only to those adhering to some approximation of high fidelity standards.

Question: I am not happy with the reception we are getting of multiplex stereo programs. I notice that when the station plays the same stereo records that I have in my collection, the separation and quality are much inferior than what I get when I play it on my hi-fi system. I have tried several tuners but none of them solves the problem. What can I do?
C.R., Toledo, Ohio

Answer: Wait patiently and when you want the best stereo, use your own records.

Your experience is being duplicated all over the country. The trouble is that many stations have not yet solved all the problems of stereo transmission. The MX system of stereo depends vitally on maintaining the original phase relationships between the two channels of a stereo program. Unfortunately, until MX arrived nobody paid any particular attention to the phase characteristics of audio equipment. Hence, some of the audio equipment used by broadcast stations, which was perfectly satisfactory for monophonic programs, presents problems in stereo programs. Also, until MX arrived recordings were cut and edited without considering phase relationships and hence possess phase differences which seriously degrade separation when they are broadcast even by a perfectly adjusted transmitter and received on a perfect tuner.

These things are being corrected and, as you have no doubt noted, some broadcast stereo programs are very good indeed and the general run of them is improving.

Nevertheless, it will probably remain true that you can get better stereo reproduction on your own hi-fi system than over the radio. First, few stations use record play-back equipment as good as that used in good hi-fi installations, largely because it is too delicate and critical. Secondly, when you play records directly you eliminate the distortion, however slight it may be, which occurs in the extra steps involved in passing the program through the transmitter, over the air, and through your tuner.

Question: I have just bought an expensive new pick-up that is supposed to operate at ¼ of a gram; but it just don't do it. It keeps skipping and jumping, and on most records the distortion is high. Have I bought a dud?
I.N.F. Dallas, Texas

Answer: There are pickups, including the one you bought, which are capable of operating satisfactorily at ¼ gram of pressure *on some records and when installed in certain, properly adjusted arms on turntables immune to external shock.*

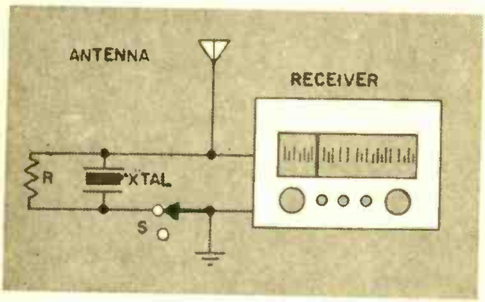
The fact that yours is skipping indicates that the tone arm you are using is either not suitable or not properly adjusted; or that the turntable is sensitive to external shock. It doesn't take much of a shock to lift a stylus with ¼ ounce of pressure right out of the groove. In fact, a footstep can do it at 1 gram stylus pressure. Most turntables were designed for pressures of 2 grams or more. There are a few new ones, among them the *AR* and the new *Empire* with floating suspension, that will permit stable operation with very low pressures, because they are quite immune to external shock or vibration. Similarly, only the latest type of elaborately balanced, low-friction arms will permit operation at pressures less than 1 gram. It looks like you're not giving the pickup a square deal in these respects.

Question: I want to listen to a station on 1500 kc., 300 miles away; but a local station on 1520 kc., causes too much interference. What can I do to eliminate the interference?
GAS, Cranford, N.J.

Answer: The simplest and least expensive

ask me another

way to handle this problem is to obtain a transmitting type crystal cut for 1520 kc., and connect it as indicated below, with a switch so you can cut it out of the circuit when you want to listen to the local station. Suitable crystals can be bought surplus for as little as one dollar, or for between $3.00 and $5.00 from Texas Crystal Co. and other crystal manufacturers. A tolerance of .05 percent is good enough. If you still have interference from the sidebands, try resistors across the crystal from 50 ohms up; use the highest value that will do the job.



Question: I note that the transmission of music by amateurs is banned. Why?
ADC, Los Angeles, Calif.

Answer: Once upon a time amateurs were permitted to test with music; but as so often happens the privilege was abused and tests became broadcasts. The FCC then banned musical transmission.

It makes sense. No really useful purpose is served in amateur service by transmitting music and unless the bandwidth of the transmitter is carefully limited to 3 kc., music can produce sidebands 10 kc. or more from the carrier and thus cause a great deal of interference. On the other hand if the bandwidth is limited to 3 kc. music is scarcely worth listening to.

Question: Can you give me the titles of some books on fundamentals of radio and electronics that are really simple to understand?
LJ, Bryan, Ohio

Answer: We think one of the best is our own ELEMENTARY ELECTRONICS. The 1964 edition should be obtainable on your newsstand for only 75¢. We can also recommend the following:

Getting Started in Electronics
Allied Radio Corp. #37K705 50¢
Understanding Amateur Radio
American Radio Relay League 2.00
ABC's of Electronics
Howard W. Sams Co. 1.95

After a few bites of the above you should be able to make sense out of:

Radio Amateur's Handbook
American Radio Relay League 3.00

In each and every issue of RADIO-TV EXPERIMENTER there is an interesting column called *Bookshelf* that highlights the best in hard and soft cover books. The column's author, *Bookworm*, reviews both new and old texts that are rated the best in their areas.

Your local library undoubtedly has others that will serve the need. Why not visit it and look over the shelf on radio and electronics and pick one that seems right for you.

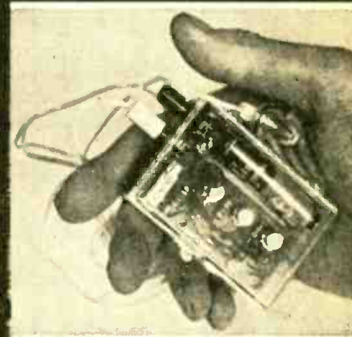
Question: I read somewhere that experiments have shown that the average person can't hear distortion of less than 1%. If that is so why do we have to have distortion as low as .1% in hi-fi amplifiers? A.D.C., Passaic, N.J.

Answer: Research also shows that the average American male wears a size 40 suit and the average American female a size 14 dress. But a size 40 suits fits me like a circus tent fits a Philadelphia lot and a size 14 dress fits my wife—well, let's not get into that. How would this average size fit you and your wife?

The "average persons" in statistics are always a minority. Anytime you have an average figure, it must be true by statistical mathematics that there are as many people above the average as there are below the average. So the experiment you cite also proves that a lot of people hear distortion a good deal less than 1%; in fact, it probably proves that there are just as many people who can hear distortion smaller than 1% as there are people who can discern distortion only if it is more than 1%.

High fidelity is not designed for the average person or the average ear. The finest amplifiers are designed to have distortion so low that it will be below the hearing ability of even the most acute ear. The high fidelity industry leaves the satisfaction of that very tolerant average person to the package industry which apparently has never heard of

Anyone Can Build These High Quality
Precision S&M Kits
At a Substantial Savings



Precision Decade Resistance Box

Designed so the electronic experimenter can get any value of resistance at 1% accuracy. Made of precision components, this decade box offers such advantages as fast fingertip switching from any resistance value from 1 ohm to 1,111,110 ohms within seconds. Add or subtract as little as 1 ohm with 1% accuracy. And ordinary hand tools are all that's needed to assemble it in less than 2 hours.

All Purpose Shop Tachometer

This tachometer is guaranteed to outperform any $50 tach available today or your money will be refunded. This tach belongs in the tool chest of every machinist, electrician, model maker, motor serviceman and inventor. A six position rotary switch enables you to select three speed ranges in either forward or reverse rotation. Three ranges—0—500, 5000 and 15,000—cover the gamut of rpms in the home workshop or laboratory on machine tools, such as lathe cutting speeds, motor rpm, drilling speeds and other motor driven tools where rpm is an important factor.

Pocket-Size Hearing Aid

New hearing aid design provides a minimum of 42 decibels of gain and is adequate for 75% of all cases of partial deafness. The aid weighs only three ounces and is smaller than a king-size cigarette pack. Uses latest electromagnetic earphone and miniature crystal microphone. Powered by a 10¢ pen light flashlight battery and has a switch for turning power off when not in use and a control that lets you adjust the volume to a comfortable sound level.

SCIENCE & MECHANICS, KIT DIVISION 108
505 Park Avenue, New York, N. Y. 10022

Please send the S&M kits that have complete asssembly plans, or the assembled and fully tested electronic aids checked below. I understand that if I am not completely satisfied I may return the kits within 10 days for a complete refund of the purchase price.

Hearing Aid	☐ $24.95 Kit	☐ $34.95 Assembled
Tachometer	☐ $16.95 Kit	☐ $21.95 Assembled
Decade Box	☐ $24.95 Kit	☐ $29.95 Assembled

Add 10% for Canadian and Foreign orders. New York City residents add 4% for N.Y.C. sales tax.

NAME ______________________________
(Please Print)

ADDRESS ______________________________

CITY ______________ STATE ______________ ZIP CODE ______________

☐ Check or money order enclosed, ship post paid.

☐ Enclosed $3.00 deposit, ship balance C.O.D., plus postage and C.O.D. charges.

the research you mention because it still permits an amplifier with 5 per cent distortion to be called "undistorted."

Question: Exactly what causes an FM tuner to distort the signal of some stations. None of the books I consulted could specifically answer the question?

SRW, Los Gatos, Calif.

Answer: In FM transmission the higher the modulation level the wider the bandwidth of the transmitted signal. If the tuner has a wide enough bandpass to accept the wide deviation there is no distortion; but if the tuner bandpass is narrower than the deviation of the signal, there will be distortion.

A deviation of 75 kc. is allowed for FM broadcasting. Theoretically, a receiver needs a bandpass of around 240 kc. to pass a fully modulated signal without distortion. Very few tuners do; most have a bandpass between 150 and 200 kc. This is usually sufficient because the maximum deviation occurs usually on occasional peaks and at the very highest frequencies only.

But some stations use a lot of compression or limiting, so that their *average* modulation tends to approach the maximum permissible level. The result is that the distortion occurs a considerable percentage of time, instead of only occasionally, and is of course very noticeable.

Question: I notice that most experts have a very high opinion of acoustic suspension speakers like the AR and KLH; but they sound dull and dry to me as compared with several others. I really favor another speaker but on the other hand I don't like to go against the judgment of so many people who ought to know. What do you say?

E.G., Aiken, S.C.

Answer: The obvious answer is to go ahead and buy the speaker you like and the devil take the experts; after all it's you, not they, who's going to be listening to it.

On the other hand, there is this to be said for the experts—a lot of the best things in life take getting used to—like very-dry, very-pale sherry, caviar, camembert cheese, yenidge tobacco, and black-eyed peas, not to mention snails, whether French or Chinese, and abstract art. The tastes of experts and connoisseurs are always more highly developed and sophisticated than those of the newcomer to any field. Specifically, in the case of speakers, the expert usually listens for sharp definition and the ability to reproduce the finest detail of music. The dullness and dryness you mention is evidence of a fine transient response which reveals the fine detail. On the other hand the brightness you like evidences some hangover which, though it may produce a liver, more reverberant and possibly even a more pleasant sound, tends to obscure the finer details of music and sound.

Your choice should be based not so much on the word of experts or your own off-the-cuff judgment or preference, but on how you want to enjoy the music or sound that comes from the hi-fi. If you want the maximum detail, choose as the experts choose because that's their criterion; but if your interest in music is casual, or more emotional than analytical, choose the speaker that sounds best and produces the highest emotional appeal to you. But remember, you too may like caviar, camembert, or black-eyed peas if you permit yourself to acquire a taste for them.

Question: I have my FM tuner and TV connected to the same antenna with a two-set coupler. This works fine except that when I tune the FM to a station on 94.9 mc, I get serious interference on TV channel 13. What causes this and what can I do about it?

EP, Winslow, Maine

Answer: When your FM is tuned to 94.9 mc, the local oscillator is operating at 105.6. The second harmonic, 211.2 is smack in Channel 13. Hence, the interference.

You could make a harmonic filter and install it between tuner and coupler but actually the sensible solution is not to use the FM when you're looking at Channel 13. Or else, listen to FM stations above about 100 mc so the second harmonic falls outside channel 13.

Question: What's the difference between IHFM Music Power and sine-wave power and how are they related?

L.P., Brooklyn, N.Y.

Answer: It is often the difference between good and superb amplifiers but the relationship is usually purely coincidental.

The IHFM Music Power rating is one of the most remarkable measurements of anything that human ingenuity has involved and one of the most meaningless. Its principal purpose is to make the lowest category of amplifiers look more respectable to the uninformed purchaser.

It is supposed to be the power output an amplifier will deliver on musical waveforms; and if there were some really valid way of measuring this it would be a good idea. But the means of measuring it are just about as indirect as making love by mail and just about as good a substitute for the genuine article. To measure an amplifier's music power they replace the power supply you get when you buy the amplifier, with an "ideal" power supply and then measure the power output with sine waves. This curious measurement is justified by the assumption first, that hi-fi amplifiers are called upon to deliver maximum power only during peaks of very short duration; and secondly, that a practical, imperfect power supply can deliver the same power for a short peak as the same amplifier will deliver continuously with a perfect power supply.

The assumptions are by no means completely valid; but even if they were the resulting rating doesn't offer much guidance and can be quite deceiving because it makes a poor amplifier look much better than it is and a good amplifier little of any better than it is.

It is almost as if we measured the power of automobiles by replacing the motor that we are going to buy, with another more ideal motor. With this procedure the *Falcon* would enjoy a much greater improvement in rating than a *Jaguar* or *Ferrari* which already have nearly ideal motors. The music power output of a poor amplifier may be twice as high as its continuous sine wave power output; on the other hand in the case of the superb amplifier there may be little if any difference. Hence, two amplifiers with the same music power output may have a difference as great as 50 per cent in their continuous sine-wave power output.

The music power measurement actually measures the quality of the power supply in an amplifier, rather than the performance of the amplifier itself. It is really significant only if the music power output is compared with the continuous sine-wave power output —the smaller the difference the better the power supply and the better the power supply, in most cases, the better the amplifier it powers.

Actually the best measure of amplifier performance is the sine wave power output over the entire audio range from 20 to 20,000 cycles. Since the manufacturer of fine amplifiers gains little or nothing from the use of "music power output" ratings he usually rates his amplifier in terms of power output over the entire audio range; or at least gives both the music power and sine wave power output.

The only thing safe to assume in this curious business is that the amplifier that is rated *only* in terms of music power output has nothing to brag about in terms of sine-wave power output.

Question: I plan to take two Edu-Kit courses. Both of these include a broadcast receiver and transmitter. I wonder if the transmitters would be of good enough quality to use in Novice amateur operation? After I get my General license I would naturally go to better equipment.

TB, Evansville, Ind.

Answer: The courses are excellent ways to learn about radio. However, the transmitters would not be suitable for amateur operation although they will teach you a good deal about transmitters. By all means take the courses, but figure on buying more suitable equipment for actual use on the ham bands.

Question: When I increase the volume of my hi-fi system after a certain point the sound is all cut-up and the loudspeakers kind of burble. What's wrong?

T.C.K., Clearwater, Fla.

Answer: Almost certainly your system is suffering from acoustic feedback. The bass output of the speakers—probably the rumble of your changer—is vibrating the changer which in turn is feeding the vibration into the amplifiers through the pick-up and as a result the system is oscillating at a very low frequency.

The probability is that you're trying to get too much bass boost. If you have the loudness control or switch in the ON position, turn it to the OFF position. If you have the bass control in the boost position, turn it to the neutral position.

You can minimize the occurrence of acoustic feedback by putting a foam rubber pad under the turntable or changer. The type you buy to put under a typewriter is usually just the right size. You can also put foam rubber pads under the speakers. The self-adhering foam rubber weatherstripping you can buy at auto supply stores is ideal. Cut strips of it and attach to the speakers so the foam rubber is between speaker and floor or shelf.

Another solution would be to get rid of your present changer or turntable and replace it with an AR which is virtually immune to acoustic feedback.

Of course, if you have a one-package deal in which the speakers and changer are mounted in the same cabinet there is nothing much you can do except keep the volume low and the bass down.

Question: Is it possible to obtain a schematic diagram of electronic equipment by sending a patent number to the patent office? If this is not a practical way of obtaining schematics is there a way of getting them other than waiting for a magazine to publish them?

RJH, Lincoln, Nebr.

Answer: Electronic patents do include schematics of the specific circuit patented. However, this is not a practical way of obtaining schematics for a specific radio, TV, or other gadget. First, the schematics are usually very generalized and sometimes in block form and would require considerable engineering knowledge to adapt to useful form. Secondly, the patent is always for one specific portion of piece of equipment, and even if you got all of the dozen or more patents covering a piece of gear, you wouldn't have anything useful.

The manufacturer of a radio, TV or test instruments will usually supply a schematic or service manual for a small charge or none at all. Service manuals of TVs, radios, phonographs, hi-fi amplifiers, etc., can also be obtained from Howard W. Sams & Co. Inc. 4300 W. 62nd St., Indianapolis, Ind. for $2.25 a set. Schematics of older radios can be obtained from Rider Manuals and most city libraries have complete sets of these which you can consult.

Question: Something is wrong with my transistorized amplifier; but my serviceman won't touch it. And he says he wouldn't let any other serviceman touch it and I should send it back to the factory. I'm doing that but I don't understand why I have to. It might be something simple.

P.U.M., Des Moines, Iowa

Answer: Yes, and it might be very simple for a serviceman to compound your troubles by blowing out several transistors in the course of trying to find out what the trouble is.

Transistors cannot be serviced or tested safely with the ordinary type of equipment used for tube amplifiers, TV's and radios. Putting the probe of an ohmmeter on a VTVM at the wrong spot could destroy a transistor or two. There are special instruments for safely trouble shooting transistor gadgets such as computers: but these run into hundreds of dollars and it is doubtful that one serviceman in a million owns one.

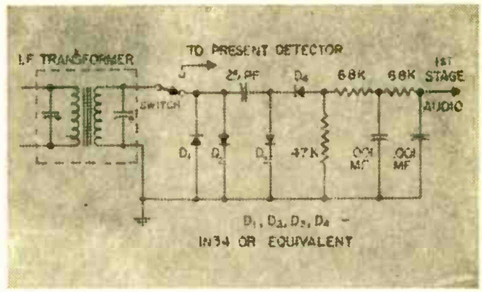
This is one disadvantage of transistorized hi-fi units at present. As they come into greater use manufacturers undoubtedly will develop methods and instruments for trouble shooting and adjustment that are relatively fool-proof. But as things stand only the manufacturer of the specific devise is certain to have the knowledge and the facilities for servicing the thing with minimum risk.

Our condolences on your troubles; but congratulations on having a *wise* and *honest* serviceman.

Question: I added the converter you described some time ago to my broadcast receiver and it works fine. Can you give me the circuit for an FM detector I can add to it now?

FF, Ontario, Canada

Answer: The simple circuit diagrammed below will operate with I.F. between 125 and 500 kc. It should be switched into the circuit in place of the present diode detector.



However, assuming you use it with a broadcast or communications receiver, it will only detect narrow-band FM such as is permissible but seldom used on the ham bands; and possibly that used in the 30-40 mc emer-

ask me another

gency services band. It will not provide reception of stations on the FM broadcast band which require a bandpass at least 150 kc. wide. But it is a very convenient, simple and inexpensive way to add capability of receiving FM to an amateur receiver. For FM reception disable the AVC and run the R.F. gain up as high as possible.

Question: Some of my older records have got a lot of static on them and wiping them with a "jocky cloth" doesn't seem to do much good. What can I do to get rid of the pops and crackles. D.B., Rye, N.Y.

Answer: Take your discs into the kitchen. Dissolve a couple of pinches of detergent in a clean basin full of tap water. Immerse the record in this and if it is dirty and has fingerprints on it, wipe gently in a rotary motion along the grooves with a soft cloth. Rinse the record with a gentle stream of clean water from the faucet; dry it with a very soft cloth or a chamois: touch the record to the faucet to remove any static charge buildup; and then try it. This will often do the trick when nothing else will.

Question: If one does not understand the language spoken by a foreign station, what data should one take down to prove reception when sending for a QSL card?

EJR, Philadelphia, Pa.

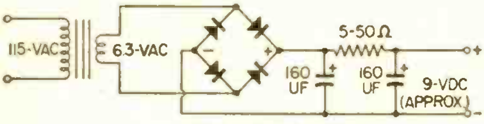
Answer: Note the exact time in Greenwich Mean Time. State whether voice or music, and if voice, whether male or female; if music, give general description—like brass band, symphony, guitar, etc. . . . Give the station frequency as near as you can and the quality of reception. Add any other information that you may understand or deduce. ■

Question: How can I turn a plain 6.3-volt filament transformer with no center tap into a filtered 6 volts for operating my transistor radio?

RK, Montreal, Canada

Answer: Try the circuit below. Since your radio draws only a fraction of an amp., the inexpensive top-hat rectifiers will do. Lafayette offers four 750 mil., 100 PIV diodes for 89c (Lafayette Part No. SP-276). You can use the miniature electrolytic condensers rate at

160 mfd; 15 WVDC, or for better filtering a 2000 mfd., 15 WVDC, following the resistor. The output voltage will depend on the resistor. It will run about 9 volts without a resistor; this would replace the typical 9 volt battery. If you need 6 volts try resistors in the 5 to 50 ohm range. The resistance will depend on the current drawn by the radio.



Question: How can I convert a Knight-Kit transistor to the broadcast band for use in a "carrier-current" radio station, and how would I couple it to the power line?

BG, Cincinnati, Ohio

Answer: It can be done but first, it would take a pretty long article to tell you how and second, unless precautions are observed you might easily run afoul of the Federal Communications Commission and become a candidate for one of those nice stiff fines they are imposing. My suggestion is that you go to your library and obtain a copy of the Radio Amateur's Handbook for 1944—the 21st edition. This has an entire chapter on this subject of carrier current communication. And if you enjoy assembling kits, many of the major kit manufacturers carry power line intercoms in their kit line.

Question: I overheard someone say that with a simple revision on a transistor pocket radio it can be turned into a broadcast band "walkie talkie." How can I do this?

AWB, Providence, R.I.

Answer: Get hold of the guy and ask him to give you the secret; and if he'll write it up the chances are the RADIO-TV EXPERIMENTER would be interested in publishing it and paying him for it.

Yes, this could be done but the only way I can think of it would require quite a bit of rewiring and reconnecting which is far from simple, especially considering the miniature size of a transistor pocket radio.

Keep in mind that there are some FCC regulations on radio equipment of this type. Best thing to do is check into Part 15 of the FCC regulations before any soldering is started.

Question: How long should a short-wave antenna be? How long should an antenna be

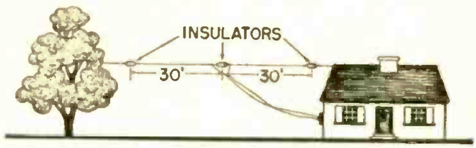
ask me another

for DX on broadcast band? What commercial wire is best and most economical for this purpose?

FJC, San Francisco, Calif.

Answer: It isn't that simple but we'll try to give a simple answer. The modern receiver is so sensitive that it does not need an elaborate antenna. Much more important is favoring the pick-up of signal over the pick-up of noise, especially man-made electrical noise. A simple antenna that will give good results consists of two pieces of 30-foot wire fed at the center with twisted pair wire, as diagrammed below. The antenna should be located where noise pick-up would be low—away from power and telephone lines, transformers, and house wiring. It is best not to put it over the roof of a house because usually there is a lot of electric wiring in the ceiling of a home which can transfer noise to antenna. Stretching from your house to a garage, tree, or pole is better. You can buy kits for this kind of antenna for between $2 and $5.

To give more uniform results over entire short-wave spectrum there are antennas which have two or three or more dipoles like the above—or a single long dipole with tuned traps which is equivalent to several dipoles. Hy-Gain and Mosley offer multiple trap antennas for about $15.



The simplest antenna for broadcast band reception is simply a 50-foot piece of wire run from the receiver, out a window, to any convenient tall support. It will not have the interference rejection of the di-poles fed with the twisted pair line, but in a quiet location it will do a good job with a good receiver. And if you are on a budget, this long-wire antenna can also serve for short-wave reception.

As for wire, insulated hook-up wire will do for the last type of antenna. No. 7 x 24 braided copper wire has been the standard antenna wire for generations and runs about a penny a foot.

Question: I have a 10-watt Sergent-Rayment hi-fi amplifier and I wonder if it would do any good to hook it up to my AM-FM-SW radio, and if so how can I do it?

FJC, San Francisco, Calif.

Question: I have a Hallicrafter short-wave radio and I would like to feed it into my hi-fi system. How can I do this without modifying the receiver?

JKK, Little Rock, Ark.

Answer: Both you gentlemen will probably get a decided improvement in tone quality in this way: connect an 8-ohm resistor from 1 to 4 watts across the speaker terminals of the radio and disconnect the speaker. Now run a *shielded* lead from the same speaker terminals to the input jack on the amplifier or to the accessory input jack on the hi-fi preamplifier.

Question: I cannot find the GE 1493 lamp for the Microscope Illuminator described in ELECTRICAL HANDBOOK, **Volume 3. Is there a substitute?**

RR, Reading, Pa.

Answer: You can buy the GE 1943 from Allied Radio (Catalog No. 52 E 656) or Lafayette Radio (Catalog No. PL-86). It is best to use this lamp. However, it may be that you can find something that will do the job for you at your automobile dealer. It should be rated at 6 volts, have a single-contact bayonet base, and put out at least 50 candlepower.

Question: We are interested in installing a city wide community antenna TV distribution system. Can we have information on what is needed, and the name and address of some firms which make the equipment needed?

J. T. Camden, Ark.

Answer: There are two ways of serving a community with TV signals from stations too remote to be receivable with good quality with ordinary TVs and antennas. The oldest is the community antenna system. In this system a high gain antenna is located in a good location; it picks up the signals which are amplified in amplifiers and then distributed through coaxial cables to the individual homes. This is a pretty expensive proposition because of the amount of cable required. A more recent system uses "trans-

ask me another

lators." This, too, starts with an antenna in a very good location. However, after being amplified the signal or signals are fed into a small transmitter and re-broadcast through an antenna array covering the community. No complex cable system is necessary. Each customer picks up the signal with his own regular type TV antenna. The total cost is lower and maintenance is simpler. Translators, however, are regulated by the Federal Communications Commission and a license is required to install and operate one. It is suggested that you write the commission (Washington 25, D. C.) requesting a copy of the regulations applicable to community TV distribution systems and a list of manufacturers supplying approved equipment for this service. Jerrold Electronics Corp., 15th and Lehigh St., Philadelphia, Penna., is one of the largest manufacturers, and operators, of community TV systems.

Question: In my area and on my receiver I hear station WKBW on 1520 kc and also on 610 kc. Can you tell me the reason for this?

RAS, New York, N. Y.

Answer: Your receiver is undoubtedly a superheterodyne in which the local oscillator frequency is equal to the station frequency plus the intermediate frequency, which typically is in the region of 455kc. When you have your receiver tuned to 1620, the local oscillator is at 1975 and the difference beat note is 455 which goes through the IF amplifier, is detected and becomes audible. When you tune to 610, the local oscillator is at 1075. The difference between 1520 and 610 is also 455 and goes through the IF amplifier to become audible though probably at *reduced* volume. This unwanted signal at 610 on the dial is called an "image."

Question: Which is more harmful to people, to get shocked by a 6-volt 10-ampere source or by a 500-volt 10-milliampere source?

CG, Lincolnwood, Ill.

Answer: Ohm's Law also applies to people when they become part of an electric circuit. You will recall that Ohm's Law says that the current (I) flowing through a circuit, or

(Continued on page 50)

Classified MARKET PLACE

For information on Classified ads—to be included in our next ELEMENTARY ELECTRONICS HANDBOOK and other Handbooks—write C. D. Wilson, Mgr., Classified Advertising, SCIENCE & MECHANICS HANDBOOK DEPT., 505 Park Ave., New York, N. Y. 10022

ADDITIONAL INCOME

YOU can receive 20 letters daily, each containing $2.00. For 4 unusual, complete plans. Rush $2.00 to T. R. Grimes, Box 505-SM Dawson, Georgia.

MAKE Mail Order pay. Get "How To Write a Classified Ad That Pulls." This handbook tells how, with examples. Includes certificate worth $2.00 toward classified ad in S & M. Send $1.00 to C. D. Wilson, Science & Mechanics, 505 Park Ave., New York, N. Y. 10022.

AUTHOR'S SERVICE

PUBLISH your book! Join our successful authors; publicity advertising promotion, beautiful books. All subjects invited. Send for free manuscript report and detailed booklet. Carlton Press, Dept. SMH, 84 Fifth Avenue, New York 11.

AUTO TRAILERS & SUPPLIES

BUILD Expanding eight foot Trailer. Accommodates five. Literature 10¢. Fra-Mar Company, Wilmington, Mass.

BOATS, MOTORS & MARINE SUPPLIES

GENUINE Northway Fiberglass Canoes Direct Deal. Details Free. Write to Northway Canoes, Hebron, Ill.

INTERESTED In Boats? Of course you are. You don't want to be without the best of the boating magazines. Order your special 4 issue subscription now. Send $3.00 to BoatCraft, 505 Park Avenue, New York, N. Y. 10022.

BOOKS & PERIODICALS

DREAM Book $1.00. Walter Kazaks, 234 East 58th Street, New York 10022.

CATALOG of all Science and Mechanics Craftprints. Send 25¢ to cover postage and Handling to Craftprint Div., Science and Mechanics, 505 Park Ave., New York, N. Y. 10022.

BUSINESS OPPORTUNITIES

I Made $40,000.00 a Year by Mailorder. Helped others make money! Start with $10.00—Free Proof. Torrey, Box 3566-T, Oklahoma City 6, Okla.

CAMERAS & PHOTO SUPPLIES

AT last! Build your own supersensitive light meter from complete kit with easy to follow instructions. Send $19.95 to Kit Division, Science and Mechanics, 505 Park Ave., New York 22. Money completely refunded if Kit returned within ten days for any reason.

CAMPING, EQUIPMENT & TENTS

CAMPER'S 1964 Catalog: A complete guide to supplies and equipment. Everything for year round hunting, fishing, camping. Send 25¢ to Cover Postage and Handling to Valley Surplus Co., Inc., Dept. MO-4, Route 59, Nanuet, New York.

COINS, CURRENCY & TOKENS

TRUNKFUL 25,000 Indian-Lincoln cents mixed (from the 1920's & older). Will pack "Grab-Bag" style, 400 mixed—$25.00. Sample bag of 20—$2.00. Mrs. Fischer, Box 5490, Sherman Oaks 13, California.

EARTHWORMS

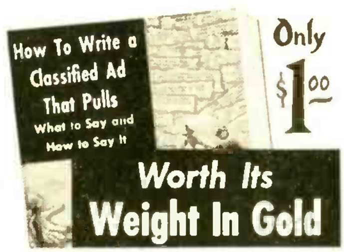
BIG Money Raising Fishworms and Crickets. Free Literature. Carter Farm-O, Plains, Georgia.

ELECTRICAL EQUIPMENT & SUPPLIES

BUILD a high precision all purpose tachometer, 3 ranges. Measures speeds on tape recorders, lathes, cutting tools, auto engines, many more uses. Only $16.95. Kit Division, Science & Mechanics, 505 Park Ave., New York, N. Y. 10022.

EMPLOYMENT INFORMATION

OVERSEAS Jobs. List $1.00. Universal P. O. Box 643-H, Kenosha, Wisc.



Make your classified ad pay! This handbook tells how—with examples; included is a Credit Certificate worth $2.00 toward the cost of a classified ad in S & M. For a copy of "How to Write a Classified Ad That Pulls," send $1.00 to C. D. Wilson, Science & Mechanics, 505 Park Ave., New York, N. Y. 10022

FIREARMS & AMMUNITION

NEW, 20-page catalog contains pictures, specifications and prices of Marlin Guns for 1964 . . . 35 different models of rifles and shotguns in all . . . at prices ranging from $17.95 to $126.95. This comprehensive catalog gives you all the information needed to select the best gun for anybody young or old . . . novice or marksman . . . target-shooter or big game hunter. You'll also learn why America's finest marksmen and huntsmen agree . . . "you pay less and get more from a Marlin." Bonus: Copy of the Bill of Rights, guaranteeing Americans the right to keep and bear arms printed on parchment paper and suitable for framing included free with every catalog. Write Dept. 391, The Marlin Firearms Co., New Haven 2, Connecticut, U.S.A.

FLORIDA LAND

FLORIDA Water Wonderland: Homesites, Cottagesites, Mobilsites. Established area. $390.00 Full Price. $5.00 Month. Swimming, Fishing, Boating, Hunting, Golfing. Write Lake Weir 102, Silver Springs, Florida.

FOR INVENTORS

INVENTIONS needed immediately for manufacturers. For additional information write Kessler Corporation, C-70FI, Fremont, Ohio.

NO Letter to write! Special "Invention For Sale" form presents your idea to buyers. 6 for $1.00. Science & Mechanics, Craft Print Div., 505 Park Ave., New York, N. Y. 10022.

HYPNOTISM

NEW concept teaches you self-hypnosis quickly! Free literature. Smith-McKinley, Box 3088, San Bernardino, Calif.

MAGIC TRICKS, JOKER NOVELTIES & PUZZLES

FREE—Big Magician's Catalog—Houdini sensational. Escapes, handcuffs, mystifying tricks, stage illusions, jokes. Write Heaney Magician, Oshkosh, Wis.

MONEY-MAKING OPPORTUNITIES

MEN-WOMEN! Start Money-Making Plastic Laminating Business at home in spare time. Material that costs 11¢ brings back $2.58. No canvassing or selling but mail orders bring in $20.00 a day. Write for full particulars free. Rush name on postcard to Warner, Room CL-426J, 1512 Jarvis, Chicago 26, Ill.

EASY to start rubber stamp business at home in spare time. Make up to $9.80 an hour without experience. Facts free. Write to Roberts, 1512 Jarvis, Room CR-426J, Chicago 26.

MODERN Ideas! For mother and baby. Send 25¢. H. Flannery, 105 Knollwood Drive, Cherry Hill, N. J. 08034.

PATENT SERVICE

PATENT Searches, $6.00! For free "Invention Record" and "Important Information Inventors Need," write: Miss Hayward, 1029-D Vermont, Washington 5, District of Columbia.

PETS—DOGS, BIRDS, RABBITS, ETC.

MAKE big money raising rabbits for us. Information 25¢. Keeney Brothers, New Freedom, Penna.

RADIO & TELEVISION

CRAMMED with Electronics Articles of interest to novices and pros alike. Subscribe now: 6 issues for $4.50. Order from Radio-TV Experimenter, 505 Park Ave., New York, N. Y. 10022.

REMAILING SERVICE

SPECIAL Remailing 25¢. $3.00 Receiving System. Smith, 914-H Pueblo Street, Boise, Idaho.

SCIENCE EXPERIMENTS

"SCIENCE EXPERIMENTER"—A must Handbook for high school science students, spelling out the kind of projects they can develop into Science Fair winners. A favorite of teachers. Send $1.00 for #651 to Science & Mechanics, Handbook Div., 505 Park Ave., New York, N. Y. 10022.

START YOUR OWN BUSINESS

MAKE Mail Order pay. Get "How To Write a Classified Ad That Pulls." This handbook tells how, with examples. Includes certificate worth $2.00 toward classified ad in S & M. Send $1.00 to C. D. Wilson, Science & Mechanics, 505 Park Ave., New York, N. Y. 10022.

SURPLUS EQUIPMENT

SURPLUS Catalog. The most amazing Surplus Bargain Catalog ever printed being compiled now. Features unusual and different items at greatest bargains ever! A must for purchasing agents, technicians, scientists, schools and universities, experimenters and hobbyists, farmers, home owners, and sportsmen. Write today—Reserve your free copy: Surplus World, P. O. Box 785, Dept. A, 1025 Chili Ave., Rochester, New York.

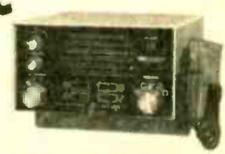
FOR HAM RADIO—Heathkit 80 Meter SSB Transceiver, Kit HW-12, $119.95.

FOR SPORTS—Heathkit 1-Watt Walkie Talkie, Kit GW-52, $74.95.

FOR STEREO/HI-FI—Heathkit 40-Watt All-Transistor Stereo Amplifier, Kit AA-22, $99.95.

Here are a few Heathkit values... there are 245 more where these came from!

FOR YOUR BOAT—Heathkit 25-Watt Radiotelephone, Kit MWW-13, $164.95.



FOR COLOR TV—Heathkit GR-53, $349.00.

FOR YOUR HOME—Heathkit Electronic Organ, Kit GD-232, $349.95.

FOR TEST EQUIPMENT—Heathkit "Service Bench" VTVM, Kit IM-13, $32.95.

Heathkit . . . world's largest electronic kit line—now bigger and better than ever!

Kit builders will find savings of up to 50%, and a selection of over 250 kits behind our catalog cover.

Each kit is backed by over 30 years of kit building experience, and comes complete, right down to an easy to follow instruction manual that will enable you to build the kit of your choice in a matter of hours, without experience! If you've built a Heathkit in the past 2 years, you'll receive your FREE copy of the new Heathkit catalog automatically! If you haven't already gotten the Heathkit habit, now's the time to find out why Heathkit building is becoming America's most popular pastime.

HEATHKIT-1964

HEATHKIT by Daystrom

HEATH COMPANY 139-6-1
Benton Harbor, Michigan 49023

Please send Free Heathkit Catalog.

Name ______________________
(please print)

Address ______________________

City __________ State __________ Zip No. ______

CL-170

working with

electronic tools and parts

By John Potter Shields

In what better way can you learn all about electronics than by actually building and assembling electronic projects? But before you go any further, you should know how to work with electronic tools and parts

As you progress further into electronics, there will be many instances when you will want to "roll your own," designing and building up projects from scratch. Quite often, the only way to obtain a piece of electronics gear specifically tailored to your needs is by conjuring it up yourself—this entailing perhaps the punching and drilling of a metal chassis, mounting of components, etc.

In order to do a creditable job of electronic assembly, it is most important that you become familiar with the various electronic "tools of the trade" and how to use them properly. The success or failure of many an electronic project will depend upon the care taken in its assembly. In the following pages, we'll take a look at the various tools you'll be using, their proper use, and general "good practice" assembly and soldering techniques.

Required Tools. The question that generally first enters the mind of the electronics neophyte is . . . what tools should I purchase to get started? There are actually two sets of answers to this question; do you plan to just build electronics kits, or do you plan to

Fig. 1. It takes a good man with good tools to do a topnotch job in constructing and repairing electronic equipment. Check the photo above to determine whether your stock of tools is greater. Since tools can be purchased separately, cost shouldn't be a determer.t to the acquiring of a tool box filled with quality tools.

tools & parts

go all out and assemble the projects from scratch . . . punching out all the chassis yourself.

If you intend to concentrate on kit assembly, your choice of tools is quite simple . . . the following tools should put you in business.

- Screwdriver—4 to 6 inch, ½ inch blade
- Screwdriver—4 to 6 inch, ¼ inch blade
- Long-nose pliers—4 to 6 inch
- Diagonal cutters—6 inch
- Wire strippers
- Low wattage (30-50 watts) soldering iron
- Soldering iron

In addition to these basic tools, you will probably want to acquire a set of "spintites," (nut drivers), a plastic nut starter and perhaps a screw holding screwdriver. While not essential, these extra tools often make assembly a lot easier. The choice of a soldering iron or gun is a matter of personal preference and working habits.

On the other hand, if you prefer to build up your projects from scratch, you'll want the following tools in addition to those mentioned above.

- Tube socket hole punches (⅝", ¾", 1⅛", 1¼")
- Hack saw, 12 inch blade
- Hammer
- Center Punch
- Steel straight edge or tape rule
- Hand or electric drill
- Twist drill set, including No. 18, 28, 33, 42 and 50 drill sizes, plus ¼ inch
- Phillips screwdriver, 6 to 8 inch
- Set of Allen wrenches
- Set of small metal files: round, flat, triangle
- 100 to 200 watt soldering iron or gun
- Slip-joint pliers
- Nibbling tool

These additional tools are just about all that will be required to construct even the most elaborate piece of gear. A few of these tools are pictured in Figure 1.

In addition to the tools outlined above, it is a good idea to maintain a small stock of "electronic hardware" including:

- Machine screws, round and flat head, with nuts to fit.

Most useful sizes include: 4-40, 4-36, 6-32, and 8-32. Lengths should range from 3⁄16" to 1".

- Rubber grommets in assorted sizes
- Rosin solder core
- Terminal tie point strips

Most of these items are available in small quantities, usually being packaged in handy, reusable, plastic boxes.

Laying Out A Chassis. Assuming that you are going to "roll your own" project, the first step is to lay out the chassis, decid-

Fig. 2. Unless you are a design engineer with years of experience in electronics, it would be wise to place parts on a chassis to see if there will be ample room.

Fig. 4. After some careful planning a novice can punch and drill a chassis that an old pro would admire.

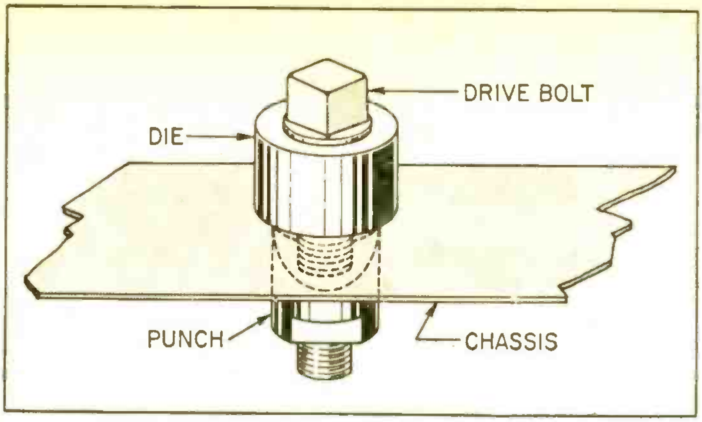


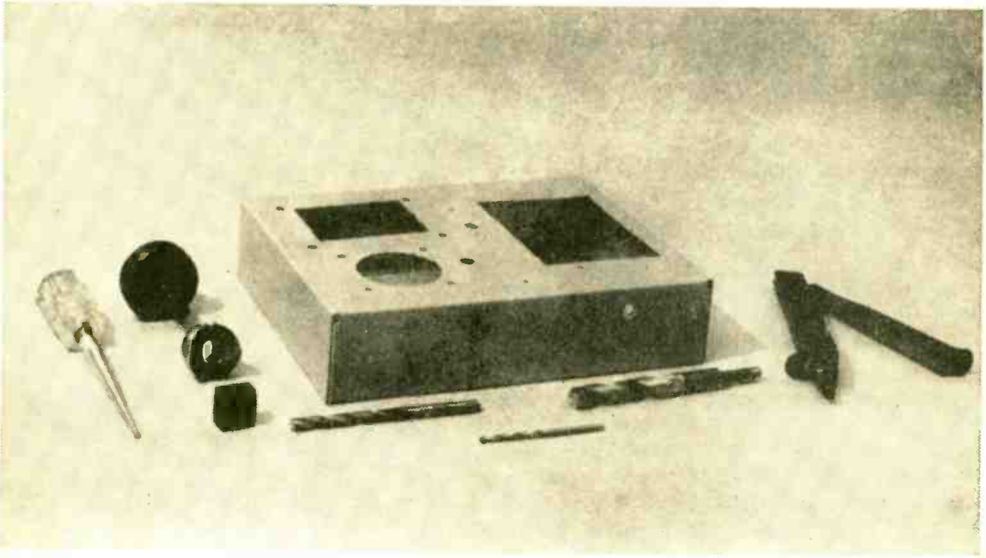
Fig. 3. If you don't have a complete set of Greenlee round and square punches, it's time you start buying. Start off with a 5/8", 3/4", and 1 1/8" round punch and a 1" square punch. Parts stores stock these and other sizes and shapes.

ing where the various components such as tubes, transformers, etc. are to be placed. For example, as shown in Figure 2, the chassis is laid out in "sections," the power transformer and filter capacitor in one corner of the chassis, output transformer and output tubes in the other corner, and the rest of the circuit along the front portion of the chassis. Aside from a neat, symmetrical layout, this component allows the most direct lead placement between the various components.

After deciding the best component location, the next step is to mark the paper clad chassis with the various part locations in preparation for drilling and punching. The easiest way of doing this is to use the component mounting holes as guides, placing a pencil mark at each mounting hole. The components may then be removed, and the pencil markings "trued up" with a T-square or triangle as a guide. The next step is to *lightly* center punch the locations where the various holes are to be drilled. A block of wood or metal should be placed directly under the point being center punched to avoid denting the chassis. Placing the chassis over a closed vise is a good way to work this.

Drilling and punching of the chassis comes next. In the case of drilling, it's a good idea to drill all the punch marks with a small drill to provide "pilot holes." This neatly solves the problem of a large drill "skittering" out of a punch mark and marring the chassis surface.

Holes much larger than about 1/2" are best made with a hole punch. In operation, a hole



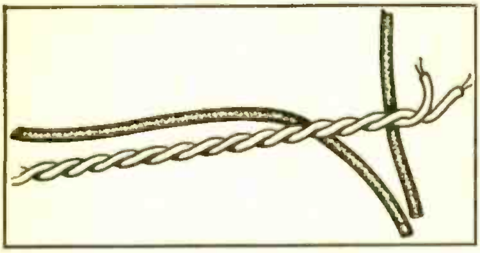


Fig. 5. Twisted AC heater leads reduce hum.

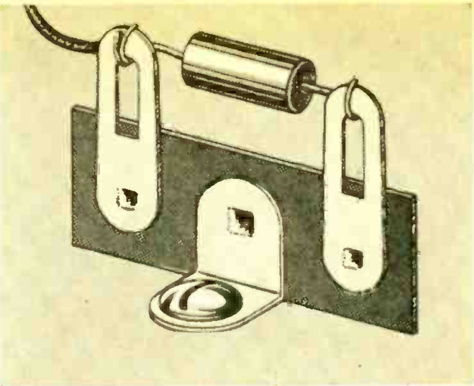


Fig. 6. Mechanically secure leads to lugs.

(diameter depending upon size of punch) is drilled in the chassis. Next, the die is placed on top of the chassis and the punch under the chassis as pictured in Figure 3. The drive bolt is drawn up with a wrench.

Figure 4 illustrates a slick method for cutting various odd-sized holes in chassis. A "nibbling tool" is used which "nibbles" out small sections at a time until the desired size hole is obtained. Using this approach it's a fairly easy matter to cut out large openings for transformers, etc.

Mounting of Electronic Parts. Mounting the various components is next after all chassis drilling and punching has been completed. Such items as standard tube sockets and tie-point strips are conveniently mounted with 6/32 x 1/4" round head machine screws,

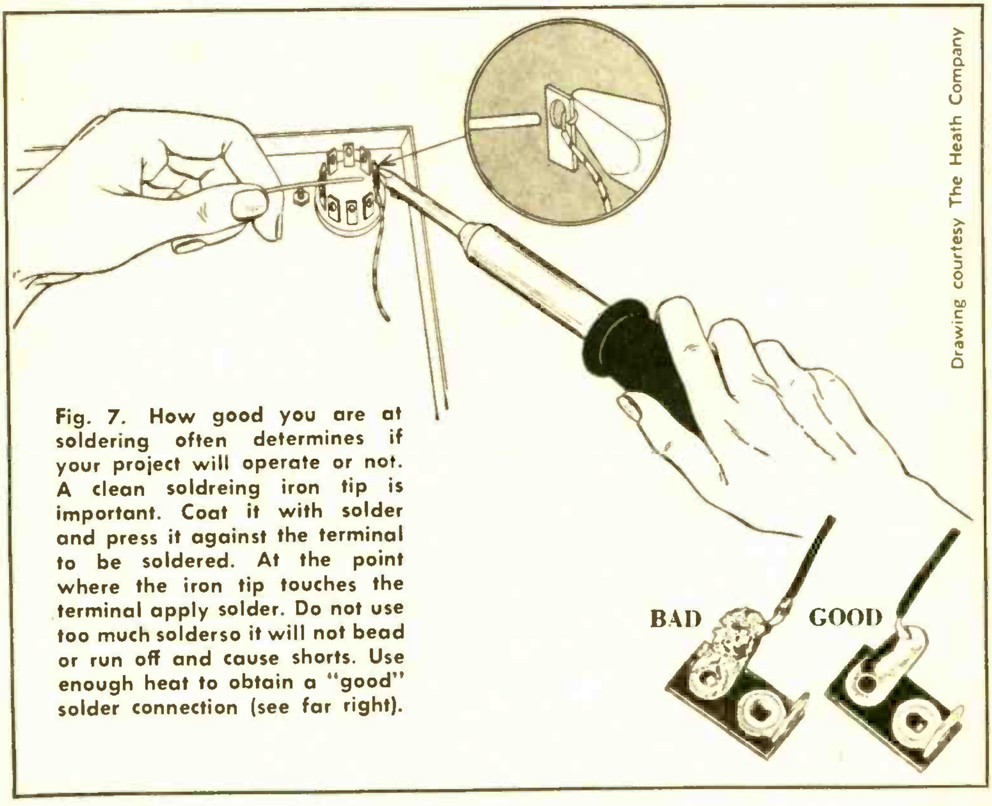


Fig. 7. How good you are at soldering often determines if your project will operate or not. A clean soldreing iron tip is important. Coat it with solder and press it against the terminal to be soldered. At the point where the iron tip touches the terminal apply solder. Do not use too much solderso it will not bead or run off and cause shorts. Use enough heat to obtain a "good" solder connection (see far right).

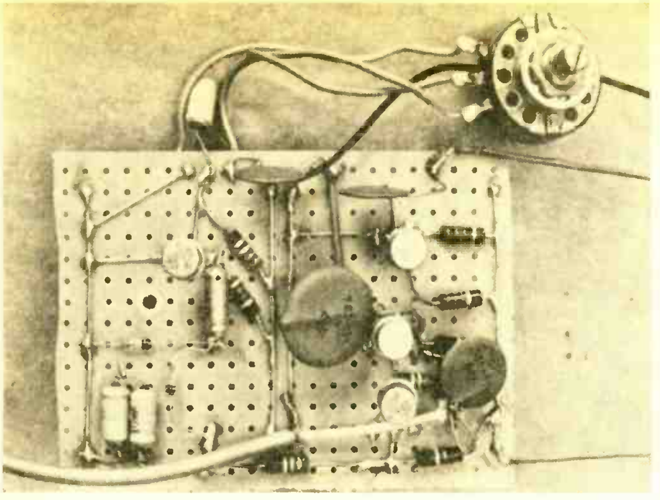
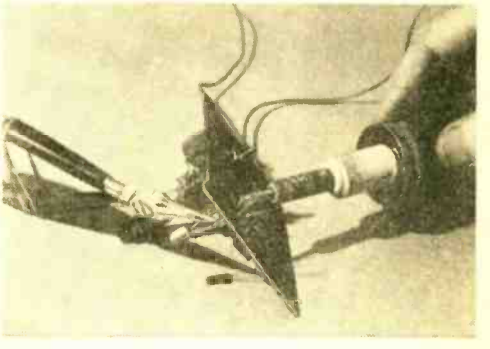


Fig. 8. Wiring up transistor circuits calls for different wiring techniques. Parts are smaller and can be placed on a phenolic board stamped with many evenly spaced mounting holes.

Fig. 9. Transistors and solid state diodes can be damaged by excessive heat. When soldering place a heat sink between the semiconductor and the point being soldered. A plier with a rubber band clamping it shut holds on to a wire and will draw away the heat.



lockwashers, and 6/32 hex nuts. Miniature tube sockets are best mounted with 4/40 x 1/4" machine screws. Such items as tie-point strips, mounting brackets, small transformers and chokes are mounted with 6/32 x 1/4" or 3/8" hardware. Larger components, such as power transformers, output transformers, etc. are provided with usually either 6/32 or 8/32 studs which may be used for mounting the component.

Panel mounted components, such as potentiometers, rotary and toggle switches, and pilot light assemblies are mounted by means of threaded bushings which are passed through the single mounting hole and secured with a lockwasher and nut. Standard potentiometer (pots) require a 3/8" mounting hole, while most toggle switches mount through a 1/2" hole. Rotary selector switches, as in the case of pots, generally take a 3/8" mounting hole.

Wiring Procedure. Next in line comes wiring of the various components. Here again, the proper technique will more often than not spell the difference between a successful project and one that provides only mediocre results. This is especially true with circuits designed to operate at high frequencies where careful attention must be given to proper wiring procedure.

Assuming that you are putting together a "conventional" project, such as an amplifier, receiver, etc., the accepted, and by the way, the most convenient wiring sequence is as follows:

1. Power supply
2. Heater (or filament circuits)
3. Ground (or common) circuits
4. Leads from major components such as output transformers, pots, switches, etc.
5. Resistors
6. Capacitors

The virtue of this wiring procedure is that the wiring ends up in "layers" . . . you don't suddenly find that a ground connection for example has to be made under a layer of previously installed capacitors and resistors.

Next, we come to the matter of lead length between components. Aside from appearance sake, it is highly desirable to maintain as short as possible connecting leads. There are several reasons for this. First, excessive lead length can cause hum and noise pickup in the case of signal carrying leads. Second, AC power leads, such as from the 115 volt AC line and 6.3 volt heater leads may radiate hum into low-level portions of the circuit if excessively long. Third, excessive lead length can cause excessive circuit losses due to their inductance which becomes appreciable at high frequencies. This is why you'll find VHF (very high frequency) and UHF (ultra-high frequency) circuits constructed with their components very closely spaced.

When a long lead run cannot be avoided, as in the case of tube heater leads, AC field radiation from them can be minimized by twisting the leads as pictured in Figure 5.

There have been a number of suggested methods of attaching component leads to tube socket lugs, tie-point strips, etc. You have your choice all the way from the "military style" of passing the lead through the lug, wrapping it around the lug a number of times, and then crimping it, to simply tacking the lead to the lug with a drop of solder. Actually, these two cases are extreme . . . the former is too involved while the latter is not considered mechanically acceptable, except for perhaps an experimental circuit where the lead will be connected and disconnected a number of times.

Figure 6 shows the generally accepted method of attaching a lead to a terminal or tie-point lug. As you can see, the lead is passed through the hole in the lug, bent back upon itself, and crimped. This provides a connection that can be fairly easily "detached" and yet provides a good mechanical joint.

Soldering. Here's a subject which perhaps causes the most difficulty to the beginner, and yet it is not a difficult art to master. There are three basic steps to a good soldered connection. They are:

1. plenty of heat
2. clean point
3. proper iron

The correct procedure for soldering a joint is illustrated in Figure 7. First, coat the tip of the iron with solder. Next, *firmly* press the flat side of the tip against the parts to be soldered together. After allowing a second or two for the iron to heat the work, apply solder between the parts to be soldered and the iron. Use only enough solder to flow over the surface of the connection. Remove the iron and do not move any of the soldered parts until the solder has cooled.

One very important point . . . *always use only rosin-core solder* as acid core solder will corrode the soldered connections, thus resulting in increased connection resistance and attendant improper circuit operation.

While soldering guns have become popular due to their "instant heat" characteristics, a good 30 to 50 watt soldering "pencil" is excellent for most electronic work, and has the advantage that it will not overheat the work . . . a common problem with a large wattage soldering gun.

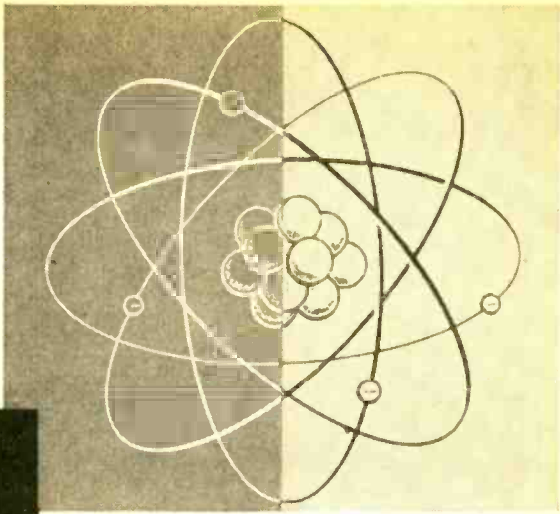
And Now Transistors. This section would not be complete without touching on the proper "mechanics" of transistor construction. As you might well imagine, assembly techniques differ considerably with transistor circuits . . . one major reason being the much smaller physical size of the associated components.

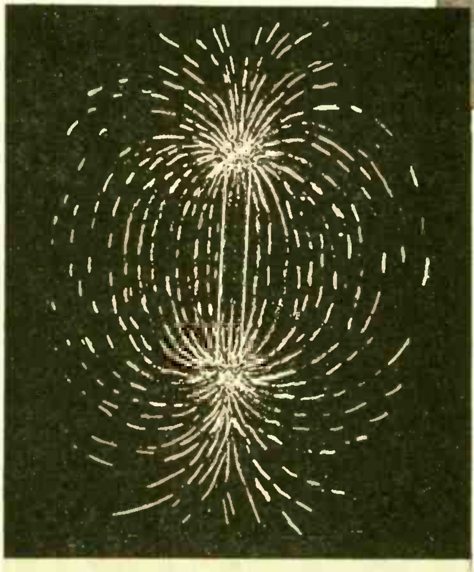
Figure 8 shows the typical construction technique of a simple transistor circuit. As you can see by the photo, the "chassis" is a piece of perforated phenolic board. Instead of conventional tie-point strips, small brass eyelets are used, these being inserted through the holes in the perforated board. Component leads are simply pushed into the eyelets and soldered. The small transformers are mounted to the board by means of their lugs which are simply passed through enlarged holes in the board. Incidentally, this perforated board can be easily cut to the desired size by the use of a "nibbling" tool.

In mounting transistors and diodes, it's a wise idea to leave the leads at least one inch long when possible to minimize the chance of transistor or diode damage when soldering into place. Along these same lines, gripping the transistor or diode leads with a pair of long-nose pliers as pictured in Figure 9 will minimize heat damage during soldering.

When working with transistor circuits, it is highly recommended that the use of a soldering gun be avoided. The reason for this is that the intense magnetic field developed around the gun while it is in operation can induce currents in nearby coils and transformers . . . these currents often being sufficient to damage transistors or diodes connected into the same circuit. Also, the more controlled heat of a low wattage soldering pencil will prevent possible damage of excess heat to the rather delicate leads of some of the associated components.

Well, that's pretty much the story on working with electronic tools and parts. While space did not permit us to give a really detailed coverage of the subject . . . many, many more words could be said, we have tried to cover the high spots, and hope that you have found this section both interesting and informative. ■





basic electricity

The study of complex electronic circuits is based upon an easy-to-understand electron theory and how electrons flow through circuits. A good ground floor knowledge of electricity is mandatory prior to probing into electronics.

IN ORDER to gain a clear understanding of basic electricity, let's take a close look at the structure of the atom. All matter can be broken down into basic chemical elements. These basic elements in turn can be subdivided into minute particles, called atoms; the smallest state in which chemical elements can exist without losing their identity.

Early in the 19th century it was revealed that the atom, which up until this time had been considered the fundamental particle of matter, could be subdivided still further into even smaller particles. These smaller particles—electrons, protons and neutrons, are present in all atoms . . . their number determining the particular type of atom, carbon, hydrogen, etc. For example, the element hy-

basic electricity

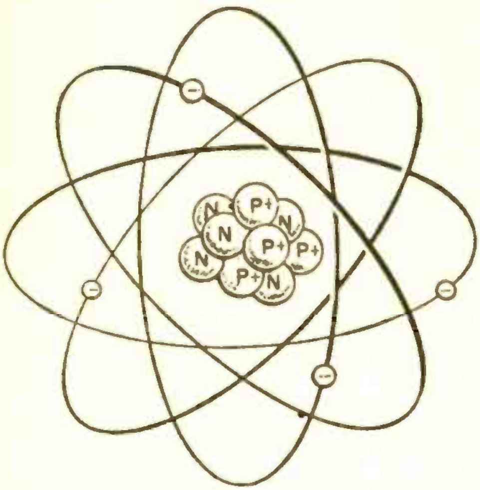


Fig. 1. Diagram of the beryllium atom.

drogen has one electron and one proton, while the sodium atom has 11 electrons, 11 protons, and 12 neutrons.

The structure of the atom is somwhat like our own solar system. Figure 1 is an atomic diagram of the beryllium atom. The atom's central nucleus consists of protons which carry what is known as a positive electrical charge and neutrons which possess a zero electrical charge. Around this positively charged nucleus, orbit negatively charged electrons. In a normal atom, the number of electrons in the orbits exactly equal the number of protons in its central nucleus. Thus, the negative charged orbiting electrons neutralize the positive protons and the atom has a zero net electrical charge.

Atomic weight. Almost the entire weight of any atom is concentrated in its nucleus. Both the electrically positive proton and electrically neutral neutron are about 1800 times heavier than the orbiting electrons. Actually, "weight" is a rather poor term to use here as the weight of even the heavier protons and neutrons is infinitesimal compared to objects we see and handle every day. The approximate weight of one electron is expressed by a very small number, .000,000,000,000,000,000,000,000,000,9 gram (9 x 10^{-28}).

A moment ago, we said that all atoms are composed of three basic types of particles, electrons, protons, and neutrons, and that the different elements are determined by the number and arrangement of these particles. The atomic number of an element's atom is equal to the number of electrons orbiting about its nucleus. Thus, the hydrogen atom, with its single electron is given the atomic number of one. On the other hand, the element fluorine has nine electrons and is thus given the atomic number of nine.

An atom's atomic weight is determined by the number of protons and neutrons in its nucleus. Atomic weights are relative and are useful in comparing the weight of one atom against that of another. Since the atomic weight of hydrogen is one, and the atomic weight of neon is 10, the neon atom is 10 times heavier than the hydrogen atom. Figure 2 is a table of the atomic weights and numbers for the first eleven elements.

Going back to our atom's orbiting electrons for a moment, these electrons are arranged in rings or shells around the central nucleus—each ring having a definite maximum capacity of electrons which it can retain. For example, in the copper atom shown in Figure 3 the maximum number of electrons that can exist in the first ring (the ring nearest the nucleus) is two. The next ring can have a maximum of eight, the third ring a maximum of 18, and the fourth ring a maximum of 32. However, the outer ring or shell of electrons for any atom cannot exceed eight electrons when the shell may have more than eight in heavier atoms.

Symbol	Element	At. No.	At. Wt.	Protons	Electrons	Neutrons
H	hydrogen	1	1	1	1	0
He	helium	2	4	2	2	2
Li	lithium	3	7	3	3	4
Be	beryllium	4	9	4	4	5
B	boron	5	11	5	5	6
C	carbon	6	12	6	6	6
N	nitrogen	7	14	7	7	7
O	oxygen	8	16	8	8	8
F	fluorine	9	19	9	9	10
Ne	neon	10	20	10	10	10
Na	sodium	11	23	11	11	12

Fig. 2. Atomic table for the first 11 atoms.

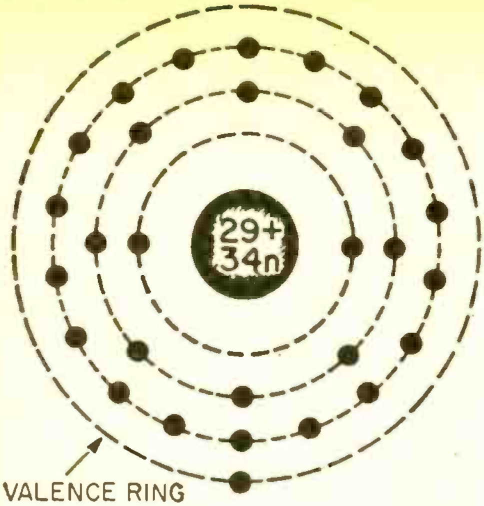


Fig. 3. Flat diagram of the copper atom.

Valance. The ring of electrons furthest from the atom's nucleus is known as the *valance ring* and the electrons orbiting in this ring are known as *valance electrons.* These valance electrons, being further from the nucleus, are not held as tightly in their orbits as electrons in the inner rings and can therefore be fairly easily dislodged by an external force such as heat, light, friction, and electrical potential. The fewer electrons in the valance ring of an atom, the less these electrons are bound to the central nucleus. As an example, the copper atom has only one electron in its valance ring. Consequently, it can be easily removed by the application of only the slightest amount of external energy. Ordinary room temperature is sufficient to dislodge large numbers of electrons from copper atoms; these electrons circulating about as free electrons. It is because of these large numbers of free electrons that copper is such a good electrical conductor as you shall shortly see. There could be no electrical or electronics industry as we know it today if it were not for the fact that electrons can fairly easily escape, or be stripped from the valance ring of certain elements.

Electronic charges. If an electron is stripped from an atom, the atom will assume a positive charge because the number of positively charged protons in its nucleus now exceed the number of negatively charged orbiting electrons. If on the other hand, the atom should gain an electron, it will become negatively charged as the number of electrons now exceed the protons in its nucleus. The atom with the deficiency of electrons is known as a *positive ion,* while an atom with a surplus of electrons is known as a *negative ion.*

You are probably familiar with the "electricity" produced when you comb your hair with a hard rubber or plastic comb. What happens here is that the friction of passing the comb through your hair strips electrons from the atoms of the material from which the comb is made, leaving the comb negatively charged. This is the earliest form of electricity known to man and is known as *static electricity* as it simply accumulates on a surface rather than flowing continuously in an electrical circuit as does electricity produced from a battery, generator, etc.

So far, we've talked only about static electrical charges which accumulate either by a deficiency or surplus of electrons. Let's go a bit further and see what constitutes a continuous flow of electric current.

Figure 4 shows two oppositely charged bodies. The negative charge of the right hand body is due to there being a greater number of electrons than protons in this body, while the left hand body is positively charged due to its having fewer electrons than protons. When an electrical conductor is placed between these two oppositely charged bodies as shown in figure 5 the negatively charged free electrons will be repelled into the connecting wire by the negative charge of the right hand body. At the same time, these free electrons are attracted by the positive charge of the left hand body—free electrons moving through the wire from the right hand body to the left hand body. This movement of free electrons will continue only until the excess of electrons are equally divided between the

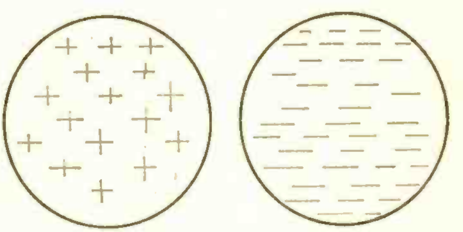


Fig. 4. Two bodies with opposite charges.

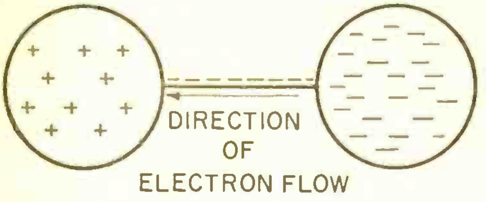


Fig. 5. Electron flow reduces charges.

two bodies. Under these conditions, the charges on the left and right hand bodies will be equal and the electron flow will end.

Electric charges produce current. While figures 4 and 5 serve to illustrate the basic flow of an electric current by means of electric charges, you can see that the flow of current will stop as soon as the charges are neutralized—this taking but a fraction of a second. What we need is some method of continuously maintaining a charge or potential difference between the two ends of the electrical conductor. In effect, what we are looking for is an "electric charge pump."

Let's look at figure 6A. Here we see a water wheel and water pump connected by a length of pipe. Mechanical energy applied to the shaft of the pump causes the water to flow through the pipe and turn the water wheel due to the difference in water pressure at the two ends of the pump. The pump, water wheel, and connecting pipe form a circuit through which the water can flow. Now, look at figure 6B. Here is a battery, lamp, and connecting leads between the battery and lamp. In this instance, the battery serves as the electric charge pump—free electrons continually developed at its negative terminal by chemical action flowing through the connecting leads and lamp back to its positive terminal of the battery by the attraction of oppositely charged bodies. The battery, connecting leads, and lamp form an electrical circuit which must be complete before the free electrons can flow from the battery's negative terminal to its positive terminal via the lamp. Thus, the battery serves as a source of potential difference or voltage by continually supplying a surplus of electrons at its positive terminal. Summing this whole thing up, we can say, a flow of electric current consists of the movement of electric charges (electrons in most cases) between two oppositely charged bodies.

Now that we have seen just what makes up a flow of electric current, in which direction does the current flow . . . from positive to negative or from negative to positive? Actually, there are two schools of thought on this . . . the so-called conventional direction and the direction of electron flow. The

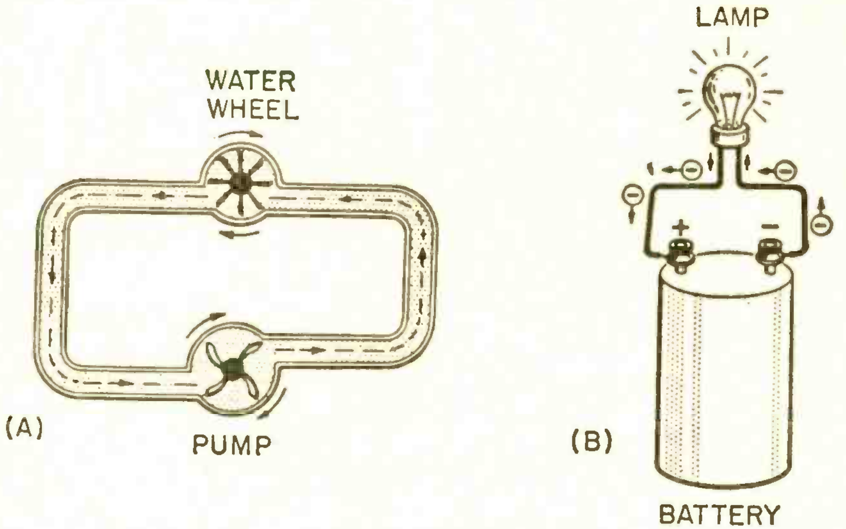


Fig. 6. The action of a water pump (A) compared to the electrical battery (B).

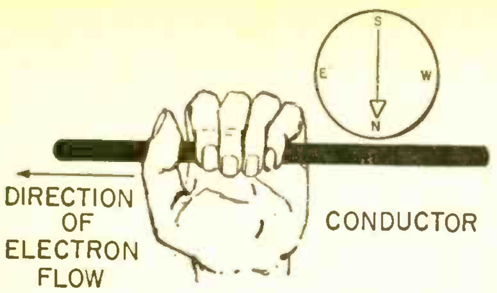


Fig. 7. Using the left hand rule to find the direction of electron flow in a conducting wire.

conventional direction is the earliest, and assumes that an electric current flows from positive to negative. The more modern theory states that current flow is the same as electron flow (from negative to positive) since most current flow consists of the movement of free electrons.

The direction of current flow through a conductor can be determined with the aid of a compass as shown in figure 7. When the fingers of the *left hand* are wrapped around the conductor in such a manner that they point in the same direction as the north pole of the compass, the left thumb points to the direction of current flow.

Electrical quantities. We cannot progress very far into the study of electricity without first becoming familiar with the basic properties of electrical circuits. Just as we define distance in feet and inches, so do we define electrical properties in specific terms and units.

Potential. Earlier, we saw that an electric charge difference has to exist between the ends of an electrical conductor in order to cause a flow of free electrons through the conductor . . . this flow of electrons constituting an electric current. This electric charge difference, or potential difference exerts a force on the flow of free electrons, forcing them through the conductor. This electric force or pressure is referred to as electromotive force, abbreviated EMF.

The greater the charge or potential difference, the greater will be the movement of free electrons (current) through the conductor as there will be more "push and pull" on the free electrons. The symbol used to designate electrical potential is the letter E which stands for electromotive force. The quantity of EMF is measured by a unit called the volt. Hence, the common name most often used in place of EMF is *voltage*.

Current intensity. We have learned that an electric current consists of a flow of charge carriers (most generally free electrons) between two points of different electrical potential. The rate of flow of these charges determines the intensity or strength of this current flow.

Let's take a look at Fig. 8 which shows a wire connected between the positive and negative terminals of a battery. Since the battery serves as a source of potential difference, free electrons will be repelled out of the negative terminal, through the wire, and back into the positive terminal which has a deficiency of electrons. The number of these free electrons flowing in the conductor determine the current strength. This current strength is expressed in units known as the *ampere* . . . 1 ampere of current flowing in the circuit when 6,240,000,000 electrons flow out of the battery's negative terminal, through the conductor, and back into the battery's positive terminal in one second. The symbol for the ampere is the letter *I* which stands for intensity.

Resistance. The flow of electric current through a conductor is caused by the movement of free electrons present in the atoms of the conductor. A bit of thought then indicates that the greater the number of free elec-

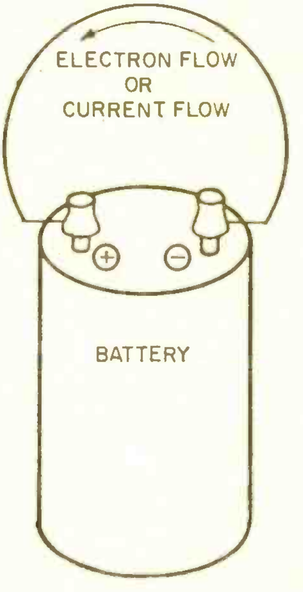


Fig. 8. Electron flow caused by a dry cell.

trons present in the atoms of a particular conductor, the greater will be its electrical conductivity. Gold, silver, and copper rank as excellent electrical conductors as their atoms readily release of free electrons. On the other hand, the atoms of such elements as sulphur have almost no free electrons available and they are thus very poor electrical conductors . . . such materials are known as electrical insulators. Between these extremes, lie elements such as carbon whose atoms have a moderate number of free electons available and thus are relatively good electrical conductors.

Even the best electrical conductors offer some opposition to the passage of free electrons . . . this opposition is called resistance. You might consider electrical resistance similar to mechanical friction. As in the case of mechanical friction, electrical resistance generates heat. When current flows through a resistance, heat is generated; the greater the current flow, the greater the heat. Also, for a given current flow, the greater the resistance, the greater the heat produced.

Electrical resistance can be both beneficial and undesirable. Toasters, electric irons, etc. all make use of the heat generated by current flowing through wire coils. Resistance is also often intentionally added to an electrical circuit to limit the flow of current. This type of resistance is generally lumped together in a single unit known as a resistor.

There are also instances where resistance is undesirable. Excessive resistance in the connecting leads of an electrical circuit can cause both heating and electrical loss. The heating, if sufficient can cause a fire hazard, particularly in house wiring, and the circuit losses are a waste of electrical power.

Electrical resistance is expressed by a unit known as the *ohm*, indicated by the letter *R* which stands for resistance as you might guess. An electrical conductor has a resistance of one ohm when an applied EMF of one volt causes a current of one ampere to flow through it.

There are other factors beside the composition of the material that determine its resistance. For example, temperature has an effect on the resistance of a conductor. As the temperature of copper increases for example, its resistance decreases. A little thought will show why this is so. You remember that heat is one of the external forces which will strip electrons from the valance ring of atoms comprising an electrical conductor. These electrons then circulate as current carrying free electrons. As the amount of heat is increased, the number of these free electrons increase, and the resistance of the conductor

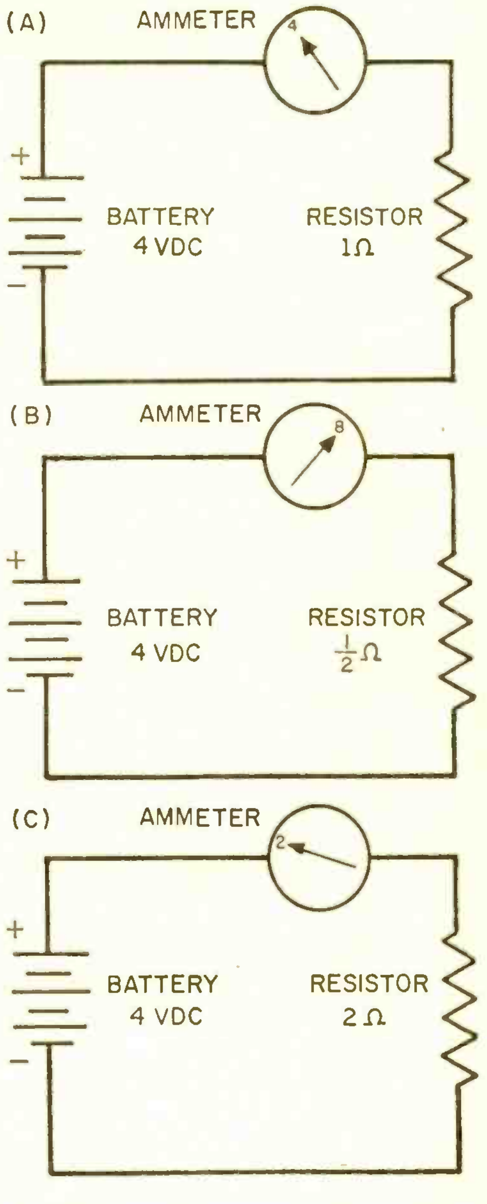


Fig. 9. Simple demonstration showing that current in a circuit is directly proportional to the voltage impressed across the circuit.

drops. This drop in resistance with an increase in temperature is known as a *positive temperature coefficient*. Not all conductors show this decrease in resistance with an increase in temperature . . . their resistance increasing with an increase in temperature. Such materials are said to have a *negative temperature coefficient*. Certain metallic alloys have been developed which exhibit a *zero temperature coefficient* . . . their resistance does not change with changes in temperature.

As you might suspect, the length of a conductor has an effect upon its resistance. Doubling the length of a conductor will double its resistance as the current carrying free electrons have twice as far to travel and thus twice the resistance. By the same token, having the length of a conductor will cut its resistance in half. Just remember that the resistance of a conductor is *directly proportional to its length*.

The cross-sectional area of a conductor also determines its resistance. As you double the cross-section of a conductor, you halve its resistance . . . halving its cross-section doubles its resistance. Here again, the "why" of this is pretty easy to see . . . there are more current carrying electrons available in a large cross-section conductor than in a small cross-section conductor of the same length. Therefore, the resistance of a conductor is *inversely proportional to its cross-sectional area*.

Relationship—voltage, current, resistance. Now that we have a basic understanding of voltage, current, and resistance, let's take a look at just how they interact.

Figure 9A shows a battery, ammeter (a device to indicate current strength), and resistor connected in series. Notice that the ammeter indicates that 4 amperes are flowing in the circuit.

Figure 9B shows the identical setup with the exception that the battery voltage has now been doubled. The ammeter now shows that twice the original current, or 8 amperes, are now flowing in the circuit. Therefore, we can see that doubling the voltage applied to the circuit will double the current flowing in the circuit.

In Figure 9C the same circuit appears again, this time however, the battery voltage is one-half its original value. The ammeter shows that one-half of the original current, or 2 amperes, are now flowing in the circuit. This shows us that halving the voltage applied to the circuit will halve the current flowing through the circuit.

All this boils down to the fact that assuming the same circuit resistance in all cases, *the current flowing in a circuit will be directly proportional to the applied voltage* . . . increasing as the voltage is increased, and decreasing as the applied voltage is decreased.

In Figure 10A we again see the circuit consisting of the battery, ammeter, and resist-

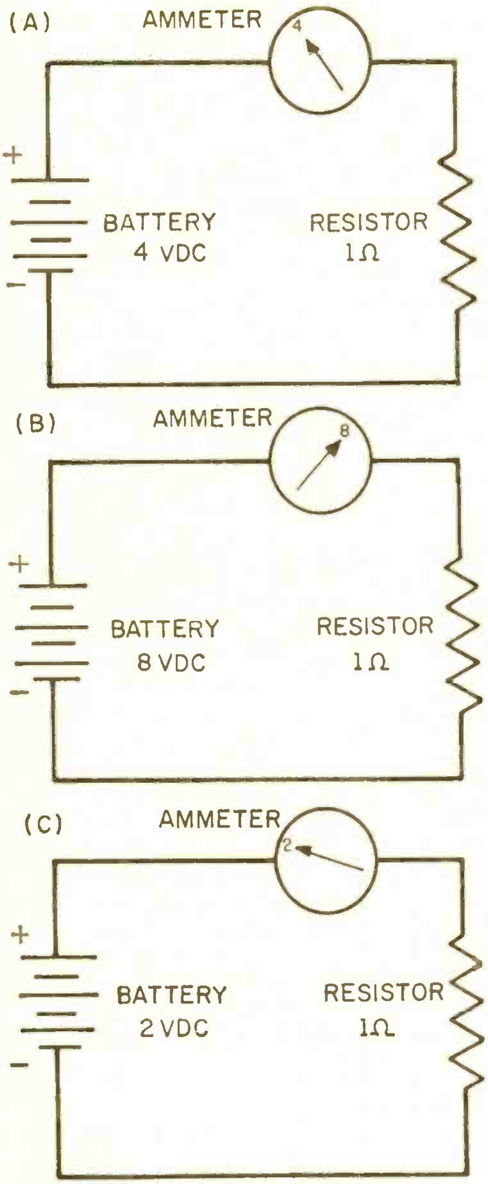


Fig. 10. Simple demonstration showing that current in a circuit is inversely proportional (1 over R) to the resistance in the closed circuit.

ance. Notice that the ammeter indicates that 4 amperes are flowing through the circuit.

In Figure 10B we see that the value of resistance has been cut in half and as a result, the ammeter indicates that twice the original current, or 8 amperes, is now flowing in the circuit. This leads us to the correct assumption that for a given supply voltage, halving the circuit resistance will double the current flowing in the circuit.

Figure 10C again shows our basic circuit, but with the resistance now doubled from its original value. The ammeter indicates that the current in the circuit is now one-half of its original value.

Summing things up . . . for a given supply voltage, *the current flowing in a circuit will be inversely proportional to the resistance in the circuit.*

Ohm's law. From what you have seen so far, you are probably getting the idea that you can determine the current flowing in a circuit if you know the voltage and resistance present in the circuit . . . the voltage if you know the current and resistance, or the resistance if the voltage and current are known.

All this is quite correct, and is formally stated by Ohm's Law as follows:

$$E = \frac{I}{R}$$

Where: E = voltage
I = current
R = resistance

Now, let's take a look at how this formula is used:

To find voltage:

E(voltage) = I (current) times R (resistance)

To find current . . .

$$I\ (\text{current}) = \frac{E\ (\text{voltage})}{R\ (\text{resistance})}$$

To find resistance:

$$R\ (\text{resistance}) = \frac{E\ (\text{voltage})}{I\ (\text{current})}$$

A handy way to remember Ohm's Law is by means of the "wheel" shown in figure 11. Simply cover the quantity, voltage, current, or resistance, that you want to determine, and read the correct relationship of the remaining two quantities from the wheel. For example, if you want to know the correct current (I), put your finger over I and read $\frac{E}{R}$. Similarly, covering E or R will yield I x R or $\frac{E}{I}$ respectively.

Ohm's law to determine voltage. Let's delve a bit more deeply into Ohm's law by applying it to a few cases where we want to determine the unknown voltage in an electrical circuit.

For a beginning, take a look at figure 12, which shows a simple series circuit consisting of a battery and resistor. The value of this resistor is given as 200 ohms, and 0.5 ampere of current is flowing through the circuit. We want to find the value of battery voltage. This is easily done by applying Ohm's law for voltage as follows:

$$E = I \times R$$

E (unknown voltage) = 0.5 (current in amperes) × 200 (resistance in ohms) = 100 V.

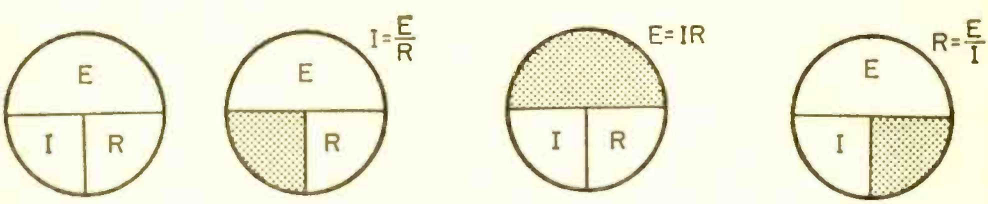


Fig. 11. The Ohm's law memory wheel—cover one value with your finger and the equation is given by the remaining two values.

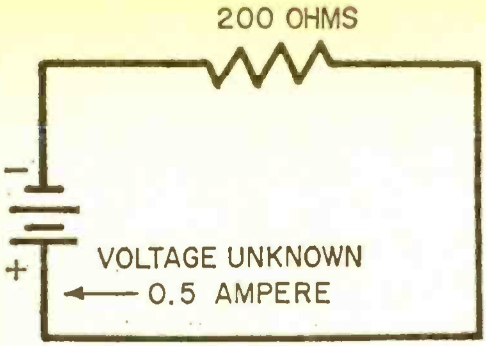


Fig. 12. Using Ohm's law to determine voltage from values of current and resistance.

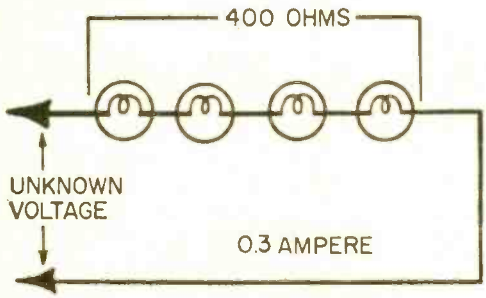


Fig. 13. Find the unknown voltage impressed across this series Christmas lamp circuit.

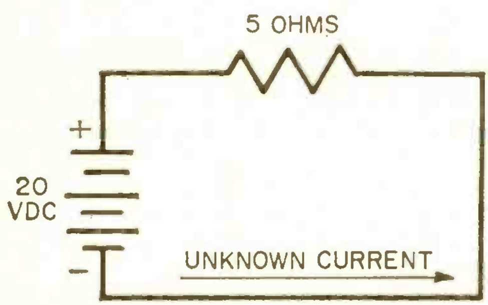


Fig. 14. Use Ohm's law to determine the unknown current in this simple series circuit.

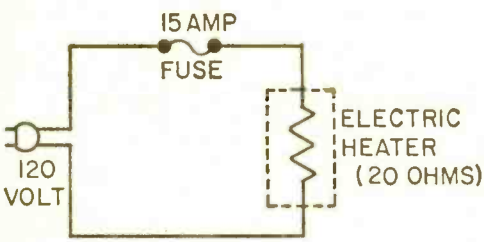


Fig. 15. Here, Ohm's law helps you determine whether the fuse size is satisfactory.

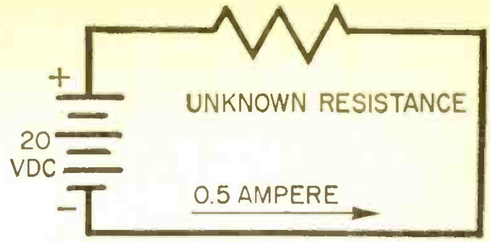


Fig. 16. Knowing the dry cell voltage and circuit current, the unknown R can be found.

Let's go through this again, this time using a more "true to life" illustration. Figure 12 shows a string of light bulbs, the total resistance of which, is 400 ohms. You find that the bulbs draw 0.3 amperes when fully lit. Let's say you would like to operate this string of bulbs from the standard 120-volt house current, but you don't know the voltage rating of the individual bulbs. By using Ohm's law for voltage, you can easily determine the voltage to light the bulbs as follows: E (unknown voltage) = 0.3 (amperes) x 400 (bulb resistance) = 120 volts

Ohm's law to determine current. Now, let's take a look at a few examples of how to determine the value of unknown current in a circuit in which both the voltage and resistance are known.

Figure 14 shows a series circuit with a battery and resistor. The battery voltage is 20 volts DC and the value of resistance is 5 ohms. How much current is flowing through the circuit?

$$\text{Ohm's law for current} \quad I = \frac{E}{R}$$

$$I \text{ (unknown current)} = \frac{20 \text{ (battery voltage)}}{5 \text{ (resistance in ohms)}}$$

$$I = 4 \text{ amperes}$$

Again to get a bit more practical, let's take a look at figure 15. Here we see an electric heater element connected to the 120-volt house line. We know that this particular heater element has a resistance of 20 ohms. The house current line is fused with a 15-ampere fuse. We want to know whether the heater will draw sufficient current to blow the fuse. Here's how to find this out by use of Ohm's law for current.

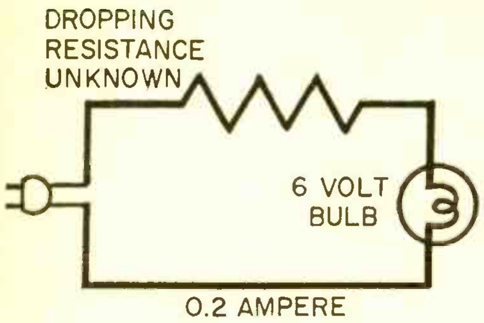


Fig. 17. Series dropping resistors can be calculated by Ohm's law and some reasoning.

$$I \text{ (unknown current)} = \frac{120 \text{ (line voltage)}}{20 \text{ (Heater resistance in ohms)}}$$

$$I = 6 \text{ amperes}$$

We find from the above use of Ohm's law for current that the heater draws 6 amperes, so it can be safely used on the line fused with the 15 ampere fuse. In fact, a 10 ampere fused line can also do the job.

Ohm's law to determine resistance. Ohm's law for resistance enables us to determine the unknown value of resistance in a circuit. Here's how it's done. Figure 16 again shows a simple series circuit with the battery voltage given as 20 volts and the current flowing through the circuit as 0.5 ampere. The unknown resistance value in this circuit is found as follows:

$$\text{Ohm's law for resistance } R = \frac{E}{I}$$

$$R \text{ (unknown resistance)} = \frac{20 \text{ (battery voltage)}}{0.5 \text{ (current in amperes)}}$$

$$R = 40 \text{ ohms}$$

Figure 17 is a practical example of how to determine unknown resistance. Here, we want to operate a 6-volt light bulb from the 120 volt house line. What value of series dropping resistor do we need to drop the 120 volt house current down to 6 volts? The bulb draws 0.2 ampere.

We must first determine the voltage which must be dropped across the series dropping resistor. This is done by subtracting the line voltage (120) from the bulb's voltage (6). This gives us a value of 114 volts which we use in conjunction with Ohm's law for resistance as follows:

$$R \text{ (unknown resistance)} = \frac{114 \text{ (voltage dropped by resistor)}}{0.2 \text{ (bulb current in amperes)}}$$

$$R = 570 \text{ ohms}$$

Resistance in series. Many practical electrical and electronic circuits use two or more resistances connected in series. The point to remember in this case is that the total resistance is the sum of the individual resistances. This is expressed by the simple formula:

$$R \text{ (total resistance)} = R1 + R2 + R3 + \text{etc.}$$

where R1, R2, R3, etc. are the individual resistances (the dashed line indicates any additional resistances). Thus, in figure 18 the total of the individual resistances is R (total) $= 40 + 6 + 10 + 5 = 61$ ohms.

Resistances may also be connected in parallel in a circuit as in figure 19. In this case the current flowing in the circuit will divide between the resistances; the greater current flowing through the lowest resistance. Also, the total resistance in the circuit will always be less than any of the individual resistances as the total current is greater than the current in any of the individual resistors. The formula for determining the combined resistance of the two resistors is:

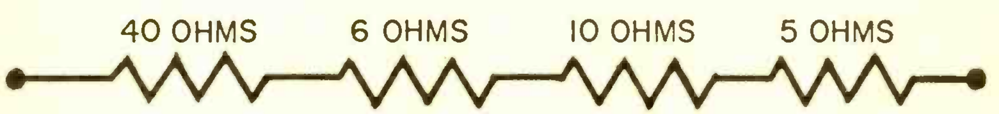


Fig. 18. The resistance of a series circuit is equal to the sum of all resistances.

$$R\ (total) = \frac{R1 \times R2}{R1 + R2}$$

Thus, in figure 19 the combined resistance of R1 and R2 is:

$$R\ (total) = \frac{2 \times 4}{2 + 4} = \frac{8}{6} \text{ or } 1.33 \text{ ohms.}$$

It is generally not necessary to carry the decimal point beyond two places.

In a circuit containing more than two parallel resistors as in figure 20 the easiest way to determine the total circuit resistance is as follows: first, assume that a six volt battery is connected across the resistor network. Pick a value that will make your computations simple. Then determine the current flowing through each of the resistors using Ohm's law.

$$I = \frac{6}{2} = 3 \text{ amperes}$$

$$I = \frac{6}{3} = 2 \text{ amperes}$$

$$I = \frac{6}{6} = 1 \text{ ampere}$$

Next, add the individual currents flowing through the circuit:

2 amperes + 3 amperes + 1 ampere = 6 amperes

Substituting this 6 amperes in Ohm's law, the total circuit resistance is found to be:

$$R = \frac{6}{6} = 1 \text{ ohm}$$

Quite often an electronic circuit will contain a combination of series and parallel resistances as in figure 21. To solve this type of problem, first determine the combined resistance of R2 and R3:

$$R\ (total) = \frac{6 \times 12}{6 + 12} = \frac{72}{18} = 4 \text{ ohms}$$

This total value of R2 and R3 may be considered a single resistance which is in series with R1, and forms a simple series circuit. This simple series circuit is solved as follows:

R (total) = 6 + 4 or a total of 10 ohms.

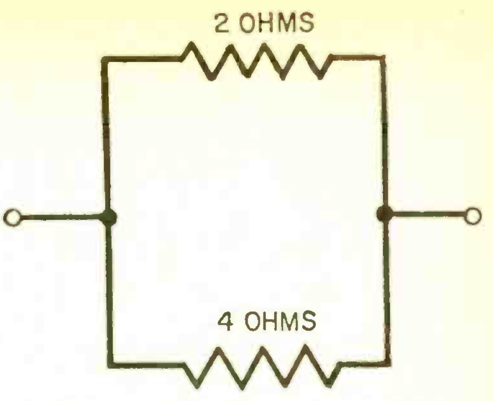


Fig. 19. Parallel resistance can be computed by the simple "product over the sum" rule.

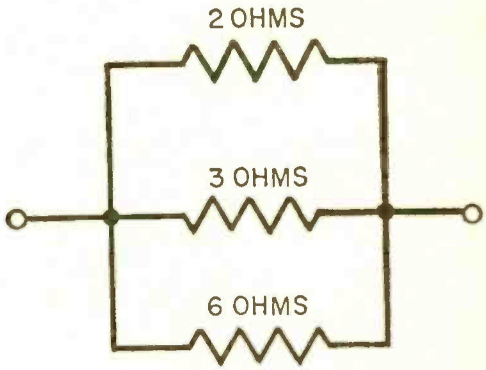


Fig. 20. Three resistors in parallel can be solved by calling on Ohm's law to help.

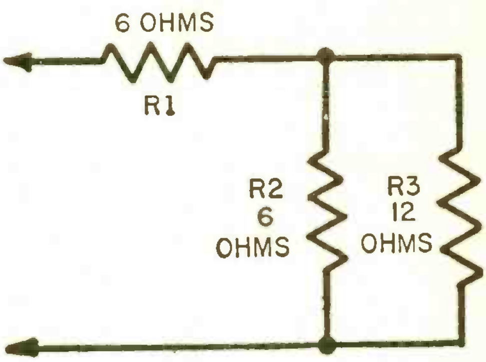


Fig. 21. Series-parallel combinations of resistors require some thinking to solve.

Power: The amount of work done by electricity is termed the *watt* and one watt is equal to one volt multiplied by one ampere. This may be expressed as: $P = E \times I$ where E = Voltage in volts, I = the current in amperes. Also:

$$P = \frac{E^2}{R} \text{ and } P = I^2R$$

As an example, assume that a toaster draws 5 amperes at an applied voltage of 115 volts. Its wattage would then be: $P = 115 \times 5$ or 757 watts.

Basic magnetism. Before we go any further with our investigation of basic electricity, it might be well to become familiar with the basic principle of magnetism due to the very close relationship between electricity and magnetism.

Some of the basic principles and effects of magnetism have been known for centuries. The Greeks are credited as the ones who first discovered magnetism . . . they having noted that a certain type of rock had the ability of attracting iron. Later, the Chinese noted that an elongated piece of this rock had the useful property of always pointing in a North-South direction when suspended by a string as shown in figure 22. This was the beginning of our compass.

This strange stone which intrigued people over the centuries is actually a form of iron ore known as magnetite. Not all magnetite shows magnetic properties. Another name for the magnetic variety of magnetite is lodestone . . . the term lodestone being derived from two separate words, lode and stone. The term lode stands for guide, hence lodestone means "guide stone."

All magnets, whether natural or man made, possess magnetic poles, which are commonly known as the magnet's north and south poles. As is the case of the electrical charges which we studied earlier between unlike magnetic poles and repulsion between like poles. It has been found that this magnetic attraction and repulsion force varies inversely as the square of the distance from the magnetic poles.

The magnetic field. We all know how a magnet exerts a force of attraction on a piece of magnetic material such as iron or steel. Also, when the north poles of two magnets are brought close together, they will try to repel each other, while there will be attraction between the north and south poles of two magnets. Although it is not clearly understood just what this force of magnetic attraction and repulsion is, it is convenient to visualize magnetic lines of force which extend outward from one magnetic pole to the other as illustrated in figure 23.

Permeability. Magnetic lines of force can pass through various materials with varying ease. Iron and steel for example, offer little resistance to magnetic lines of force. It is because of this that these materials are so readily attracted by magnets. On the other hand, materials such as wood, aluminum and brass offer great resistance to the

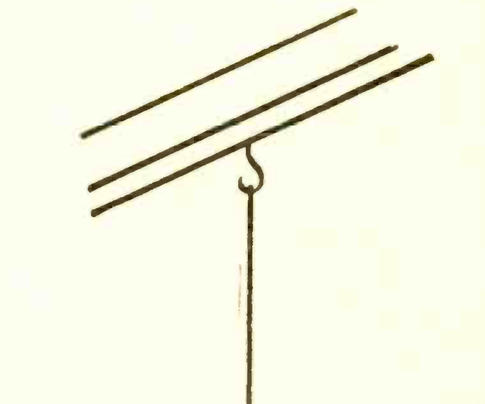


Fig. 22. The lode stone is a ferrous rock that was the first useful magnetic compass.

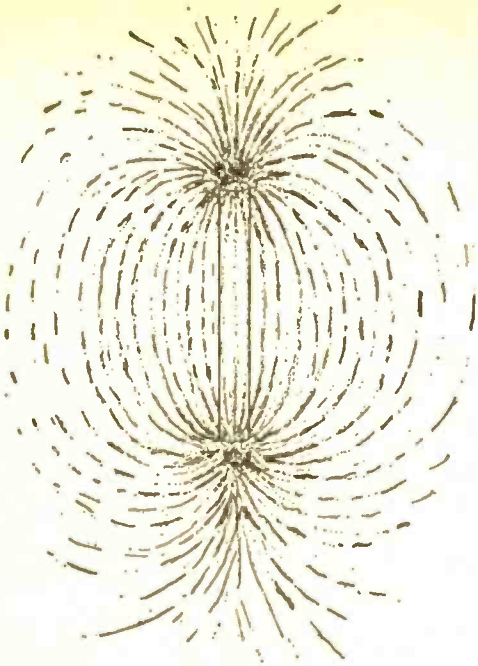


Fig. 23. Place a bar magnet under a piece of paper and sprinkle iron filings on top. Filing will trace out the magnetic field's force lines when the magnet aligns them.

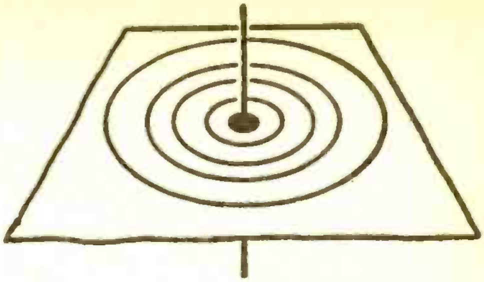


Fig. 24. The magnetic lines of force around a conducting wire is illustrated above.

passage of magnetic lines of force, and as a consequence are not attracted by magnets.

The amount of resistance a material offers to magnetic lines of force is known as its permeability. Iron and steel for example are said to possess high permeability as they offer little resistance to magnetic lines of force. Non-magnetic materials have low permeability. For practical purposes, we can say that permeability is to magnetic lines of force as resistance is to an electrical circuit.

Electromagnetism. Any electrical contor through which flows an electrical current will generate a magnetic field about it which is perpendicular to its axis as shown in figure 24. The direction of this field is dependent upon the direction of current flow, and the magnetic field strength proportional to the current strength. If this current carrying conductor is wrapped into a coil, forming a solenoid, magnetic field will be increased each individual turn is added to the field due to the fact that the field generated by generated by the other turns in the coil. If an iron core is inserted in this current carrying coil the generated field will be increased still further. This is because the lines of

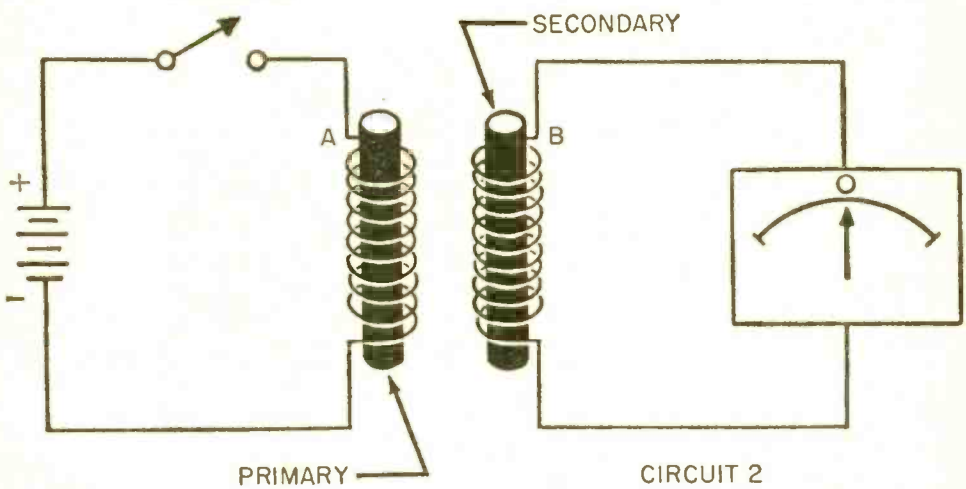


Fig. 25. A simple demonstration that illustrates how currents are induced.

force are concentrated within the iron core which has considerably less reluctance than the surrounding air.

The magnetizing power of a multi-turn current carrying coil through which a core is inserted is proportional to the current flowing through the coil as well as the number of turns in the coil. The current through the coil is termed ampere turns. As an example; if a coil consisting of 200 turns is carrying 2 amperes, its ampere turns equal:

Ampere turns = 200 turns x 2 amperes or 400 ampere turns

On the other hand, a coil of 100 turns through which a current of four amperes flows also has 400 ampere turns.

Ampere turns = 100 turns x 4 amperes or 400 ampere turns.

Electromagnetic induction. We saw earlier how a current carrying conductor will generate a magnetic field which is perpendicular to the conductor's axis. Conversely, a current will be induced in a conductor when the conductor is passed through a magnetic field. The strength of this induced current is proportional to both the speed at which it passes through the field and the strength of the field. One of the basic laws pertaining to electromagnetic induction is Lenz's Law which states: "The magnetic action of an induced current is of such a direction as to resist the motion by which it is produced."

Figure 25 illustrates two coils, A and B, which are placed in close proximity of each other. Coil A is connected in series with a switch and battery so that a current may be sent through it when the switch is closed, and coil B is connected to a current indicating meter. When the switch is closed, current will flow through coil A, causing a magnetic field to be built up around it. In the brief instant that the field is building up to maximum, it will "cut" the turns of Coil B; inducing a current in it, as indicated by a momentary flick of the indicating meter. When the switch is opened; breaking the current flow through coil A, the field around coil A will collapse, and in so doing, will again induce a current in coil B. This time however, the flow of current will be in the opposite direction. The meter will now flick in an opposite direction than it did when the switch was closed. The important thing to remember is that the conductor must be in motion with respect to the magnetic field or vice versa in order to induce a current flow. You can perform this simple experiment using two coils made of bell wire wrapped around large nails, a few dry cells in series, and a DC center scale meter.

Self induction. As mentioned a short while ago, a magnetic field is built up around a coil at the application of current through the coil. As this field is building up, its moving lines of flux will cut the turns of the coil; inducing a counter electromotive force or counter EMF which opposes the current flowing into the coil.

The amount of counter EMF generated depends upon the rate of change in amplitude of the applied current as well as the

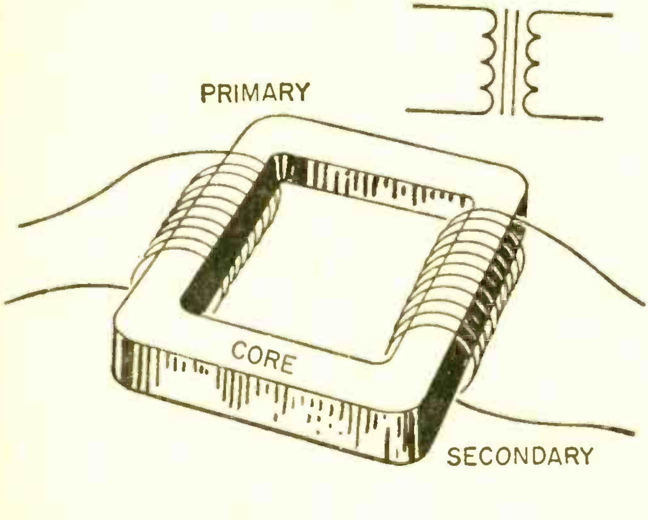


Fig. 26. A simplified drawing of a two winding transformer on an iron core. The primary winding is determined by its connection to the input circuit. Schematic diagram (upper right) is typical for a ferrous-core transformer.

inductance of the coil. This value of inductance is dependent upon the number of turns in the coil; a coil with many turns will have greater inductance than a coil with few turns. Also, if an iron core is inserted into the coil, the inductance of the coil will increase sharply. The unit of inductance is known as the Henry.

The transformer. One of the most important and widely used application of magnetic induction is the transformer. Transformers find the major application in stepping up or down voltage and current in countless applications.

Figure 26 shows the basic construction of a typical transformer. While two separate winding core shown here, some transformers such as those used in radio and receivers, can have as many as five or six individual windings.

A transformer consists of two or more separate windings, electrically insulated from each other. One winding which is known as the primary winding, is led from a source of alternating current.

The alternating current flowing through the primary induces a current in the secondary winding by virtue of magnetic induction. The transformer core is constructed from a relatively high permeability material such as iron which readily conducts magnetic flux between the primary winding and secondary winding.

The alternating current flowing in the primary of the transformer produces variation in the magnetic flux circulation in the transformer core which tends to oppose the current flowing in the primary winding by virtue of self-induction. This counter EMF is just about equal to the voltage applied to the primary winding when no load is connected to the transformer's secondary winding. This accounts for the fact that very little current flows through the primary winding when no load is connected to the secondary. The negligible current that does flow under this no-load condition is known as the transformer magnetizing current. As the current drawn from the secondary winding increases, the primary current will increase proportionately due to the reduction in the counter EMF developed in the primary winding of the transformer.

In any transformer the ratio of the primary to secondary voltage is equal to the ratio of the number of turns in the primary and secondary windings. This is expressed mathematically as follows:

$$\frac{Ep}{Es} = \frac{Np}{Ns}$$

where Ep = primary supply voltage
Es = voltage developed across secondary
Np = number of primary turns
Ns = number of secondary turns

The above formula assumes that there are no losses in the transformer. Actually, all transformers possess some loss which must be taken into account.

Transformer losses. No transformer can be 100 per cent efficient due to losses in the magnetic flux coupling the primary and secondary windings, eddy current losses in the transformer core, and copper losses due to the resistance of the windings.

Loss of magnetic flux leakage occurs when *not all* the flux generated by current flowing in the primary reaches the secondary winding. The proper choice of core material and physical core design can reduce flux leakage to a negligible value.

Practical transformers have a certain amount of power loss which is due to power being absorbed in the resistance of the primary and secondary windings. This power loss, known as the copper loss appears as heating of the primary and secondary windings.

There are several forms of core loss—hysteresis and eddy current losses. Hysteresis losses are the result of the energy required to continually realign the magnetic domain of the core material. Eddy current loss results from circulating currents induced in the transformer core by current flowing in the primary winding. These eddy currents cause heating of the core.

Eddy current loss can be greatly reduced by forming the core from a stack of individual sheets, known as laminations, rather than from a single solid piece of steel. Since eddy current losses are proportional to the square of core thickness, it is easy to see that the individual thin laminations will have much less eddy current loss as compared with a single thick core.

Another factor which effects eddy current loss is the operating frequency for which the transformer is designed to operate. As the operating frequency is increased, the eddy current losses increase. It is for this reason that transformers designed to operate at radio frequencies have air cores and are void of ferrous metals. ■

(*Continued from page 26*)

branch of a circuit will depend on the voltage (E) across the circuit and the resistance (R) of the circuit. Your body resistance is very high, usually well over 10,000 ohms. If you insert it across an electric circuit, your body will be the added resistance in that circuit.

Assuming your body resistance is quite low, say 60,000 ohms, in the case of the 6-volt source the current flowing through your body would be 6/60,000 or 100 microamperes, the total power would be .0006 watt. In the case of the 500-volt supply the current would be 500/60,000 or 8.3 milliamps and you would be called to dissipate 500 x .0083 or 4.15 watts. Clearly the latter is more dangerous.

There are no hard and fast rules, however, on how much voltage and current a body can stand without damage. Anything above 10 milliamps can be dangerous and anything above 50 milliamps can be fatal. In view of high body resistance it usually takes a high voltage to draw that much current. But if the body resistance is low, as for instance if it is moist, a relatively high current may flow with even a relatively low-voltage source. The only way to outwit Ohm's Law is by keeping your body out of electric circuits.

Incidentally, in about 90 per cent of the cases of electric shock where breathing has ceased, a fatality can be avoided if "mouth-to-mouth" artificial respiration is applied to the shocked individual within about 4 minutes. Everybody who has occasion to work with dangerous electrical currents, and his associates and family, should learn the technique. Consult your local Red Cross Chapter or family doctor.

Question: Many times I have heard the term "WPE Short-Wave Monitor." How can I become one?

RF, Birmingham, Ala.

Answer: The WPE program is sponsored by one of our competitors, Popular Electronics, One Park Ave., New York, N. Y. 10016. Write them and ask for an application form, enclosing a dime.

Question: When the power supply transformer of an AC superhet shorts or burns out, is it feasible to convert the power supply to AC-DC without altering any other section of the set?

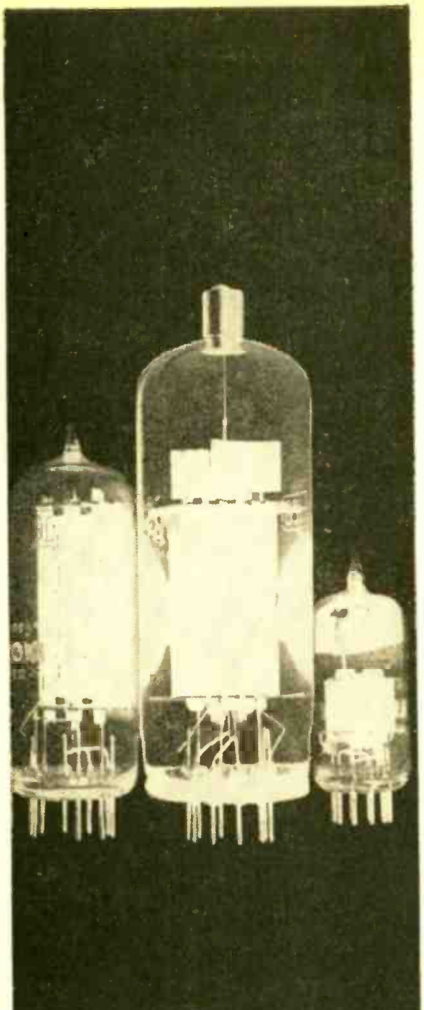
WW, Greensboro, N. C.

Answer: It would be possible but not very feasible in terms of the cost and labor involved. Trouble is that transformer type sets have the filaments of the tubes wired in parallel and supplied from the 6.3-volt (or 2.5-volt) winding of the transformer. To adapt to AC-DC it would be necessary either to rewire the filaments in series, possibly changing tube types, and/or add a series resistor or ballast tube to bring the line voltage down to the proper value. You will find it much simpler, cheaper and more satisfactory to get another transformer. You can find suitable ones in other old radios, or pick one up from a surplus dealer. McGee Radio, 1901 McGee St., Kansas City 8, Mo. is the best source I know of for replacement transformers suitable for such an application. You can get one that will do the job for between $3 and $6, from them; and believe me this will save you money and bushels of trouble.

Question: What's the best product for cleaning records and keeping them free of pops and crackles?

JNB, Dallas, Texas.

Answer: It is called *water*, produced by your city, county or sanitary district, and comes out of the faucets in your kitchen or bathroom. Let a gentle stream of it flow over the surfaces of the record, then wipe in a circular direction following the grooves, with a very soft, very fine piece of chamois. If you touch the record to the faucet while washing or, preferably, after chamoising, the static charge will be discharged. If the record is very dirty, or has fingerprints or signs of any kind of film or grease, or is heavily charged with static put just a little household detergent into a pan of water, and wash record with this, rinsing with flow of clean water and chamoising as above. Incidentally, here is a very simple test to check whether any record has a static charge: tear a small piece of newspaper into small bits, like confetti, and place on any surface. Bring record near bits of paper. If paper is attracted and jumps to record, it is charged. If record does not attract bits of paper it is neutral. Aside from the fact that it is cheap, the big virtue of WATER is that (if it is fit to drink) it will leave no grease, silicone, or any other kind of film to bind dust to record. ■



Since the efforts of Thomas Edison, J. J. Thomson and Lee de Forest over a half century ago, vacuum tubes and electronic devices using tubes contribute to our welfare, comfort and entertainment in almost every facet of our lives. Vacuum tube theory still remains one of the most significant and vital subjects that newcomers to the field of electronics should learn to master.

By W. F. Gephart

an introduction to vacuum tube theory

Your first big step into electronics is made by learning and understanding the design and operation of the vacuum tube

THE electronics industry as we know it today owes its birth and growth to the vacuum tube. It was, however, a slow start. The first vacuum tube ever built and operated remained unknown and unappreciated for many years. Thomas A. Edison discovered the basic principle of the vacuum tube, later known as the *Edison effect* back in 1883, but ignored it in favor of our electric lamp research. In 1906, Lee de Forest added empitus to this slow start when he designed and operated the first triode vacuum tube. In the 58 years that followed the vacuum tube triode, and its subsequent multiple-element kin folk, begot the enormous electronics industry that provides the comforts and science developments we now enjoy.

Inside the glass bulb. Since all tubes involve electron flow, a source of electrons must be included in the envelope. This is

EF vacuum tubes

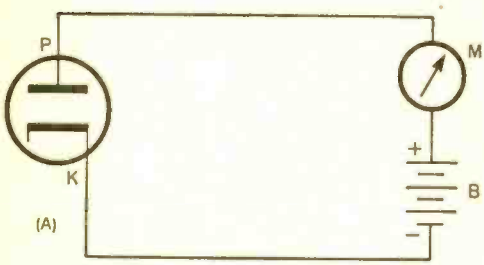
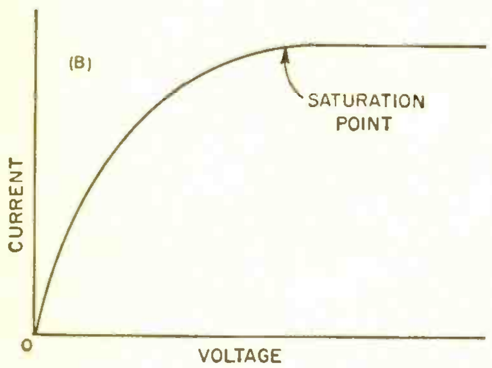


Fig. 1. The schematic diagram shown in (A) is typical for a setup to determine the characteristic curve of a diode. The curve in (B) shows how the diode's current varies with voltage.



usually a heating element in the tube, since metals such as tungsten and thorium, and compounds such as barium oxide, give off large quantities of electrons when heated. In some tubes, the electrons are taken directly from the heated wire, or filament. This is suitable when direct current from a source such as batteries can be used to heat the wire. If a low frequency alternating current is used, the flow of electrons varies at the AC frequency, creating an undesirable hum in the tube output.

To provide electrons from tubes powered by AC, a *cathode* is used. This is a metal sleeve, made of tungsten (or other metal coated with barium oxide) which is heated by a *filament* (or *heater*) located inside of it. Since the amount of metal in the sleeve is sufficient to hold heat better than the wire filament, it cannot appreciably change temperature with the variation in AC frequency on the filament. Since electron emission is based on temperature, the cathode's emission of electrons is not affected by the AC frequency of the voltage applied to the filament, and it does not introduce a hum in the tube's output.

The diode. Since the electrons emitted by the cathode have a negative charge, they will be attracted to any element in the tube that has a positive charge, since unlike charges attract. By placing a positively-charged element, called the *plate*, in the tube, the flow of electrons between the cathode and plate would then create a current flow, if proper external connections were made. Figure 1A shows the connections for this type of simple, two-element tube, called a *diode*.

The plate (P) is connected (through a meter) to the positive side of a battery, and the cathode to the negative side. Electrons being emitted by the cathode (heated by a filament not shown) are attracted to the plate, through the meter and battery, and back to the cathode. As the graph shows in

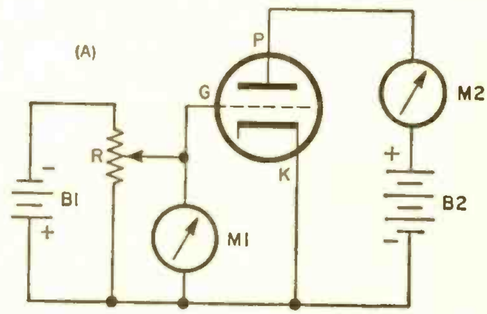
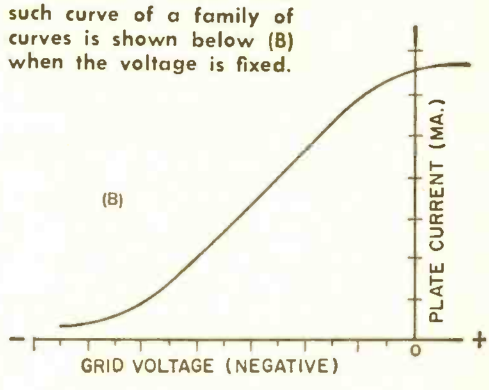


Fig. 2. The schematic diagram shown in (A) above is a typical test setup circuit for determining a triode's characteristic curves. One such curve of a family of curves is shown below (B) when the voltage is fixed.



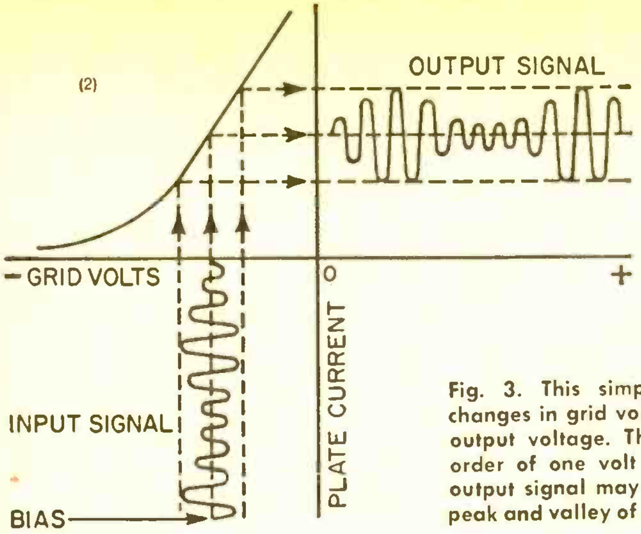


Fig. 3. This simple diagram shows how small changes in grid voltage causes changes in the plate output voltage. The input signal is usually in the order of one volt or less in audio amplifiers. The output signal may have swings in voltage between peak and valley of 300 volts with gains in the 1000's.

figure 1B, the current increases as the voltage increases, up to a point. The leveling off point is where the plate is attracting all of the electrons that the cathode can emit, and further increase in voltage can no longer increase current flow. This is known as the *saturation* point for diodes, which are primarily used for rectification and detection.

The triode. In 1906, a man named Lee de Forest added a third element, making tubes useful for more than just rectification and detection. Signal amplification was now possible. This added element was a series of fine wires, placed between the cathode and plate. Since the electron flow, consisting of negative charges, had to flow between these grid wires, the electrostatic charge on the grid could control the flow of electrons. This new tube with the element of fine wires, called the *control grid*, was named a *triode*, because it had three elements; cathode, grid and plate.

Suppose we connect a triode tube as shown in figure 2A. When the arms of potentiometer R is at the bottom, control grid G will have the same potential as cathode K, and the triode will conduct like a diode. The amount of plate current (shown on M2) will depend on battery B2 voltage and tube design.

If we move the wiper arm of potentiometer R up, however, the grid becomes negative with respect to the cathode (due to the polarity of battery B1) as indicated on M1. As this occurs, the plate current will decrease, since some of the negative electrons moving from the cathode toward the plate will be repelled by the negative electrostatic charge on the control grid. Plotted on a graph, the effect of grid voltage on plate current is shown in figure 2B. Notice that, the more negative the grid (with respect to the cathode), the less plate current that flows.

Amplification. The amount of current change per grid voltage change depends on tube design and plate voltage. A 6AB4 triode with 300 volts on the plate will have an increase of 11 milliamperes plate current with a 2-volt change on the control grid. On the other hand, a 6J5 triode with 300 volts on the plate will only have a 2 milliamperes change in plate current with a 2-volt change on the control grid. These figures indicate how a triode amplifies. Suppose, in the two examples above, there is a 10,000 ohm resistor in the plate lead of each tube. In the 6AB4, the 11 milliamperes change in plate current would result in a change in voltage drop across this resistor of 110 volts; in the 6J5, the 2 milliampere plate current change would only change the voltage drop across the resistor by 20 volts. In one case, the grid voltage change of 2 volts was amplified 55 times (to 110 volts), and in the other case only 10 times (to 20 volts). The difference is due to tube design, the 6AB4 being a *high mu* (high amplification factor) triode, and the 6J5 being a *low mu* (low amplification factor) triode.

Amplification can also be seen graphically in figure 3. The small change input signal on the control (vertical signal on the graph) produces a change in plate current (horizontal signal) that is identical in form. This plate current change (output signal) going through the plate load resistor produces a larger voltage change than appeared on the control grid, but having the same pattern as the grid voltage changes.

Notice, that, to faithfully reproduce the grid wave pattern in the plate current, there must be limits as to how much voltage can be placed on the grid. If we allow the grid to swing too far negative from its starting point, the operating curve flattens out, and there is less change in plate current per volt change on the grid. If the signal swings the grid too far positive from its starting point, it may even became positive. When this happens, it then attracts electrons, reducing the number going to the plate, and again the current change per grid-volt change will be reduced. Excessive signal inputs to grids cause this *distortion*, where the pattern of plate current change does not match the pattern of grid voltage changes.

Bias. Notice that we related these changes to a "starting point." This is the voltage (usually negative) on the control grid without any signal, and is called *bias*. See figure 3. The signal then swings the grid voltage (more or less negative) on either side of this point. Even if our signal was not too large, distortion could occur if the bias was not set at the proper point. For example, if the bias is set at -1 volt, and a 2-volt signal is applied, there will be distortion, since the grid will go positive.

Bias can be obtained from a battery (as in

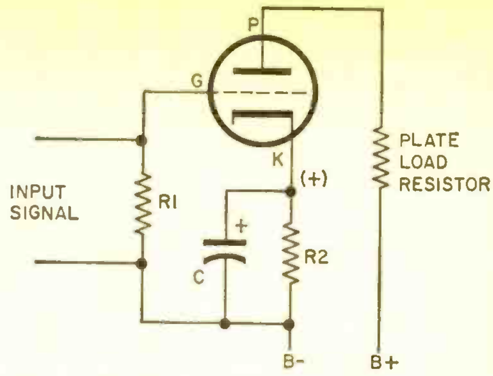


Fig. 4. Control grid bias can be obtained from the voltage drop across plate load resistor R2.

figure 2A) or from a negative power supply, but the most common method is by *cathode bias*, illustrated in figure 4. In this case, with no signal input and no current, the grid is the same potential as the cathode. As soon as the filament heats up and current starts to flow, it flows through R2, causing a voltage drop across it. This voltage is positive at the top of the resistor and negative at the bottom, due to the direction of the electron flow. Since the grid is connected to the bottom of R2 (through R1) and the cathode to the top of R2, the cathode is then positive with respect to the grid. By the same token, the grid is then negative to the cathode, with a bias equal to the voltage drop across R2.

An alternating input signal appearing across R1 then changes the grid voltage in relation to the cathode. This causes changes in plate current, but the DC voltage across R2 remains fixed, since the signal-induced changes in the plate current are bypassed by condenser C.

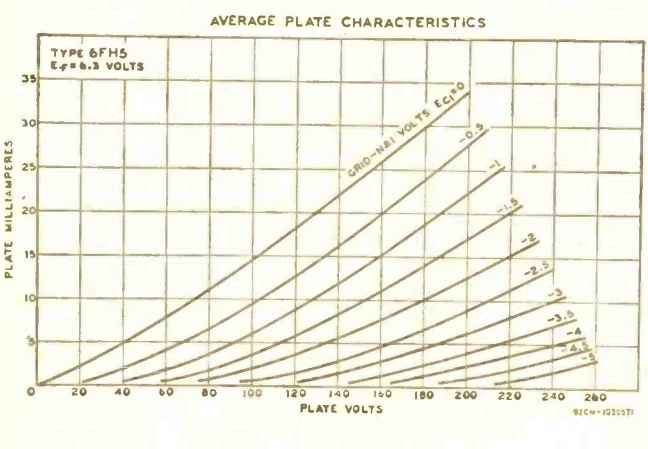


Fig. 5. The average plate characteristics for a triode tube. Note that a curve is drawn for several control grid voltage potentials. This tube is best operated at a bias of −1 volt at a plate voltage of about 135.

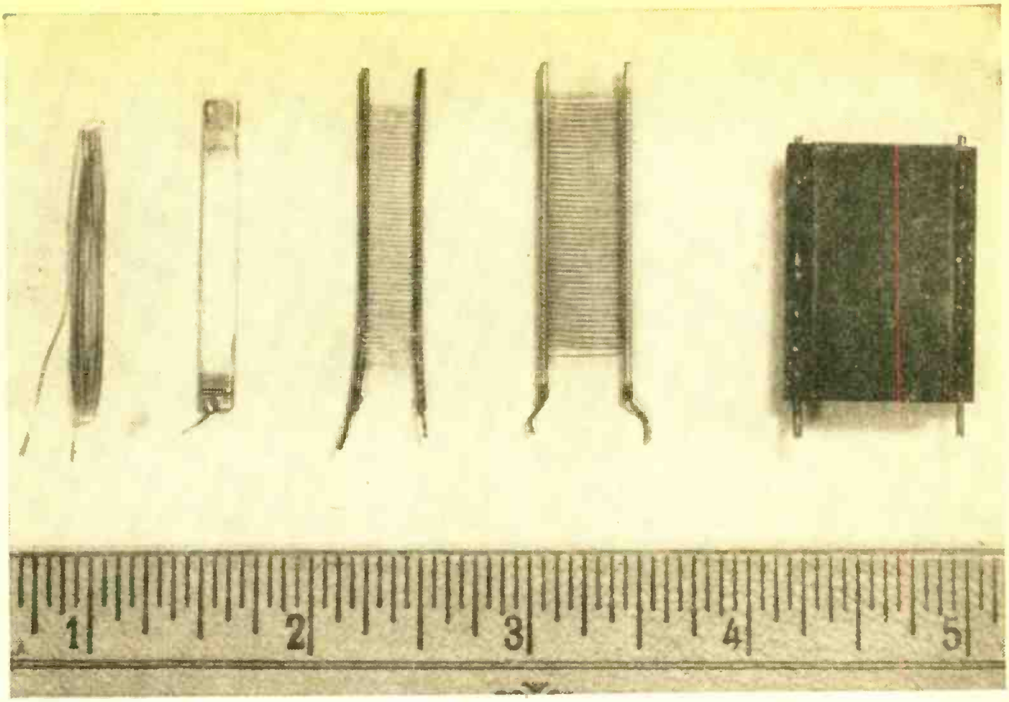


Fig. 6. Left-to-right: filament, cathode, grid, screen grid and plate of a small receiving tube shown life size. Each element fits inside the element to its right.

In diodes, increasing the plate voltage increased the plate current. The same is true for triodes, and various changes in grid voltage will give different changes in plate current at different plate voltages. Tube specifications are usually shown in the form of "Average Plate Characteristics," similar to figure 5.

The tetrode. One of the limitations to the amplification of triodes was feedback, due to the capacitance between the plate and grid. This was overcome by inserting another grid between the original grid and plate to act as an electrostatic shield and reduce the capacitance. This new grid was called a *screen grid*, and since it was the fourth element in the tube, tubes with just two grids are called *tetrodes*.

Since it cannot be permitted to slow the flow of electrons to the plate, the screen grid carries a positive voltage only slightly lower than the plate. It attracts electrons too, but being a mesh, most pass through it to the plate. See figure 6.

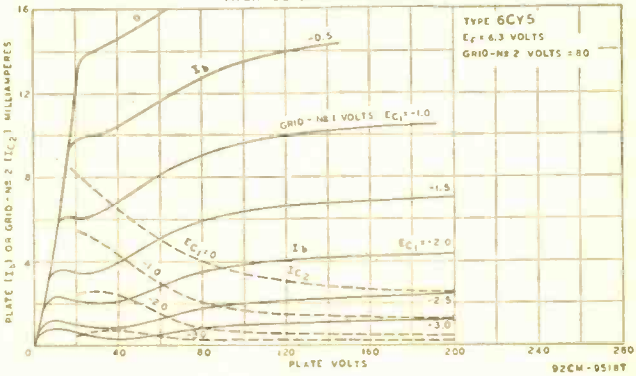


Fig. 7. The average characteristics for a typical tetrode. In this case it is the 6CY5 vacuum tube. Note how the curve dips as the plate voltage is increased from zero to 40 volts when the control grid bias is −3 volts. The solid lines indicate plate current and the dashed lines indicate screen grid current. Curve was drawn with 80 volts on screen grid.

vacuum tubes

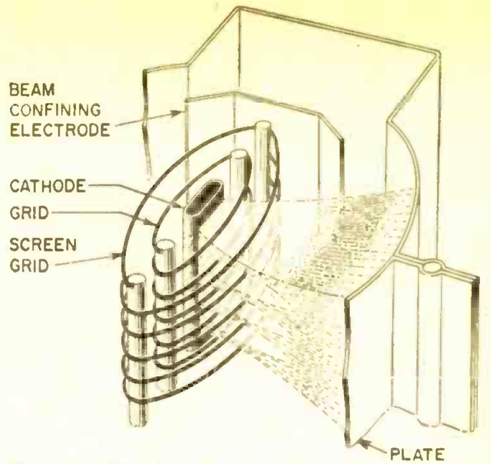


Fig. 8. The beam power tube focuses the electron cloud and aims it at the plate.

While the tetrode overcame the feedback problem, permitting higher amplification, it had a serious drawback. With certain combinations of grid and plate voltages, there was a serious "dip" in plate current, as seen in figure 7. This was due to the fact that, under these certain conditions, some electrons "bounced" off the plate (*secondary emission*) and were attracted to the positive screen grid. Since this meant that fewer electrons flowed in the plate circuit, current was reduced at this point, resulting in non-linear operation.

The pentode. Ultimately, two developments overcome this problem. The *beam power* tube, though a later development, should be covered first, since it is still the tetrode tube. Here the problem was solved by the physical construction shown in figure 8. Two shaped metal plates were placed at the sides of the grid-cathode structure, and connected to the cathode. The main plate receives the beam of electrons, and is curved. The focussing effect of this curvature, and the constricting effect of the beam plates cause the secondary emission ("bouncing electrons") to form a "cloud" between the ends of the beam-forming plates. Once this "cloud" is formed, any more electrons "bouncing" off the plate are repelled by the like charges of the electrons in the "cloud" and return to the plate. This virtually eliminates the "dip" in the curves in figure 7.

The original solution to the secondary emission problem was to add a third grid between the screen and plate. This is known as the *suppressor grid*, and made the fifth element in tubes called *pentodes*. The suppressor grid is connected to the cathode (either internally or externally) and, being negative with respect to the plate, repels any electrons that "bounce" off the plate.

Figure 9 shows the characteristic curves for a typical pentode. Notice that the "dip" evident in the tetrode curves (figure 7) has been eliminated. Also note that the addition of tube elements between the cathode and grid has minimized the effect that plate voltage has on current, as compared to the diode and triode. Due to the increased isolation of the input and output in the pentode, very high amplification factors (as high as 2000) can be secured.

Multielement vacuum tubes. While the

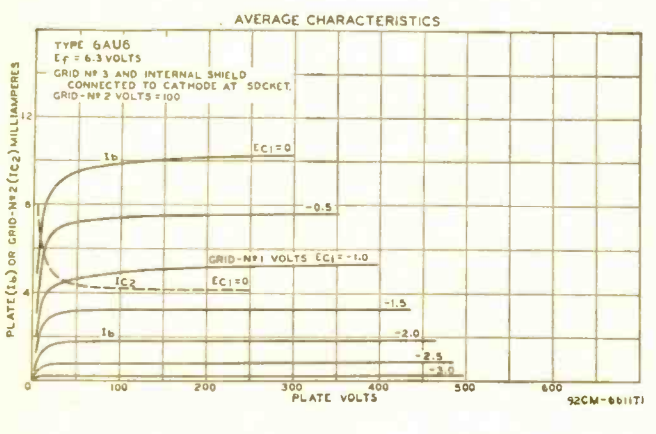


Fig. 9. Characteristic curves for a typical pentode (6AU6). Note that the dip in the curves common to the tetrode does not appear here. Also, plate current reaches a peak at a very low plate voltage and increases after that are small.

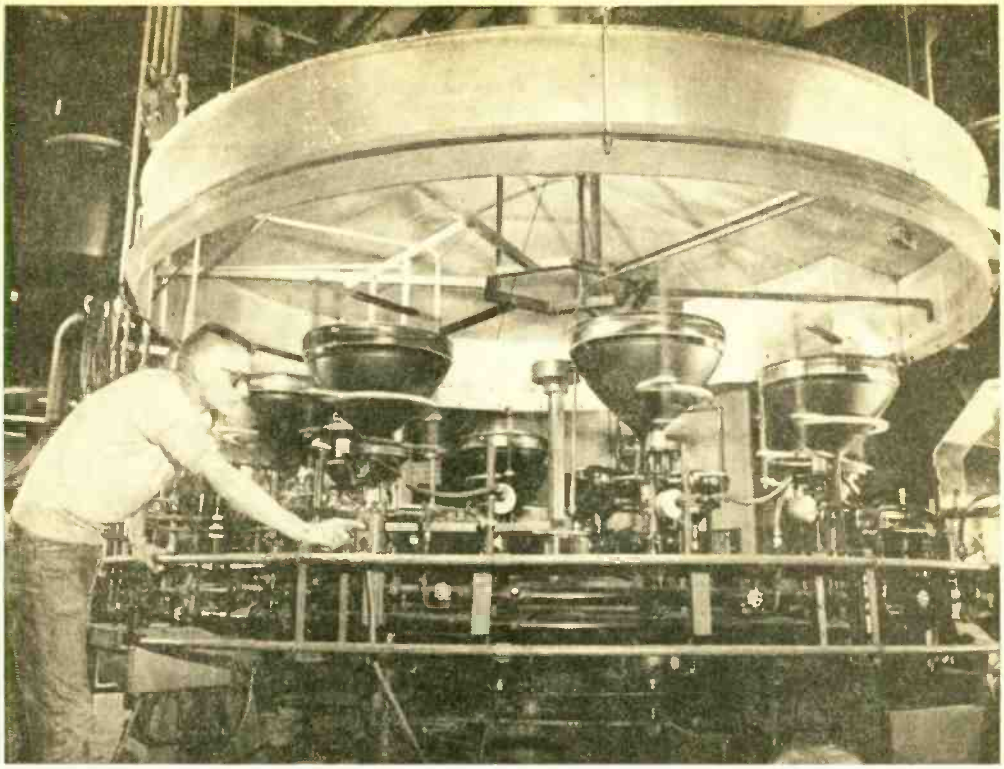


Fig. 10. This machine, which installs the electron gun, removes the air and then seals the television picture tube, is typical of automatic equipment in modern vacuum tube plants.

diode, triode, tetrode and pentode cover most tube designs, some have even more elements. The *pentagrid* and *heptode* tubes have additional grids which allow two signals to be fed into the same tube and appear "mixed" in the output from the plate. They also include a grid which acts as a plate. It attracts electrons from the cathode after they have passed the first input grid, but being mesh construction, permits the electrons (carrying the first signal) to pass through, by the second signal grid, and on to the plate.

Today most tubes are multi-purpose tubes that have two or more sets of tube elements in one envelope. These are often twin units (twin diode, twin triode, etc.) or are combination units, such as diode-triode, triode-pentode, etc. Compactrons pioneered by General Electric have three or more vacuum tube sections in each glass bulb. They save space and permit one heater (or filament) to operate two or more tube sections.

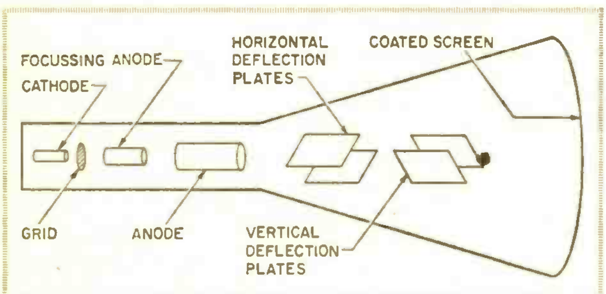


Fig. 11. A cathode ray tube of the type used in small TV sets and oscilloscopes. The electron stream from the cathode is shaped into a pencil beam by the anodes and positioned up and down, left and right by the deflection plates. Where the beam strikes the coated screen light rays are generated.

vacuum tubes

The odd balls. In addition to basic tube types, there are many special types. One common special type is the cathode-ray tube, used in TV sets (figure 10), oscilloscopes, radar, etc. In this tube, electrons from a cathode are arranged in a beam and accelerated to high speed by cylindrical focussing and acceleration anodes (or "plates"). They pass through these cylindrical elements at such high speed that most electrons go through the elements and strike the inside wall of the front of the glass envelope. This is coated with a fluorescent material that glows every time an electron hits it. By varying the grid voltage, the number of electrons in the beam can be varied, and the light on the face of the tube varied.

The tube, shown in simple form in figure 11, also includes two sets of elecro-deflection plates, which can deflect the beam up or down, or left or right, depending on the polarity of the voltage on the deflection plates. For example, on the two vertical plates, if the top plate is positive and the bottom negative, the beam will be deflected upward, since the positive charge attracts the electrons, and the negative repels them. TV tubes rely on magnetic deflection rather than electrostatic means.

Another specialized tube in common usage is the gaseous voltage regulator. These are diodes filled with gas or mercury vapor. When the anode (or plate) voltage reaches a given point, the gas ionizes (as explained in the article on Rectification). As soon as the gas becomes ionized, the voltage drop across the tube tends to become constant over a wide current range.

Once ionized the gas remains ionized at a slightly lower voltage than required to start ionization, due to the additional electrons created by ionization. In the OD3 tube, approximate ionization voltage is 160 volts, but after "starting" (or ionizing), voltage across the tube remains constant at 150 volts, within the operating range of 5 to 40 ma.

These tubes are used with a resistor, as shown in figure 12. This resistor limits the tube to its maximum rating. With the OD3 (150 volt, 5-40 ma. regulator), and a power supply output of 200 volts, the value of the resistor is determined by using Ohm's law.

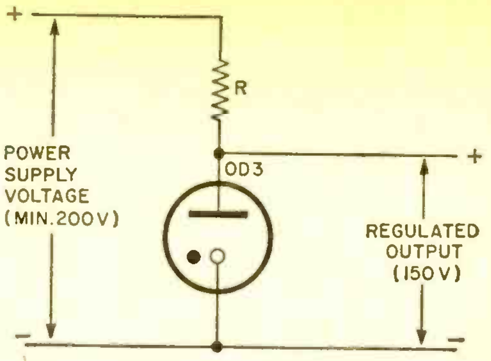


Fig. 12. The voltage regulator tube is not a vacuum tube but a gas filled tube that glows with a weak "neon-like" glow when on.

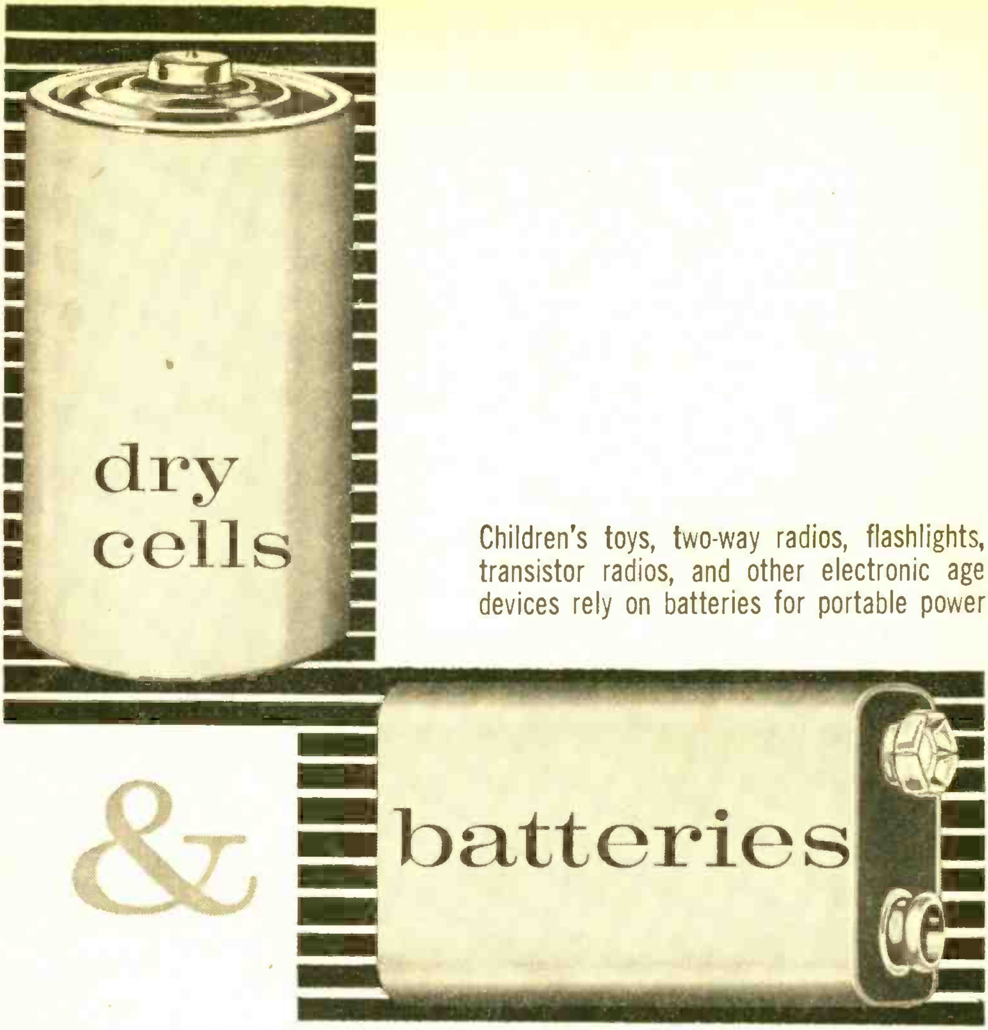
The difference between the power supply voltage and regulator voltage is 200 - 150, or 50 volts. The tube can handle 40 milliamperes (or .04 amperes), so the value of the resistor will be the 50 volt drop divided by the current of .04 amperes, or 1250 ohms. With this resistor in the circuit, and with a 200 volt power supply, the tube will draw 40 milliamperes, and have a 150 volt drop across it.

Now suppose some current is drawn by the load. This flows through R, which *tends* to increase the drop across the resistor to more than 50 volts, which *tends* to drop the voltage across the regulator tube. The gas then *tends* to ionize less, fewer "collision" electrons are released, and current flow through the tube decreases. The tube current decrease offsets the load current increase in R, and the drop across the resistor remains at 50 volts, and the drop across the tube remains at 150 volts.

The tube can respond to the "tendencies" only up to a point; when the current in the tube drops below 5 ma., the gas de-ionizes, the tube stops conducting and loses control. It is obvious that if the load draws more than 40 ma., the drop across R will be so great that the tube will de-ionize and lose control.

No one article can ever hope to cover the entire subject on vacuum tubes nor can any one volume do a satisfactory job. If you wish to learn more about vacuum tubes, the *Editor* suggests you continue to read scientific texts and magazines. Future editions of ELEMENTARY ELECTRONICS will contain additional information on the subject as will RADIO-TV EXPERIMENTER —its parent magazine. ■

dry cells & batteries



Children's toys, two-way radios, flashlights, transistor radios, and other electronic age devices rely on batteries for portable power

THE invention of the first electrochemical cell is credited to the Italian physicist Allesandro Volta. This noble Italian observed that an electric current flowed between copper and zinc electrodes when immersed in acetic acid. From this crude beginning, the chemical "battery" has evolved to a highly developed state, although the basic electrochemical principles demonstrated in Volta's original cell still form the basis for present day wet and dry electrochemical cells.

The first relatively practical electrochemical cell was developed by a Frenchman by the name of George Leclanché in 1868. Leclanché substituted a carbon rod for the copper positive electrode used by Volta, and an electrolyte consisting of ammonium chloride in place of the acetic acid. A "depolarizer" consisting of manganese dioxide (MnO_2) was placed around the positive carbon electrode.

dry cell batteries

The first "dry cell" was produced by Dr. Gassner in 1888. This unit consisted of a zinc container which also served as the cell's negative electrode. A central carbon electrode formed the positive electrode and the electrolyte was absorbed in a porous material—the complete cell being sealed off at the top.

How Volta did it. To get a good understanding of just how electricity is produced from chemical action, let's go back to Volta's original zinc-copper cell, although this time, substituting dilute sulphuric acid for his original acetic acid electrolyte. In figure 1, we see two strips of metal, one of copper and the other of zinc, immersed in a dilute solution of sulphuric acid and water—called the *electrolyte*.

The following is the action that takes place between the sulphuric acid (H_2SO_4) and the zinc strip (Zn). In going into solution, the sulphuric acid breaks down into its constituent atoms. Its SO_4 molecules accept elec-

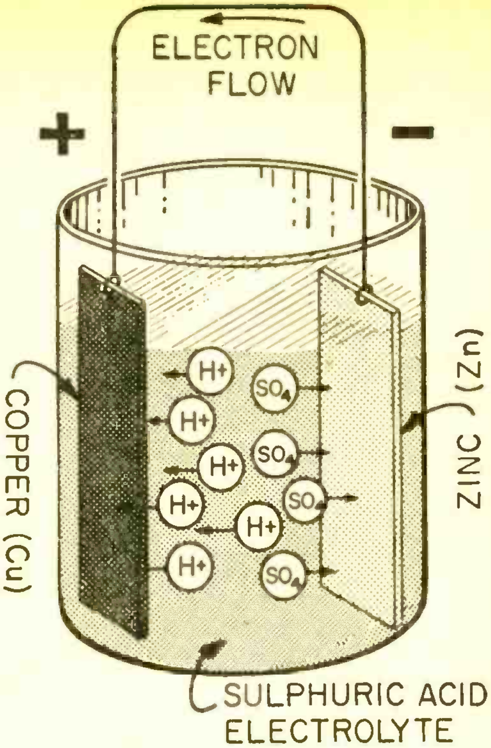


Fig. 1. Allesandro Volta's Zn-Cu cell.

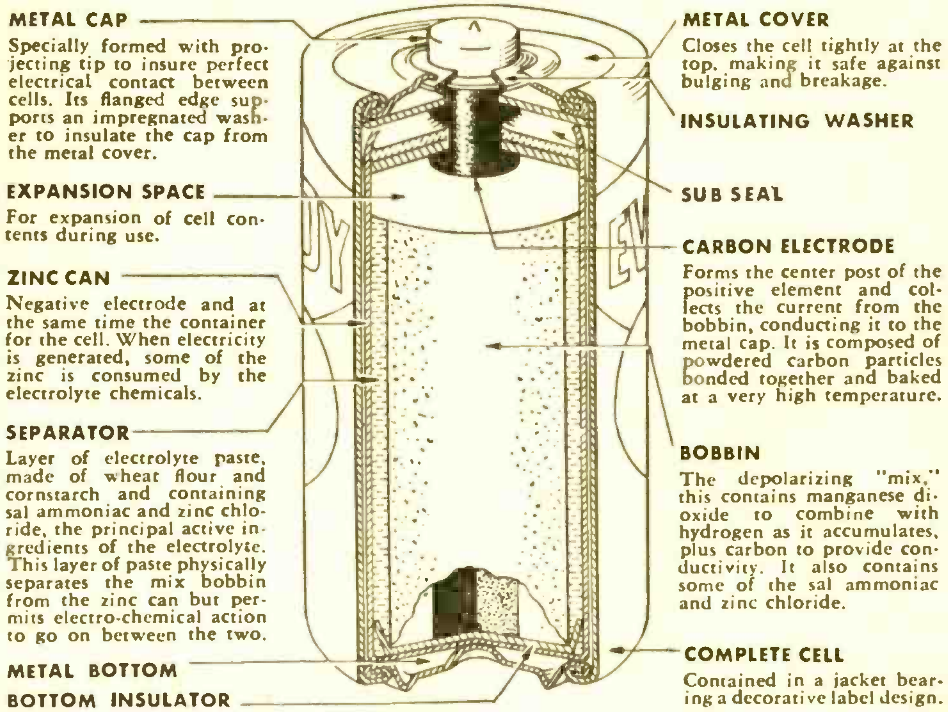


Fig. 2. "Cut away" detail diagram of a typical flashlight dry cell.

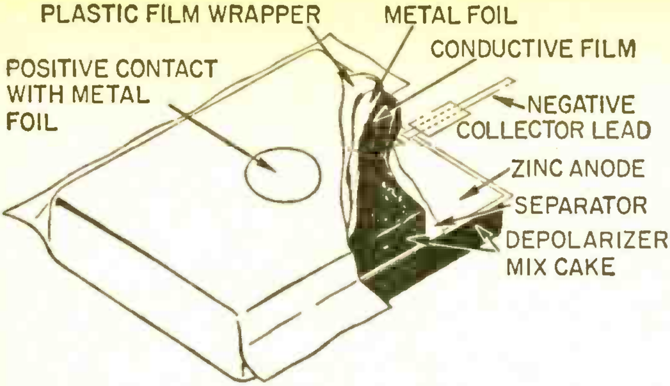


Fig. 3. "Cut away" detail drawing of a flat cathodic-envelope dry cell. Many of these cells are connected in series to obtain high voltages for portable transistor radios and many other gadgets such as hearing aids and test gear.

trons from the hydrogen atoms, with the result that the sulphate molecules become *negatively charged* sulphate ions and the hydrogen atoms become *positively charged* ions. Remember, a deficiency of electrons results in a positive ion while a surplus of electrons produces a negative ion.

The presence of the zinc strip in the electrolyte causes some of the zinc electrode to enter the electrolyte; these atoms readily releasing free electrons which are deposited on the zinc electrode. The resulting positive zinc ions go into the electrolyte, leaving the zinc electrode with a negative charge due to its surplus of negatively-charged free electrons. After a short while, a point is reached where no more ions can go into the electrolyte as they are attracted back to the zinc electrode by virtue of its acquired negative charge. Thus, a state of equilibrium is reached.

The chemical action between the copper strip and electrolyte is essentially the same as with the zinc strip, although not as intense. While the copper electrode does develop a negative charge, it is not as great as that developed on the zinc electrode. Since the copper electrode is "less negative" than the zinc electrode, a *potential difference* will be developed between the copper and zinc electrodes. This potential difference amounts to 1.1 volts. This potential difference is called the *open circuit voltage* for the zinc-copper cell.

Now, let's see what happens when we connect an electrical conductor between the zinc and copper electrodes as illustrated in Figure 1. The surplus of electrons acquired by the zinc electrode flow through the wire conductor to the less negative (positive) copper electrode. As this occurs, more zinc dissolves into the electrolyte; additional positive zinc ions are introduced into the electrolyte, driving hydrogen ions over to the less negative copper electrode. Each hydrogen ion reaching the copper electrode combines with an electron reaching the copper electrode via the conductor. This reaction causes hydrogen gas to be developed at the copper electrode until the electrode becomes completely covered with hydrogen. This effect is known as *polarization.* When polarization occurs, the hydrogen bubbles cover the copper electrode surface completely. Hence, no copper is in contact with the electrolyte, the chemical action stops, and the cell ceases to deliver current (electron flow) to the external circuit. To depolarize a cell of this type, all you have to do is shake the bubbles off the copper electrode.

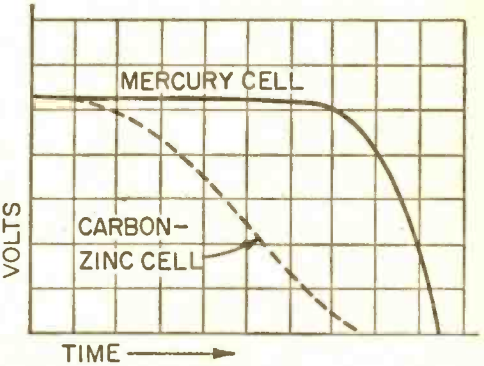


Fig. 4. Comparison of dry cell output voltages and how they decrease under constant load for equal time/work periods.

The Modern Day Cell. Earlier, it was mentioned that Dr. Gassner developed the dry cell as we know it today. Figure 2 shows a "cut away" sketch of a flashlight cell which is typical of the hundreds of thousands of such units now in service. The zinc container serves as the cell's negative electrode, with a

dry cell batteries

central carbon rod forming the positive terminal. The cell's electrolyte consists of a paste of ammonium chloride and manganese dioxides, the latter serving to take up hydrogen gas developed at the positive electrode during operation of the cell. The cell is sealed at the top to prevent leakage, or drying out, of the electrolyte.

This type of cell will generate an open circuit voltage of just about 1.5 volts. It's interesting to note that regardless of the physical size of this type of cell, the *open circuit voltage* will always be 1.5 volts. This is because the cell's generated voltage is determined by the chemicals used in its construction, not the quantity of chemicals. However, the size of the cell does determine its electrical capacity as we shall see a bit later on a number of specialized forms of the basic zinc-carbon cell have been developed to meet specific needs.

Secondary Cells. The chemical action in a primary cell cannot be reversed, that is, once its electricity producing chemicals are exhausted, they cannot be efficiently rejuvenated by the passage of an electric current through the cell.

On the other hand in a "secondary" cell, the chemical action can be reversed, the

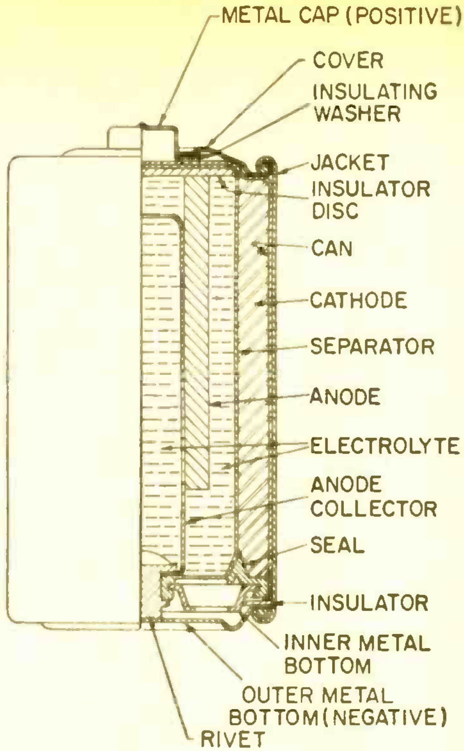
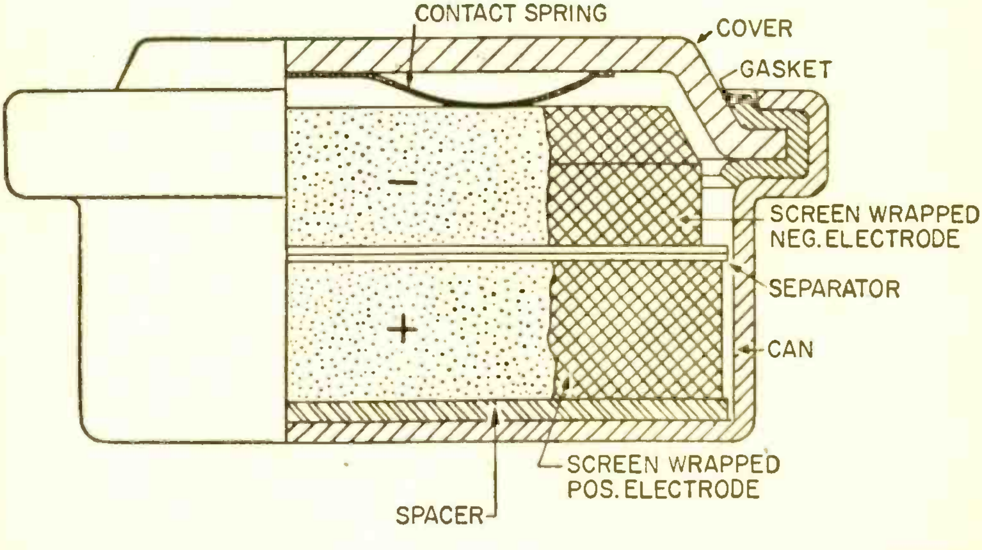


Fig. 5. Internal construction details of an alkaline cell. In this cell the electrolyte is a highly alkaline (opposite of an acid) solution.

Fig. 6. "Cut away" detail diagram of a typical button nickel-cadmium dry cell. Cell is noted for constant (regulated) voltage out.



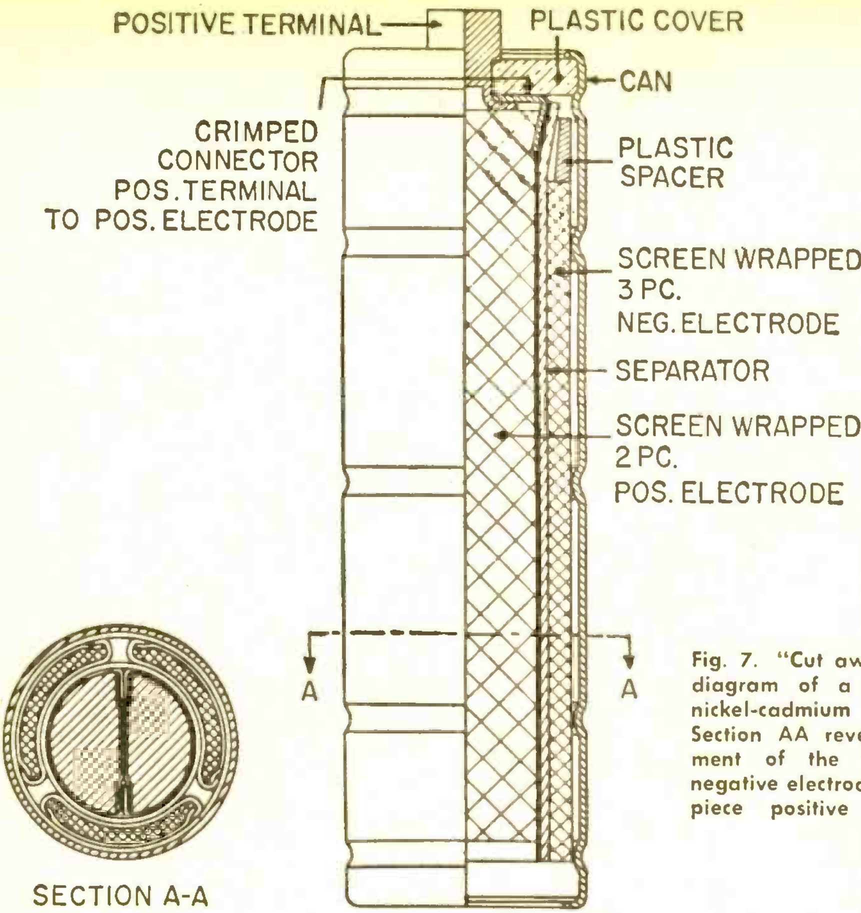


Fig. 7. "Cut away" detail diagram of a cylindrical nickel-cadmium dry cell. Section AA reveals placement of the three-piece negative electrode and two-piece positive electrode.

passage of current through it causing a chemical reaction that restores it to its original condition.

The most familiar example of a secondary cell is the lead-acid storage battery which lies under the hood of your automobile.

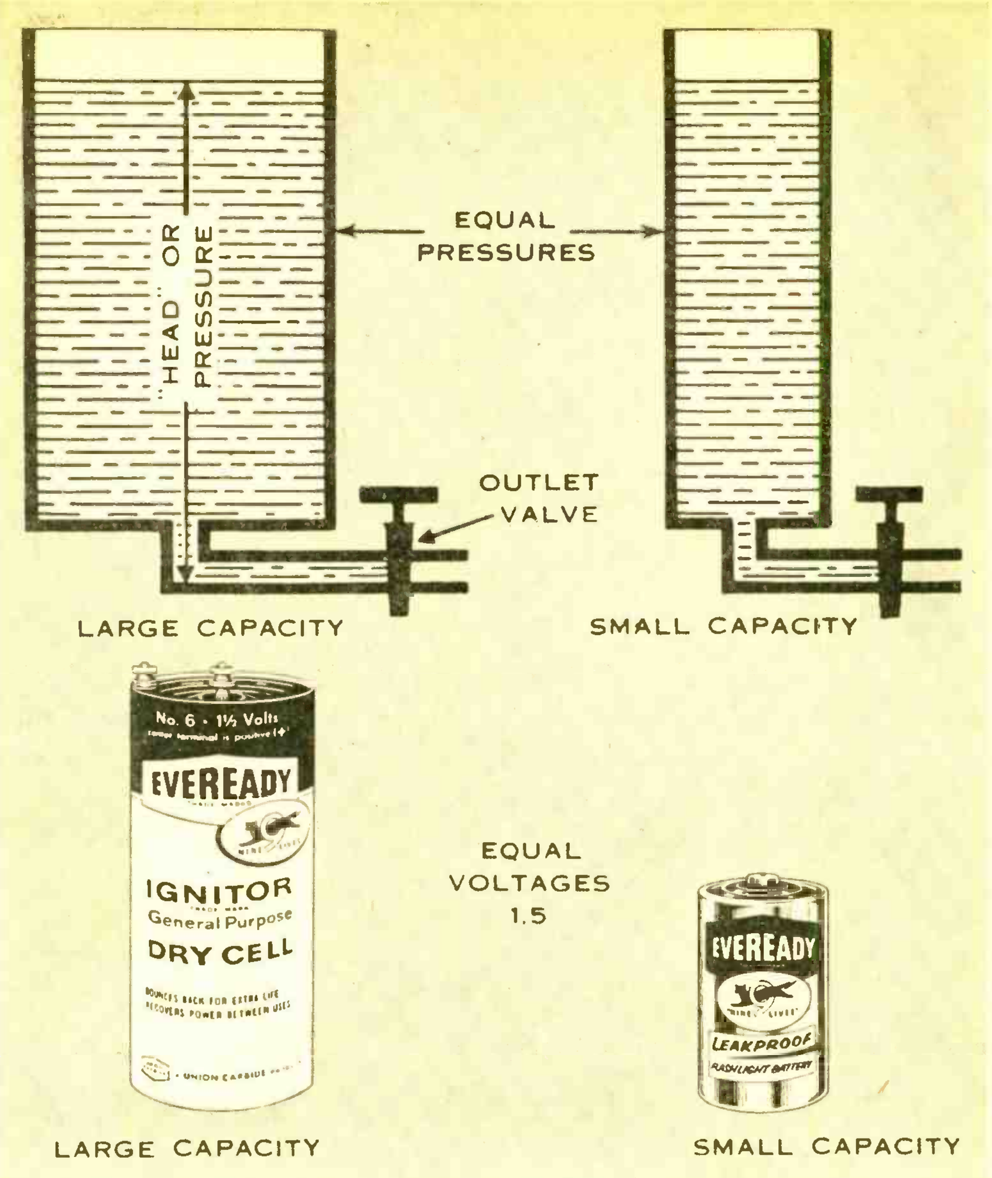
The positive electrode of the lead-acid storage battery consists of a grid structure coated with porous lead peroxide (PbO_2). The cell's negative plate is also a grid structure on which is deposited spongy lead (Pb).

Let's take a look at the basic electro-chemical reaction that takes place in a lead-acid storage cell . . . first under conditions of discharge (cell delivering current to load). The sulphuric acid electrolyte is broken down into positive hydrogen ions and negative SO_4 ions. The spongy lead negative electrode dissolves slightly in the electrolyte, forming positive lead ions and free electrons which flow through the negative terminal to the external circuit. The negative sulphate ions combine with the positive lead ions to form lead sulphate which is deposited on the negative electrode.

The lead peroxide at the cell's positive electrode first reacts with the electrolyte to form positive lead ions. These ions now react with electrons released by the spongy lead to form lead sulphate which builds up on the positive electrode.

The electro-chemical reaction during discharge of the lead-acid cell partially replaces the sulphuric acid on the electrolyte with water. This lowers the *specific gravity* of the electrolyte. Thus, it is important to determine the condition of charge of this type of cell by checking its electrolyte's specific gravity. This is done by means of *hydrometer*.

To charge a lead-acid cell, current is sent through it in a direction opposite to its discharge current. Although the electro-chemical processes involved in the recharging operation are quite involved, basically what



happens is that the chemical reactions involved in the discharge of the cell are reversed. The lead sulphate deposited on the positive electrode is converted back to lead peroxide, and the negative plate is restored to spongy lead.

The open circuit voltage of a lead-acid storage cell is 2.1 volts.

Specialized Cells and Batteries. The *cathodic envelope* battery, a modified version of the standard carbon-zinc configuration, has been developed for low voltage, relatively

Fig. 8. The voltages in both cells shown above are the same. In this case, it is 1.5 volts. In the analogy, the valve diameter is the same for both tanks, but the tank at the left has a greater capacity due to its larger size. While the water pressure will be the same in either case as the valve opening is similar, the larger tank can provide water flow for a greater period. Similarly, the larger cell, while it will produce current for a longer period of time, will produce no additional voltage or pressure at the terminal. Volume is to pressure as current is to capacity.

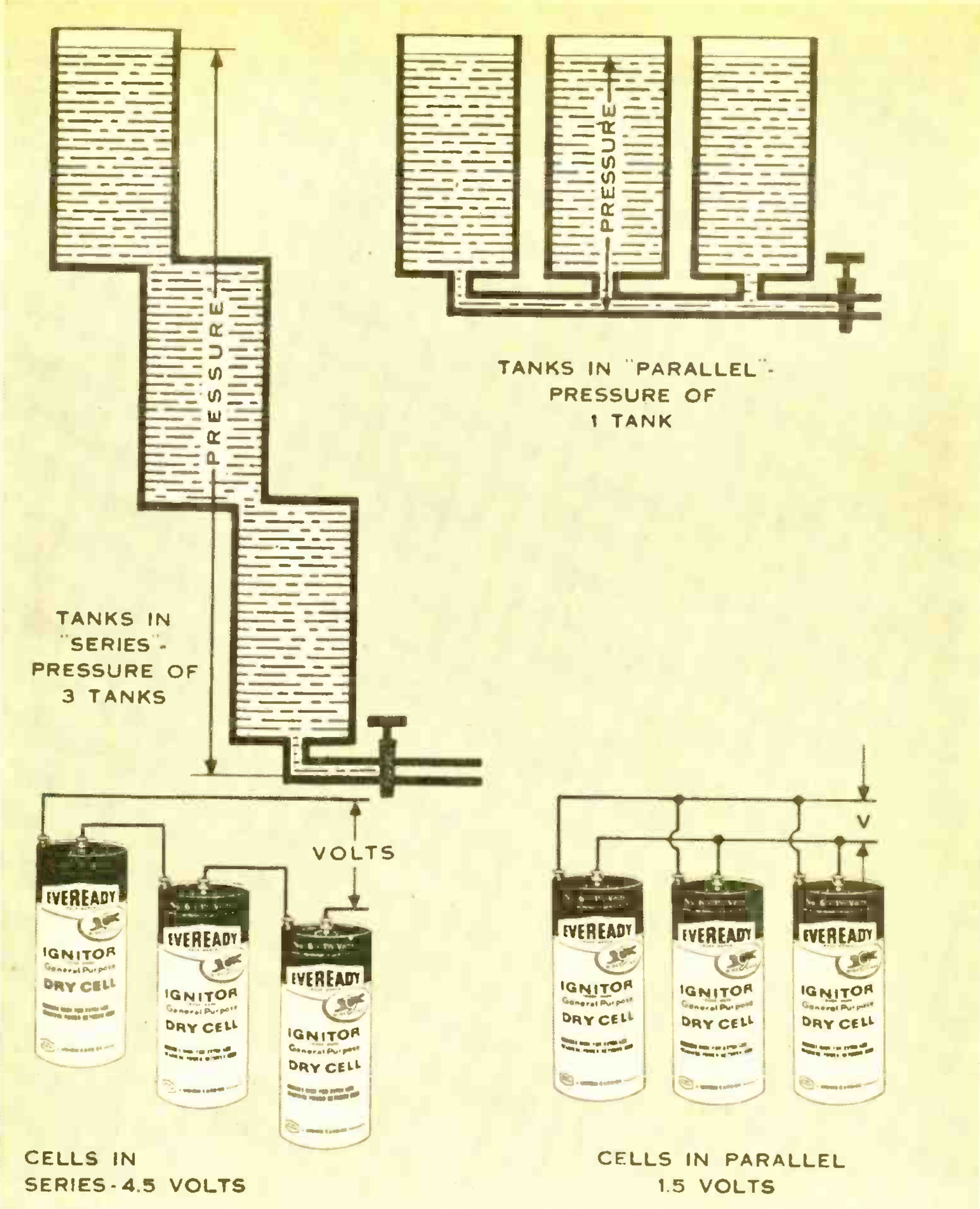


Fig. 9. Three tanks stacked up in a line as in left above, will provide three times the pressure. In right above, the tanks are on the level, and the total pressure is that of one tank. However, there is three times as much water, so the water will flow for a longer time. Dry cells in series provide three times the pressure drop or voltage. The current remains the same as for a single cell. If the batteries are connected in parallel, the voltage is the same as one cell, but current capacity is the sum of all three dry cells. Current is to capacity as voltage is to pressure.

high current requirements of modern semiductor circuits. Figure 3 shows the construction of "Eveready" cathodic envelope cell. Notice that this cathode is made up of two cakes of depolarizer mix, with the zinc anode sandwiched between them. This doubles the effective anode area and reduces the chemical mix's current density . . . the net result being a much greater electro-chemical efficiency under conditions of heavy current drain.

Another type of cell, although it is not new, is becoming increasingly popular due to its high efficiency and relatively constant output voltage, is *the mercury cell.* This type of cell consists of a depolarizing mercuric oxide cathode, amalgamated zinc anode, and an electrolyte of potassium hydroxide saturates with zincate.

The mercury cell offers the highest efficiency of any primary cell, concerting between 80 per cent and 90 per cent of its active chemicals into electrical energy.

Mercury batteries are unique in that they provide a nearly constant output voltage during almost their entire useful operating life. This is in contrast with other types of primary cells such as the zinc-carbon variety. This fact is shown in Figure 4, which represents the voltage versus life of a mercury cell and a conventional zinc-carbon cell.

Since the open circuit voltage of mercury cells remains constant approximately 1.25 volts during their life, they are often used as a "poor man's" voltage standard or reference.

The *alkaline* battery is a fairly recent primary cell development which offers superior performance in application requiring high current drain over extended periods of time.

Figure 5 shows the internal construction of an Eveready alkaline cell. Alkaline cells differ from conventional carbon-zinc cells in that they make use of a highly alkaline electrolyte. A high density manganese dioxide cathode material is used in conjunction with a steel can which serves as the cathode current collector. A large area of metallic zinc serves as the anode. The cell is hermetically sealed and encased in a steel jacket. The open circuit voltage of the alkaline cell is 1.5 volts.

The *nickel-cadmium cell,* while used extensively in Europe for many years, has only recently become popular here in the U. S. While these are like lead-acid storage cells in that they are "secondary" cells and may be recharged, they offer none of the disadvantages of the lead-acid cell such as the constant addition of water and the problem of leakage.

Figure 6 illustrates a *button* nickel-cadmium cell, while Figure 7 shows a *cylindrical* nickel-cadmium cell. In its charged condition, a nickel-cadmium's positive electrode is nickel hydroxide and its negative electrode is metallic cadmium. The electrolyte is potassium hydroxide. The open circuit voltage of a nickel-cadmium cell is 1.2 volts.

Voltage. Once again it is worth while mentioning that the physical size of a given type of cell has no bearing on its output voltage. The size does, however determine the cell's *capacity,* or the overall quantity of electricity which it can deliver. See figure 8. Although both liquid tanks provide the same pressure, the tank on the left holds a greater quantity of water than the tank on the right, and thus can supply water for a greater length of time. By the same token, so can the large dry cell shown on the left deliver current over a longer period of time.

Cells may be connected in *series* to increase the total available voltage . . . the voltage

(Continued on page 126)

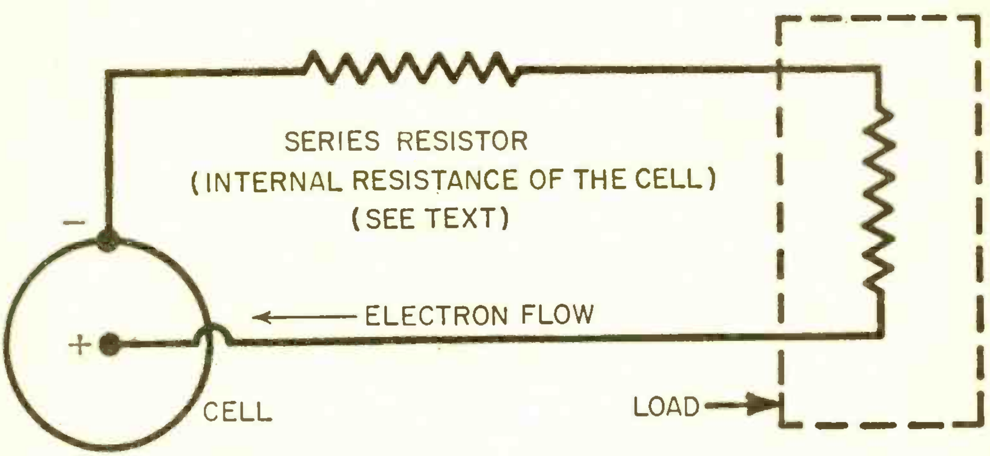
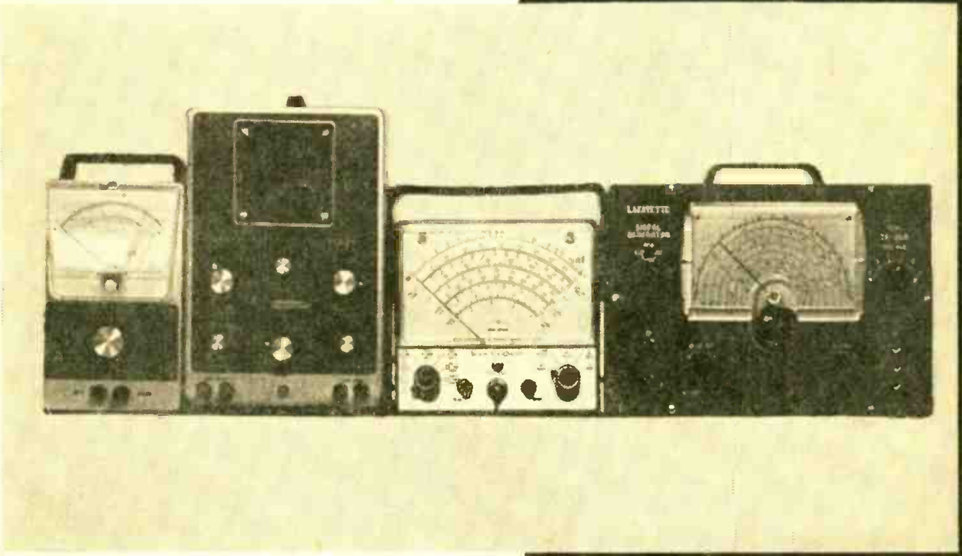


Fig. 10. Diagram shows how a cell's internal resistance limits current flow.

basic test equipment

Every experimenter should have some basic test equipment and know how to use them



Only you can best determine what test equipment must be on your workbench. If audio is your forte, your test gear may consist of a VOM, VTVM, AC VTVM, oscilloscope, and audio signal generator. If ham radio is your call, a grid dipper, RF signal generator, and SWR bridge will be a bit more practical. In any phase of electronics, test instruments are necessary for doing a good job while tinkering at your hobby.

By Leo G. Sands

TEST EQUIPMENT is used for obtaining go-no-go and quantitative information. It can be extremely simple or highly complex, cheap or expensive. In the early days of electronics, there were but few pieces of test equipment available. Much of it was designed for use by electricians. The basic essential was a voltmeter with which voltage, current and resistance could be measured.

GO-NO-GO Testers. One of the simplest go-no-go testers is a buzzer test set consisting of two No. 6 dry cells and an ordinary house buzzer, connected as shown in Figure 1. This is a continuity tester. When the test leads are applied to a circuit, the buzzer sounds if the circuit is closed and does not sound if the circuit is open. Its use is limited to very low resistance devices and circuits since insufficient current will flow to make the buzzer sound if the resistance of the circuit being tested is too high. It's very handy for testing cables and tracing wires.

A neon lamp voltage tester is a handy gadget. It can be used to detect the presence

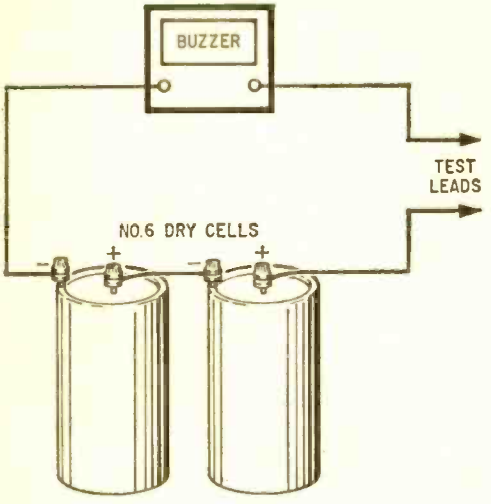


Fig. 1. The continuity checker shown above is an inexpensive testing device for checking wire shorts and opens in long hidden cables.

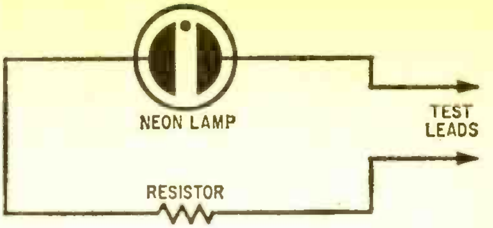


Fig. 2. A neon bulb with series resistor makes an excellent line voltage checker. Use an NE-51 bulb with 200,000-ohm ½-watt resistor.

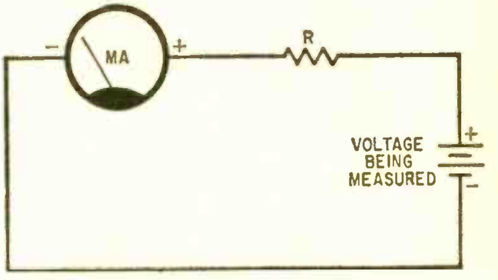


Fig. 3. Simplified DC voltmeter circuit.

of AC or DC voltage and to determine whether the voltage is AC or DC. It can also be used for determining if a chassis is hot with respect to ground and for identifying the grounded side of the AC power line. It consists of a tiny neon lamp with a resistor connected in series with it to limit the current through the lamp. The value of the resistor depends upon the type of lamp used. These testers usually sell for a dollar or so and are available in almost every hardware store.

The neon lamp will not light until the voltage being tested is in excess of about 70 volts. Hence, when used to check voltages in electronic equipment, you will know that the voltage is more than about 70 volts if the lamp glows and by its brilliance you can, with some experience, determine if the voltage is around 115 volts or much higher. If the voltage is DC, only one half of the lamp will light up (glow around one of its plates), and if it is AC, the entire lamp will light up (glow around both plates).

To find out if a chassis is hot with respect to ground, connect one of the test leads to the chassis and the other to a wire leading to an earth ground (water pipe, radiator, etc.). To determine which side of the AC power line is grounded, touch one test lead to the screw holding the plate of the electric outlet and push the other test lead into one of the outlet slots, then the other. The side of the power line that is *not* grounded is the one that makes the lamp light. This will work only when the outlet box is grounded, which it should be.

Voltmeters. There are several kinds of voltmeters. The most widely used type consists of a DC milliammeter and a series resistance, as shown in Figure 3. The meter actually measures the current flowing through the series resistance, which is relative to the voltage applied to the circuit. The meter scale can be calibrated in volts. The maximum range of the voltmeter is determined by the value of the series resistor. For example, if the meter is a 0-1 DC milliammeter, and the resistor has a value of 1000 ohms, the voltmeter will indicate "1", its full-scale point, when the measured voltage is one volt. However, we have not taken into account the internal resistance of the meter. If it is 100 ohms, the meter will actually read 0.909 instead of 1. Therefore, the series resistor should have a value of 900 ohms. Thus, the total circuit resistance is 1000 ohms and the current through it with one volt ap-

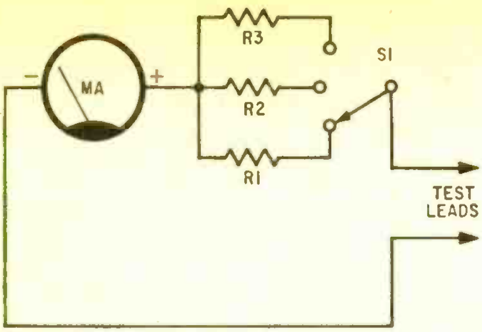


Fig. 4. DC voltmeter with three ranges.

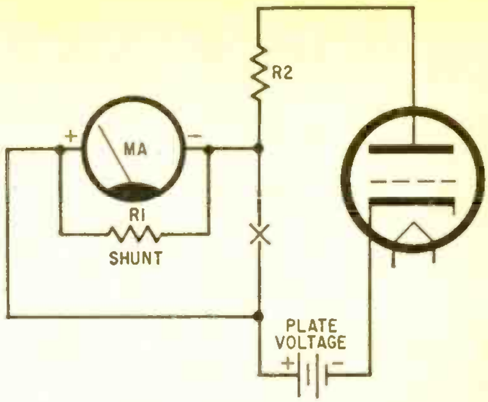


Fig. 5. A milliammeter with shunt resistor measuring plate current. Shunt bypasses most of plate's current so meter is not overloaded.

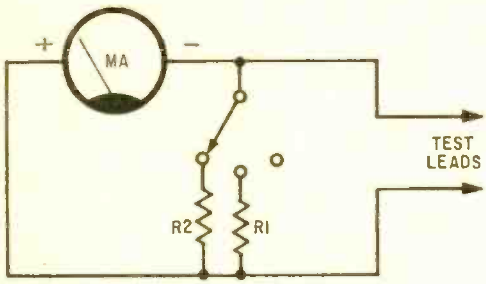


Fig. 6. A multi-range DC milliammeter.

plied is 0.001 ampere, which is one milliampere. The meter will read 1 at the full-scale point.

The accuracy of such a voltmeter depends upon the meter and the resistor. Most panel meters are rated at 1 percent or 2 percent accuracy, but at full-scale only, some are only accurate to 5 percent. In some cases, the meter is rated at being of certain accuracy at all points along its scale in terms of percentage of full-scale deflection. Ordinary carbon resistors have values within 20 percent of their rating and more expensive types are rated at 10 percent and 5 percent. There are also precision resistors accurate to better than 1 percent.

If the meter is accurate to 2 percent and the resistor is within 1 percent of its rated value, the total error could be as much as 3 percent. It could be less if the meter read 2 percent high and the resistor were 1 percent higher than rated value.

In the example given, the milliammeter is used as a 0-1 D C voltmeter and it is not necessary to recalibrate the meter scale since the indications are correct for volts or milliamperes.

By changing the resistor value to 10,000 ohms less 100 ohms, or 9900 ohms, to allow for the internal resistance of the meter, full-scale meter indication will be obtained when the measured voltage is 10 volts. Hence, we now have a 0-10 DC voltmeter. If we change the resistor to 99,900 ohms, we have a 0-100 DC voltmeter, and so on. By providing a switch (S1) for selecting various series resistors, as shown in Figure 4, we have a multi-range voltmeter.

Many DC voltmeters employ a more sensitive meter, such as a 0-50 DC microammeter. The series resistor must be of a higher value than when a 0-1 DC milliammeter is used. Not allowing for internal meter resistance, the series resistor is calculated on the basis of 20,000 ohms per volt. For full-scale reading with one volt applied, the resistor value is 20,000 ohms, 200,000 ohms for 10 volts, and so on.

Current meters. The same basic DC meter can be used for measuring current. Obviously, a 0-1 DC milliammeter will read full scale when one milliampere flows through its coil. But, if we shunt a resistor across the meter terminals, as shown in Figure 5, part of the current flows through the meter and part through the shunt resistor. If the internal meter resistance is 100 ohms and the shunt resistor also has a value of 100 ohms, the range of the meter will be doubled. The range can be further increased by reducing the value of the shunt resistor. A multi-range milliammeter can be formed by using a selector switch, as shown in Figure 6, to select various values of shunt resistors.

When measuring voltage, the meter is connected across the voltage to be measured

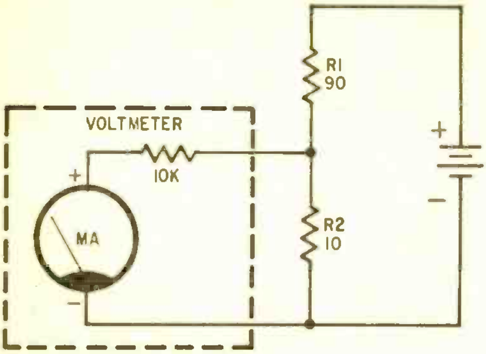


Fig. 7. The DC voltmeter shown simplified as a meter and series resistor connected to an external circuit of much lower resistance.

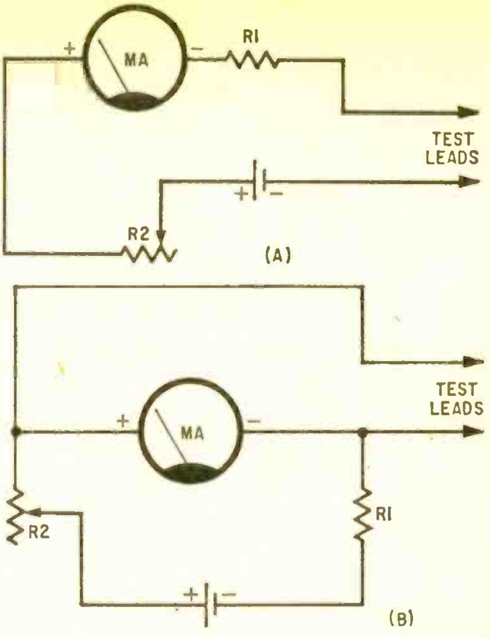


Fig. 8. Diagram (A) above shows a milliammeter with series battery used as an ohmmeter. Diagram (B) shows a modified ohmmeter circuit useful for measuring low resistance values.

through a series resistor. But, when measuring current, the meter is inserted in series with the circuit as shown in Figure 5 which shows how tube plate current can be measured. The circuit is broken at X and the meter is then in the circuit.

Current can also be measured by determining the voltage drop across a resistor which is in series with the circuit being metered and calculating the current value. As shown in Figure 7, we are trying to measure the current flowing through R1 and R2, which are in series, and through which the same value of current flows. If it is known that R1 is 90 ohms and R2 is 10 ohms, and the meter reads 0.9 when R3, the meter series multiplier resistor has a value of 10,000 ohms, we also know that there is a 9-volt drop across R2. Since current in amperes is equal to *E/R* (voltage divided by resistance), we can calculate that the current is 0.9 ampere since 9 divided by 10 equals 0.9.

Resistance meters. The same basic DC meter can also be used to measure ohms by using the circuit shown in Figure 8A. If the battery voltage is 1.5 volts, we will require 1500 ohms of series resistance in the circuit to obtain full-scale deflection on a 0-1 DC milliammeter when the test lead terminals are short-circuited. If the internal resistance of the meter is 100 ohms, we need 1400 ohms more resistance. We can make R1 a 1200-ohm resistor and R2 a 300-ohm rheostat. With the test lead terminals shorted, R2 is adjusted until the meter indicates full-scale deflection before going further; R2 is the zero adjust control, which makes up for drop in battery voltage and error in R1.

Now, if we connect a 3000-ohm resistor across the test lead terminals, the meter will read 0.33 milliamperes (0.00033 amperes) since the total circuit resistance is 4500 ohms. Hence, the meter scale can be calibrated directly in ohms.

Another ohmmeter circuit is given in Figure 8B. This circuit is used for measuring very low values of resistance. Here, R1 and R2 have the same values as in Figure 7, but the test leads are connected across the meter. When the leads are shorted, the meter will read zero, and when they are open, the meter will indicate full scale. But, if the leads are connected across a 100-ohm resistor, the meter will read 0.5 milliamperes since half the current flows through the meter coil and half through the resistance being measured. The smaller the value of the resistor being measured, the lower the meter reading, just op-

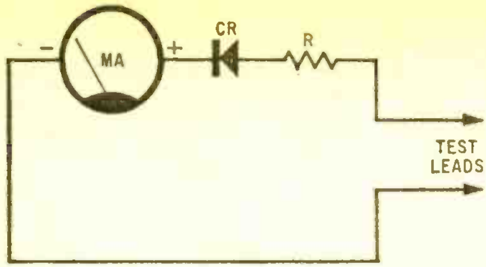


Fig. 9. Rectifier makes DC circuit go AC.

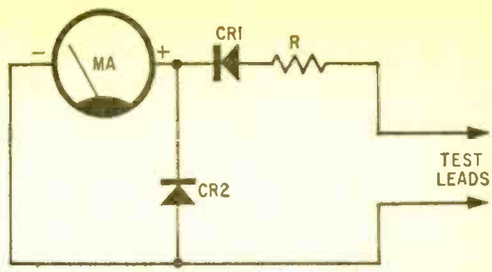


Fig. 10. CR2 eliminates negative pulses.

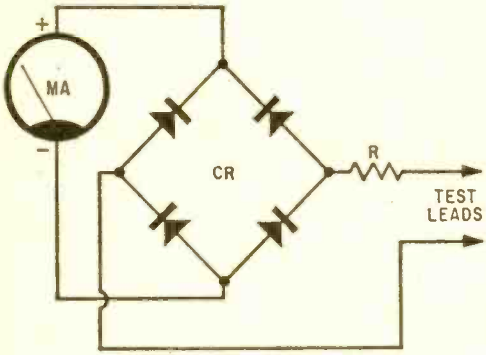


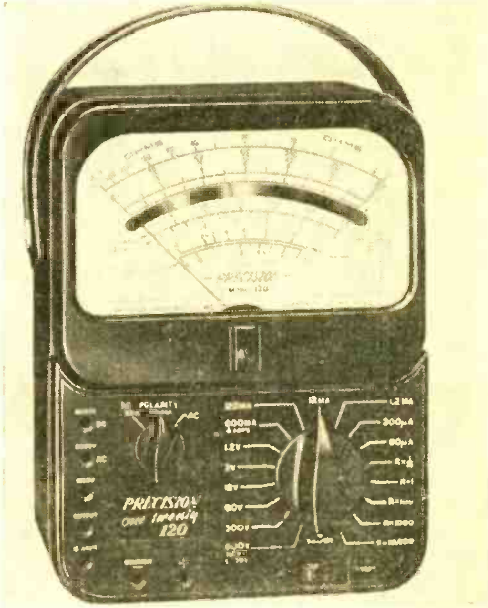
Fig. 11. Full-wave bridge rectifies AC.

posite to the effect obtained when using the circuit shown in Figure 7.

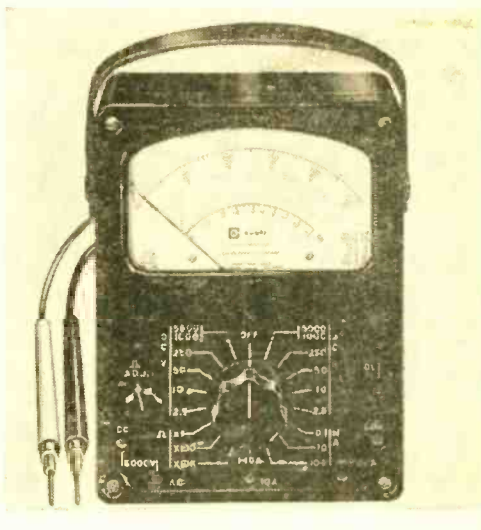
AC Voltmeters. The same basic meter can be used to measure AC voltage. If we add a diode rectifier to the circuit shown in Figure 3, as now illustrated in Figure 9, the meter will read DC voltage when the positive terminal of the measured voltage is applied to the test lead connected to the anode of the diode and the series resistor. If we reverse the test leads so that the negative side of the circuit is connected to the anode of the diode, the meter will indicate zero since the diode blocks passage of current. But, if we apply an AC voltage to the circuit, the diode rectifiies the AC and DC flows through the meter, and it doesn't matter which way the test leads are connected.

A more commonly used circuit is shown in Figure 10. Here, two diodes are used, one in series with the meter circuit and the other shunted across the meter coil. The second diode shunts off any negative voltage that might leak through the first diode. As in a DC voltmeter circuit, series resistor R determines the full-scale range of the meter.

Still another AC voltmeter circuit is shown in Figure 11. Here, four diodes are used in a full-wave bridge rectifier circuit.



Figs. 12 and 13. Shown above is the Precision 120 VOM. Below is the Knight-Kit volt-ohmmeter that is available in kit form.



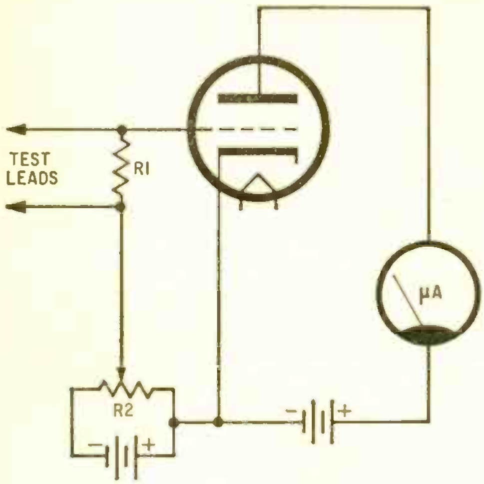


Fig. 14. A basic single-ended vacuum tube voltmeter circuit—R2 provides meter zero set.

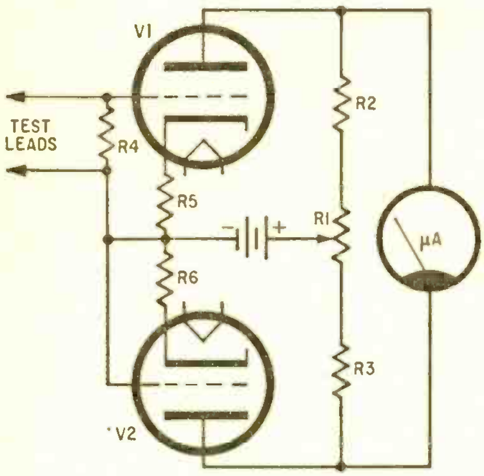


Fig. 15. A balanced VTVM circuit using two vacuum tubes. With no input signal, plate voltages are equal and meter reads zero.

Volt-ohm-milliammeters. The most widely used piece of test equipment is a volt-ohm-milliammeter, known in the trade as a *VOM*. It combines all of the functions described above in a single instrument. The instruments shown in Figures 12 and 13 are typical. The one in Figure 13 employs a basic DC microammeter with several scales. The top scale is calibrated in ohms for measuring

Fig. 16. Once considered "lab equipment only," the VTVM such as the Heath IM-11 shown above is now a workbench must item.

resistance. The second scale is calibrated in DC volts in three full-scale ranges, 0-12, 0-60 and 0-300. The third scale is calibrated in AC volts in the same ranges as DC, but the scale marking are slightly offset from the DC markings.

The fourth scale is also calibrated in AC volts, 0-3 on the top of the scale and 0-1.2 on the bottom of the scale. The two bottom scales are calibrated in decibels (db) and are used for making audio level measurements, which can be simultaneously read also in terms of AC volts.

Vacuum tube voltmeters. A DC milliammeter or DC microammeter is used in vacuum tube voltmeters, as in multi-meters, except they are preceded by a vacuum tube amplifier. In the circuit shown in Figure 14, the meter is connected in series with the plate of the tube and indicates plate current. By adjusting bias control R2, we can set the negative grid voltage to a value that will cause the plate current to cut off and the meter to read zero. Then, if we apply a DC voltage to the test leads which are shunted by R1, the voltage applied across R1 will be in series with the bias voltage fed in from R2. If the voltage at the grid end of R1 is positive, the bias on the tube will be reduced and the tube will conduct and the meter will

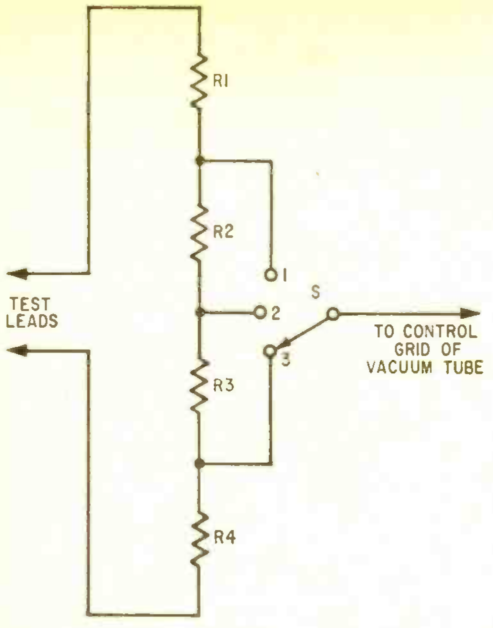


Fig. 17. Voltage divider resistors provide rapid and accurate VTVM range selection.

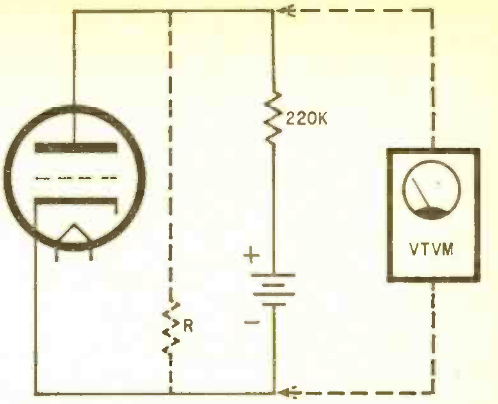


Fig. 18. Diagram shows a VTVM connected to a circuit for voltage measurement. Extreme high internal resistance of the VTVM does not change circuit parameters during testing.

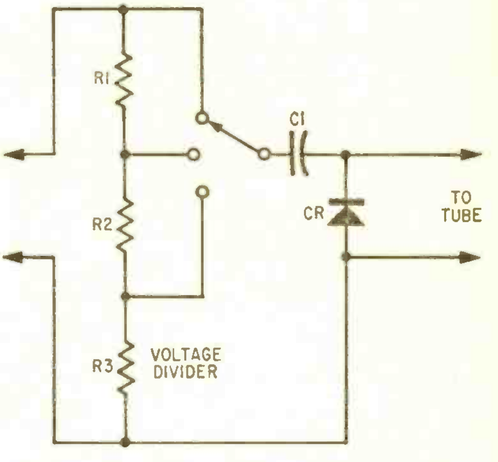


Fig. 19. Typical diode circuit used by VTVM to rectify AC voltages that'll be measured.

indicate the value of plate current flowing. The higher the measured voltage, the higher the meter reading. The circuit is not linear and it is necessary to calibrate the meter scale against a known voltage reference source.

A more popular basic VTVM (vacuum tube voltmeter) circuit is given in Figure 15. Two tubes are used in a balanced circuit with the meter connected from one tube plate to the other. The meter reads zero when both tubes draw the same plate current and when potentiometer R1 is set so that the plate load resistances (R2 and R3 included) are equal. R2 can be adjusted for zero meter reading when there is no test voltage across the test lead terminals and R4. The tubes are biased by cathode resistors R5 and R6.

When a positive voltage is applied to the grid end of R4, V1 draws more current than V2 and the voltage at the plate of V1 is smaller than the voltage at the plate of V2, causing the meter to deflect. The higher the test voltage, the greater the circuit unbalance and, hence, the greater the meter reading.

Potentiometer R1 can be set so that the meter normally rests at mid-scale. Thus, when a negative voltage is applied to the grid end of R4, the meter needle moves from its mid-scale position. The needle moves in the opposite direction when the input voltage is positive. Hence, it is easy to denote whether the measured voltage is positive or negative.

The full-scale range of a VTVM (Figure 16) can be made variable by providing a voltage divider at its input as shown in Figure 17. By means of selector switch S1 it is possible to tap the voltage divider at various points. The resistance values could be so selected as to provide 0-10 volt full-scale reading when set to position 1, 0-100 at position 2 and 0-1000 at position 3.

The big advantage of a VTVM over a conventional voltmeter is that it has only a slight loading effect on the circuit being metered. For instance, when a voltmeter is used to measure the voltage at the plate of a tube, as shown in Fig. 18, the voltage drops when the meter is connected and the true normal voltage is not indicated. If the voltmeter is of the type shown in Figure 3, using a 0-1 DC milliammeter and a 100,000-ohm series resistance, the meter will indicate a much lower voltage than is actually there when the meter is not connected across the circuit. The meter load is the same as adding the shunt resistor R, shown connected in dotted lines, from plate to ground. If the meter is a 0-50 DC microammeter, the loading effect will be only 5 percent as severe since the meter and its series resistor for 0-100 volt full-scale reading will represent a load of two megohms. But, the input resistance of a vacuum tube voltmeter is usually in the order of several megohms and has but slight loading effect on the circuit.

AC vacuum tube voltmeters. Some vacuum tube voltmeters are designed for DC or AC measurements only, while some can be used for measuring either. All that is necessary to convert a DC VTVM for AC measurements is to add a rectifier at the input. A basic circuit is given in Figure 19, which shows an input voltage divider for range selection and a shunt diode rectifier. When the applied AC voltage swings negative, current flows through the diode to ground and capacitor C is charged in the indicated polarity. When the AC voltage swings positive, the diode no longer conducts since it is reverse-biased and the positive charge in C1 is applied to the grid of the tube in the instrument.

Oscilloscopes. The most useful piece of test equipment in many respects is the oscilloscope. You can measure voltage, current, power and other quantities with it and you can observe the waveform of electrical voltages and currents. An oscilloscope employs a cathode ray tube, somewhat similar to a television picture tube or radar display tube. Its cathode squirts a narrow stream of electrons toward a screen which glows when the electrons strike it. The electron stream can be swung so that it scans the screen from left to right in a straight line at a fast rate, extinguishing its beam during the return trip from right to left. This is done by applying a sawtooth wave signal to its horizontal deflection plates. Then, if a signal voltage is applied to its vertical deflection plates, the spot on the screen can be made to vary up or down.

There are so many applications for an oscilloscope that it would require an entire

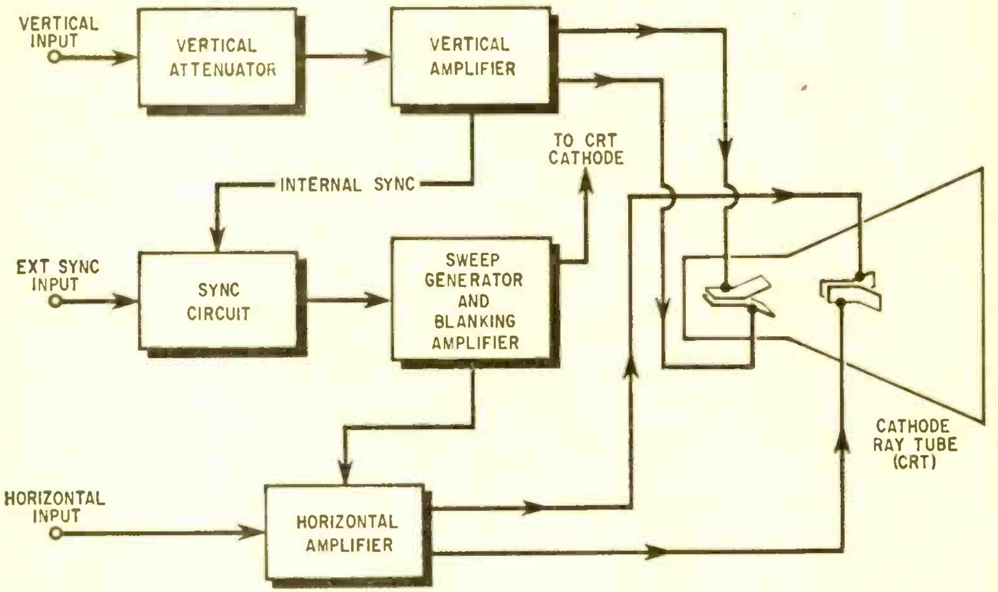


Fig. 20. Block diagram of a Heath oscilloscope using electrostatic deflection.

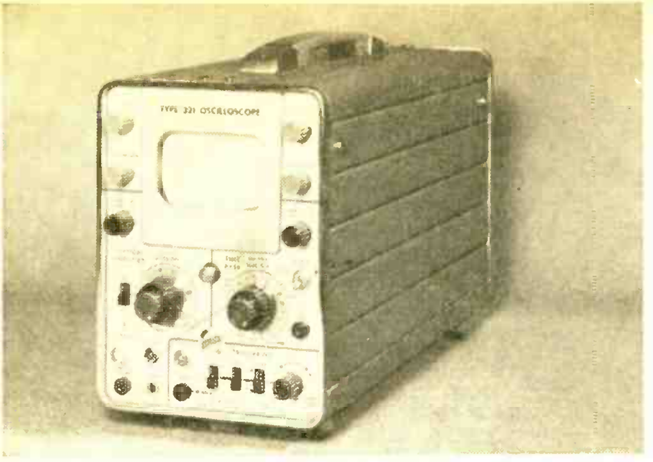


Fig. 21. The advanced experimenter who works on elaborate and critical projects will find the oscilloscope a valuable piece of test gear. The 'scope (such as the Tektronix Type 321 at left) lets you look at waveforms as they occur in the operating circuit. Modern units are compact and easy to tote from job to job.

Fig. 22. The signal generator is the test instrument most often neglected by the experimenter. No matter what your hobby interest area is, there's a signal generator designed to meet your special needs. The unit at right is a Lafayette TE-23 sine wave and square wave generator useful for audio and high fidelity.

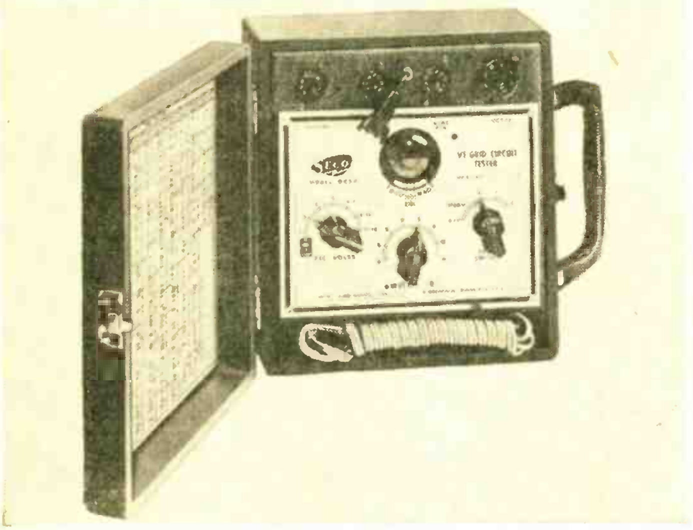


Fig. 23. There are a host of specialized test instruments designed to be used in limited applications but occur repeatedly in certain professions and hobby areas. The Seco Model GVT-9 grid circuit tube tester checks for vacuum tube grid emission, leakage, shorts and gas. This easy to operate test gear is carried by repair men on service calls.

book to describe them. Scopes can be bought in kit or ready-made form at prices ranging from about $45 to several thousand dollars. A scope contains a sawtooth timing generator, vertical and horizontal amplifiers and, of course, a power supply, as shown in Figure 20. Most employ tubes throughout, but the one shown in Figure 21 employs transistors and can be operated from batteries, making it useful in the field as well as on the bench.

Signal generator. Another valuable instrument for the experimenter is a signal generator, but what kind? There are so many. It depends upon whether you're working with audio or RF and how high in frequency.

For audio work there is a wide selection of audio signal generators, sometimes called audio oscillators. You can get a single-frequency unit that operates at 1000 cycles only for a few dollars from one of the big mail order houses, or you can pay several hundred dollars for a lab-type instrument. One that is extremely useful is the Lafayette TE-23 (Figure 22) which puts out either a sine wave or a square wave signal at any frequency from 5 cycles to one megacycle, spanning all of the audio range as well as RF up to the middle of the AM broadcast band.

A signal generator is simply an oscillator which can be tuned over a broad range of frequencies and whose output signal level can be varied. An audio signal generator is often used for making amplifier frequency response measurements and for signal tracing. RF signal generators are mainly used for producing a reference signal at a desired frequency when aligning the circuits of a radio receiver.

Tube testers. To test vacuum tubes you either need your own tube tester or access to a do-it-yourself tester at the neighborhood super market or drug store. The kind of tube tester you need depends upon what you plan to use it for. The simple two or three dollar tube testers that are sold by mail are not really tube testers. All they do is check tube heater or filament continuity. In the next higher price bracket are the emission type testers which will tell you whether a tube is totally defunct, very tired or apparently still useful. In an emission tester, the tube heater is operated at normal temperature and the total cathode current is measured when an AC or DC voltage is applied to all of the elements.

More critical tests can be made with a transconductance or mutual dynamic conductance type tube tester which operates the tube at somewhat near its actual operating conditions and measures the change in plate current when a small voltage change takes place at the grid. There are more knobs to set and a reading other than "good, fair or replace" can be obtained. But, they cost more than emission type testers.

Some are equipped with a grid emission test feature which is important when checking certain tubes used in TV and CB sets as well as mobile radio equipment. Separate grid emission testers, such as the one shown in Figure 23, are also available. They do not check tube merit, but instead check inter-element leakage and grid emission, which is a common failing of some types of tubes, even brand new ones.

The best test for a tube, however, is the substitution method. When checking amplifiers, for example, feed a square wave signal into the amplifier and monitor the amplifier output with a scope. Then, replace each tube, one-at-a-time, and note if there is any difference in the shape or amplitude of the output waveform. Or when checking a radio receiver or hi-fi tuner, feed a very small RF signal into the antenna connector and meter the AVC voltage in an AM set or limiter voltage in an FM set (with a VTVM) and try new tubes, one-at-a-time, and note any increase in metered voltage.

What to buy and where to buy it. All radio parts stores sell test equipment normally used for servicing or by experimenters. Laboratory-grade test equipment is usually sold directly from the factory to the user through manufacturers' representatives. The electronics mail order catalogs list many kinds and makes of test equipment and will give you an idea of what's available.

Test equipment is available in kit form too from several sources including Allied, Heath and Eico. Whether to assemble your own or to buy ready-made equipment depends mainly upon which is worth more to you, time or money. The kit type equipment is good. Lots of it is in use in laboratories by engineers whose employers can usually afford to buy ready-made equipment. The important thing is to obtain and use test equipment. You can never fully understand the VOM, VTVM, signal generator, oscilloscope and tube testers unless you use them. ■

getting started in amateur radio

THE fascination of ham radio lies in the fact that it is the most personal, most international and most technical of all hobbies. Imagine the thrill of sitting in your own home and talking directly to strangers in practically all corners of the world! They may be strangers initially, but very quickly you are on first-name terms with them. Many gratifying, life-long friendships have developed among people who would never have the chance otherwise to exchange ideas and sentiments. And because the hobby attracts women as well as men, it is not unusual to hear of romances that have grown out of casual contacts over the air.

You must understand right off that the expressions "ham radio" for the activity and "hams" for the participants are perfectly respectable. The more formal terms are "amateur radio" and "amateur operators," but these appear mostly in government publications and are never used by hams themselves.

By Robert Hertzberg, W2DJJ

Ham Radio—a world-wide hobby combines electronics with the magic of radio

amateur radio

Well known on just about every ham band is Dr. Harold Riker, K2JHA. Here he is seen in his well equipped basement "shack." While the major part of "Doc's" activity is on the 10 through 80 meter ham bands (see equipment at left), he is a familiar operator to New York area 2 meter hams (the 2 meter rig is at his elbow in this photo). Even though his schedule as a physician keeps him going at a hectic pace, "Doc" nevertheless always seems to be able to find a few hours per week of "hamming" time where he can relax with the many good ham friends he has made.

What does it take to be a ham? United States citizenship and a little know-how, that's all. Newcomers are always pleased to learn that there's no age limit in either direction, and they are surprised to learn that boys and girls as young as 10 have no difficulty in qualifying for the government licenses that are required by international law. In most cases these youngsters are trained by their parents, grandparents or great-grandparents, some of whom may be hams with more than half a century of experience!

The government encourages the hobby, because hams have made many notable contributions to the art of electronic communication. In fact, they are directly responsible for the development of short-wave radio as we know it today.

The FCC and Hams. The control of ham operations is one of the functions of the Federal Communications Commission. In radio circles this tongue-twister is invariably shortened to "FCC." The main office is in Washington, but the paper work involved in the processing of hundreds of thousands of licenses of many kinds is done in Gettysburg, Penna.

While Uncle Sam looks kindly on hams, he expects them to obey the strict laws that have been laid down for all radio communication. Newcomers and old-timers alike will

Robert Gunderson, W2JIO, is really a remarkable fellow. Blind since birth, Bob builds all of gear used at his ham station and teaches ham radio to many other blind persons.

Bil Harrison, W2AVA, didn't have enough room for his Collins rig under the dash of his Caddy so he mounted it behnd the driver's seat. While this may, at first look impractical, Bil can operate (and even change frequency) without having to turn around. His ham license plate (these are available in most states) gives his installation and car a special note of distinction.

find it to their advantage to read and study Part 97 of the Rules and Regulations of the FCC, entitled "Amateur Radio Service." This is not available as a separate document, but is combined with Part 95, "Citizens Radio Service," and Part 99, "Disaster Communications Service," to form "Volume VI" of the Rules and Regulations. In loose-leaf form for insertion in a standard three-ring binder, Volume VI is sold only on a subscription basis, with amendments mailed out as they are adopted. The price is $1.25. Order this from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., *not* from the FCC. However, the FCC itself will send you, free of charge, a general-information bulletin entitled "Amateur Radio Service" which is worth having. Address your request to the Federal Communications Commission, Washington, D. C., 20554, and write your name and address clearly.

Definition. An "amateur" is a person who engages in a game, sport or other activity just for the love of it, and not for pay. It follows, then, that amateur radio stations must not handle messages for material compensation, direct or indirect, paid or promised. Furthermore, they must not transmit music or engage in broadcasting of any kind. Hams communicate *with each other individually*, either by voice or by the dot-and-dash characters of the International Morse Code. Voice transmission is usually referred to as "phone," and code transmission as "CW." These letters are short for "continuous waves." When two operators are in communication, they are said to be "working."

Certain forms of one-way ham transmission are not considered "broadcasting" by the FCC and are therefore permissible. They are:

1) Emergency messages, including emergency practice drills.

2) Bulletins consisting solely of matter of direct interest to hams.

3) Net-type operations wherein three or more stations are in communication, each station taking a turn at transmitting while the others listen. These nets are known popularly as "round robins."

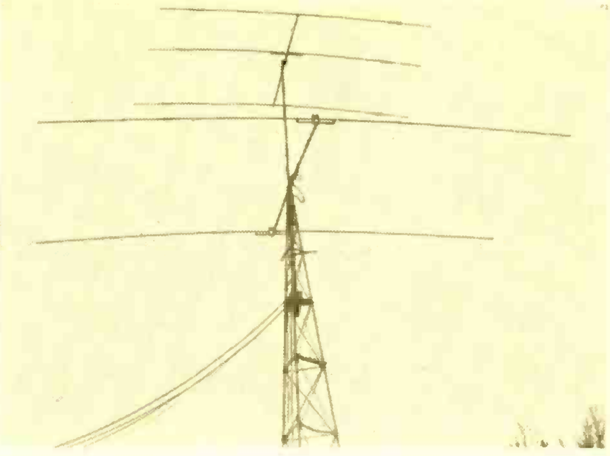
4) Code-practice transmissions intended for persons learning the code or improving their speed.

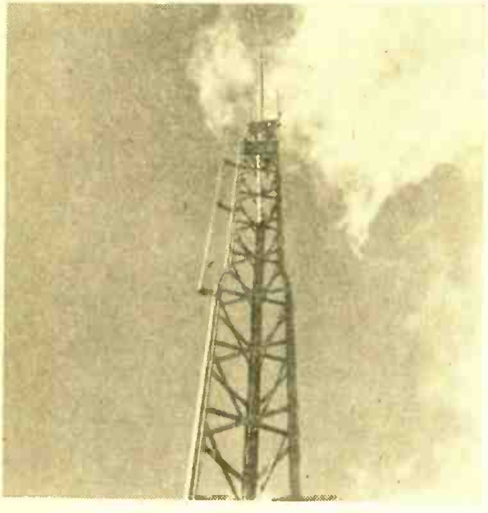
Types of Ham Licenses. There are six distinct kinds of ham licenses, or "tickets." Of these, four are of immediate interest to newcomers to the game.

General Class. This is the ticket most would-be hams aim for, because it carries the most operating privileges. With it, you can work freely in a dozen or more fre-

amateur radio

The antenna systems at many ham stations are just as intricate as the transmitting and receiving gear. At right we see an arrangement whereby the operator has set up directional "beams" for operation on several different ham bands. Below we see another approach, that of omnidirectional vertical antennas for different bands on one tower. While these antenna systems are great for operating ease and efficiency, many operators "get out" very well using any of several types of inexpensive homemade "long wire" antennas.





quency bands, use phone, CW, radioteletype and even television, and run on the maximum power of 1,000 watts. A General ticket is good for five years and is renewable repeatedly without re-examination. The filing fee, payable to the FCC, is $4.00.

The requirements for a General license are simple. You must appear *in person* at an FCC office and take a two-part test. The first is the code, which you must be able to transcribe at the rate of 65 characters per minute. This is equivalent to 13 words of five letters each. You wear earphones and hear clear tone signals sent by an automatic keyer. The transmission lasts five minutes, but you don't have to copy all of it; *you pass if you copy any one-minute section of it free of errors.* If your paper doesn't satisfy the examiner (who is probably a ham himself and is happy to see you get through), you are finished for the day. Your $4.00 fee is not returned, but you can return yourself after 30 days, pay another fee, and try again.

Suppose you pass the receiving test. About *half a million* applicants have, so why shouldn't you? The examiner will then ask you to send a few words to him just to prove that you know how to use a telegraph key; it is not likely that you'll lose out here. This over, he'll hand you the written part of the test. Actually, this involves very little writing, as the questions are of the multiple-choice-answer type. They deal with amateur radio apparatus and operation and with the provisions of treaties, statutes and rules and regulations affecting amateur stations and operators. The passing grade is 74 per cent.

The examiner will check your answers immediately and tell you if you made it or not. If you pass, you merely thank him and depart. Your ticket is not issued here. Your papers are sent to Gettysburg, and the license is mailed to you from there. You can expect a delay of several weeks. The ticket will bear the call letters assigned to you and an endorsement showing General Class privileges.

The permanent offices of the FCC are listed in the free bulletin mentioned earlier, and temporary examination points are set up in more remote areas several times a year; these are listed in ham magazines and

This assortment of parts assembles into a multimeter, or "circuit analyzer," as it is sometimes called. It permits the ham to have the functions of several types of test instruments in a single enclosure. These meters are available from a number of manufacturers (this one is by EICO) in kit or wired form. Assembling a kit of this type takes a few hours but has the advantage of relatively low cost. In addition, the kit building venture is both fun and experience for new hams.

various other radio periodicals. You are not limited to taking the exam in the office nearest your home. Regardless of where you live, you can go to *any* of them. By mail or telephone, just make sure that the one you select is open and ready for applicants on the day you want to appear.

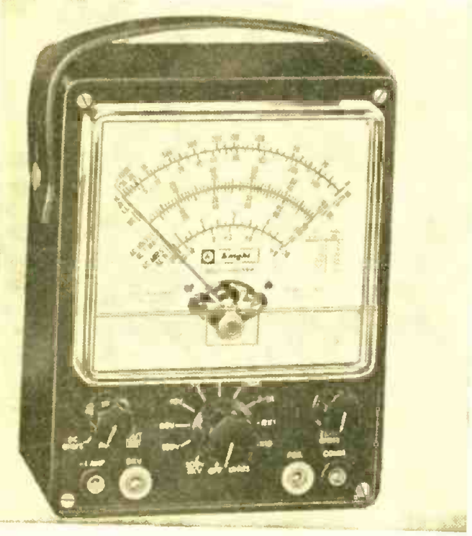
Conditional Class. This is a mail-order version of the General, carries the same full operating privileges, and is available under one or more of the following conditions:

1. The applicant's actual residence and proposed station location are more than 75 miles airline from either a permanent or temporary FCC office where examinations are given.
2. The applicant is physically disabled, cannot travel, and can show a physician's certificate to this effect. Special provisions are made for the blind.
3. The applicant is shown by certificate from his commanding officer to be in the armed forces of the United States and for that reason is unable to appear in person at an FCC office.
4. The applicant is living for a continuous period of at least 12 months outside the continental limits of the United States, its territories or possessions.

The Conditional exam is exactly the same as the General, but is conducted by a voluntary examiner selected by the applicant. He or she must be at least 21 years old and the holder of a current General, Advanced or Extra Grade amateur license or of a Commercial class radiotelegraph license, or he can be a U. S. Government radiotelegraph operator.

Here is the routine to follow to save time. When your code speed is up to about 10 words per minute, address a letter to the Federal Communications Commission, Get-

Every grade of ham license exam requires that the prospective operator know how to send and receive code (CW). Transistorized code practice oscillators, such as this one by Knight, are invaluable aids to learning. Usually, instructions for how to learn CW are included with the unit.



This is a Knight volt-ohm-meter which was constructed from a kit in only a few hours. The "VOM" measures AC/DC volts, current and resistance, just about a must for any ham operator who likes to build or fix gear.

tysburg, Penna., 17325, and simply ask for a Form 610; say nothing else. While waiting for it to arrive, practice more code, and when you've hit about 15 wpm ask your friend to give you the code test. Since you'll take this in familiar surroundings and not in a strange office, you'll probably pass readily. Now, within 10 days of this test, again write to Gettysburg. Send the Form 610, carefully filled in; a check for $4.00 payable to the FCC; and a written request signed by the voluntary examiner for the written part of the Conditional exam. This latter request must also include the full names and addresses of both you and the examiner, a description of his qualifications (that is, class and date of license, or government identification), and a statement from him that you passed the code at 13 words per minute.

Gettysburg will send all the necessary papers to the examiner, not to you. He will administer the test but not grade it, and return all papers to Gettysburg. If you passed OK, your notification will be in the form of your ticket. If you failed, you can try again in thirty days.

Novice Class. This is a rather easy ticket to obtain. The required code speed is only 5 words per minute, and the written is so simple you can guess at most of the answers. As it is intended primarily to get youngsters started in the game, it is good only for one year and cannot be renewed. At the end of this period the holder is expected to have enough knowledge to qualify for a higher license. He does *not* have to serve out the full year of apprenticeship, but can take a test for the higher license any time he wants.

Novice operating privileges are restricted. Maximum transmitter power is 75 watts. Voice transmission may be used only between 145 and 147 megacycles ("2 meters"); CW may be used here too. On the other bands CW is limited between 3700 and 3750 kilocycles ("80 meters"); 7150 to 7200 kilocycles ("40 meters"); and 21.10 to 21.25 megacycles ("15 meters"). This isn't as bad as it sounds; the 15- and 40-meter bands offer many opportunities for long-distance ("DX") working. All Novice transmitters must be crystal-controlled.

No matter where you live, you *must* take the Novice test with a voluntary examiner, as described for the Conditional, with the important difference that there is no filing fee. Local FCC offices do not handle any aspect of this class of license.

Technician Class. This too is strictly a mail-order ticket. The examination is conducted by a volunteer exactly as with the Conditional, down to the $4.00 filing fee.

The Technician requirements are odd in that the code test is at the 5 wpm rate of the Novice exam, while the written part is identical with that of the General/Conditional. This license is good for five years and is renewable repeatedly, like the latter two. However, operating privileges aren't as good as those available to Novices. Technicians may use the 145-147 and 50-54 megacycle bands ("2" and "6" meters), which are effective usually only for local communication, and all bands from 220 megacycles and up. The latter, from the amateur standpoint, are relatively unexplored.

It should be mentioned that the Novice and Technician frequency assignments are not exclusive. Generals and Conditionals may use *all* ham bands.

Advanced Class. An obsolete designation. Years ago the ticket carried certain extra phone privileges, but these are available now to all Generals and Conditionals. No new examinations for this ticket are given.

Amateur Extra Class. There are two ways

If you can acquire the habit of repairing your own ham gear you can really learn some "behind the scenes" aspects of electronics which are seldom discussed in textbooks. Fixing a complex receiver is a theory course in itself!

A high powered transmitter is always a help in working DX stations, but if you can't work 'em then you can't hear 'em. That's why there's never been a "good" DX'er without a good receiver, such as this Hammarlund.

of qualifying for this license:

1. Be the holder for at least two years of a current General or Conditional, and show proof that you had a valid ham ticket during or prior to April, 1917, when the United States entered World War I and shut down all private radio operation. Because no additional examination is required or additional operating privileges allowed, this "grandfather ticket" is largely of sentimental value.

2. Apply in person at an FCC office, take a very stiff test that includes the code at 20 words per minute and a written dealing with highly advanced theory and operation. Usual $4.00 filing fee. So obtained, an Amateur Extra Class ticket is a document of honor and not merely a tribute to a man's longevity, but it still carries no extra operating privileges.

There are very few Amateur Extras in circulation, because only a very few survivors of the World War I period still retain licenses. Younger men, although well qualified technically, see no point in spending the required time on the examination.

Upgrading a License. The Conditional and the Technician are provisional licenses, and the Novice is definitely a temporary one. Holders can upgrade themselves at any time by arranging to visit an FCC office and qualifying for a General. For a serious ham such a trip is a good investment, because a General license is good for the holder's lifetime.

Getting Started. Because no license of any kind is needed for short-wave reception, a receiver should be a would-be ham's first purchase. I recommend buying a factory-made set, rather than attempting to build one either from a kit or from the raw components. For a beginner, the alignment of a modern superheterodyne is a rather difficult job, especially if he does not have a signal generator and certain other gear, which he is not likely to have if he is a beginner. A reliable receiver puts its owner immediately into the swing of things. It brings him not only code practice but also live conversations between active hams; it familiarizes him with both CW and phone operating procedures; it teaches him the local and DX characteristics of the popular bands. So prepared, he will go on the air with assurance and skill when his license arrives.

Receivers range in price all the way from below $60 to over $600. How do you make a sensible choice? First, you should know that there are two types of short-wave receivers. The first is the "all-wave." In its more or less standard form it tunes from about 30 megacycles all the way up through the regular AM broadcast band, in several switch-selected stages. Provision is made for spreading out either the ham bands alone or any desired section of any band, to make tuning easier. On the main dial an entire ham band might occupy only five or eight degrees on an 180-degree scale, whereas on the bandspread dial it is expanded to cover half or more of a similar scale.

The second type of set is the "ham bands only," and its name pretty well describes it. It is usually more sensitive, more selective and more stable (and, naturally, more expensive) than an all-wave model, and it spreads the ham bands over very large scales of either circular or linear design. Most receivers of this type tune only the 10-, 15-, 20-, 40- and 80-meter bands, with a little runover at each edge.

For a modest start, I recommend an all-wave set in the vicinity of $150. This will be fine for your first station, and it will continue to serve usefully as an auxiliary receiver when you eventually enlarge your radio "shack" (as all hams call their stations) and buy more elaborate equipment.

For receiving, any outdoor wire works satisfactorily. In some locations, 25 or 35 feet of wire merely stretched along the floor brings in more stations than you can count.

Most medium-price all-wave sets have built-in loud speakers. Since a steady output of CW and phone signals might annoy other members of the family who haven't been bitten by the ham bug, it is advisable to use earphones most of the time.

Receivers, transmitters and all manner of accessories are shown in manufacturers' and dealers' catalogs, which you can obtain for the asking.

Construction Experience. The ham who buys his equipment ready-made and assembles it without recourse even to a soldering iron not only misses much of the fun of the hobby but also deprives himself of valuable and essential construction experience. Fortunately, you can acquire this electronic know-how without having a complete workshop at your disposal: *work from kits*. You need only a modest collection of common hand tools and a small table on which to work.

I recommend three inexpensive projects for the beginner:

1. A code-practice oscillator employing transistors. This is an easy one-evening job, and you can put the completed unit to use immediately.

2. A multi-purpose meter that measures resistance and AC and DC voltages. This is without question the most versatile of all electronic testing instruments, and is absolutely indispensable in any shack. Two types are in general use: the vacuum tube voltmeter ("VTVM"), and the volt-ohm-meter ("VOM"). The VTVM is the more popular because it cannot be burned out accidentally and because it does not disturb sensitive circuits to which it is connected. It is essentially a bench or shack item because it works

Made especially for the Novice ham, this low cost (about $70) Lafayette communications receiver offers good solid reception without some of the high priced fancy operating frills desired by "old timers." It comes wired.

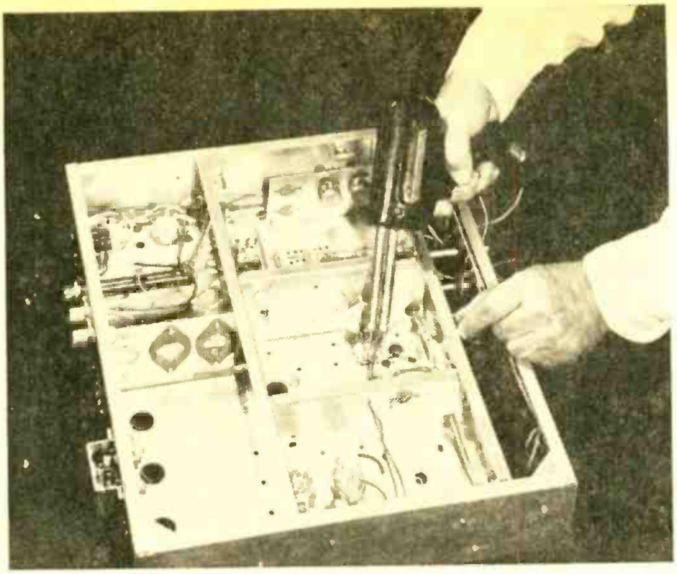
on 115 volts AC. The VOM, which is self-contained and therefore portable, is handier for outside applications. Many hams provide themselves with one meter of each type.

3. A low-power transmitter. You don't need an FCC license to buy or build this; you need it only to put it on the air. Anyway, by the time you finish it you will probably have your ticket. By "low power" I mean a rating of 50 or 60 watts. This is comfortably within the 75-watt limit for Novice operation, yet quite adequate for both local and DX communication by Generals and Novices alike.

The lowest price transmitters are for CW only. To them can be added, later, "modulators" for phone operation. However, if you obtain a General or Conditional license you'll certainly want to try phone as well as CW right away, so a better purchase is a transmitter that includes both facilities. The difference in cost is reasonable.

With the experience of the first two projects to your credit, you will sail through the transmitter assembly and wiring without hitch.

All transmitter kits include tubes, but not quartz crystals or key, and not usually a microphone. Crystals are available by the thousands and are quite cheap. You don't have to buy a key, because you can use the one from the code-practice set. The price range of microphones ("mikes") is so great as to be confusing. For a first mike, set a price limit of about ten dollars and you'll do very well.



While the transmitter shown here is technically a "kit," the chassis comes fully punched and formed, a great time and effort saver. A number of "big" ham kits are further simplified because they are furnished with prepared printed circuit boards which need only to be secured onto the chassis and then hooked into the circuitry with only a few solder connections. These kit building innovations are something relatively new for hams and are included in many of the kits supplied by Knight, EICO, Heath, International Crystal, E. F. Johnson and other kit makers.

Antennas for transmission are a subject in themselves, and are treated later.

Special Coverage Equipment. The receivers and transmitters under discussion so far are all designed for 10 through 80 meters, the bands best suited for DX. For 2 and 6 meters, which are the special provinces of Novices and Technicians (but open as well to Generals and Conditionals), the usual practice is to employ entirely separate equipment. There are some combination 2-and-6 units, and many individual sets for one band or the other. There are also frequency converters that permit 10-through-80 meter sets to work on 2 and 6 meters, but they tend to be expensive and require rather bothersome switching of antenna leads.

The 2- and 6-meter bands are basically for short-distance work, normally to perhaps 35 or 50 miles. However, under freak meteorological conditions, particularly temperature inversions, there are sometimes startling two-way contacts up to hundreds and even thousands of miles.

Learning the Code. Because all license tests start with the code, you must make up your mind early that you *will* learn it. This determination is half the battle.

With the aid of the code-practice oscillator you can teach yourself how to send and to recognize the difference between a short "peep" for a dot and a longer one for a dash. With the aid of the receiver, you can hear actual sending from thousands of stations; better, you can tune in the timed practice messages broadcast by W1AW, the headquarters station of the American Radio Relay League, in Newington, Conn. The schedule of this station is published monthly in the League's official organ, *QST*.

The combinations of dots and dashes that form the letters of the alphabet and the numbers are purely arbitrary. The only way to learn them is to keep repeating them over and over until you can recognize them without thinking. Give yourself small but frequent practice sessions. Fifteen or thirty minutes every evening shouldn't bore or tire you. If you can maintain this routine religiously you'll find yourself up to five words per minute at the end of a week. From there on, only practice will raise your speed.

Most hams tackle the code all by themselves, for the simple reason that they don't have friends or family members who want to learn with them. If you can find another interested person, try working with him (or her!) a few times. If your learning rates are about the same, fine. If they are markedly different, the faster man may become impatient with the other, and the partnership will soon break up.

Only an utter moron or an unprepared individual can flunk the five word speed required of Novices. The 13 word speed for the General and Conditional is admittedly more difficult. The smart thing to do, before attemping the tests for these tickets, is to work yourself up to about 15; this gives you a small margin for nervousness, which afflicts most people when they take examinations.

Antennas for Transmitting. For the most efficient radiation of energy into space, a transmitting antenna should be approximately a half wavelength long for the operating frequency. For 10 meters the length is thus 5 meters, or about 16½ feet; for 20 meters, about 33 feet. Straight, simple wires work quite well, and hams using them even with low-power transmitters enjoy many DX contacts.

Called "doublets" or "halfwaves," the wires are usually cut in the exact center, and the two ends thus formed are supported physically by an insulator and connected electrically to coaxial cable. The latter functions only as a transmission line to carry energy from the transmitter to the antenna; if it is properly connected it radiates little or no energy on its own account. All present-day ham transmitters are designed to use coax as the "pipe line" to the exposed antenna.

Beginners like the halfwave because it is cheap, easy to put up, and virtually foolproof in operation. A disadvantage is that it is good for only a single band. However, some long wires can be made to work not only on their fundamental bands (the length in meters multiplied by two), but also on harmonics, which are electrical fractions of the length. The tuning process for multi-band operation is a bit tricky.

Multi-band antennas are most practical when the number of bands to be covered is kept to two or three. The most popular combination by far is 10, 15 and 20 meters. The effectiveness of such an antenna is greatly increased by the addition of a "reflector" wire behind it and a "director" in front of it. This arrangement acts very much like a searchlight, and tends to concentrate or "beam" much of the radiated energy in one direction. Aluminum tubing rather than ordinary wire is used for beam antennas because the three elements can be supported conveniently on a horizontal pole and the whole assembly then aimed in any direction by a motor drive or "rotator."

The three-element beam for 10, 15 and 20 meters is the most widely used of all ham antennas, probably because these happen to be the most active DX bands.

There are dozens of variations to beam construction. Some beams use only a single reflector behind the radiator element; others have two, three or more reflectors and as many directors; still others consist of several identical beams mounted one above the other, or "stacked." The limiting factor in ham antenna construction is merely physical size and weight.

The greater the number of elements in a beam, the greater the beaming effect. This is equivalent to an increase in the strength of the signal in the aimed direction, at the expense of a considerable reduction in all other directions.

Beams for 40 and 80 meters are not generally practical because of their mere dimensions; also, the beaming effect is much less marked at these relatively long wavelengths than at 10, 15 and 20. Going in the other direction, we find that beams for 2 and 6 meters are small, light and easy to construct and erect, and are highly directional. The elements for 2 meters are only a little more than a yard long!

Beams and horizontal wires need roof and backyard space. Where this is limited, hams resort to vertical antennas. These take the form of a stiff aluminum tube, usually unguyed and fitted with an adjustable loading coil at its base; or of a slender lattice-work tower. Such verticals do not have the power-increase of beams, but hams using them manage to push their signals into every corner of the globe.

Mobile Operation. The only equipment limitation under a ham license is on power: 75 watts for Novices, 1,000 watts for General and Conditionals, and a variable figure on certain special frequencies for various licensees. You can use as many transmitters as you like, not only in your home shack but also in your car, boat, airplane or other vehicle. This "mobile" operation is almost a hobby in itself. It represents an interesting technical challenge because space for equipment is tight, power is limited, and the antenna must be very short. None of these restrictions seems to bother mobile enthusiasts. With 50 watts and a five-foot antenna, they rack up almost as much DX from the driver's seat as they do with 500 watts and a 50-foot beam at home!

Many hams who live in apartment houses don't even have home shacks, but fix up mobile rigs that make the front of their cars look like the control cabin of a Buck Roger's space ship. ■

getting started in CB radio

Join up with over 500,000 CB'ers in the nation's largest two-way radio service. Whether your needs are on land, sea, or air, CB radio will be the answer to your short-range, two-way, radio communications needs.

Did you ever envy the fellow with the radio telephone in his car? Did you ever think how convenient it would be for you to have your own private and personal two-way radio telephone system—suitable for instant communications with your home, office, factory, store, or with any of about 500,000 other radio telephone units located throughout the United States?

Today, keeping in line with the "instant" trend of the 1960's (instant coffee, credit, and cocoa), the Federal Communications Commission has thoughtfully come up with a relatively new radio service, the Citizens Rádio Service, which adds "instant communication" to the list.

How instant? Well, it's as simple as walking into a store, buying a set, taking it home, connecting an antenna similar to a TV aerial, plugging the set in and pushing a button. That's all there is to it—oh, yes, there is a

By Robert Hertzberg, 2W4922

The Citizens Radio Service (better known as CB for Citizens Band) can fill your business communications wants. The radio link between your office and the salesman, dispatcher, fork truck operator, trucker, serviceman, and even your home offers a business convenience that will increase sales, service, and profit besides increasing good will and making your business and personal life enjoyable. □

CB radio

CB goes to sea. Above right the skipper of a boat can keep in contact with his shore station or with nearby boats (upper left).

By far the favorite spot for a CB transceiver is under the dashboard of your business or family automobile. Designers are making units smaller so not to snag the Mrs. stockings.

Part 15 receivers operate in the Citizen Band and can be used by Dad as part of his CB network if type approved. When used in one service do not talk to other services.

license required, but you don't have to take a test to get it. All you need be is a U. S. citizen eighteen years of age or older.

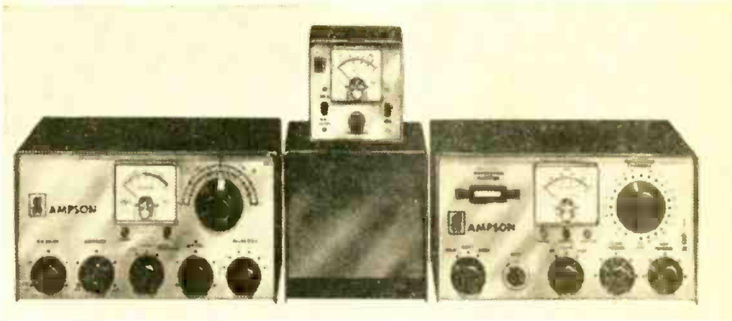
History of the CB service. The Citizens Radio Service (*CB*) actually was originated way back in 1947 on the 460 megacycle band. At that time, there was very little public interest in the band because equipment was difficult to design, even more difficult to get to work, and just about impossible to sell.

Well, that was "it" for CB for many years. It lay a dormant service on the FCC's records. There it stayed until 1958, when the FCC, took the so-called "11-meter" band away from the Amateur Radio Service ("hams"), because it more or less duplicated anything that could be done on the adjacent 10-meter band, and assigned it instead to the still-existent but dormant Citizens Radio Service. This band was given the designation Class "D," to distinguish it from the original Class "A" and Class "B" bands in the 460-megacycle region, and from the Class "C" band which is also on 27 megacycles but used only for the remote control of model airplanes, garage doors and similar devices. The FCC allotted 23 specific frequencies between 26.965 and 27.255 megacycles for two-way voice communication with a maximum transmitter power of 5 watts.

The Class D CB service. This time, radio manufacturers and prospective users of the service reacted in an entirely different man-

Knight-Kit KG-4000 Transceiver

The Sampson Model CB1A complete station is shown below. From left to right; receiver, loudspeaker and S-meter and transmitter.



ner than in 1947. Hams had been using low power on 27 megacycles for years. Circuits for both transmission and reception has reached a high state of performance and reliability. Antennas of all kinds were already available. The characteristics of the band were well known. Virtually overnight, the market was swamped with inexpensive gear, the FCC was swamped with license applications, and the 27-megacycle band was swamped with chatter.

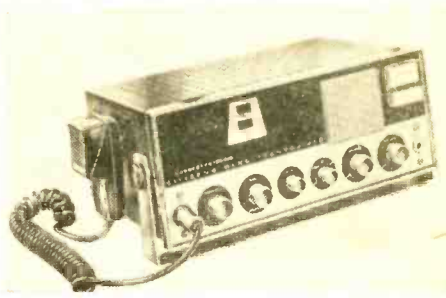
In fact, the band was swamped with too much chatter that didn't belong there at all. The FCC had (and still has) a major headache in explaining to legitimate users of the service that the 23 channels are like so many party-line telephones, open to all to use.

Permissible communications. It is unquestionably (and unfortunately) true that the no-test aspect of the CB license attracted many people who wanted to go on the air with no technical preparation whatsoever, not for necessary personal business or purposes but solely for their own amusement. The FCC apparently did not expect this development. After all, even the easy-to-get Novice ham ticket offers far better operating privileges than the CB license. In this connection, the Commission issued a statement entitled "Permissible Communications in the Citizens Radio Service," with which all present and prospective license holders should be familiar. (The full CB requirements are laid down in "Part 95," a section of the Rules and Regulations of the FCC.) Here are a few pertinent quotes:

"The Citizens Radio Service is for private short-distance radio communications between units of the same station or other stations licensed in the service, limited to the minimum practicable transmission time.

"The FCC License Application Form 505 must show *specifically* in connection with what business or other activity radio is to be used and the purpose and manner of such use. It must be remembered that stations in this service are licensed to fulfill a definite need for communications connection with business or personal activities.

Hallicrafters CB-3A transceiver



Lafayette HB-222 transceiver

CB radio

"The Commission's monitoring stations are continuing to detect violations of the Citizens Radio Service rules and are issuing large numbers of citations to licensees. The violations cited fall mainly into two large groups: off-frequency operation and the use of stations for communications which are not permissible under the rules.

"Most citations for improper use result from the mistaken belief that the Citizens Radio Service is similar to the Amateur Radio Service with respect to permissible communications and that certain amateur-type communications (such as calling CQ, contacting distant stations, radio experimentation, etc.) are permitted. *Nothing is further from the truth.*

"It seems likely that the former association of the CB frequencies with the Amateur Radio Service is partly responsible for the misunderstandings regarding the use of Class D stations. However, persons desiring to pursue radio communications as a hobby should refer to Part 12 of the Commission's rules and should apply for a license in the Amateur Radio Service.

"Don't put your Citizens Radio transmitter on the air unless you have a message you *need* to send."

CB equipment. Virtually all CB units are combination transmitters-receivers ("transceivers"), with a minimum number of controls to make operation as easy as ordinary telephoning for non-technical users. Transmitter frequency must be crystal-controlled within close limits to minimize adjacent-channel interference.

In the lowest price sets, the transmitter section works only on one selected frequency, while the receiver section uses a manually tuned super-regenerative circuit that is very simple but generally has very poor selectivity. In better sets, the transmitter offers a choice of channels, from 2 all the way to 23, and the receiver is a highly selective superheterodyne. Virtually all worthwhile CB sets are of this type. The same circuit elements are used interchangeably for both transmission and reception. No tuning on the part of the user is required; he merely turns a selector knob to the channel he wants and adjusts the volume control.

Since the usefulness of CB lies mainly in mobile-to-base and mobile-to-mobile applications, most sets are made thin and flat so that they can be mounted readily under the dashboard of a car, within easy reach of the driver. Loudspeakers are built in. The microphones are fitted with thumb switches for push-to-talk, release-to-listen operation.

Many units have universal power supplies which work equally well on 6 or 12 volts in a car and 115 volts AC in an office or home. The car antenna is a "whip," about eight feet long. For fixed stations the most common antenna is the "ground plane," a vertical rod with four horizontal radial rods at the base. In remote areas many CB users install beam antennas, exactly like those in the ham service, to stretch their communications coverage.

The five-watt power limit was adopted to make CB coverage purely local; that is, normal communications are limited to perhaps five or ten miles, depending on terrain. However, because of the well-recognized "skip effect" of short waves, there is sometimes bedlam on all the CB channels as stations across the country pour in without invitation. The first time he hears this sort of thing, a CB user becomes indignant, but he soon becomes accustomed to it.

Getting a license. The license for Class "D" operation is test-free, but nevertheless it is still required. To obtain the necessary application Form 505, address a request to the FCC, Gettysburg, Penn., 17325. When you return this form, *carefully* and *fully* completed, include a check for $8.00 made out to the Federal Communications Commission; this is the filing fee prescribed by law.

In addition to Class "D," the FCC authorizes another CB service which does not require a license of any kind. There are several catches to it. The transmitter power is limited to 100 milliwatts (one tenth of a watt) and the antenna length to four feet. Furthermore, users of these flea-power units may talk only to each other, and not to licensed CB-ers. There is nothing to prevent the latter from using low power if they want to. This service is known as "Part 15" CB.

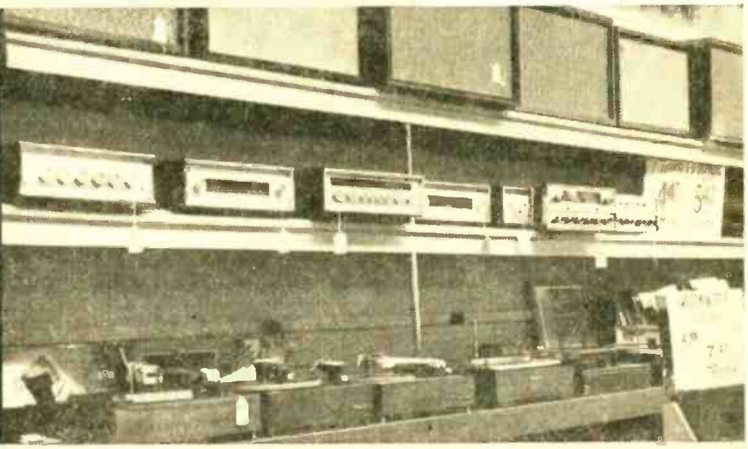
Many of the license-free "walkie-talkies" that have come on the market actually use less than 100 milliwatts, and are hardly more than toys. The better ones have a range of perhaps a mile or so under favorable conditions, and they find important applications among policemen, firemen, construction workers, etc. ■

putting together a hi-fi system

It takes much more than just plugging in audio cables and connecting antenna and speaker leads to assemble your home entertainment music center.

Walk into any high fidelity salon and you'll see walls lined with shelves displaying exotic components . . . turntables, amplifiers, tuners, receivers, changers, preamps, tape decks, mikes, and speaker systems. What should you buy? This article may solve your problem.

—John Potter Shields



EVER since the early days of high fidelity 'way back around 1948, the music lover has been faced with the problem of getting the best audio quality for his dollar . . . in a reasonably attractive package to boot. Hi-fi equipment manufacturers have done a creditable job of approaching these objectives, so that now, the audio neophite has an almost overwhelming selection of hi-fi components and completely assembled systems from which to choose.

In the following pages, we're going to cover a number of practical tips that will aid the beginner audiophile in the selection of a high fidelity system as well as looking at the overall component and completely assembled system picture.

hi-fi system

Store-Bought Console or Components? This is a question which has plagued the beginning audiophile ever since the early days of monophonic hi-fi. The completely assembled hi-fi units, with all components, such as amplifier, speaker(s), tuner, etc. mounted in a cabinet, offer the purchaser considerable convenience as the unit is all set to "plug in and play." Since all components are housed in one cabinet, rather than a number of individual components which by their very nature don't harmonize with home decor, the housewife is much more likely to be more receptive to having this unit hold a prominent spot in the living room.

On the other side of the fence, a "component system" almost without exception offers the most hi-fi per dollar when compared with the completely packaged units. The major reason for this is that the purchase dollar goes almost entirely for the components . . . about the only "cabinetry" being involved is perhaps an amplifier or tuner cover.

Component hi-fi is becoming more acceptable for other reasons besides price. Manufacturers have made available a wide variety of attractive cabinets to house the various system components. Modern hi-fi components, such as tuners, amplifiers, etc. are so designed as to be most easily connected and interconnected by the novice, and a number of excellent hi-fi components are available in kit form. Kit manufacturers have done a creditable job of instruction preparation so that the person with almost no experience can turn out an excellent job. A point not to be overlooked with kit construction is that a considerable dollar saving is possible as the kit builder is performing all the labor. Another point in favor of kits is that the builder acquires knowledge of the kit by its construction . . . this knowledge may be later put to good use in servicing the unit.

Selecting the Right Components. Whether you elect to build from kits or start with assembled components, the most important task is to choose those components which best meet your own specific needs. Do you plan a "built in" installation with all components installed in the wall? Are separate speaker enclosures going to be used or do you want everything in a single cabinet? Can the components be "out in the open" or must they be enclosed for appearance sake? Are you going to have a monophonic or stereophonic installation? The answers to these questions will decide to a large extent the type of an arrangement of the hi-fi components.

Speakers and Speaker Systems. The speaker, or speaker system, is one of three major components of your hi-fi system, and is responsible for converting applied electrical signals into corresponding sound vibrations.

Individual speakers suitable for hi-fi installations range in diameters from 8 inches to 15 inches (special low frequency speakers are available in sizes up to 30 inches in diameter). Price tags range from around ten dollars for an inexpensive 8 inch speaker to one hundred dollars or more for a quality 15 incher. Several representative quality single-cone speakers are shown in Figure 1.

The coaxial speaker is very popular as it provides extended frequency response by use of a tweeter (high frequency speaker) mounted centrally within the frame of the larger woofer (low frequency speaker) as illustrated in Figure 2. Coaxial speakers are available in diameters ranging from 8 inches upwards to 15 inches and carry price tags anywhere from about twenty dollars to one hundred dollars or more.

The coaxial speaker is an excellent choice for "upgrading" that older single cone speaker system with a minimum of effort. All that is generally necessary is to unbolt the old single cone speaker, slide it out and slip in the coaxial speaker. The wide choice of coaxial speaker diameters makes possible their district physical substitution in most cases. The only thing to watch is that the voice coil impedance of the coaxial speaker be the same as that of the unit being replaced. This should cause no difficulty as just about all speakers manufactured for the last twenty years have voice coil impedance of either 4, 8 or 16 ohms. The coaxial speaker is known as a "two way" system as two separate speakers are used.

The tweeter speaker may often be mounted separately from the woofer rather than coaxially with it. A "three-way" system results when a third, mid frequency range, speaker is added to a woofer and tweeter. At this point, you may ask: won't the frequency responses of a woofer and tweeter overlap enough to cover the mid-frequency range? While the answer is yes, the addition of a

Photos on this page courtesy of Electro-Voice

Fig. 1. Single-cone speakers can be designed to cover the entire useful audio range.

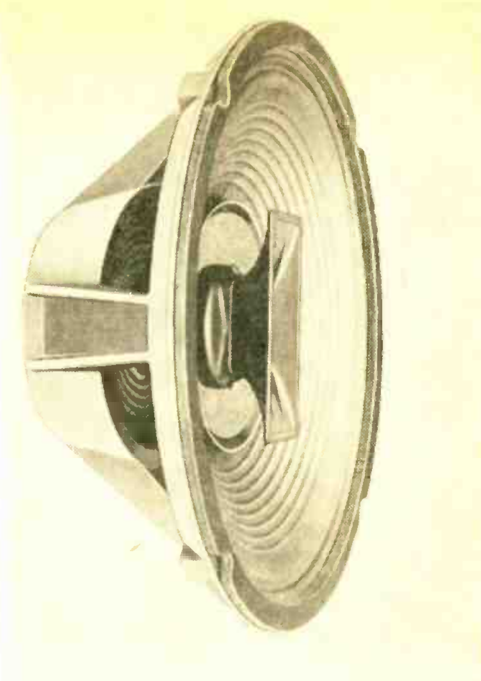


Fig. 2. The most popular speaker type in single speaker systems is the "co-axial."

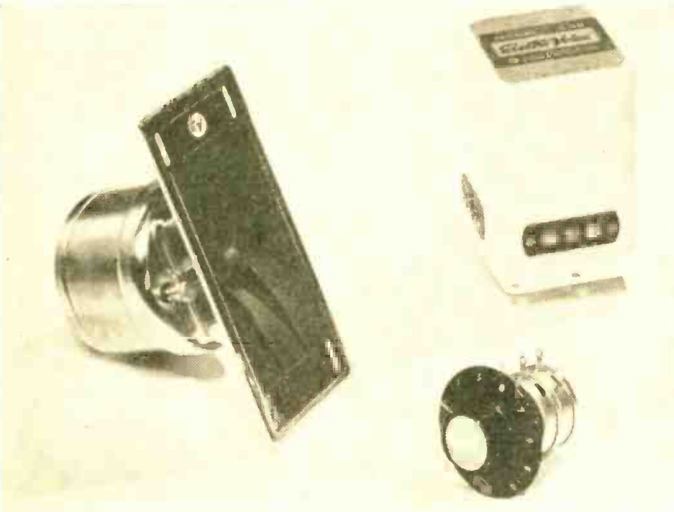


Fig. 3. High frequency tweeters boost the highs in speaker systems where large single-cone units are used to reproduce the low audio sounds.

third speaker to handle the mid-range frequencies means that the woofer and tweeter can take a "smaller bite" of the overall frequency range. This results in less overall speaker system distortion.

The woofer, tweeter and mid-range speakers must be fed only those frequencies which they are intended to handle . . . low frequencies only to the woofer, high frequencies only to the tweeter, etc. The task of directing the right range of frequencies to the right speaker is accomplished by a device called a "dividing network." Figure 3 shows a horn type tweeter with its dividing network. The level control shown in this photo is used to control the amount of signal fed to the tweeter.

The speakers talked about so far are good choices for mounting in an existing speaker enclosure, in the wall, or in conjunction with other hi-fi components in an "equipment cabinets" as pictured in Figure 4. Another approach which is becoming increasingly popular with the advent of stereo are the new "compact" speaker systems. Figure 5 illustrates two such speaker systems which are sufficiently small to solve the problem of how to blend two speaker systems into existing room decor. These diminutive speaker systems achieve their excellent sound reproduction qualities by the use of specially designed woofers which are capable of reproducing low frequencies with low distortion without relying on specialized enclosure designs such as the bass reflex or folded horn. Time was when the sound quality of a speaker system, particularly at the bass end, was almost in direct proportion to its physical rise. As a result, the audio buff was forced to have a large, coffin-like box in one corner of the living room to get really good sound reproduction . . . worse, two for stereo. It's easy

Fig. 4A. With the doors open, this system displays its H. H. Scott, Sony and Rek-O-Kut components. Grille hides one of two speakers.

Fig. 4B. This unique installation boasts a Sherwood amplifier and tuner, Garrard type-A changer with a Shure cartridge and a pair of James. B. Lansing D47LE8 speaker systems. Unused space under changer can be used to tack on a tape recorder at a later date. As is, the entire high fidelity system costs $1000.

Fig. 4C. A perfect home entertainment center combining hi-fi and TV. System consists of Fisher FM-stereo receiver, Garrard type-A changer, Sony tape recorder and two J. B. Lansing speaker systems. TV is a 21" unit.

Fig. 4D. This unusual built-in high fidelity system sports Sherwood components and a Garrard changer. AR-3 speaker system is hidden behind grille at top of cabinet with mating speaker located elsewhere in room.

Fig. 4E. This custom system consists of all Allied and Knight-Kit components. From left to right on equipment shelf: professional turntable and tone arm, record amplifier, transistorized stereo amplifier and receiver with clock, and finally a pair of KN-4000 tape decks. Cost less wood cabinet—$790.

to see why these new speaker system "compacts" have become so popular.

Amplifiers and Preamplifiers. Amplifiers and preamps are next on our list of hi-fi components. As in the case of speakers, amplifiers come in a variety of sizes and shapes to suit almost any conceivable installation. Before going any further, let's list the basic amplifier/preamp requirements; then examine each in turn.

1. Monophonic or stereophonic
2. Required power output
3. Number and type of operating controls
4. Tube or transistor

In selecting your hi-fi amplifier, the first choice is, of course, whether you want a mono or stereo system. If you should decide to start with a monophonic system, it's a good idea to do so with an eye toward stereo conversion at a later date. By doing this, needless duplication of components at a later date can often be avoided, or at least minimized. For example, if the components are going to be housed in an equipment cabinet, a cabinet can be chosen which has provisions for the mounting of two speakers . . . only one speaker being installed at this time for the monophonic system. Another good idea is to select a stereo phono cartridge . . . its two stereo outputs can be tied together to form an excellent monophonic cartridge.

Several factors must be taken into consideration when deciding the required amplifier power output. Of these, the most important is the type of speaker(s) which you plan to use. The modern "acoustic suspension" speaker system, variations of which are being offered by several manufacturers, require a power input of 20 to 30 watts due to their relative inefficiency. This inefficiency however should not be misconstrued as a weakness as the inefficiency is traded for extended low frequency response, low distortion, and small cabinet size . . . more than a fair trade. Thus, if you plan to use this type of speaker, your amplifier should be capable of providing 20 to 30 watts output at low distortion. This poses no great problem these days as reasonably priced amplifiers, both vacuum tube and transistor, are available with power outputs in excess of 40 watts each channel.

You'll notice that we haven't mentioned frequency response or distortion in our list of amplifier criteria. The reason for this is that just about all modern amplifiers possess more than adequate frequency response and distortion characteristics. Just for the record however, any amplifier worth its hi-fi salt should have a power response rating of at least 30 to 20,000 cycles per second. Distortion ratings should be under 2% for both harmonic and intermodulation, (harmonic distortion is usually stated at 1000 cycles per second).

Next, we come to the subject of amplifier controls. Here again, most amplifiers nowadays offer the full range of operating controls, including volume (sometimes called loudness), individual bass and treble tone controls, and a complete array of input and output switching facilities. As a consequence, the choice is mainly that of operating convenience. One manufacturer has come up with a novel approach to the problem of unintentional movement of those "set once and forget" controls such as speaker phasing, input level, etc. by placing these controls behind decorative front panel trim as illustrated in Figure 7. This neatly minimizes the chance of unauthorized fingers flipping the speaker phase switch or a level control which could cause much headscratching as to the "unexplainable" change in sound quality.

Finally, we come to the matter of whether to choose an amplifier using tubes or transistors. There has been much written of late about the relative merits of both tube and transistor approaches. Generally speaking, on an equal dollar basis, vacuum tube amplifiers appear to be the best bet at this time from a power output and distortion standpoint. *Quality* transistor electronics don't come cheaply—wideband power transistors are still relatively expensive and a greater number of transistors than vacuum tubes are required to perform the same amplifier circuit functions. Also, due to their rather delicate nature electrically, transistors require a number of built-in protective circuits that are unnecessary with tubes. Many early attempts to market all transistor amplifiers were disappointing due to both improper circuit design and inadequate circuit protection.

On the plus side, a *well designed* transistor amplifier such as the unit pictured in Figure 8, can boast a number of advantages that cannot be obtained from even the best vacuum tube unit. Since transistors have no heaters to burn out, as do vacuum tubes,

Fig. 5. Bookshelf type speaker systems can be stood on end and used as end tables.

their life, under proper operating conditions is many, many times that of vacuum tubes. Transistors mean much cooler amplifier operation due to the absence of heat generated by the heated cathodes of vacuum tubes. A side advantage of transistor operation not mentioned too frequently, is that longer component life may be expected due to their much cooler operating environment.

Other significant transistor amplifier advantages include freedom from microphonics (a condition peculiar with vacuum tubes in which they are electrically sensitive to mechanical vibration), and elimination of the output transformer (a necessity with vacuum tube circuits). The direct coupling between speaker and amplifier output stage, practical only with transistors has resulted in significantly improved transient response and overload characteristics providing a cleaner sound which some have come to call "transistor sound." Here again though, care must be taken in choosing the transistor amplifier; wired or kit as that "different transistor

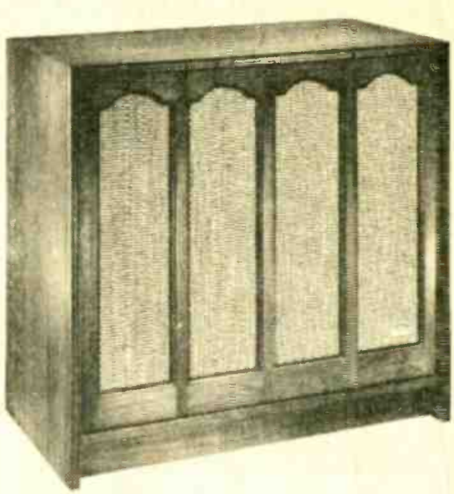


Fig. 6. The Electro-Voice "Regency 400" speaker system is typical of the many good units available at high-fidelity salons.

sound" may be a result of excessive harmonic distortion . . . particularly at low output levels. Many early circuits were plagued with this problem so carefully check the distortion figures *at all power levels* before making your purchase.

The following points should be kept in mind when purchasing a transistor amplifier . . . either kit or wired.

1. Amount of distortion at *all* power output levels.
2. Power output (IHFM ratings are a good standard to judge by rather than "peak power" or "music power" which can be misleading.
3. Frequency response at rated power output.
4. Circuit protection devices . . . a power-line fuse is generally not considered fast enough to protect the output stage power transistors in the case of accidentally shorted speaker terminals. This is a most important point and should be clarified before the purchase of any transistor amplifier, as if not well protected, a momentary shorted speaker terminal or lead can mean by-by to expensive power transistors, one, or more likely a handful.
5. Price . . . beware the "bargain priced" transistor amplifier wired or kit. As we said earlier, considerably more components are involved in transistor circuitry, these of course, costing money.

Record Changers, Turntables, and Cartridges. As in the case of amplifiers, there are several points to consider before purchasing either a record changer or manual turntable.

1. Personal convenience
2. Mono or stereo
3. Type of cartridge

The most important point in deciding between a changer or manual turntable is convenience. Are you the kind who likes to stack up a number of records for "background music" for an entire evening, or do you find the "mechanism" of a changer just getting in the way when playing a single record? There are a number of excellent changers on the market, with price tags ranging from around $30, upwards to $80 or more, and are available nowadays in speeds ranging from 16⅔ RPM through 78 RPM. Turntables are a bit more expensive, prices starting in the neighborhood of $50, going upwards to around $1,000 or more for professional units. Before making your selection on convenience and price alone, let's weigh some of the other factors.

An important consideration in the choice of either a changer or turntable is whether you are planning a monophonic or stereo system. As you probably know, a mono record groove is laterally modulated . . . that is the playback stylus moves from side to side as it tracks the record. On the other hand, a stereo record groove contains both lateral and vertical modulation. At this point

Fig. 7. Concealed controls help keep the appearance of hi-fi equipment simple. Here, a Heathkit AJ-43 all-transistor all-mode tuner is shown with all controls exposed. There are enough to scare away any housewife. However, the panel below the controls can swing up and cover these controls. Tuner is quite simple to operate.

you're probably wondering, what does this have to do with the choice of a changer or turntable? The answer is that a cartridge intended to play mono records only is designed so as not to be responsible to vertical movement of its stylus. This is done to minimize pickup of changer or turntable motor vibration (*rumble*). On the other hand, a stereo cartridge must respond to both lateral and vertical stylus movement in order to properly reproduce stereo records. This, of course, means that a stereo cartridge will be much more sensitive to motor vibration than a mono cartridge.

Another point should be brought up while on this subject of changer and turntable rumble. This is that the more extended the hi-fi system's low frequency response, the more susceptible it will be to rumble problems. Thus, if you are planning a relatively inexpensive system incorporating speakers whose low frequency limit are around 70 or 80 cycles per second, you would be foolish to shell out for a belt drive manual table as either a less expensive rim drive table or good quality changer will be acceptable from the rumble standpoint. On the other hand, if your speaker(s) go down to 20 or 30 cycles per second you must take care in choosing your changer or turntable as only a few types in each category will make the grade rumble-wise.

The choice of changer or turntable will also depend upon the type of cartridge you intend to use . . . a matter of cartridge "compliance" entering into the picture. By cartridge compliance we mean the "stiffness" of the stylus mechanism. A high compliance cartridge has a very flexible stylus mechanism and will "track a record groove with much less pressure than a comparatively "stiff"

Fig. 8. A very simple hi-fi system for playing LP records. Tuner and other speaker system can be added on later. Budget hi-fi systems sound good to the new comer to hi-fi, but as the ear becomes accustomed to the sounds of your budget-priced system, a new and more expensive high-fidelity system is in order.

low compliance cartridge. Obviously then, a high compliance cartridge is desirable as the less tracking pressure it requires means larger record life. Increased compliance however, is not without its problems. In the case of a record changer, the decreased cartridge tracking pressure means less force is available to actuate the changing cycle trip mechanism. Putting this another way, when sufficient cartridge pressure is used to assure positive trip action, excessive tracking pressure may be applied to the rather delicate "works" of a very high compliance cartridge. A few of the better changers will work well with the low compliance cartridges as they will track down to about two grams. Generally speaking though, for tracking pressure much below two grams, the use of

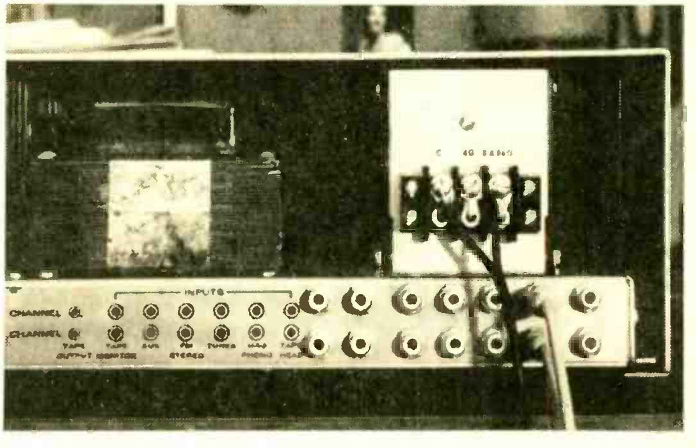


Fig. 9. You don't have to know much about hi-fi components to interconnect them. Just carefully read the instructions provided by the manufacturer and follow the markings on back of the chassis. Ordinary "zip" cord can be used for speaker leads. Audio cables are usually supplied with component when bought.

precision arms such as are intended for use with manual turntables is required. The turntable-arm combination pictured in Figure 8 is typical of the high quality units available, and is suitable for use with very high compliance cartridges.

Tuners. Tuners round out our discussion of basic hi-fi components. As in the case of all the components discussed previously, price and intended results are the main considerations.

In the case of prices, tuners may range from around $30 for a mono. FM only tuner up to several hundred dollars for a FM stereo AM tuner boasting a full complement of controls. As in the case of the other hi-fi components, excellent FM only or FM-AM tuner kits are available . . . an excellent example being shown in Figure 7. This unit offers FM-AM multiplex and AM, and is completely transistorized thus offering all the previously outlined advantages of transistor operation.

If you live in an area serviced by multiplex FM and are planning a stereo system, your choice perhaps should be a stereo tuner. In connection with this, one point to keep in mind is that a much better antenna is required for FM stereo reception than for just mono FM. An inadequate FM signal delivered to the antenna terminals of your tuner will result in increased signal distortion and stereo channel separation depreciation.

Assembling the Chosen Components. After deciding upon and purchasing your hi-fi components, the next step is their installation and interconnection. There are three basic approaches that can be taken in the installation of your hi-fi system . . . built-in installation, equipment cabinet or components out in the open.

Built-in installations offer the greatest flexibility of the three approaches . . . a typical built-in system being shown in Figure 4. There are several important points to watch out for in this type of installation however. In any built-in installation proper ventilation is of prime importance, as all vacuum tube equipment, whether it be a tuner, preamp, a power amplifier, generates considerable heat which must be removed. The obvious matter of a possible fire hazard as well as greatly impaired component life are the consequence of poor equipment ventilation. Most manufacturers include detailed information as to the amount of ventilation required and the best method of obtaining the ventilation for their equipment. Many built-in installations include a small, low RPM fan to hasten air circulation around the various pieces of equipment. Component accessibility for service in an important point that is often overlooked in a built-in installation.

Transistorized hi-fi gear, as mentioned earlier, generates negligible internal heat and thus greater liberties can be taken in its installation. However, care must be taken not to subject the transistor equipment to excessive sources of heat, such as near a radiator, etc. as while they themselves generate little heat, transistors must not be subjected to excessive temperatures.

Equipment cabinets are the logical choice for those desiring all their hi-fi components grouped together in a single housing. The same good practice regarding ventilation should be followed as in the case of built-in installations.

The problem of interconnecting the various components presents no problem these days as tuner, changer (a turntable), and amplifier input and output connections have been pretty well standardized. Shielded cables are used from tuner or changer (or turntable) outputs to the amplifier inputs, and ordinary lamp cord sometimes called "zip cord," is used between amplifier output and speaker(s). One point in particular to watch is the amplifier's speaker terminals where a strand or two of the speaker's connecting leads may short across the terminals. One transistor amplifier kit manufacturer has lessened this problem by providing barrier type speaker terminals . . . insulating barriers between the screw terminals minimizing the chance of shorts between terminals (Figure 9).

Proper grounding of the chassis of the various system components such as tuner and amplifier, changer or turntable base is of utmost importance to minimize hum. That extra lead, aside from the signal cable(s) and power cord, is meant to be placed under a screw on the amplifier chassis to ground the changer frame.

Well, that's about it. We have attempted to cover the high points of how to put together a hi-fi system in an interesting and informative manner, and we sincerely hope you have found it both interesting and helpful. ■

how to service home entertainment equipment

By Leo G. Sands

You can learn much about electronics when you repair radios, hi-fi's, and television sets

YOU CAN often diagnose and repair troubles in your radio and television receivers, or hi-fi system. There are some repairs that should be tackled only by a competent technician. Since it costs money to have a technician diagnose the trouble, it would be cheaper if you were to do the preliminary diagnosis and perform the easy and simple repair tasks.

The only test equipment you need is a volt-ohm-milliammeter, called a VOM by engineers and technicians. It is a multi-purpose meter that will measure AC and DC volts, current in milliamperes and resistance in ohms and megohms. They range in price from $10 for an import to as much as $75 for a domestic-made instrument.

AC/DC radios. Most radio sets, except transistor portables, are of the so-called AC/DC type. The AC/DC radio

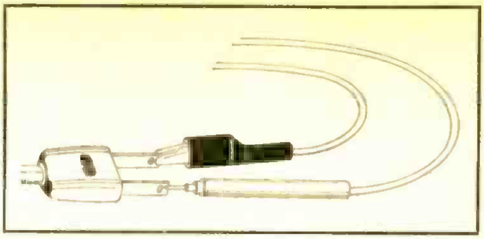


Fig. 1. The ohmmeter is the best instrument for checking out the appliance's major Nemesis—the open line cord. Wire breaks are common.

was devised some 30 years ago by Barnet Trott who saw a need for a radio that could be operated either from AC house current or DC power, which was still in use in some cities at the time. Today, nearly all homes and apartments have AC power and the AC/DC radio still exists mainly because it is cheaper to build, since a power transformer is not used.

● ● ● **Tubes don't light.** In radios of the AC/DC type, the heaters (filaments) of the tubes are connected in series in Christmas tree light fashion. If one tube burns out, none will light. This is the most common cause of failure.

If your radio fails to play when turned on and plugged in, and no hum is heard when your ear is held close to the loudspeaker, suspect a burned out tube. If the set is left turned on for several minutes and the cabinet does not get warm, and you see no light at any of the tubes (dull red glow), the trouble can be a defective switch, broken connection at the power plug, or a burned out tube.

Disconnect the power plug and connect the leads of an ohmmeter (volt-ohm-milliammeter set to measure ohms) to the prongs of the power plug. See figure 1 with the switch turned on, the meter should indicate less than 1000 ohms. If it indicates that the circuit is open (meter needle does not move), examine the power plug to determine if one of the wires has been pulled loose from its prong. If this is the case, cut the cord an inch or so from the plug and install a new plug.

If this does not cure the trouble, remove the set's rear cover carefully, the chassis holding screws and the knobs, and remove the chassis from the cabinet. With the power plug disconnected, connect the ohmmeter leads to the ends of the power cord inside the chassis, and short circuit the power plug prongs with a screw driver blade with the switch in the "off" position. The meter should now indicate zero ohms (full-scale meter deflection). If this does not happen, the cord is defective and should be replaced with a new one. If the cord is OK, you are ready to check the on-off switch by connecting the ohmmeter across its soldered terminals. With the switch turned on, the meter should indicate zero ohms.

Depending upon which is handier for you, take the tubes out of their sockets and have them tested, or use the ohmmeter to measure

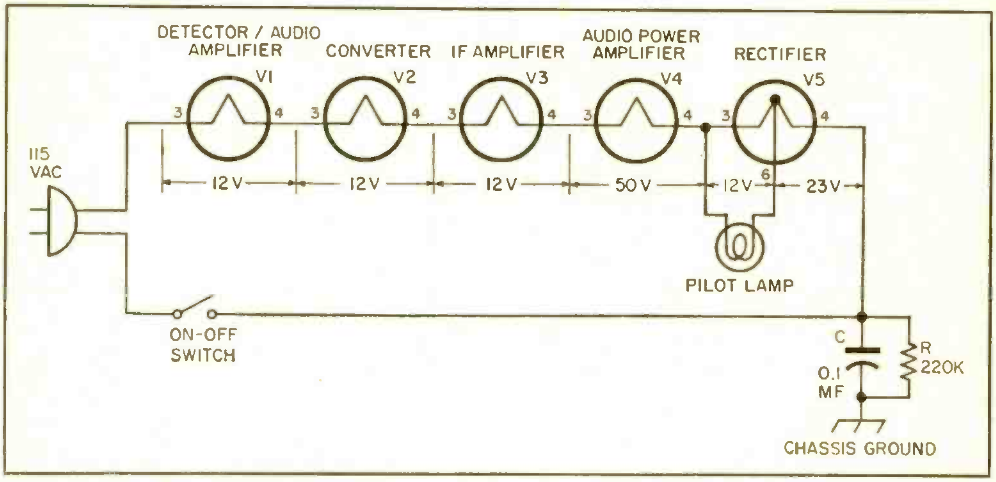


Fig. 2. Filament line-up for a typical "all American five" superhet table radio.

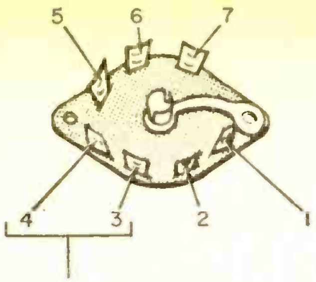


Fig. 3. Typical 7-pin miniature socket.

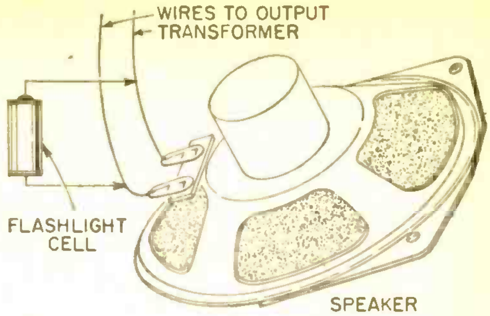


Fig. 4. Cell causes speaker to "thump."

the continuity of the heater of each tube with the tubes in their sockets. You have to know which socket terminals to check.

A schematic diagram of the heater circuit of a typical AC/DC radio is given in figure 2. In this case, terminals 3 and 4 of all of the tubes are the heater connections. The terminals may be numbered. If not, see figure 3 for the numbering arrangements used for common types of tubes, looking at the bottom of the socket.

Touch the ohmmeter leads to the heater connections of each tube, one at a time. If you get an open circuit reading (meter needle does not move) at one of the sockets, the tube in that socket is apparently burned out. Replace the tube with one of the same type. Now, you should not get an open circuit indication.

Turn on the radio switch and plug in the power plug. The tubes should light and, if nothing else is wrong, the set should operate. Make sure that the set chassis does not make contact with any metallic grounded object. Don't touch the chassis unless you are standing on a dry insulated surface, in order to avoid possible shock.

To test the set while it is out of its cabinet, put the knobs on the shafts (with power plug disconnected) and touch only the knobs when adjusting the set. If it works OK, disconnect the power plug and reassemble the set.

On the other hand, if you choose to take all of the tubes out for testing, make a chart noting which tube belongs in which socket so you will know where to reinstall them after testing.

● ● ● **Pilot lamp.** Most AC/DC radios no longer have a pilot lamp which glows when the set is turned on. When a set is equipped with a pilot lamp, it is usually connected as shown in figure 2, across part of the heater of the rectifier tube. The set will continue to play even if the pilot lamp burns out since the series circuit is not broken, although slightly changed in total resistance.

The pilot lamp should be replaced only with one of the same type number as originally installed in the set by the manufacturer, usually a number 47 lamp. When the set is first turned on, the lamp may glow brightly and then dim as the tubes warm up. The resistance of a tube heater is quite low when it is cold compared to its resistance after it has reached operating temperature.

● ● ● **Tubes light—set doesn't play.** While a burned out tube is the usual cause of trouble, there are many other defects that can prevent a radio from operating. A tube can be defective even if not burned out. So, have them tested and replace any bad ones.

If the tubes light and the cabinet gets warm, listen for a slight hum in the loudspeaker. If none is heard, disconnect the power plug and pull the chassis. Momentarily connect a 1.5-volt flashlight cell across the speaker terminals as shown in figure 4. A click should be audible as the battery leads touch the speaker terminals. If no click is heard, the speaker voice coil circuit is probably open and the speaker should be replaced with one of the same physical size and impedance rating.

Presence of hum indicates that the speaker is live and that the trouble is elsewhere. With the chassis out of the cabinet, the power plug connected, the switch turned on, and the volume control set wide open, touch a test lead (not connected to anything) to the center volume control terminal. A buzz should be heard. If not, the trouble is in the audio section of the receiver, in any one of the many components, including either of two tubes.

Among the possible troubles in the audio section are an open coupling capacitor from the plate of the first amplifier tube to the grid of the audio power amplifier, a shorted capacitor across the primary of the output transformer or an open first amplifier plate resistor or open power amplifier resistor.

A buzzing sound caused by touching a test lead to the center volume control terminal indicates that the trouble is ahead of the audio amplifier. If the set can't be made operative by replacing one or more tubes, further diagnosis should be made by a technician, unless you want to attempt it yourself. But, don't touch the IF transformer alignment screws since you will need a signal generator to get them back on the correct frequency.

Look for a charred resistor and for swollen capacitors or chemical oozing out of a capacitor and replace such components with exact equivalents. In the case of a charred resistor, a capacitor in the same circuit may have blown causing the resistor to overheat.

● ● ● **Excessive hum.** A loud hum may be caused by a shorted tube or a dehydrated filter capacitor. The set may or may not play. The first step is to test the tubes and replace defective ones. If the hum persists, chances are the filter capacitors need replacement. Note the ratings marked on the filter capacitors and buy an exact equivalent. See figure 5. Unsolder and remove the old ones and install the new ones, being careful to observe color coding or polarity marks. If this was the cause, the hum should be gone or diminished. After the set has been played a while, the hum may get weaker as the capacitor forms.

● ● ● **Distortion.** Highly distorted sound, often accompanied by hum, is often caused by a shorted tube or electrically leaky coupling capacitor between the plate of the first audio amplifier and the grid of the power amplifier. Disconnect the old one and solder in an exact equivalent. At the same time, as added insurance, replace the capacitor between the plate and screen of the audio power amplifier tube (bridges output transformer primary).

● ● ● **Lack of sensitivity.** Inability to pick up as many stations as in the past may be due to aging tubes, dehydration of filter capacitors or change in the characteristics of a resistor or capacitor. Test and replace weak tubes first. If the set hums, replace the filter capacitors. These steps usually restore performance. Further diagnosis should be made by a technician.

● ● ● **Fading.** The sudden rise or fall in the volume of a radio is often caused by inadequate pick up by the built-in antenna. In some cases, the volume drops or falls when a light switch is turned on or off. The lighting circuit changes its characteristics as a switch is opened or closed, and may re-inforce or attenuate the level of the signal reaching the radio's antenna. The simplest cure is to move the radio to another location in the room, or to re-orient it to change its antenna position with respect to the stations to be received.

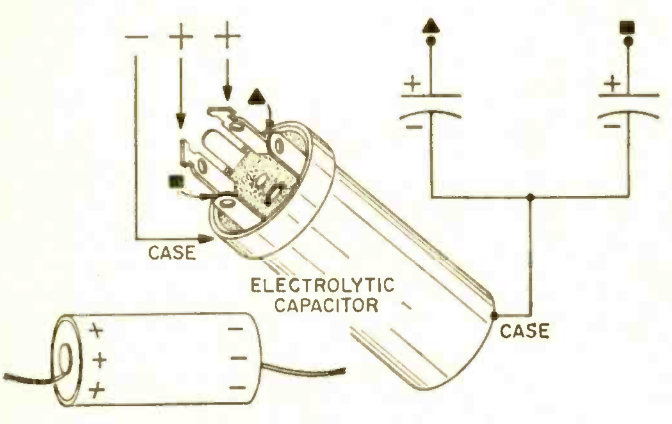


Fig. 5. Electrolytic capacitors come in two standard types. Single units and transistor circuits type usually come with wire leads. Can types are multiple units as a rule and very often have large microfarad ratings that can handle high plate voltages.

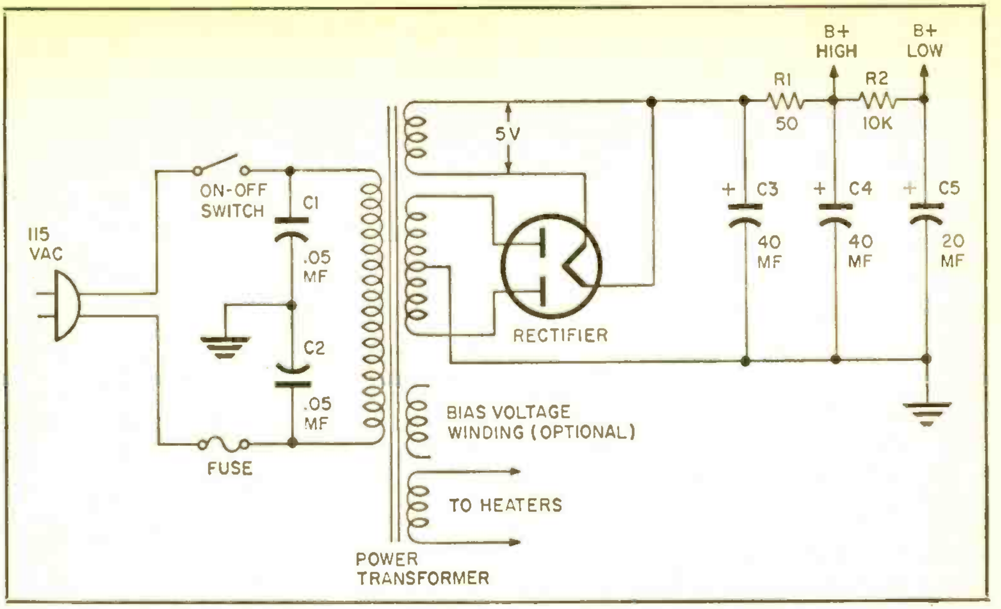


Fig. 6. Typical full-wave rectifier circuit used in high-fidelity components.

A loose connection inside a tube or capacitor can also cause sudden changes in volume. Slow fades on all stations are generally caused by a tube with an intermittent heater. Fading of volume when listening at night to stations more than 50 miles away, but with nearby programs remaining steady, is due to cancellation of the ground wave radio signal by its sky wave, which is not the fault of the radio.

Transformer type radios and hi-fi tuners. Nearly all hi-fi radio tuners and some radio receivers employ power transformers, particularly those inside of large console cabinets, and particularly those that were manufactured several years ago. In these sets, the tube heaters are generally wired in parallel and the plate and screen voltages are usually much higher than in AC/DC radios.

● ● ● **Tubes don't light.** Failure of the pilot lamp to light when the tubes light is generally due to a burned out pilot lamp. Failure of all the tubes to light is most often caused by a blown fuse, if the set has a fuse. Generally, the fuse is at the rear of the chassis and can be replaced by merely turning the fuse holder counter clockwise and pulling it out. It can be checked with an ohmmeter to determine if it is open, if it isn't obvious when looking at it that it is burned out. Replace the fuse only with one of the same type and rating as specified by the manufacturer of the set.

Should the fuse blow when the set is plugged in and the switch is turned on, there is trouble inside the set.

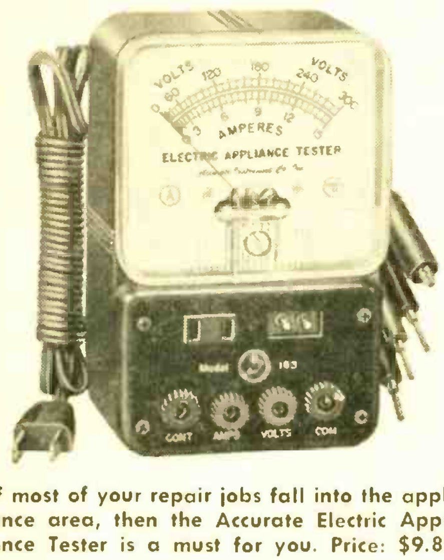
If the fuse is Ok, or a new fuse does not blow, pull out the power plug and connect the ohmmeter leads to its pins with the radio switch turned on. If an open circuit condition is indicated, inspect the power plug connections to the cord and replace the plug if one of the wires has pulled loose from its prong. Pull the chassis if the trouble is not at the plug.

Touch the ohmmeter test leads to the ends of the power cord inside the chassis and short the power plug prongs with a screw driver blade with the switch in the "off" position. You should get a short circuit indication. If not, replace the cord and plug. Now, check the switch with the ohmmeter. A short circuit (zero Ohms) condition should be indicated when the switch is in the "on" position, and open circuit when in the "off" position.

Then connect the ohmmeter leads to the power transformer primary leads. One is usually connected to the fuse (or to one wire of the line cord when there is no fuse), and the other to one terminal of the switch. An open circuit reading indicates that the power transformer primary is open, which means that the transformer must be replaced by an exact equivalent.

● ● ● **New Fuse Blows.** Blowing of a newly installed fuse of the proper rating usually indicated that there is a short circuit within the set. If the set is connected to an external ground, remove the ground connection. Now, if the fuse does not blow when the set is plugged in and turned on, chances are that one of the line filter capacitors (C1 and C2 in figure 6) is shorted. Disconnect the power plug and touch one ohmmeter test lead to the chassis and the other to either power transformer primary lead. You should get an open circuit indication. If not, replace the line filter capacitors with new ones of equivalent value and rating. However, if you still get other than an open circuit reading, the power transformer primary winding may be grounded to its core and replacement of the transformer is indicated.

Trouble on the other side of the power transformer, which causes the fuse to blow, could be due to a short or ground in one of the transformer secondary windings, or a short circuit or ground in the tube heater winding. Pull out the rectifier tube and turn the set on. If the fuse does not blow now, but does blow when the rectifier tube is re-installed, the trouble is probably due to a shorted filter capacitor.



If most of your repair jobs fall into the appliance area, then the Accurate Electric Appliance Tester is a must for you. Price: $9.85.

The shorted filter capacitor can be identified by measuring the resistance with an ohmmeter from the hot terminal of each filter capacitor to the chassis. Sometimes two or more capacitors are inside the same container. If a very low resistance or short circuit condition is found, disconnect the wire at the capacitor terminal and check it again with the wire removed. If the short isn't cleared now, replace the capacitor with an equivalent type. Observe color coding or polarity marks.

● ● ● **Tubes light—set doesn't play.** When the tubes light, but the set is inoperative, any of dozens of components could be defective. If there is an odor and the power transformer gets hot, it could be transformer trouble or a short circuit elsewhere. Look at the rectifier tube for reddening of its plates which is indicative of a shorted filter capacitor.

On the otherhand, if the set does not give off an odor and does not seem to overheat, the trouble could be a defective tube. All should light. The light in some may be difficult to see. After the set has been turned on for a while all tubes should feel warm to the touch. Nevertheless, have all the tubes tested and replace any defective ones. Check the loudspeaker as explained earlier about AC/DC sets.

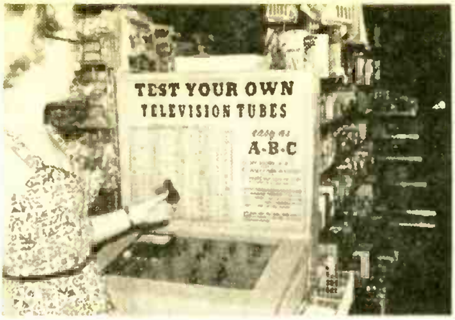
Other troubles, such as hum, distortion, lack of sensitivity and selectivity and fading can be due to the same causes as explained earlier, regardless of whether the set is of the AC/DC type of transformer type.

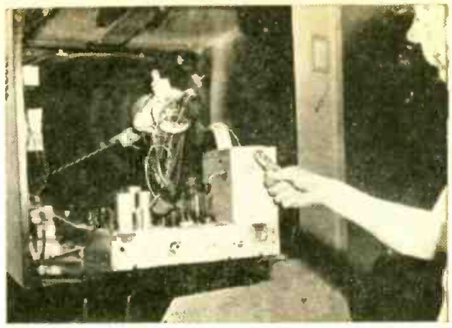
Hi-fi amplifiers. The power input circuits of hi-fi and other audio amplifiers, as well as AM/FM tuners, are similar to those of transformer type radios and the same check-out procedures can be used.

● ● ● **Excessive hum—volume control turned down.** Some amplifiers are equipped with a hum control at the rear or top of the chassis which can be adjusted with a screw driver. With the volume control turned to minimum volume, adjust the hum control slowly for minimum audible hum. If the hum cannot be reduced to a satisfactory level in this manner, have the tubes tested and replace any defective ones.

The audio power amplifier tubes may have to be closely matched in order to minimize hum and distortion. When buying new tubes, have them checked and take those which check most alike.

While it may not be specified in the user instruction book, a ground connection may





Some servicemen claim that 95% of all radio and TV set faults can be eliminated by replacing a vacuum tube. This kind of service anyone can do, including a housewife (upper right). If you have your own tube tester (left), you can cut out those trips to the corner drug store. Remember, in TV sets there are one or more tubes hidden in the HV cage (upper right). Be careful! Be sure to short out the high voltage to ground.

reduce hum level. Get a ground clamp and fasten it to a freshly cleaned spot on a cold water pipe and run a wire from it to a screw on the chassis. (Don't do this if the amplifier is of the transformerless type).

The hum could be caused by dehydrated filter capacitors. This can be checked out by turning the chassis over to gain access to the wiring. Take a 20-ufd, 450-volt tubular electrolytic capacitor and temporarily bridge it across each filter capacitor or section, one at a time, making sure that the + terminal of the test capacitor is connected only to the positive terminals of the capacitors in the amplifier, and note any reduction in hum. Be careful to hold the test capacitor by its insulated housing and avoid touching any of the wires, terminals or test capacitor leads, to avoid shock.

An appreciable reduction in hum level, when the test capacitor is tried, indicates that the filter capacitors should be replaced.

● ● ● **Excessive hum—volume controls turned up.** Hum, which increases in intensity when the volume control is turned up, in any position of the function selector switch (phono-tape-tuner, etc.) indicates amplifier trouble. It could be an improperly seated tube shield or a defective tube.

However, if the hum rises when the function selector switch is set to one particular position, the trouble could be in the particular pre-amplifier selected, in the lead from the selected input device (tuner, record player, etc.), or in the input device itself.

Check the amplifier input lead and plug, looking particularly for a broken shield at the plug at each end of the lead. Make sure that the plugs are firmly seated in their sockets.

When separate line cords are used for each hi-fi system component, try reversing the positions of their respective power plugs in their sockets.

Record changers. A record changer is an intricate and touchy mechanism which should be adjusted only by an expert. However, it can be lubricated by anyone who has available an instruction book spelling out when and where to lubricate and what kind of lubricant to use.

Rubber rimmed drive wheels and idlers wear out and cause rumble. Replacements can be purchased at radio parts stores, which you can install if you exercise care not to disturb other parts of the mechanism.

The stylus of many types of stereo and mono cartridges can be easily replaced. The new stylus is generally furnished with specific installation instructions. Sometimes it is necessary to replace the entire cartridge, or you may want to replace your cartridge with one of a type more suited to your requirements.

Portable Transistor Radios. Servicing portable transistor radios is a job for an expert with the proper tools, test equipment and spare parts. The most common trouble is worn out batteries, which you can easily replace. Symptoms of worn out batteries are lack of volume and a motor boating sound.

Replace the battery or batteries (all of them at once) with exact equivalent types, being very careful that the new ones are inserted or connected in the same polarity as the original ones. If necessary, clean the contacts with a pencil eraser and bend the clips slightly to ensure firm contact.

Television sets. Numerous books have been published about how to repair your own TV sets. While many professional TV service shops have initially lost business as a result, they have gained additional revenue undoing the damage done by some do-it-yourself TV owners.

When your TV set acts up, it will cost you several dollars to get a pro to come to check it over, quite a few dollars to get it repaired if more than a new tube is required. Some shops charge a minimum of five dollars to look over your TV set even when you bring it to the shop.

There are several things you can do before you call in an expert. Before touching the TV set, as long as it is operating, even if not satisfactorily, check out the antenna system. Look for loose, bent, broken and corroded elements and carefully examine the connections to the twin-lead transmission line. If the antenna has been in use more than five years, it might be a good idea to replace it and the transmission line, which gradually deteriorates, downgrading reception as it does. Also check the antenna connections at the set.

● ● ● **No picture—no sound.** Sudden failure of a TV set to operate is usually due to a burned out tube or fusible resistor inside the cabinet. The first step is to remove the rear cover. The power cord is automatically disconnected when the cover is removed.

Before you take out the tubes for testing, look for the label that shows the locations of the various types of tubes. If there isn't one, make one noting the locations of the tubes and the number of each tube as you remove it from its socket. Have the tubes tested and replace any defective ones.

Many TV sets have their tubes connected in series as in AC/DC radios. Hence, one burned out tube can prevent the others from lighting. Also, the fusible resistor in such sets, if burned out, can prevent the tubes from lighting. Usually, the fusible resistor is a two-wire plug-in device which can be pulled out of its sockets and replaced with a new one of the same value. You can check it with an ohmmeter.

● ● ● **Picture Troubles.** Vertical and horizontal picture instability can often be corrected by adjustment of the horizontal and vertical controls. Sometimes, replacement of a weak tube will cure the trouble. Absence of a picture, but with the screen lighted, is often caused by a defective tube. Unclear pictures and ghosts are usually caused by antenna trouble, improper tuning and antenna orientation.

● ● ● **Sound Troubles.** One of the commonest troubles is buzz in the sound which can be due to any number of causes. A screw driver adjustment is provided in some sets which is set for minimum buzz. There is also a tuning slug in the gated beam detector coil which can be adjusted with a special tuning wand. But, both of these controls are usually inaccessible unless the rear cover is removed, and adjustment cannot be made satisfactorily unless the set is turned on.

● ● ● **Tuner Troubles.** After a few years of use, the contact points inside the tuner (controlled by channel selector switch and fine tuning knob) get dirty causing unstable picture and sound. You can get a can of TV tuner cleaning fluid which you can spray into the tuner through the holes, with the set's rear cover removed. Rotate the channel selector knob as you spray. ■

construction projects

Electronic experimenting is a hobby that offers the individual a chance to learn and practice his theory while building exotic and fascinating electronic gadgets and devices. To add fun to your learning, seven construction projects have been included in this magazine. These projects have been tested and will work if you follow the instructions, parts lists and schematic drawings carefully.

The Universal Battery Tester is one piece of test gear that will pay for itself. It will check out your dry cells and tell you how long to keep them in service. The AudiAmp is a solid state audio amplifier that should be assembled just for the experience and ELVIS is just the gadget you would like to have on the test bench when working with transistor circuits.

Two short articles tell you how to get more pep out of your broadcast band receiver and how to make it come on like those transistor units. And in case your receiver or TV set is too hot, you'll learn how to beat the heat. The last construction project is the Corner Speaker —a new way to get hi-fi sound from a lo-fo budget.

110 universal battery tester

115 audiamp for x-tal sets

116 elvis—experimenter's low voltage isolated supply

119 passive booster for BCB dx-ing

120 keeping your receiver on standby

122 plan to beat the heat

123 a column speaker for your hi-fi

Universal battery tester

By James Robert Squires

BATTERIES are as much a part of our everyday life as countless other conveniences which have now become necessities. It's difficult to mention something that hasn't been converted to battery use. We are a nation on the go and we take our radios, flash cameras, walkie-talkies, shavers, and even our battery powered tooth brushes right along with us. As a normal result the average American household is knee deep in batteries in various stages of charge. No member of the family can be sure which batteries are good and which are not. Often, unfortunately, the good are thrown away with the bad. This waste can be eliminated by building your very own universal dry-battery tester.

What it can do. The tester's range is designed to test batteries up to 50 volts, and provide battery loads up to 500 milliamperes with the meter in the circuit and up to one ampere with the meter out of the circuit. Two very common loads for batteries are the screw and bayonet-based pilot lamps. So, two special sockets are provided for testing batteries by using both lamp types.

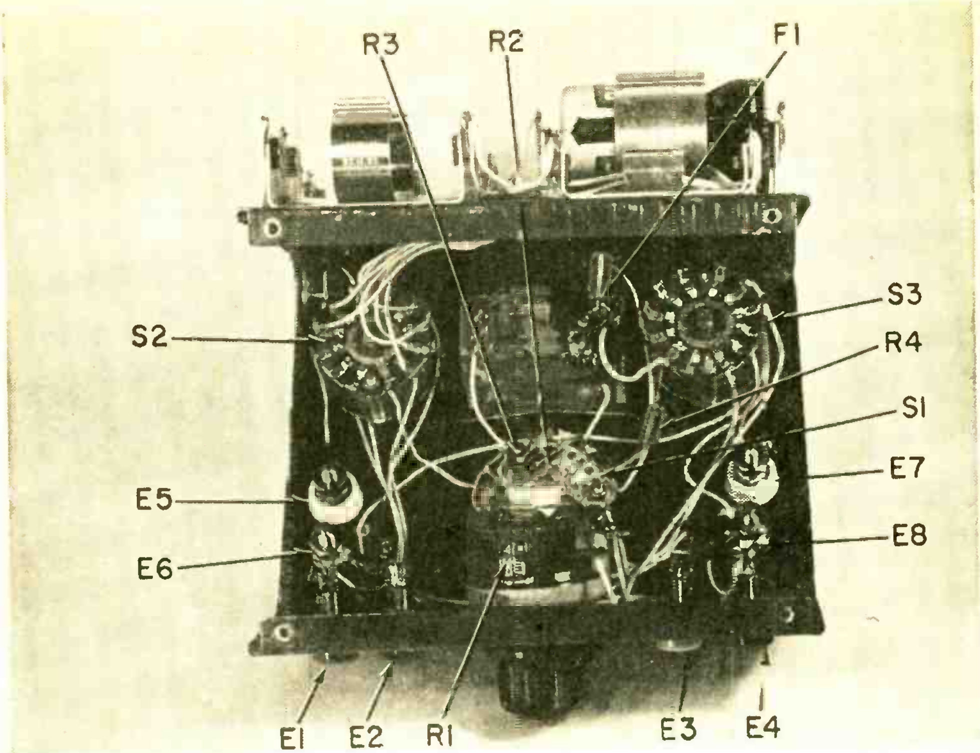
A further useful feature of the tester is its ability to give some information as to the expected life of the battery or batteries now used in your equipment. The test only requires that you have a good idea of the normal load current drawn by the equipment. The testing covers a broad spectrum of batteries which typically includes the AA, AAA, C and D cells. These four battery types can be tested by types either as singles or as a pair. The BATTERY SELECTOR switch, S2, selects the appropriate battery holder mounted on the rear of the tester.

Full-load testing. The most meaningful static test a battery can pass is a terminal voltage measurement under full load conditions. For this reason three load arrangements are possible with the universal dry-battery tester. The first of these is a lamp test. By using either the bayonet (BAY) pilot lamp socket, SO2, or the screw, (SCW) pilot lamp socket, SO1, a wide variety of lamps can be used as a load.

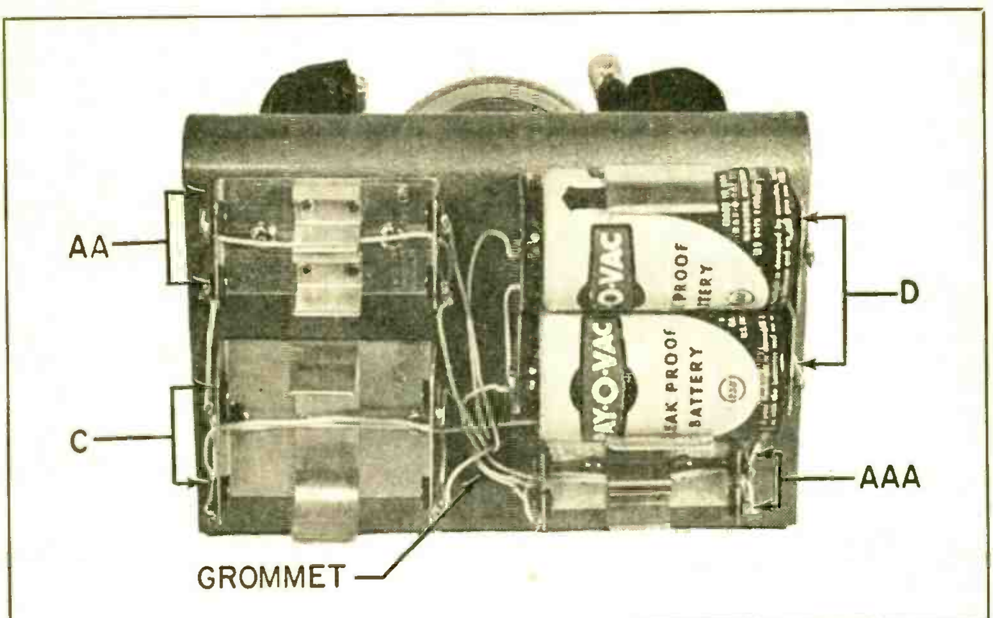
The second of these is a 25 ohm, 25 watt rheostat, R1. The VARIABLE LOAD position of the LOAD SELECTOR switch, S3, connects the 25 ohm rheostat, R1 across any battery selected by the BATTERY SELECTOR switch, S2. Load currents up to 500 milliamperes are possible through the meter. The meter is protected by a type 8AG instrument fuse rated at 0.5 ampere.

The third load position connects the se-

Now you can test dry cells and know when to replace them



Bottom view of the tester showing location of parts. Follow construction hints on pages 29-34.



Back of the tester's cover is just large enough to hold the four dual battery holders.

lected battery across the EXTERNAL LOAD white and black terminals, E7 and E8.

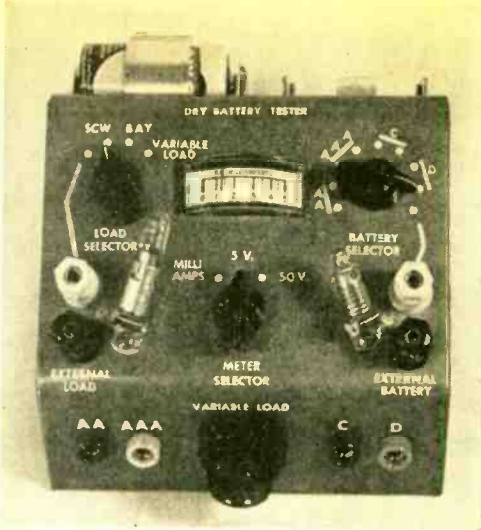
Picking the meter. In many of the applications of batteries their load current exceeds 100 milliamperes. For this reason a meter having a 0- to 500 milliampere range was selected. To bring up the ohms-per-volt sensitivity to approximately 200, a 0-5 milliampere meter movement, M1, was used. The meter has an approximate internal resistance of 127 ohms. A shunt resistor, R4, for the M1 was constructed by winding 93.3 inches of No. 32 solid enameled copper wire on a 100,000-ohm resistor body. The current error for the tester purposes with this shunt resistor is negligible. However the shunt is used only for current measurements.

For voltage measurements the same 0-5 ma. meter movement is used. This enables construction of a 200-ohms-per-volt meter which in turn reduces the tester loading on the battery or batteries under test.

Testing. Before starting battery test it's a good idea to measure the full-load drain on those batteries commonly used in the various gadgets in your house. The VARIABLE LOAD rheostat, R1, can be set to draw an identical load current. Then in future tests typical load currents can be quickly set into the tester. A normal load for many flashlights is between 200 and 350 milliamperes. For each application it will be necessary to establish your own lower limit of useful battery voltage. Usually a 30 per cent voltage drop under load is sufficient cause to discard a dry cell.

A rough estimate of future battery life can be found by selecting an average full-load current for this battery. Measure the full-load voltage at this time. With the battery or batteries connected in the tester and the METER SELECTOR switch, S1, set to MILLI-AMPS, set the VARIABLE LOAD rheostat, R1, for a load current 50 per cent greater than average full-load current. If this additional load applied for a short time causes more than say a 30 per cent drop in the battery voltage, it's usefulness in that application should be questioned.

In some battery applications there is only a small load current drain. The 9 volt-transistor battery is an example. Average load current for this battery is 20 milliamperes. Caution should be taken never to switch the LOAD SELECTOR switch, S3, to VARIABLE LOAD when low-current drain batteries are being tested. The LOAD SELECTOR switch, S3, should always be

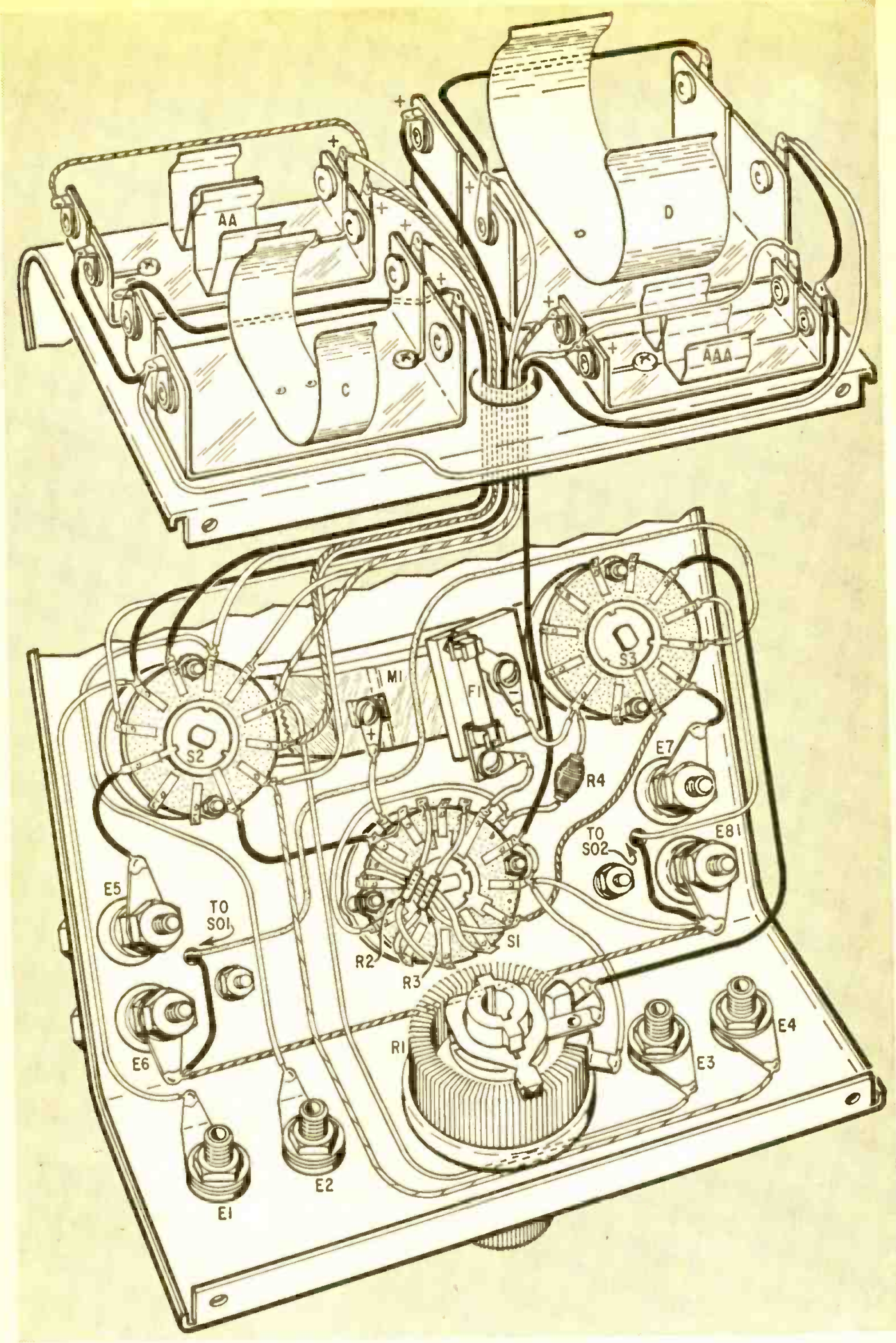


Panel lettering gives the tester a pro look.

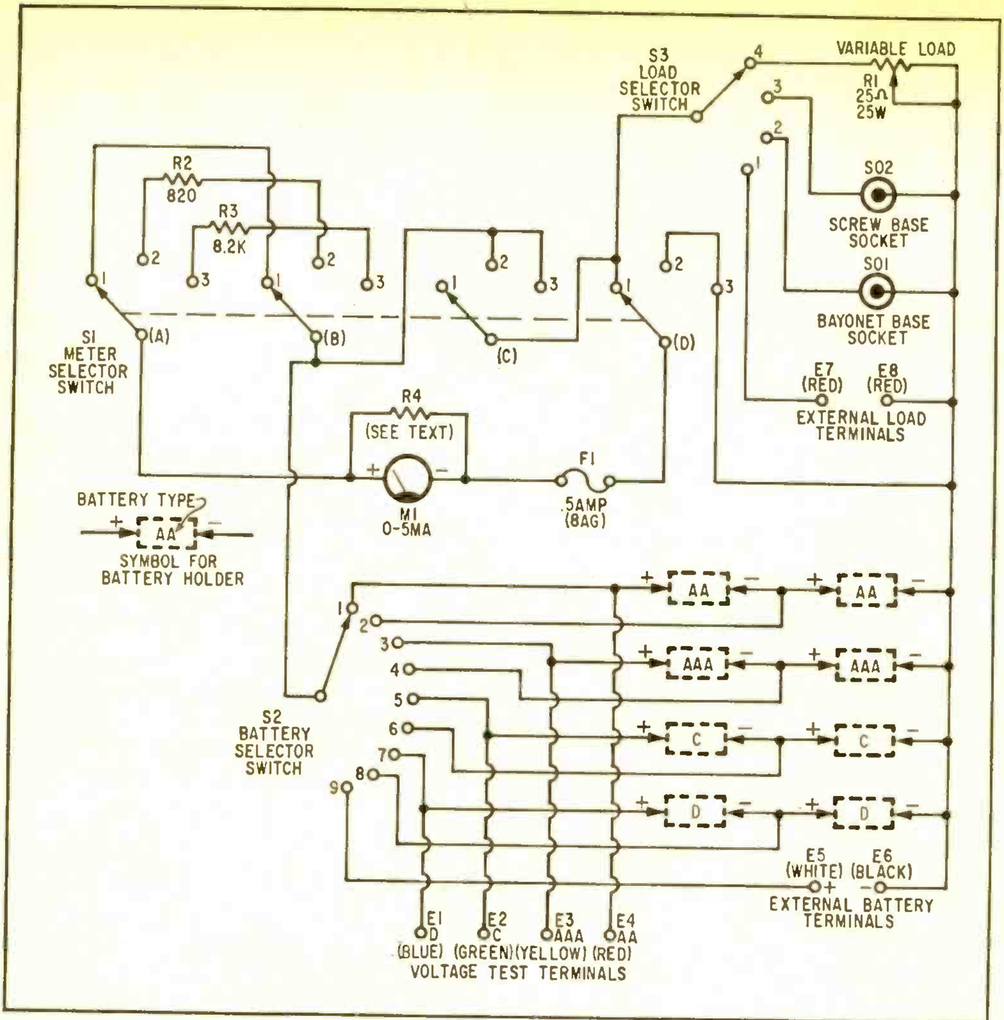
PARTS LIST

- E1—Jack, blue insulated midget banana (G. C. Electro-craft type 33-220)
- E2—Jack, green (like E1)
- E3—Jack, yellow (like E1)
- E4—Jack, red (like E1)
- E5, E7—Binding post, white (Superior DF30WTC)
- F1—Fuse, 0.5 ampere, instrument type 8AG
- M1—DC milliammeter, 0-5 ma. (Emico Model 13 Edgewise)
- R1—Rheostat, 25-ohms overwound (Ohmite type 0147)
- R2—820 ohm, ½-watt, 10% resistor
- R3—8.2k, ½-watt, 10% resistor
- R4—Meter shunt made from 93.3 inches of #32 solid enabled copper wire (see text)
- S1—4 pole—3 position rotary switch (Use 4 pole—4 position Centralab type 2515)
- S2—1 pole—9 position rotary switch (Use 1 pole—1-10 position Centralab type PA-1001)
- S3—1 pole—4 position rotary switch (Use 1 pole—11 position Centralab type PA-2001)
- SO1—Pilot lamp socket, screw base (Dialco type 505)
- SO2—Pilot lamp socket, bayonet base (Dialco type 705)
- 1—Battery holder for 2AA-size cells (Keystone type 140)
- 1—Battery holder for 2 AAA-size cells (Keystone type 138)
- 1—Battery holder for 2 C-size cells (Keystone type 174)
- 1—Battery holder for 2 D-size cells (Keystone type 176)
- 1—Cabinet aluminum universal sloping-panel 6" W x 4" H x 4¼" D (Bud type AC-1612)
- 1—Fuse holder, for meter back mounting (Littlefuse type 383002)
- Misc.—wire, solder, hardware, grommet, etc.

Estimated construction time: 5 hours
Estimated parts cost: $21.00



Considering the crowding of parts in the Universal Battery Tester, it is wise to follow the parts layout and wire placement as illustrated in the pictorial diagram above.



Be careful wiring the tester. Use colored leads to permit rapid wire tracing.

left at the EXTERNAL LOAD position. The external load for a typical 9-volt battery used in transistor radios is a 470-ohm, ½-watt resistor connected at the EXTERNAL LOAD jacks, E7 and E8. You simply see that the full-rated voltage is indicated on meter M1. Use Ohm's law to find loads.

There are four sections to the METER SELECTOR switch, S1, wafer. The first double section (A and B) selects the shunt or multiplier resistor depending on the switch setting. The next section (C) connects the load switch to the battery switch during voltage measurements. The last section (D) connects the meter either as an ammeter or as a voltmeter during load test.

Construction. Start by taping a sheet of white paper over the lower and sloping surfaces of the universal sloping panel chassis. The drill center diagram can then be laid out on this white surface. Refer to the diagram and photos. Drill and deburr all holes. Refer to the rear-view-diagram for details on mounting the holders. The Adel nibbling tool is handy for cutting the square meter hole. All parts can then be mounted except the meter and 25-watt rheostat.

When mounting the five-way terminals on the thin aluminum chassis, file off the shoulder of the under-chassis insulator of the terminal. This will assure a tight fit.

Now install the meter being careful not to mar the plastic face. The schematic diagram indicates the wiring connections. After the *meter selector* switch, S1, has been wired install the 25-watt rheostat, R1, and wire its connections. Liberal use of the external jacks on the tester allows workbench duties. ■

diAmp for tal Sets

Simple one-transistor stage peps up those weak AM signals

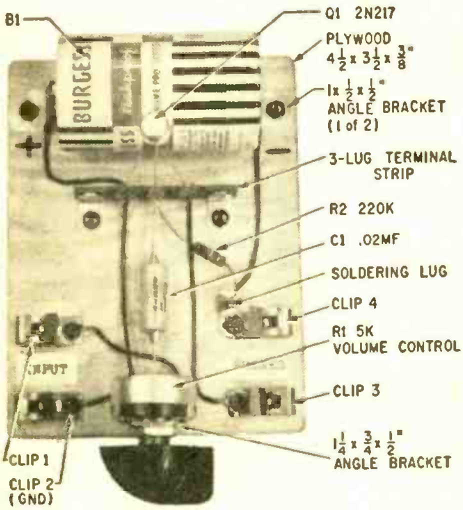
By Art Trauffer

CRYSTAL SETS are as popular today as they were before World War I. However, today the reliable semi-conductor diode has replaced the ticklish crystal and the transistor audio amplifier is pepping up the detected AM signals before they reach the headset. In case you would like to add the AudiAmp to a crystal receiver, just follow the details shown in the photos and schematic diagram.

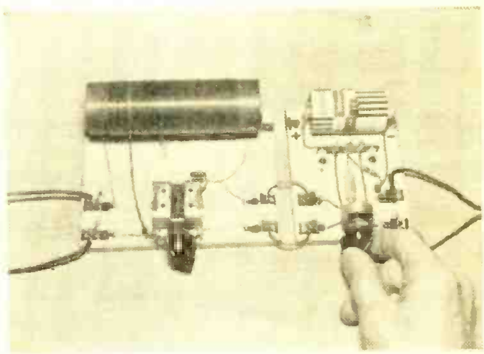
The transistor used can be a 2N217 or CK722 type. In fact, just about any *pnp* very low power audio transistor will do the job. Just in case you have a few *npn's* about, they may be used but be sure to reverse the battery connections so that B1's negative terminal connects to the transistor's emitter.

The output terminals should look into a high impedance headset. Magnetic headsets rated at 2000 ohms or better or crystal headsets will do fine. In the event you use a crystal job, connect a 4700-ohm, ½-watt resistor across the output terminals so that a DC path is provided from the battery negative terminal to the transistor's collector.

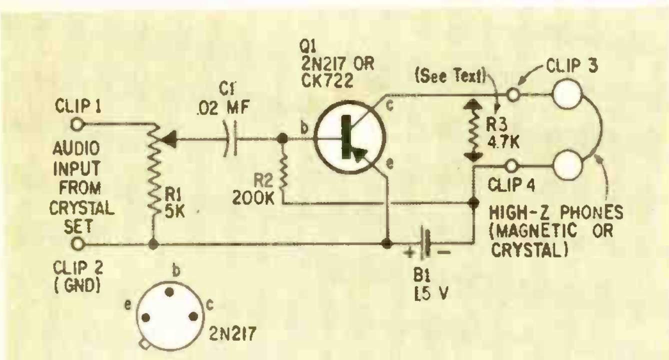
The simple transistor amplifier can also be used to amplify weak signals from telephone pickups, phono cartridges, etc. ■



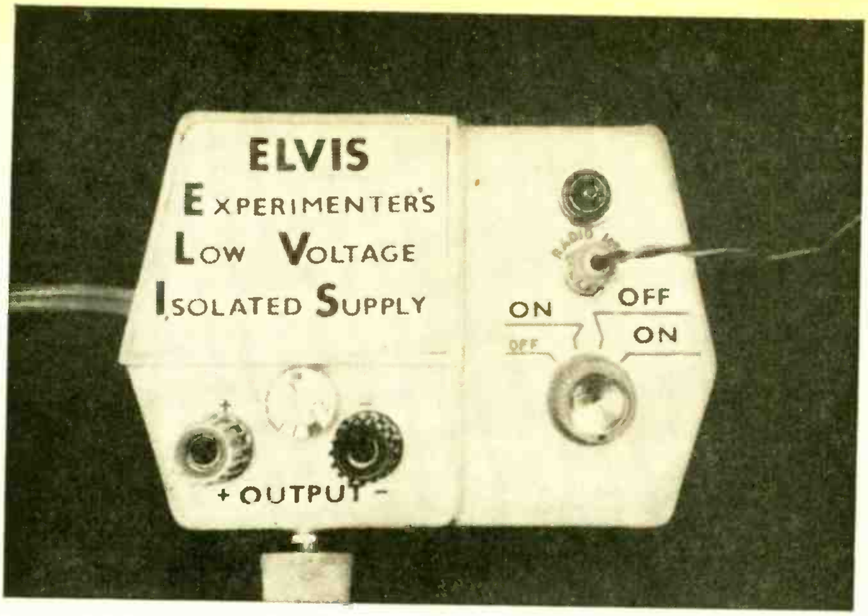
Parts needed to assemble the AudiAmp are shown above wired on a plywood chassis.



In a typical set-up, the AudiAmp (above) is connected to the phone terminals of the Knight-Kit Crystal Set 83 Y 261D.



Removing either the magnetic headset or 1.5-volt dry cell will de-energize the AudiAmp's circuit.



EXPERIMENTER'S LOW VOLTAGE ISOLATED SUPPLY

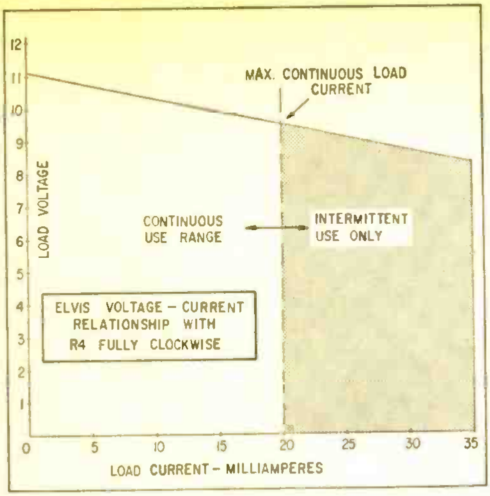
By Fred Blechman, K6UGT

THIS ELVIS, unlike its more well known namesake, does not shake, rattle, roll or make odd noises. It does, however, provide the transistor experimenter with an adjustable 0-11 volt line-isolated filtered DC power source, including a built-in voltmeter!

A lot for a little. The total cost for ELVIS, including the subminiature meter, is less than seven dollars, a remarkably low price made possible by modifying a product that contains most of the parts. The *Lafayette F-790 9-Volt Battery Eliminator and Charger* for transistor radios contains a midget isolation step-down transformer, a full wave bridge rectifier, heavy filtering, pilot light, four position function switch, output jack, battery snap terminals and an assortment of adapters, and comes completely assembled for $2.95. It plugs into any 115-volt 60-cycle outlet and provides well-filtered DC at a voltage level fixed slightly over 9 volts to power most common transistor radios. Adding a subminiature meter, a miniature potentiometer and binding posts converts the F-790 to a variable metered supply—ELVIS.

Circuit description. The schematic diagram shows the original F-790 wiring details. The dotted lines show the necessary changes and additional parts to create ELVIS. Switch S1 is a 3-pole, 4-position miniature rotary switch. When placed in position 2, power is applied across the primary of stepdown transformer T1 and the series combination of the neon bulb and current-limiting resistor R1. The bulb lights and power from the secondary of T1 is applied across the full-wave bridge selenium rectifier, SR1, points A and C. The rectified output from terminals E-D and B is applied to the pi-filter consisting of C1-R2-C2, then through S1c to the output jack J1.

Resistor R3 acts as a "bleeder" to stabilize the voltage. When the battery adapter (furnished with the F-790) is plugged into J1, the voltage appears across the adapter snap terminals, which connect to the 2U6 type battery snaps of most common 9-volt transistor radios. The radio plays loud and humfree. With switch S1 in position 3, relatively unfiltered DC is applied to the battery-charging snap terminals. Two additional



Exactly what ELVIS can put out is shown in volt-current graph with R4 fully CW.

adapters allow you to "recharge" a large variety of 9 volt batteries. In position 4, switch S1 applies voltage to both J1 (filtered) and the snap terminals (relatively unfiltered) at the same time, allowing you to play the radio and recharge the radio battery simultaneously. Notice (and this is quite important) that all output connections are fully insulated from the power line by T1—no shock hazard!

Battery "Recharging." A dry cell battery is *not* rechargeable in the accepted sense. It may be "depolarized" by the process used in the F-790, which will temporarily increase the battery output. The long term value, however, is very dubious. As a battery eliminator the F-790 is very fine; the recharge feature is just a bonus.

Step-by-step modification. Creating ELVIS from the F-790 is not complicated, but there are enough wires in the original unit to confuse the inexperienced builder, so we'll go through the conversion step-by-step.

1. Remove the bottom cover.

2. Remove and discard resistor R3 (600-ohms).

3. Remove three screws securing printed circuit board, and tilt board back out of the way.

4. Remove the battery charging snap terminals by unsoldering the blue and green wires from the nuts, and then unsoldering the nuts from the inside of the unit while turning the screws from the outside.

5. Enlarge the snap mounting holes to 3/16-inch diameter.

6. Drill a 7/16 inch diameter hole for the meter and a 1/4 inch diameter hole for potentiometer R4. See photos.

7. Install meter M1 and cement in position.

8. Install the binding posts BP1 (red) and BP2 (black). The fiber insulators are not used.

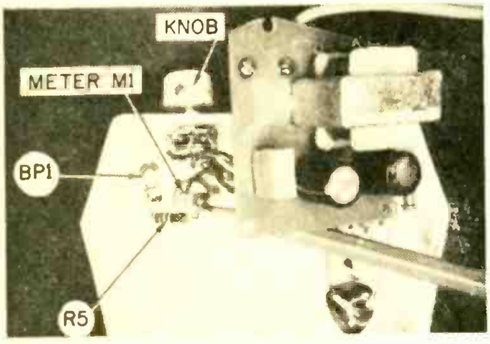
9. Solder a 56,000-ohm 1/2-watt 10% resistor (R5) from the soldering lug of binding post BP1 to the meter *positive* terminal.

10. Solder an insulated wire, 1 1/2 inches long, to positive binding post BP1 lug. You'll connect the other end of this wire in Step 14.

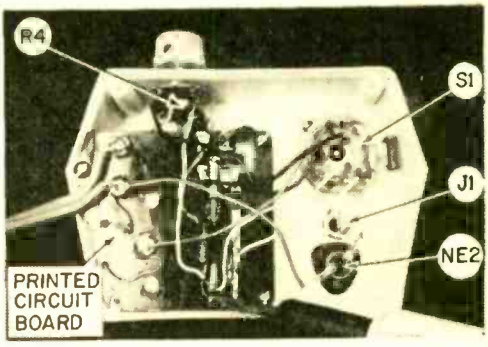
11. Solder the blue wire (this wire was connected to the negative snap terminal removed in Step 4 to the negative binding post BP2 solder lug. Solder a short jumper wire from this BP1's lug to the meter *negative* terminal.

12. Install the 1000-ohm miniature potentiometer (R4) with the lugs up. Bend the lugs slightly down.

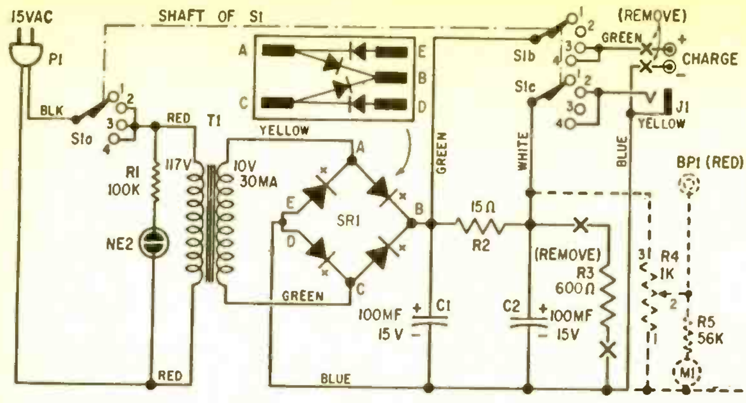
13. Replace the printed circuit board in



With the circuit board lifted out of the way, parts added underneath can be seen.



The 600-ohm resistor is unsoldered from the circuit board at the location shown.



SWITCH POSITIONS		
NO.	F-790	ELVIS
1	OFF	OFF
2	RADIO	ON
3	CHARGE	RADIO OFF
4	RADIO & CHARGE	ON

Schematic diagram for ELVIS. Dashed lines are circuit parts added to the Lafayette F-790.

ELVIS

position with the three screws removed in Step 3.

14. Solder the added wire (Step 10) to the center terminal of potentiometer R4.

15. Locate the point on the rear of the printed circuit board to which a white wire from the switch is soldered. Solder a new wire from this point to the right terminal on R4. See photos.

16. Locate the blue wire connected to the printed circuit board. Solder an insulated wire from this point on the printed circuit to the left terminal on potentiometer R4. See photos.

17. Unsolder and remove two green wires that connect to switch S1.

18. Replace the bottom cover.

19. Add the small set-screw knob for ⅛ inch diameter shafts in place.

20. If desired, relabelling can be done with decals or dry transfer letter put on white paper and cemented over the old markings. See photos.

How it works. Voltage appears at binding posts BP1 and BP2 in switch positions 2, 3 or 4, and is controlled by the setting of potentiometer R4 with the voltage indicated by meter M1. Full scale meter reading, established by series resistor R5, is roughly 10 volts, with ½ scale at 5 volts, and 0 volts at zero on the meter. Intermediate voltages can be estimated quite closely. Unfortunately, the potentiometer resistance variation with rotation ("taper") is not linear, and you'll find the greatest voltage increase near the clockwise end of the rotation, but this is not critical.

ELVIS is *not* regulated, but *is* well filtered.

PARTS LIST

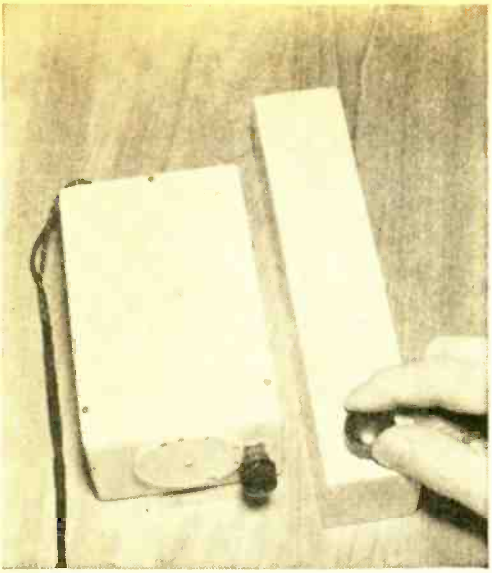
R4—1000-ohm subminiature potentiometer (Lafayette VC-32)
R5—56,000-ohm, ½-watt resistor 10%
M1—200 microamp miniature meter (Lafayette TM-27)
BP1, BP2—Binding posts (one red, one black) (Lafayette MS-566)
1—Knob, Ivory set-screw type for ⅛-inch shaft (Lafayette KN-57)
Misc.—Insulated wire, solder

All other parts are included in Lafayette F-790 9-volt Transistor

Battery Elimininator, $2.95
Estimated cost: $6.50
Estimated construction time: 2 hours

When a circuit is connected to the binding posts, the current drawn will cause the voltage to drop. Just advance the control knob to increase the voltage to the desired value. Of course, a more accurate external voltmeter may be placed across the binding posts if the voltage requirement is critical.

Just for the record. A graph of the average ELVIS output current-voltage relationship with the potentiometer set fully clockwise is given. Drawing more than 20 milliamperes continuous (35 ma. intermittent) from ELVIS is not recommended. If ELVIS gets too much exercise, he blows his stack (selenium rectifier stack, that is). The radio output jack, J1, is used as before, with the switch in positions 2 or 4. This output is *not* controlled by the new potentiometer. Do *not* use the radio jack when using the binding posts; the total current drawn may exceed the rectifier current rating. ■



Passive booster (above right) helps pull in weak signals for AM broadcast tuner (left).

Passive Booster for BCB DX-ing

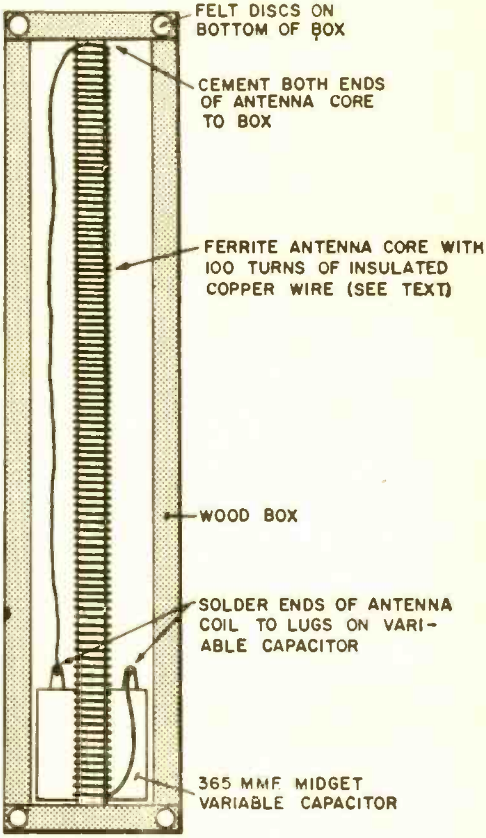
By Art Trauffer

THE PASSIVE BOOSTER will greatly increase the sensitivity of 3- to 5-transistor portable radios as well as boost the input signals to 6 and 9 transistor radios and tube jobs. Many distant weak stations that you listen to for entertainment or DX'ing will pop in crisp and clear like the strong locals with this booster.

The booster's heart is a 7½" ferrite antenna core ¼" in diameter. 100 turns of #24 enamelled cotton-covered wire are evenly spaced on the core and the ends are connected separately to the terminals on a midget 365 mmf. variable capacitor. This circuit is nothing more than a tunable "loopstick" antenna covering the AM broadcast band. Both parts mount neatly in a wooden box fabricated for the project. Plastic or fiber material will do just as well.

The parts can be obtained from Lafayette Radio (part Nos. MS-331 for the core and MS-445 for the capacitor) or almost any parts supply house.

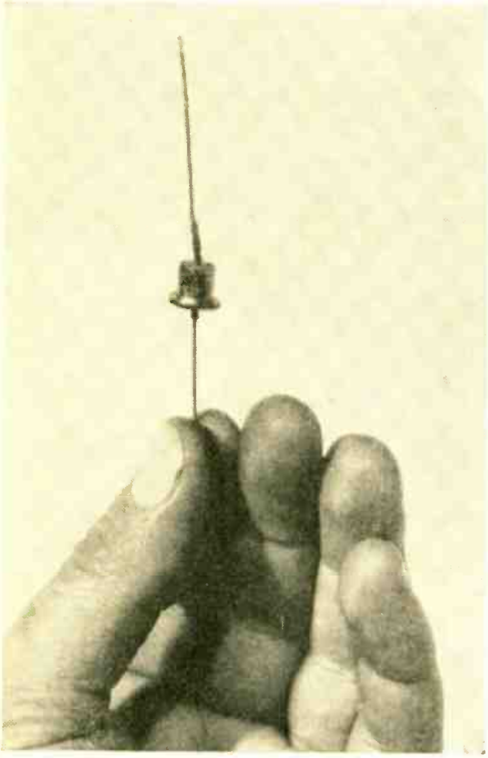
The passive booster (it gets its name because it has no amplifier and uses no power other than the signal's) is easy to use. First tune in a distant or weak station on the radio and rotate the radio until the signal is loudest. Now place the booster along side the radio with the booster's ferrite core parallel to the receiver's core. Tune the station on the booster for maximum signal. Now adjust the distance between the booster and receiver for optimum results. ■



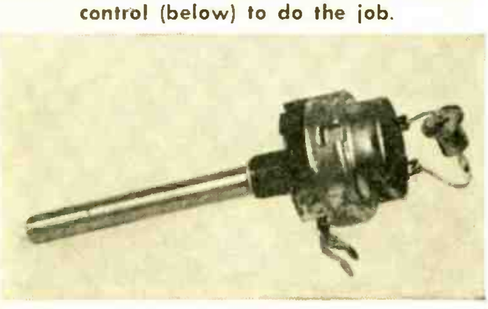
Keep your receiver on

Standby

Call on a silicon power diode to give your receiver "instant-on" operation—just like a transistor radio



All it takes is any silicon diode (top) soldered across the AC switch terminals of the volume control (below) to do the job.



By Herb Friedman, W2ZLF/KBI9457

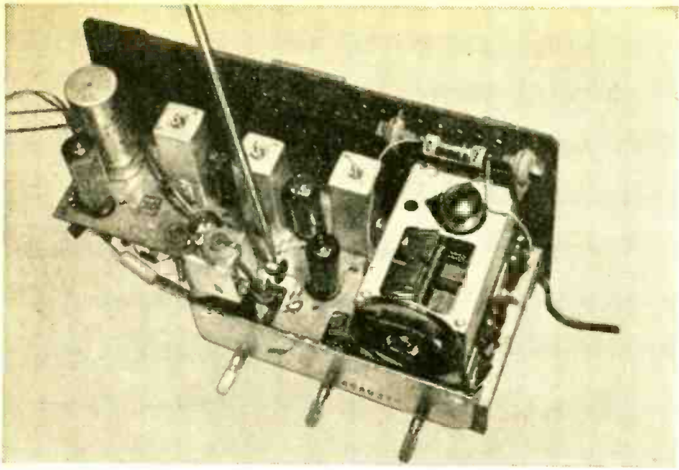
IS IT worth a dollar or so, and perhaps a half hour's work, to extend the life of your radio and television tubes by 50 percent or more? You're *durn* right it is! It's the best electronic bargain you are ever going to get. And, as a free bonus, we'll throw in "instantaneous start"—the instant you turn the power switch the sound or picture goes on—yes, just like transistors, no more warm-up time.

How to do it? Simple. Just connect a silicon power diode across your radio or television set's power switch. The only hitch is that the idea can only be used with an AC-DC chassis; that is, the set must not have a power transformer. Since most table radios and many FM and TV receivers meet this requirement, chances are you're one of the "lucky ones."

When the diode is connected across the power switch "in the right direction" reduced power is continuously applied to the filament circuit even though the power switch is "off"; and no power is applied to the rectifier circuit so the receiver is inoperative; all that happens is the receiver tubes are kept at "standby"—ready to start the instant you turn the power switch.

Where's the saving? In not turning the filaments on and off. As any broadcast engineer will tell you, maximum tube life is obtained when the tubes are turned on and *left on*. And since with the diode you idle the filament voltage at about 50 percent you can expect a markedly extended tube life.

The Hook Up. The schematic diagram shows the connection of the silicon diode rectifier plus two neon light indicators. S1 is



Installing the silicon power diode rectifier is a simple matter. If there is not enough room on the off-on switch or under the chassis, mount it on the chassis top away from tubes.

the receiver's power switch (usually on the rear of the volume control) and SR1 is a silicon diode rectifier. Be certain that SR1's *cathode* is connected to the B− or ground side of S1. SR1's anode (plate) is connected to the S1 terminal which is attached to the AC line. If you reverse the diode the receiver will be on permanently.

SR1 is rated at 400 PRV (or PIV) at 600 milliamperes or higher. While this rating may far exceed what your individual equipment may require, it's a good safe value. Listed below are common, nationally distributed silicon diodes which will do the job; your local parts distributor is sure to have at least one of them.

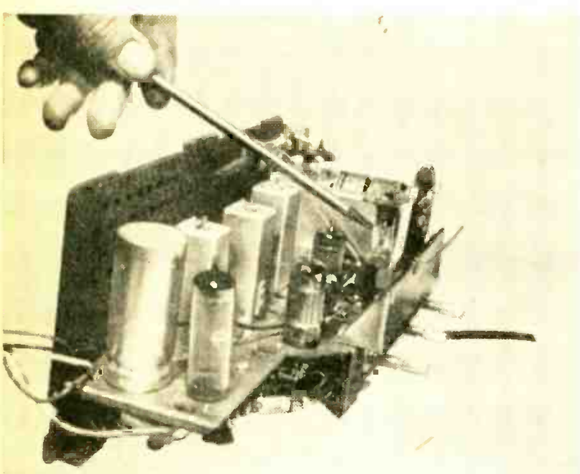
Manufacturer	Diode Type
General Electric	1N539, 1N1489
Motorola	1N2612
RCA	1N1763, 1N2861

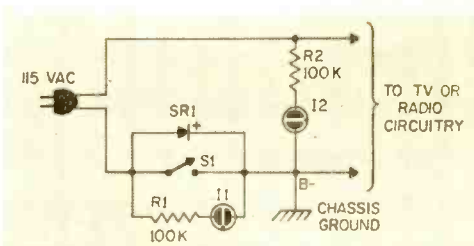
If your equipment doesn't have one it's a good idea to install a pilot light, to indicate power is on. The I1 (and R1) neon bulb circuit will indicate when the receiver is standing-by, it will extinguish when S1 is closed. If you want to indicate when the receiver is plugged into the outlet (whether it's on standby or operating) use the I2 and R2 neon bulb circuit. ■

PARTS LIST

SR1—Silicon diode rectifier type 1N539, 1N1489, 1N1763, 1N2612 or 1N2861 (See text for details.)
I1, I2—Neon light, type NE-2
R1, R2—100,000-ohm ½-watt resistor, 10%

Estimated cost: $1.25
Estimated construction time: 30 minutes

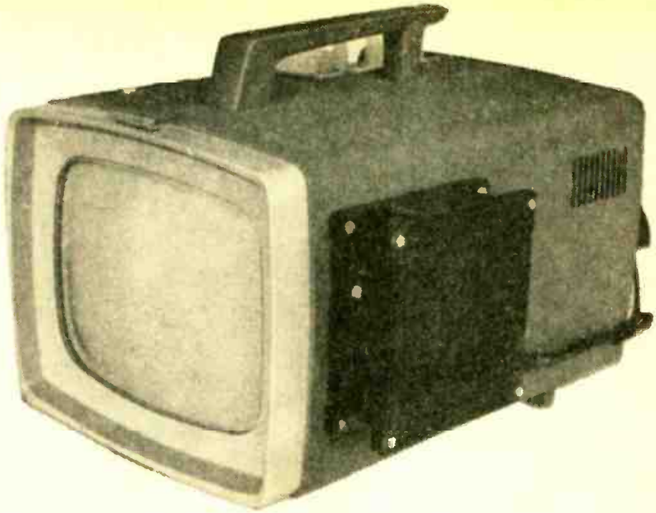




Schematic diagram of AC circuit additions that can be made in any AC/DC receiver.

Author points out neon bulb he installed. Bulb can be seen through radio's cabinet.

With a fan added to your TV set, cool air can be pushed into the front of the set, circulated around hot tubes, and vented out the rear louvers and grille.

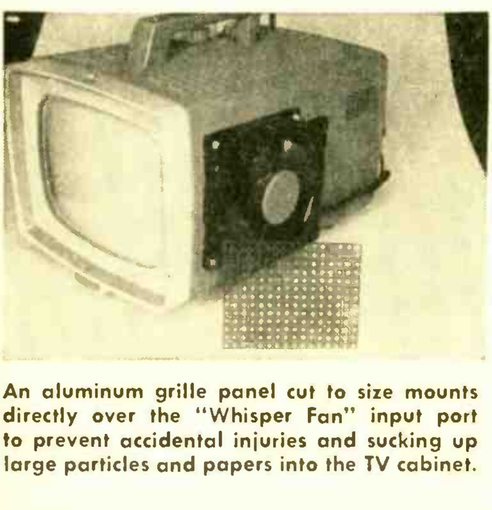


PLAN TO BEAT THE HEAT

It's like the Sahara in your TV set unless you fan it cool

By Fred Blechman, K6UGT

IF you own a portable television set, you may find the handle too hot to handle after a few hours of continuous use. Many of the sets on the market today are not adequately ventilated and the heat build up inside the set results in costly repairs and a shortened life for your TV set. Therefore, it will be wise to add an air circulating fan to the set to prolong its useful entertaining life.



An aluminum grille panel cut to size mounts directly over the "Whisper Fan" input port to prevent accidental injuries and sucking up large particles and papers into the TV cabinet.

Originally designed for hi-fi installations, the Rotron "Whisper Fan" is engineered to operate at an inaudible sound level (minus 18 db speech interference) while delivering 65 cubic feet of air per minute. The 4¾" x 4¾" x 1½" unit draws 7 watts from the 115-volt power line. Pre-lubricated bearings and relatively low speed for a fan (2000 rpm) ensure long-life operation for the fan and the TV set. There are other fans on the market, both new and surplus. Be very careful when you buy. The fan must be able to work off the AC power line continuously without overheating and to operate at a very low noise level so as not to disturb your listening pleasure. Also, avoid fans with brushes—they may cause TV snow.

The fan can be installed directly over existing vent holes without cutting any holes as the author did. However, efficiency will be higher if you reduce back pressure on the fan by cutting or punching a larger hole. Secure the fan in place and connect the fan's leads to the TV set's circuitry so that it comes on when the set is turned on. To avoid broken or cut fingers, cut a piece of decorative aluminum grille to fit over the fan's input port. The grille will keep fingers out of harms way. The brackets, pressure-sensitive foam pad, vibration grommets, bolts and nuts come with the fan, however the author found the vibration isolation unnecessary. ■

A COLUMN SPEAKER FOR YOUR HI-FI

Small enough to be set anywhere in a room, yet large enough to produce big-speaker sound, this novel unit can be completely assembled in about three hours, plus paint-drying time. Build two and get stereo performance

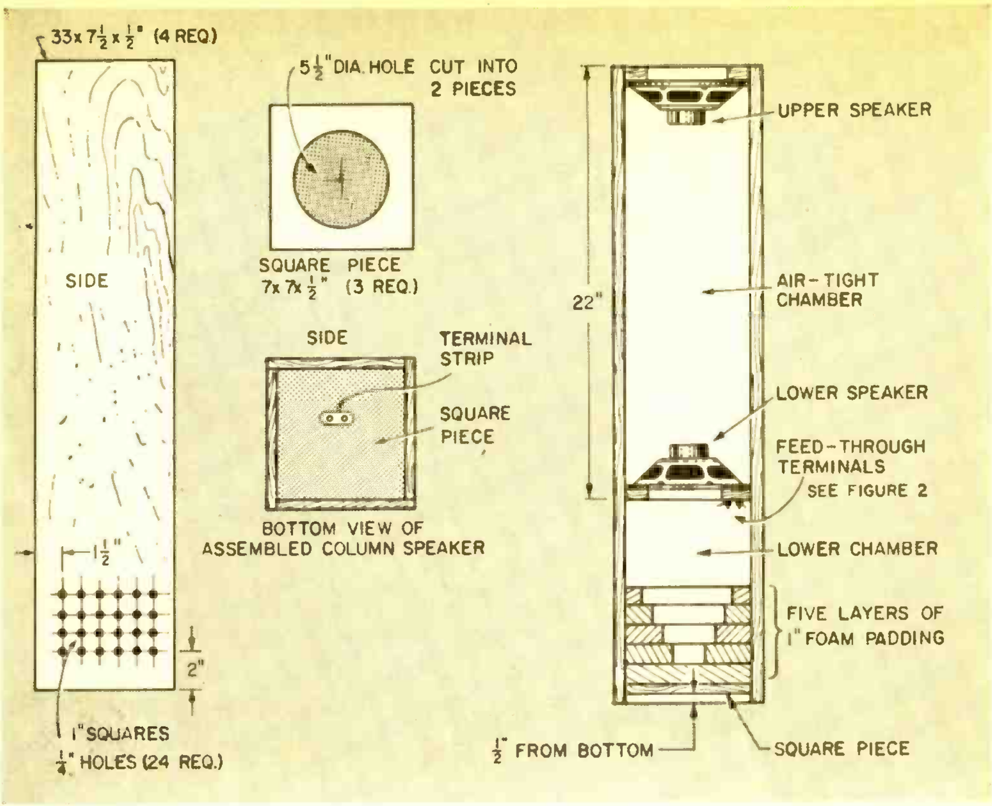
By Julian M. Sienkiewicz
WA2CQL, 2W5115

YOU'LL be more than pleased with both the appearance and performance of this two-speaker hi-fi system. It's so easy to construct that you might as well build two of them and thus achieve stereo operation.

After scanning the materials list, buying the required items, and carefully studying the drawings you could probably assemble the system without detailed instructions—it's that simple in design.

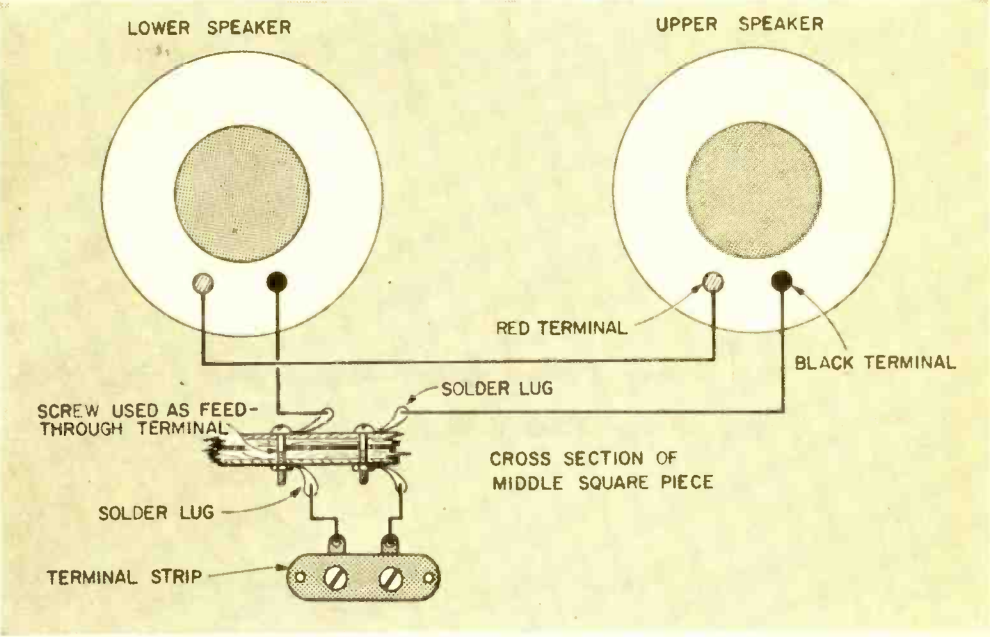
How it works. The main function of the speaker cabinet is to prevent the mixing of sound waves from the rear of the speaker with those from the front of the speaker. Since the former is 180° out-of-phase with the latter, any mixing of the two waves would cause sound cancellation, especially at the low frequencies.

The column speaker cabinet simulates an enormously large baffle in an unusual way. Two thin (2-in.-depth) high-fidelity speakers are connected out-of-phase, and located at the top and toward the bottom of a small air-



Column speaker can be assembled by following construction details shown above. Construction can be speeded up by having lumber dealer cut plywood to exact sizes.

Wiring details for the column speaker are shown below. Feedthrough terminals are necessary to prevent air leaks between the unit's air-tight and lower chambers.



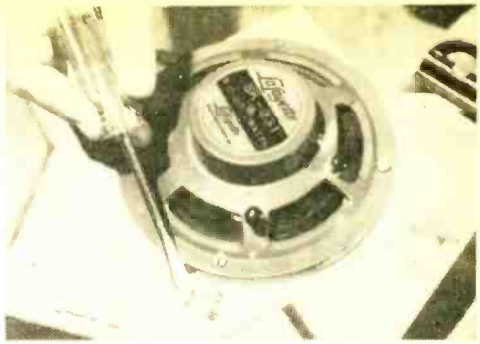
tight chamber. When the upper speaker's cone pushes up, it causes the airtight chamber to expand, which in turn thins the air, resulting in "suction." This suction loads down the upper speaker's cone. Hence, sound distortion. However, the lower speaker in the airtight chamber is doing just the opposite: When the upper speaker is enlarging the airtight chamber's volume, the lower speaker is reducing the volume by pushing its cone into the chamber. Therefore, the volume of the airtight chamber remains almost constant, simulating large-cabinet volume.

The two Lafayette SK-231 speakers are wide-range types designed to give optimum performance under adverse conditions. In the column speaker, bass response comes down to below 60 cycles, with fair results at 50 cycles. Considering the size of the speakers and column cabinet, along with the moderate cost of assembly, the column speaker is a high-fidelity miracle.

Assembly. Screw three of the four plywood sides (33 x 7½ x ½-in.) together with 2-in. flathead screws, as shown in photo. Drill holes and countersink before screwing the overlapping pieces in place.

Cut 5½-in. holes in two of the three

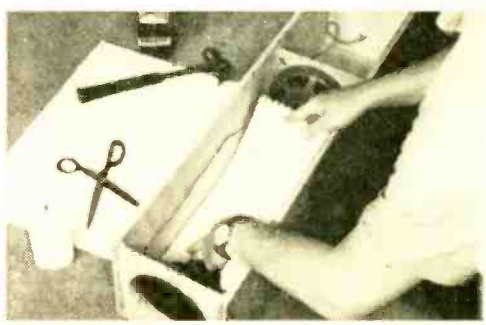
(Continued on page 128)



SPEAKER is mounted on 7-in. square of plywood. Screwdriver points to two solder lugs.

AFTER wiring the speakers, seams of upper chamber are sealed with Mortite house putty.

FITTING the four 33x7½x½-in. plywood sides together with screws is the first step.



FOAM RUBBER is used as acoustical padding to line all sides of the airtight upper chamber.

dry cell batteries

(Continued from page 66)

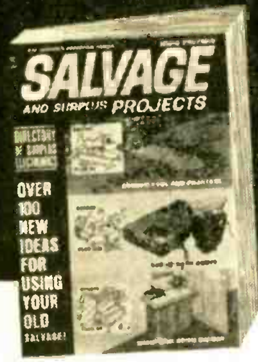
being the *sum* of the individual cell voltages. This is illustrated in Figure 9 on the left, which shows three water tanks connected "in series." The total water pressure is the sum of the individual water pressure in each tank.

The total current capacity of a group of cells may be increased by connecting the cells in parallel. In this connection, the total current capacity is the *sum* of the capacities of the individual cells. This is illustrated in Figure 9 which shows three water tanks on the right connected in "parallel." The total water capacity is the sum of the water in the three tanks. Notice that the water *pressure* remains the same as one tank. This also holds true for parallel connected cells, where the electrical pressure, *voltage*, is the same as for a single cell.

Internal Resistance. Figure 10 demonstrates the effect of the cell's internal resistance. Here we see a cell, a series resistor, and load. The series resistor represents the *internal resistance* of the cell. Assume for a moment, that the load current increases. This will draw more current through the series resistor, and an old friend, Ohm's law tells us that the voltage across the load will drop due to the increased voltage drop across the series resistor.

The series resistor shown in Figure 10 is actually the internal resistance of the cell. It was not put there by the manufacturer deliberately. Rather, its existence is due to the natural resistance of the material used and can only be minimized by careful design. Thus, as the current drawn by a load connected to the cell increases, the cell's output voltage will drop due to the increased voltage drop across the cell's internal resistance.

The internal resistance of a cell is lowest when it is new, increasing as the cell is used. This is why the output voltage of a cell drops under load after it has been in service for some time. You can visibly notice this effect by observing the diminishing light of a flashlight as the batteries near the end of their useful life.

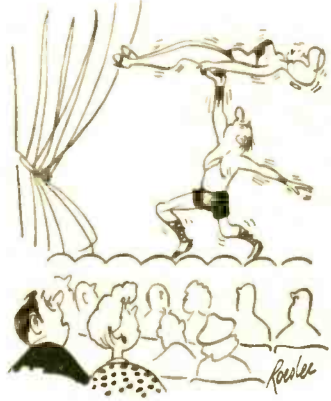


Shelf Life. Dry cells placed in storage or those which are idle for periods of time, gradually deteriorate. This deterioration is the result of slow chemical changes which take place within the cell due to impurities in the materials used. This characteristic is known as the cell's *shelf life*, and is the reason why many cells bear dates indicating that the cell should be placed in service before the time indicated. Certain types of cells, such as mercury cells, have the desirable characteristic of almost no deterioration when inactive over extended periods of time.

Temperature. The shelf life of dry cells can be decreased considerably when their temperatures exceed 70° F. The reduced shelf life of cells is due to both accelerated chemical action within the cell and loss of moisture from the cell.

Extremely low temperatures will reduce the current delivering capacity of most cells, although the cells will return to normal when brought back up to normal operating temperature. Cell shelf life is prolonged at low temperatures due to the fact that local chemical action caused by impurities within the cell is slowed down.

Testing Cells and Batteries. Cells and batteries should always be checked for proper output voltage under normal load conditions. If they are checked under no-load conditions, they may deliver their rated voltage which will then drop when they are placed in service due to their increased internal impedance. Therefore, it is always best to check battery voltage connected to the entire load. ■



"Looks like he's having trouble with his horizontal hold!"

Column Speaker

(Continued from page 125)

7x7-in. plywood pieces. Mount the two high-fidelity speakers on these pieces, using 1¼-in. roundhead screws. On the piece used to mount the lower speaker, drill two holes to pass a pair of 8/32 x 1-in. machine screws. These will serve as feed-through terminals to connect the speaker leads. Use solder lugs at both ends of each screw, and nuts and lock washers at end of each.

Using 2-in. fh screws, attach the speaker-mounted plywood squares in place at the points indicated in drawing. The third square is attached at bottom of cabinet. Now wire the speakers in series, following the diagram. Install a two-post screw-type terminal strip on the bottom square, as shown in drawing.

Seal the chamber joints with household putty and install foam rubber acoustical padding. These steps are shown in accompanying photos. Attach the fourth side piece and then paint the cabinet black.

A square yard of grille cloth will cover the sides. A smaller, 10-in. square of it will cover the top. Fold in place and attach with staples until snug. Then attach with upholstery tacks, removing staples. Connect the column speaker to the 16-ohm terminals of your amplifier and you're set to enjoy that hi-fi sound. An aluminum Jell-O mold can be used to decorate the column top. ■

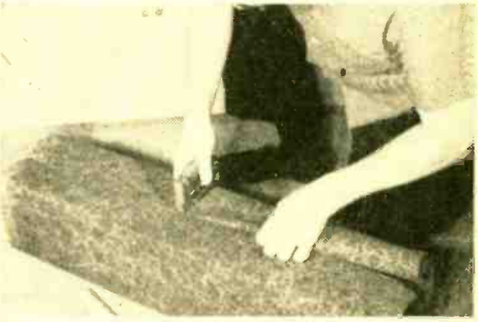
MATERIAL LIST

4—33" x 7½" x ½" plywood sides
3—7" x 7" x ½" plywood squares
5 sq. ft.—foam rubber padding 1" thick
2—6½" dia. high-fidelity speakers, 2" deep (Lafayette Radio SK-231 or equiv.)
1—2-post, screw-type terminal strip
2—8/32-1" machine screws
4—8/32 machine hex. nuts
4—#8 soldering lugs with lock washers
1 package—upholsterer's finishing tacks
1—36" x 36" grille cloth for sides
1—10" x 10" grille cloth for top
Misc.—flathead wood screws, glue, Mortite putty (29¢ size), wire, black paint, sandpaper, aluminum Jello mold (for top of column, if desired).

Estimated Cost: $16.00 for one column speaker and $28.00 for two (saving made in quantity purchases).

Estimated construction time: 3 hours per column speaker provided wood is purchased cut-to-size. Paint drying time not included.

COAT the assembled column with flat, black paint. It will highlight grille cloth's coloring.



GRILLE CLOTH is used to cover column. Use staples until secured with upholstery tacks.

TOP of speaker system (right) is also covered, using upholstery tacks to attach cloth.

TRAIN AT HOME with NRI

For 50 years the leader in training men for careers in Electronics, Radio-TV

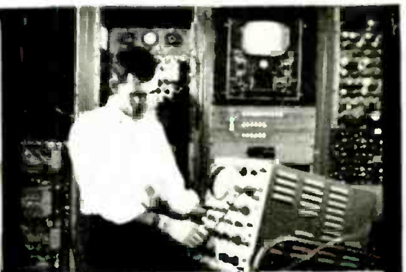
Training men to succeed in the many fields of Electronics has been NRI's only business for half a century. The NRI diploma is respected and recognized by prospective employers in business and industry throughout the U.S. and Canada. NRI graduates are enjoying higher pay, more interesting work, better futures in every field of Electronics . . . performing work for which you could qualify through NRI "learn-by-practice" methods. And NRI provides training at reasonable cost because it is the oldest, largest home-study school of its kind. If you want the security, prestige and freedom from financial worries that come with training . . . then you want to investigate NRI's specialized instruction plans and the many career opportunities in the fast-growing Electronics industry. Write **now** for our two free books. Use the postage-free card below.

SEE OTHER SIDE

THE DEMAND IS GREAT FOR SKILLED TECHNICIANS

NRI's Servicing course trains you to fix black-and-white and color TV sets, radios, hi-fi, etc., shows you how to make $3 to $5 an hour in spare time soon after enrolling. Leads to a good full time business of your own, servicing Electronic products for the home.

Prepare for a career as an Electronic Technician in industry, business, government, the military, with NRI training in Industrial Electronics. Computers, telemetry, automation, etc. all employ the same basic electronic principles, and that is what NRI training stresses.



Communications offers a choice of careers operating or servicing transmitting equipment in broadcasting, aviation, marine, mobile radio, etc. From simple circuits to FCC exams, NRI courses train you quickly in one or all of the Communications fields.

MAIL POSTAGE FREE CARD FOR

2

NEW BOOKS

First Class
Permit
(Sec. 34.9, P.L. & R.)
Washington, D.C.
No. 20-R

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed In The United States

Postage Will Be Paid By

nri

3939 Wisconsin Avenue
Washington, D.C. 20016

PICK YOUR CAREER

Join the thousands who gained success through NRI training

Thousands of ambitious men have moved up to career-level jobs or businesses of their own in Radio-TV Servicing, Communications, Industrial and Military Electronics through NRI training. The demand for skilled Technicians in this age of color TV, stereo, rockets, missiles, computers, telemetry, microwave, lasers, masers and automation is greater than the demand for engineers—4 to 7 times greater. Whether you're working in Electronics now, are a hobbyist or beginner . . . whether you're a college graduate or a man who had to leave school early . . . whatever your desire or education, there's Electronics training for you among NRI's specialized instruction plans. Choose from "short courses," specialized training in fields of Communications or intensive training for career positions. Get full details about the course of your choice without obligation. Mail card below.

1. Television-Radio Servicing
2. Industrial-Military Electronics
3. Complete Communications
4. FCC License
5. Basic Electronics
6. Math for Electronics
7. Aviation Communications
8. Marine Communications
9. Mobile Communications
10. Electronics for Automation

SPECIAL NRI EQUIPMENT MAKES TRAINING FASTER, EASIER

When you train with NRI, you "learn-by-doing" with carefully developed custom-designed equipment included—at no extra cost—with most courses. All equipment is yours to keep. Projects you build, experiments you perform, make NRI illustrated lessons come to life. Complex subjects take on practical meaning. Actual shop and laboratory experience makes learning faster, easier, makes you more valuable to prospective employers—or use it to make extra money in your own spare time or full time service business. Free books we send you show equipment, tell about the NRI Trial Enrollment Plan. Convenient monthly payments. Mail postage-free card.

SEE OTHER SIDE

MAIL FOR

2 NEW BOOKS

NO STAMP NECESSARY—NRI PAYS POSTAGE

4GA2

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

Please send me your two books about opportunities in Electronics-Automation, Radio-TV and your specialized instruction plans. (No salesman will call. Please print)

Name...Age..........

Address...

City...Zone..........State..........

ACCREDITED MEMBER NATIONAL HOME STUDY COUNCIL

nri

NATIONAL RADIO INSTITUTE

WASHINGTON, D.C.

Oldest and largest school of its kind

ACCREDITED SCHOOL NATIONAL HOME STUDY COUNCIL NHSC