TELEVISION AND RADIO REPAIRING

BOOKS BY JOHN MARKUS

Electronics Dictionary (*with Nelson M. Cooke*)
Electronics for Engineers (*with Vin Zeluff*)
Handbook of Industrial Electronic Circuits (*with Vin Zeluff*)
Electronics Manual for Radio Engineers (*with Vin Zeluff*)
Electronics for Communication Engineers (*with Vin Zeluff*)
Television and Radio Repairing

Television and Radio REPAIRING

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Preface

By giving simple instructions for testing, repairing, and replacing television and radio parts, this book trains a complete beginner to handle about 75 per cent of the repair jobs that come to the average television and radio service shop. This great amount of progress toward a professional career is possible in just one book because the emphasis is on the simple, practical procedures that are adequate for most repair jobs. Learning the easiest things first gives a feeling of confidence and a sense of rapid progress.

The book is intended both for home study and as a classroom text in vocational schools and high schools. For both types of readers, the goal in writing has been to hold interest by giving practical how-to-do information that can be applied to actual receivers right from the start.

For men working in service organizations as drivers, helpers, or apprentices, the book offers an opportunity for fast upgrading. Larger shops can readily set up their own training program based on a combination of after-hours shop discussion and assigned at-home study in the book. This will permit hiring untrained men whenever experienced servicemen become hard to get and hard to hold.

As a text for company-sponsored training courses in electronic manufacturing plants, the book can train ambitious employees in minimum time to take over more responsible work in production and test departments.

This book starts from scratch. It assumes the reader has had no previous experience in television or in radio. It assumes he knows how to read, has average intelligence, and can follow simple step-by-step instructions, but nothing more. Each tool and part is introduced as if seen by the reader for the first time. Each type of receiver is taken up with a brief and simple get-acquainted description.

Words are short, for easy reading. Sentences are short, for easy understanding. Paragraphs are short, so important ideas are clear. Bold paragraph headings are used frequently to tell what is coming next and to help find a desired topic.

Chapter organization is planned for easy and logical steps in learning. The first four chapters tell how to get started in servicing, what tools to buy, how to make a service call, how to fix simple troubles without removing the chassis, and how to remove the chassis of a television or radio receiver. The next two chapters tell how to test parts with a multimeter. Three following chapters cover thoroughly the various ways of testing tubes.

Each technique and each new idea is presented when needed, not before, so the reader always sees the practical use for what he is learning. The chapter on how to solder joints thus comes after the tube-testing chapters, because tubes are ordinarily checked before suspecting soldered-in parts.

After soldering comes a group of chapters telling how to test and replace parts that are normally soldered into receiver circuits, including resistors, condensers, controls, switches, coils, transformers, and loudspeakers. One highly practical chapter covers replacement of phono pickups and needles, and another covers cabinet repairs.

The last two chapters complete the practical training by giving step-by-step instructions for installing radio and television antennas.

It is possible to start fixing sets on a business basis after studying only nine chapters. About half the sets go bad because of tubes, and tube troubles have been covered by the end of the ninth chapter. For sets having troubles other than tubes, the reader is told how to farm out the work to shops that specialize in fixing sets for servicemen or dealers on a wholesale basis. On these sets, the beginner gains experience and can usually break even profitwise. Each succeeding chapter after the ninth reduces the percentage of sets on which help is needed, hence boosts the earning-while-learning profits.

By the time the last chapter has been mastered, the percentage of sets requiring outside help has been cut down to around 25 per cent. These remaining sets are the ones that require a knowledge of circuit operation and technical troubleshooting. The reader can continue his studies with carefully chosen advanced texts on servicing or keep up the arrangement of having the tough sets fixed elsewhere, as he chooses.

Appreciation is expressed here to the many firms and individuals who cooperated so wholeheartedly in furnishing practical information and illustrations pertaining to their products. Specific credit is given under the illustrations wherever possible, as a guide for the beginner seeking top-quality test equipment, replacement parts, service manuals, and supplies.

Credit for collaboration is acknowledged as follows: Fred Lingel—Chapters 6, 7, 8, and 9; Harold Mason—Chapter 11; Richard Evans—Chapters 12, 13, and 14; Eugene Ecklund—Chapters 21 and 22; James McDermott—critical review of entire manuscript; Marjorie Appert—typing.

Finally, sincere thanks to my wife Jenny and our children Allan, Mary, and Elaine for their patient understanding during the four long years in which this book was being written.

John Markus

New York, N.Y.
April, 1953

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Getting Started in Servicing

What Servicing Involves. The main job of a television and radio serviceman is to fix television sets, radio sets, and record changers. In general, this involves bringing the set to the workbench, finding out which tube

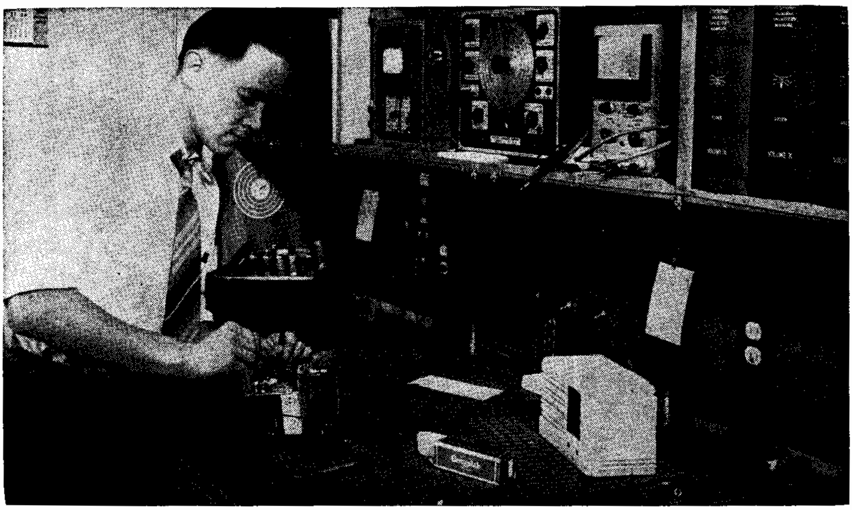


Fig. 1. Fixing a table-model radio. A few simple measurements with a multimeter locate the bad part, after which replacement with a high-quality new part is easy. (Centralab photo)

or part is bad by testing as in Fig. 1, putting in a new part, and returning the set to the customer. The work is clean and pleasant, whether done as a regular full-time occupation or in spare time to make extra money.

Servicing is an ideal combination of stimulating brainwork and easy mechanical work with your hands. As you acquire experience, the brainwork becomes almost instinctive and automatic with you. For example, you hear a certain weird sound from a misbehaving radio or see a pattern of zigzag lines messing up a television picture, and your mind immediately associates it with a particular part in a particular section of the set.

Being Your Own Boss. As an expert serviceman, you will have an interesting and varied life. In a typical day, you may repair half a dozen sets, ranging in size from a tiny battery-operated portable radio to a large floor-model radio-television combination. You can alternate as you like between relaxing on a comfortable stool at your well-lighted workbench or making outside calls and deliveries. You can stand or sit at your bench, as you prefer; you can smoke at your work or not, as you prefer; you can listen to your favorite radio programs as you work, or you can enjoy silence.

On rainy days you can concentrate on benchwork, while on nice days you can be outside more—all because you are your own boss. If you feel like working in the evening instead of the morning, you can sleep till noon. There is no time clock to punch, and yet you will find yourself putting in extra hours just because you like to.

As your own boss, you can take your vacation when you feel like it. You can take a day off when and if you like. In general, however, you will find the work so interesting that your total number of hours on the job each month will be more than that of a salaried worker. Your income will then be correspondingly higher than if you were fixing sets for someone else on a salary basis. Yes, in television and radio servicing you can write your own figures on your weekly pay check.

For many men, radio is a hobby. If it is your hobby too, you can actually make a living from your hobby. Happy indeed is the man who can do this.

Earning While Learning. There is practically no other career in which you can make extra money long before you have completed training. By learning to repair and replace television and radio parts in the practical way presented in this book, you can do repair work even while you are studying.

You will be pleasantly surprised to find that television and radio servicing is not mysterious or difficult. You do not need any special talent or education to master it. You do not even need to be handy with tools; you can easily learn how to use the few simple tools required for fixing sets.

You do not have to spend a year or more struggling with dull theoretical principles; you learn right from the start how to fix troubles, starting with the simplest and easiest ones. Thus, testing and replacing tubes as in

Fig. 2 is a money-making job you can do after studying just the first few chapters of this book.

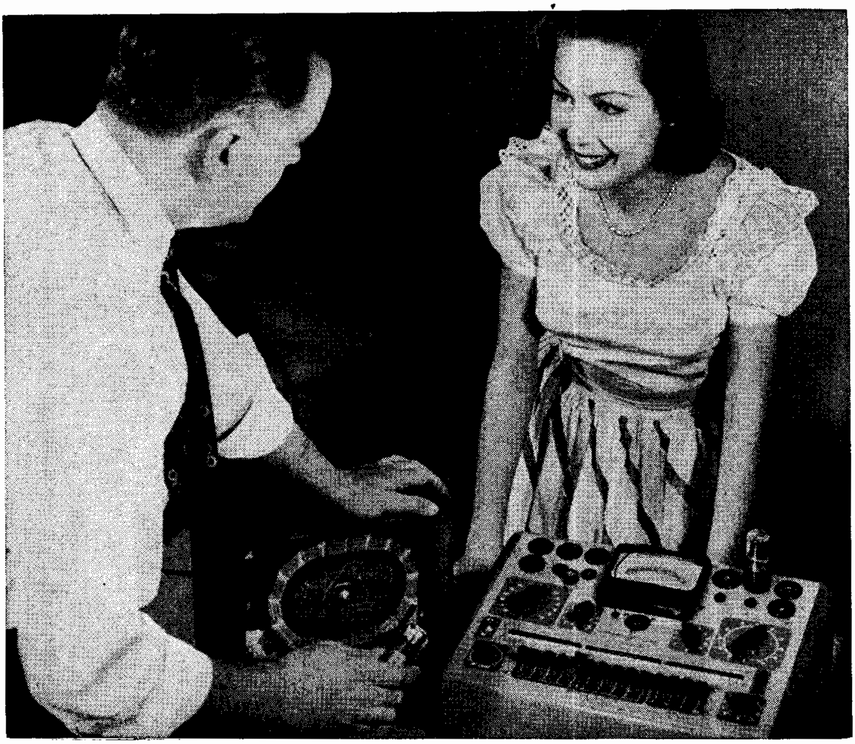


Fig. 2. Home calls provide an interesting change in the daily routine of servicing. Tubes are tested right in the home because they are the commonest cause of trouble. (Sylvania photo)

Cash Needed to Start. Another important advantage of servicing as a career is the fact that you can start with a cash investment of way less than a hundred dollars if necessary, and use the income from your first repair jobs to build up your stock of spare parts and get all of the tools and equipment you will eventually want. Only a few tools are essential right from the start. The rest can wait until you have earned the money to pay for them.

Getting Started at Home. You do not need a shop or store in order to operate a successful television and radio servicing business. You can operate right from your own home, either in spare time or on a full-time basis. Only a simple workbench like that in Fig. 3 is needed, in the basement or anywhere else that is convenient. In this way you keep overhead expenses down while building up business for your own service shop.

You can start as a spare-time serviceman, doing the work evenings and week ends while holding a regular job that provides living expenses. The more profits you put back into your business, the faster it will expand to the point where you can safely give up your regular job.

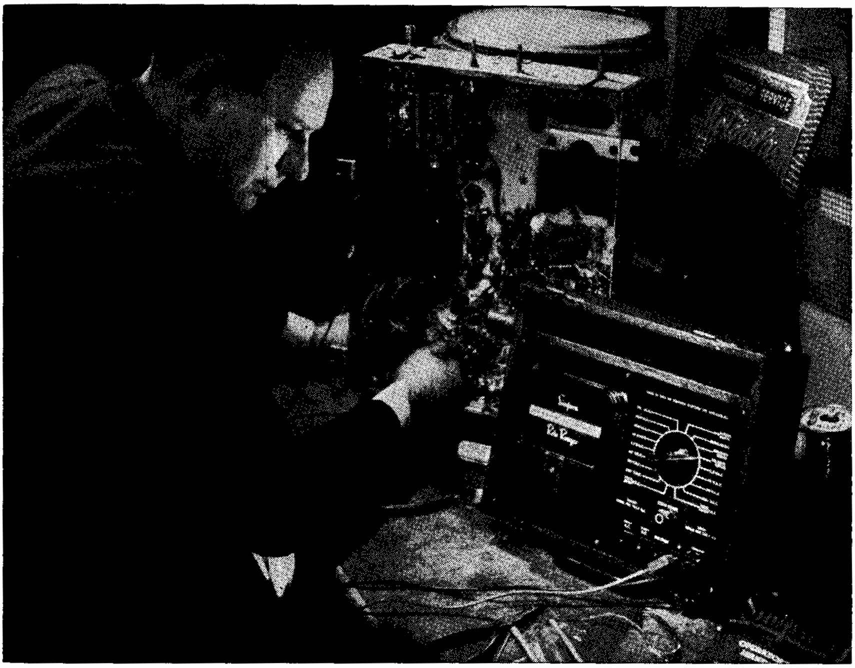


Fig. 3. A simple bench, a few tools, and a good multimeter get you started in profitable television servicing. (Simpson photo)

Later, when you have become established with your own shop or store, there will be additional profits beyond those you get for fixing sets. You will be able to buy radio and television receivers and accessories at wholesale discounts, for selling to your customers at regular retail prices. You will also be able to make arrangements with stores to install and service the sets they sell.

What Television and Radio Servicing Pays. The amount of money that you earn in servicing is entirely up to you. Your charges will vary with the rise and fall in the value of the dollar. For this reason, definite weekly or monthly salary figures for an average servicing business cannot honestly be given. The ability to change your income in this way is one important advantage of television and radio servicing as a career.

If your expenses for food, rent, clothing, and other cost-of-living factors go up 10 per cent during a half-year period, you simply boost your own schedule of charges the same amount. This is entirely fair and honest, because it was raises in wages of other people that made the cost of living go up. Products increase in price when the labor of making them costs more, because everything you buy involves labor. Nothing comes from the earth without work—not even diamonds.

Insurance for the Future. Once you learn how to fix television and radio sets, you have something to fall back on if your regular job is lost for any reason. This extra training makes you independent of the future and gives you peace of mind.

Depressions and loss of your regular job need not worry you, because there will always be television and radio sets to fix. There will always be a need for good men to do television repair work. Many men learn television and radio servicing primarily for protection against loss of their regular job. These men fix sets as a spare-time business while they have a good regular job. The extra income is, of course, welcome, and the work is fascinating and enjoyable relaxation.

Television and even radio are today still new and fast-growing. In television particularly, the future will open still more opportunities for you to advance and gain security in the years to come, no matter what your present age or occupation may be. Furthermore, television and radio knowledge is the groundwork for the still faster growing field of electronics. In the years to come, the electronic industry will have an even greater variety of opportunities for men who can fix vacuum-tube circuits.

Working for Others. Many men prefer to work regular hours for a fixed salary and have regular vacations, with no business responsibilities. Opportunities for getting the good-paying jobs broaden tremendously for those who know how to fix television and radio sets.

First, there are jobs in the larger television and radio shops where the owner cannot handle all of the business or where the owner prefers to sell sets and therefore has to hire men for the servicing part of his business. A few months of work for a highly successful serviceman is a good idea if you are a bit timid about getting started in business. Choose your employer carefully so you will not be picking up the bad habits of a careless or unbusinesslike man. Many of the servicemen who are successful today started by working for others.

There are many factory jobs where television and radio training pays off. It can help the technician in the receiver-design section of a factory, who tries all kinds of circuits and parts in a new receiver design until he finds the combination that works the best. It can help the mechanic who assembles huge transmitters. It can help the technician who supervises the work of women on assembly lines. It can help the inspector who checks finished receivers. It can help testers who make the final adjustments and check performance of sets before they are shipped out. Television and radio training also prepares you for highly responsible police radiotelephone maintenance jobs.

In the last war, advanced ratings were given to many men who had previous radio training. These men played a major role in keeping military radio and radar equipment operating in the early war years before schools could be set up for training purposes. Radio, radar, and still-newer electronic equipment for guided missiles will require still more trained men for maintenance almost immediately in any future military emergency. There just will not be time to train men for this purpose.

Getting Started Right. The first thing you learn in this chapter is where and how to get replacement parts, no matter where you live. You learn how to establish yourself as a businessman so you will get discounts from wholesale distributors. Practical suggestions guide you in building up a stock of spare parts with a minimum investment of cash. You also learn about circuit diagrams, service data, and reference manuals that can speed up your servicing work. With all this practical business information on hand, you will get started right without wasting time or money, whenever you decide to earn money in servicing.

Fixing sets efficiently means getting the required new tubes and parts quickly, once you have found the trouble. Repairs are fastest when the needed parts are right at hand on your shelves. It is impractical to keep on hand every part that you might possibly need, however. The cost of doing this would be tremendous. There are now way over ten thousand different makes and models of sets in use. Some parts fit in only one or two of these sets. Such parts would gather dust for years or even forever, while you are waiting for those particular sets to come in.

Building Up a Stock of Parts. In the beginning, you can fix sets without a stock of parts, by making more frequent trips or orders for needed parts.

Oftentimes you will not be able to get all the needed parts the first time, though. A burned-out tube may hide other defects. These show up when you put in the new tube. You then have to hold up the repair job until you can get more new parts. This means that you can fix sets faster if you have a good stock of replacement parts on hand.

The better solution is to start with a minimum stock of the tubes and parts that are most often needed. Get enough to fix the majority of sets. Make more frequent trips to your jobber or place more frequent orders by mail at the beginning. You will soon learn which tubes and parts you need most. Gradually, you can build up your stock and cut down the number of weekly orders for parts.

Stay away from bargain sales until your business is well started. Many bargains turn out to be worthless, so wait until you can afford to gamble with your money. Inferior, cheap parts are expensive in the long run, because they go bad in sets you have repaired and guaranteed. Then you have to fix these sets for free and put in the good-quality parts anyway.

Where to Buy Parts. First of all, get acquainted with all the places that sell replacement parts in your locality. This is an important part of getting started in television and radio servicing.

Two distinct types of firms should be considered: (1) parts jobbers, also called wholesalers and distributors; these have stores at which you can buy just about everything you will need; (2) mail-order houses, that correspond to jobbers but do business chiefly by mail from catalogs.

Both types of suppliers charge essentially the same wholesale prices to servicemen. On the average, they provide about the same services. Your choice of a supplier will therefore depend on your own locality and the particular firms serving it. To help you make this choice, additional information will now be given about each type of supplier in turn.

Buying from Jobbers. For most servicemen the chief source of supply for radio tubes, parts, hardware, test equipment, and manuals is a parts jobber. Jobbers sell parts at wholesale prices that permit a fair and legitimate profit to you. The usual discount to servicemen will be 40 per cent off list price. On tubes this discount is most important because small sets like that in Fig. 4 often need only new tubes. If the set is brought to you, the profit on the sale of these tubes may have to cover the time you spend talking to the customer and testing the old tubes. A business card is needed the first few times to identify yourself as a serviceman who is entitled to discounts.

Television and radio parts jobbers are located only in the larger towns. They are generally in out-of-the-way locations, so you may never have seen or noticed one of their stores. To find them, look in your classified telephone directory under the heading "Radio Supplies and Parts—Wholesale and Manufacturing." Some of the firms may serve only manufacturers, but they will gladly refer you to others that want you as a customer.

Another way to locate jobbers is to get acquainted with a serviceman

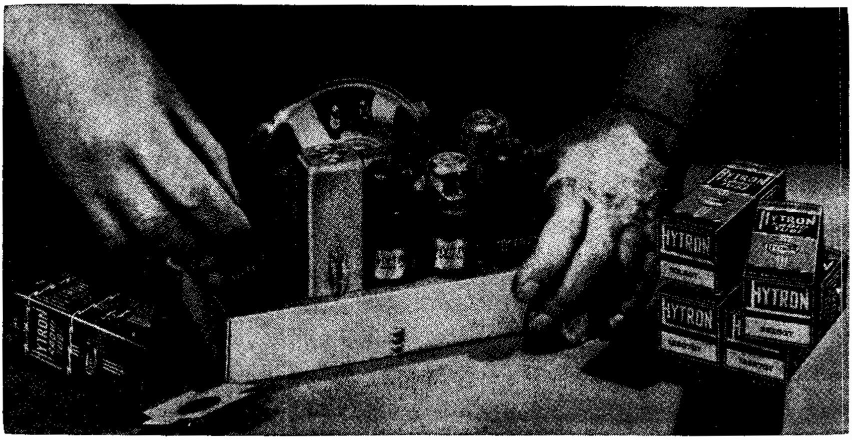


Fig. 4. Putting an entire new set of tubes in a table-model radio will make it work again about half the time. The old tubes can then be put back one by one, to find the tube that makes the set go bad again. (Hytron photo)

who has been in business for several years in the locality, and find out where he gets his parts.

Charge Accounts. Jobbers often permit charge accounts, payable once a month. An extra discount, usually 2 per cent, is generally allowed for cash payment and for bills paid within 30 days. A charge account has many advantages if used as a convenience. It establishes you as a professional businessman, builds up your credit rating, and lets the jobber know that you are one of his good customers. A charge account is bad, however, for those who yield to temptation and buy more than they can pay for at the end of the month. Overdue charge-account bills hurt your credit rating and thus spoil chances for borrowing money to expand your business in the future.

Ordering by Telephone. Many jobbers provide daily delivery service on phoned-in orders from shops in their own city. While you work during the day, you can build up your list of wants and phone it in, as in Fig. 5, thus saving the time required for a trip to the jobber.

In a few localities, aggressive jobbers make the round of service shops with trucks containing stocks of parts or come around daily taking orders for delivery the next day.

Some jobbers also provide semiweekly or weekly delivery service to shops in suburban communities and nearby towns. Even once-a-week deliveries

Fig. 5. Save time by ordering needed replacement parts by telephone whenever possible, for delivery by truck, express, or parcel post. (Radio Distribution and Maintenance photo)

can be adequate if you keep a good supply of tubes and parts on hand. The long-distance toll charge for placing an order in time for one of these deliveries is spread over many jobs and hence amounts to only a few pennies per job. This is usually about the same as the value of time and transportation mileage used by servicemen in big cities when picking up needed parts at a jobber. Thus, a small-town servicing business can operate just as efficiently as one in a big city, once it is on a full-time basis so that orders for parts are large enough to rate delivery service.

In many Western states, where towns are too far apart even for delivery service, jobbers use express or parcel post to provide practically overnight service on phoned-in orders. Some jobbers even allow you to reverse the charges on long-distance calls for ordering parts.

Any parts supply store may have rush hours. Business gets so heavy at these times that you always have to wait. Clerks will gladly tell you when their rush hours come, so you can schedule your phone calls and visits earlier or later to save time.

Buying from Receiver Distributors. In the larger towns are firms known as receiver distributors. Their main business is selling television and radio sets to stores in wholesale quantities. Some of these distributors also carry spare parts for the various makes of sets handled, along with a more or less complete stock of standard replacement parts and some test equipment.

You will have to go to the various receiver distributors in your locality to get special parts for the sets they handle. Therefore, learn who these distributors are and where they are located, so you can get special parts quickly when needed.

You will find that stocks of general replacement parts are smaller at receiver distributors than at jobbers, and perhaps a bit higher in price. Also, some distributors may give poorer counter service than jobbers.

On most parts, distributors give servicemen the standard 40 per cent discount. A few items, such as replacement cabinets or special television parts, may have smaller discounts or net prices, however.

Manufacturers of sets rarely sell parts directly to servicemen. Writing to manufacturers for special parts is usually a waste of time, except for some of the smaller manufacturers who do not have distributor setups for handling parts.

Ordering Special Parts. Examples of parts you would get from receiver distributors are new printed tuning dials, new cabinets, and special transformers. Standard parts, such as resistors and condensers, are easier to get from jobbers.

When ordering a part from a distributor by phone, letter, or personal visit, be sure to give the number of the part along with the make, model number, and serial number of the set in which it is used. The part number is usually stamped on the part. If not, look it up in the service data for that set. The prices given in the service manuals of receiver manufacturers are usually list prices from which servicemen deduct 40 per cent to determine their cost price.

The model number of the set is either on the back of the chassis or on a label glued inside the cabinet. The serial number is usually on the back of the chassis. If in doubt, give all numbers and letters found in these locations, and include a list of the tubes used in the set.

Manufacturers and their distributors rarely keep special parts in stock more than 5 years for lower-priced table-model sets. On larger and more expensive sets they may extend the time to 10 years. Therefore, on sets over 10 years old you will rarely be able to get special parts. Here the best thing to do is advise the customer to trade in his set on a new model.

Buying Parts by Mail. Many servicemen in smaller towns and remote localities get all their needed replacement parts and supplies by mail from mail-order television and radio supply firms. These firms put out complete catalogs describing the parts that they handle. The catalogs are sent free on request, and are well worth having on hand for reference. One use of such catalogs is for finding your cost prices on parts when you have to give an estimate on the cost of a repair job.

Quite often, mail-order firms buy surplus parts from receiver manufacturers and sell these at even lower than normal wholesale prices. Once you become acquainted with reliable well-advertised brand names, you can safely take advantage of an occasional money-saving special in the mail-order catalogs.

Prices given in mail-order catalogs are net prices. Postage or express charges are extra for most items.

What to Charge for Parts. On tubes and parts, a serviceman always charges list price or higher to his customers to cover the time and expense involved in ordering or getting these parts and to cover a fair part of the overhead expenses associated with any business. This means that a tube which you buy at a net price of 60 cents would be sold at its list price of $1.

When you know only your cost price, multiply it by 1.7 to get a list price that gives you a 40 per cent profit. Thus, if you pay $4 for a part, multiply $4 by 1.7 to get $6.80 as the list price that you charge the customer.

On small parts costing way less than a dollar, a profit of 40 per cent is not enough to cover the time you spend ordering and getting the part. Here you should charge at least twice your cost just to break even. Thus, a pilot lamp costing 6½ cents is normally listed at 15 cents on customer bills. A small part costing, say, 11 cents, would be billed at 25 or 30 cents. This is standard business practice with successful servicemen.

Most Needed Replacement Parts. To fix television and radio sets, the parts you need most of all are tubes. Over a thousand different types of tubes are in use today, costing an average of about a dollar apiece even at wholesale. It is thus pretty important to build up your tube stock carefully. Your parts jobber can tell you which tubes are replaced most often in your locality.

Suggestions for building up stocks of other replacement parts are given in the chapters dealing with these parts.

Keeping Your Stock Up to Date. The value of a stock of parts drops rapidly unless the stock is kept up to date. You need a system for reminding you to order a new part each time you take one from stock. An easy and foolproof reminder is a pad of scratch paper mounted on a bench or shelf with wood screws so it cannot get lost. Jot down the value and number of each part as you take it from stock. Get into the habit of doing this right from the start. Each time you go to the parts jobber or order parts by phone or mail, tear off the top sheet and use it as your order list.

New tubes and some replacement parts come in cartons having labeled covers. When you use one of these parts, tear off the top of the carton and save it in a box near the pad as the reminder for reordering.

Small parts are generally much cheaper when bought in quantities. These small parts do not need to be listed on your pad when used, because their cartons will always show when your stock is getting low. Keep your stocks of new parts stored safely and neatly on shelves or in drawers.

Getting Receiver Service Data. It is always easier to fix a set if you have the service data for it. Such data include the circuit diagram and other helpful information. Some of the larger radio and television sets are almost impossible to fix unless you have the service data for them.

Service data for a particular set can usually be obtained free from the manufacturer, but writing for it and waiting for the reply takes time. Collections of circuit diagrams and service data that are published regularly in loose-leaf form for servicemen are much more convenient. The different sources for service data will now be taken up individually, to help you decide which to get.

Manufacturers' Service Data. When you have a receiver that is not much over five years old and when the manufacturer is still in business, the chances are pretty good that you can obtain the service data for the set free of charge by writing for it. If you do not have printed business stationery yet, clip your business card to the letter. This helps to get a quick reply.

When writing, be sure to give the make, model number, and serial number of the set. As a double check, include the list of tubes in it. Your letter can be short and simple, as follows:

January 27, 1953

Glory Radio Corporation
31 Crescent Place
Ho-Ho-Kus, New Jersey

Gentlemen:

Please send me service data on your Glorytone Model 9142 table-model radio, serial number 934867, which has the following tubes: 12SA7, 12SK7, 12SQ7, 50L6, and 35Z5.

Thank you for your cooperation.

Very truly yours,

John J. Jones
Television and Radio Servicing
1340 Main Street
Oshkosh, Idaho

The list of tubes can be omitted when the set has more than about six tubes. There are fewer models of large sets and correspondingly less chance of sending you the wrong diagram.

On many sets you will find only a trade name, with no clues to the name and address of the manufacturer. Others may have the manufacturer's name but no address. In either case, the ads and directory lists in magazines published for servicemen may be of help. Remember, however, that no list of this type can be complete or up to date. In the receiver manufacturing business, some firms go out of business each year, and new ones take their places. The best place to get circuit data on these orphan sets is from publishers of receiver diagrams.

Although you may prefer to write for individual diagrams at the start as needed, you cannot operate a profitable business in this way. Writing letters is a waste of valuable working time. You have to wait days or even weeks for the reply, and even then you may not get the needed data.

Buying Individual Circuit Diagrams. Much faster service on individual receiver diagrams can be obtained from the publishers of volumes of diagrams, such as Howard W. Sams & Co., Inc., and John F. Rider Publisher, Inc. These firms sell reprints or photostat copies of individual diagrams or sell small groups of diagrams including the one you want. The charge per receiver varies considerably, depending on the number of pages of data required. Thus, the charge might be 50 cents for an ordinary a-m radio receiver and $1 for a television receiver. Groups of diagrams might cost $1.50 or more, but they contain extra diagrams for future use.

Service data can be obtained in this way for practically any receiver ever built, even though the manufacturer of the set went bankrupt long ago. You can use this individual diagram service profitably on old sets instead of buying the old volumes of diagrams, as most of your work will be on sets less than 10 years old.

Buying Photofact Folders. Circuits of practically all the television and radio sets made after the end of World War II in 1946 are available in Photofact Folder sets costing approximately $1.50 each. These are published by Howard W. Sams & Co., Inc., Indianapolis, Ind., and are sold by jobbers.

Each Photofact Folder set contains about 150 pages of complete service information on a-m, a-m/f-m, television, auto-radio, and communication receivers, record changers, and amplifiers. These data are specially prepared in a uniform style for maximum value to servicemen. New sets of folders are issued as often as three times a month to cover new receivers that come on the market. A cumulative index to all Photofact Folders is also available, telling which folder contains data on a particular receiver. By ordering a folder each time you need a particular diagram, you can build up a library of service data on the installment basis without putting out a large sum of money at any one time. The complete library of folders may also be purchased on a time-payment plan.

Photofact Folders are also available in loose-leaf binders, as in Fig. 6, each holding about 10 sets of folders. You can obtain the binders separately and put individual folder sets in them as you get them.

Buying Rider's Manuals. Circuit diagrams for practically every television and radio receiver from the beginnings of radio up to the current year can be found in Rider's Manuals, shown in Fig. 7. These volumes are published yearly or oftener by John F. Rider Publisher, Inc., New York, and are available from jobbers. Radio-receiver volumes cost about $10 to $20 each, depending on size, and television-receiver volumes generally cost more. The first five radio volumes are no longer available individually, since they represent sets made before 1935, but a single 2,000-page abridgement is available covering the old sets that are still likely to be in use.

To use Rider's Manuals, you must know the year in which the set was made. Each volume has its own index, and a cumulative index can be purchased covering a number of the volumes. This cumulative index is

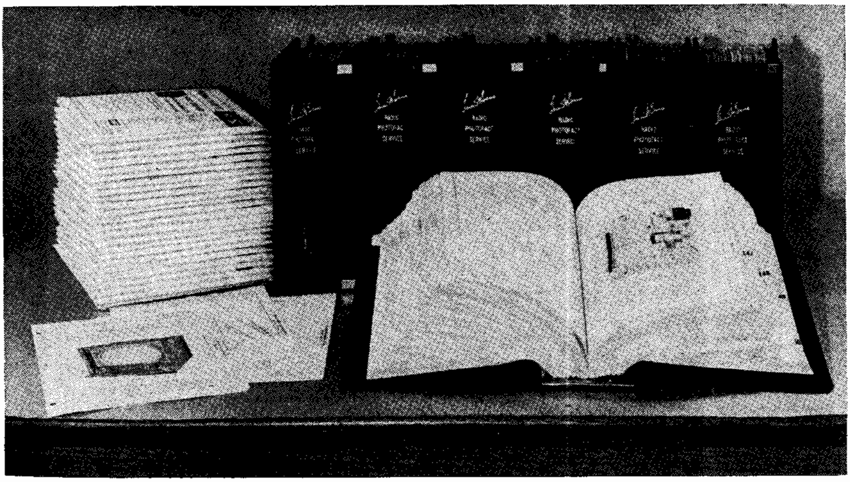


Fig. 6. Examples of Photofact Folders and binders for them. These give the essential data needed for fixing sets fast. (Howard W. Sams photo)

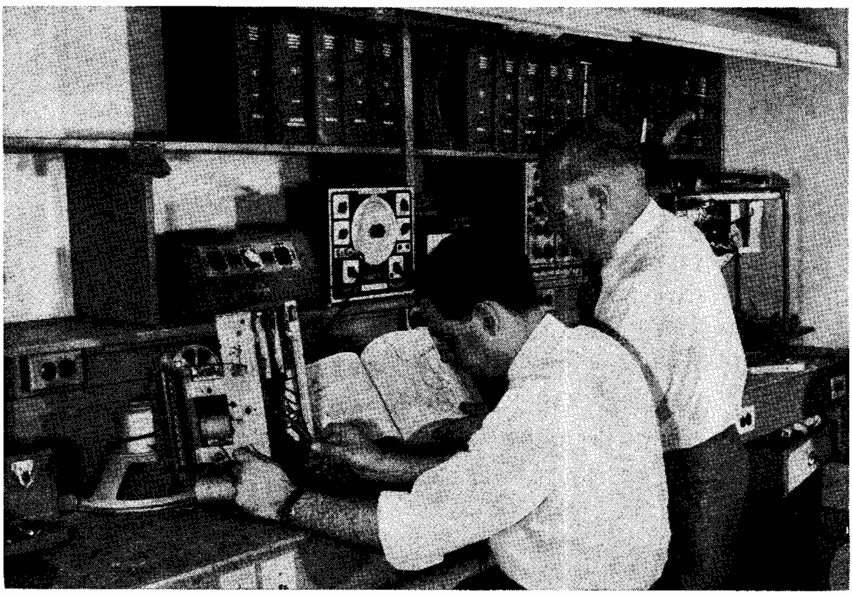


Fig. 7. Using a Rider's Manual for reference while hunting for trouble in the chassis of a console radio. Other manuals are within easy reach on the shelf. (John F. Rider photo)

well worth while, because there is seldom a date of manufacture on a receiver.

Rider's Manuals present servicing information exactly as it was released by the manufacturer, with additional diagrams of some complicated switching circuits. The quality of the information varies greatly, because some manufacturers prepare much better service information than others. The large volumes of Rider's Manuals are issued only about once a year, so circuits of brand-new sets may not be in the latest volume. To overcome this, Rider announced in 1951 a special service wherein groups of diagrams become available on approximately a monthly basis. Contact your jobber for latest information on this and other diagram services.

Choosing Your Manuals. In contrast to Rider's Manuals, Photofact Folders are uniform in their presentation of service information. Issuing of the sets of folders several times a month also means that they are up to date. Photofact Folders are not available covering sets made before World War II, however.

The choice between Photofact Folders and Rider's Manuals is pretty much a matter of personal preference. Both are good. You will find that some servicemen are boosters for one and some for the other.

In television servicing, manuals are absolutely essential. Without the circuit diagram and alignment data for a set right at hand, hours and even days can be wasted tracing out circuits on the chassis while troubleshooting. Therefore, look over the Rider Television Manuals and the television envelopes in Sams Photofact Folder sets every chance you get. Then, when you are ready to tackle television servicing, you can intelligently choose the type of manual information that best fits your personal needs.

Since receivers can last 10 years or more, you will eventually want to have a fairly complete collection of service manuals. This you can build up gradually from the profits of your business. The cost of manuals and reference books is a legitimate part of your overhead expense. Your fees for service must therefore be high enough to cover this along with your charges for labor and parts.

In general, low-priced but incomplete volumes of circuit diagrams are a waste of money for a servicing business. There is no point in having volumes containing only the most used circuits, because you still have to get the large volumes to cover the rest of the sets. Do not waste your money on cheap volumes; wait until you can afford those used by professional servicemen—Rider's Manuals or Sams Photofact Folders.

Manufacturers' Volumes of Service Data. Some manufacturers of television and radio sets publish their own volumes of service manuals, usually as yearly editions. Practically all the essential data they contain can be found in the complete volumes put out by Sams and by Rider. Manuals covering only one make of set are ideal for those who specialize in that make of set but are a waste of money for the average serviceman who has to fix all makes of sets.

"Radio and TV Industry Red Book." Here is a volume well worth getting with your very first profits from repair work. It gives the parts numbers needed to order replacement parts for television and radio receivers made since about 1938. The "Red Book" also lists the tubes in each set. The tube column will often help you to identify a set when model-number markings are missing. New editions are issued regularly to provide quick-reference data on new sets.

Mallory "Radio Service Encyclopedia." This manual is prepared somewhat along the lines of the "Radio and TV Industry Red Book," but lists only the replacement parts made by P. R. Mallory & Co., Inc.

The Mallory Encyclopedia covers practically all prewar sets as well as postwar models. The Mallory book gives the volume and page of Rider's Manual for the circuit of each set, whereas the "Red Book" gives the Photofact set number. Both volumes give a complete list of the tubes in each set, along with other useful data.

Tube Manuals and Charts. The "RCA Receiving Tube Manual," available from jobbers at a nominal price, gives the base-connection diagram for each type of receiving tube made, along with useful technical data.

Other radio-tube manufacturers also have tube manuals and charts available, some free and some costing as much as a dollar.

Catalogs. Start now to build up a collection of catalogs of parts manufacturers and supply firms. Each catalog covers different lines of parts. You may be able to find in one catalog a badly needed part that is not listed in the others. Put up a shelf in your shop to hold these catalogs, your study and reference books, and the service manuals you will be getting.

Catalogs can be obtained by writing directly to the manufacturers. Parts jobbers usually have racks filled with catalogs and literature from which you can help yourself. A charge is made for some of the larger booklets, but they are usually worth many times this charge.

Free Publications. Some manufacturers of replacement parts send out little magazines to servicemen regularly each month or every other month, free of charge. Some of these so-called house organs are also available at jobbers. You will often find in them helpful articles covering latest developments in television and radio.

Your jobber can tell you which manufacturers publish such house organs. Send a short letter to each manufacturer, identifying yourself as a serviceman and asking to be placed on their mailing list to receive their publication regularly.

Tube manufacturers often offer service aids of various kinds free with purchase of quantities of tubes.

Magazines for Servicemen. To keep abreast of new developments, subscribe to at least one of the magazines published for servicemen, or buy individual copies regularly from your jobber. Eventually you may want to get all of them.

Getting Acquainted with Fellow Servicemen. One other way of learning practical information fast is by talking to other servicemen. Better yet, join the nearest organization of servicemen and attend their meetings regularly. You will find that even though they may be competitors, they are as a rule friendly and congenial.

You cannot expect to get much free advice from servicemen at their shops. At meetings and gatherings the men talk more, and are usually eager to answer questions or to discuss their problems and successes. You can learn a lot in this way about local conditions affecting servicemen.

Show willingness to serve on committees and to do other work for the servicemen's organization. Ask for jobs like sending out notices of meetings or handling correspondence. Do a good job and you will be in with the gang in no time. Your own self-confidence will be bolstered tremendously once you are an officer of a servicemen's organization.

Fixing Tough Receivers. If you fix sets while still studying, there will be quite a few in the beginning that are too tough to handle. You are not expected to fix every set right from the start. If you realize this, you will not be embarrassed and will not waste a lot of valuable time on the tough sets before you are ready for them.

The sensible way is to try out only the test procedures that you have already learned, and then allow yourself not over three guesses as to suspicious parts. After this, turn the set over to a dealer or experienced serviceman with whom you have previously made arrangements for handling tough sets during your training period.

Dealer Service. Some service shops in the larger towns specialize in doing repairs on a wholesale cash-and-carry basis, which is known as dealer service. You bring the set to the shop and call for it when repaired. The serviceman charges you only for parts and labor, since he does not have to waste time making calls and talking to customers. Your own bill to the customer is much larger, to cover the time spent in dealing with the customer, travel time, overhead, and possible new trouble during your 30- or 90-day guarantee period.

Many distributors, especially those serving as wholesalers for receiver manufacturers, also have shops in which they fix tough sets for servicemen on this same cash-and-carry basis.

If you take advantage of dealer service, you can profitably start fixing sets right from the beginning while you are learning television and radio servicing. Make inquiries at the nearest distributor, to find out which shops will fix sets for you.

By using dealer service, you make real money right at the start on the sets that you can fix, and break even or show a small profit on the sets the dealer fixes. You learn a lot by trying to fix all the sets yourself first, since the dealer tells you what the trouble was. You preserve your reputation as a serviceman, since you do not tell your customer who actually fixed the set.

Never leave wires disconnected when taking sets to a dealer for repair. If you unsolder wires while making tests, put them all back exactly as they were, if you want to keep the charges down. Servicemen hate to get in a set that has been bungled by an amateur. It takes a lot of time to trace the wiring piece by piece and get it all back. They have to do all this before they can even start troubleshooting. If a set comes in to you with disconnected wires and you have to pass it on to a dealer, be sure to explain the situation to preserve your own reputation.

Use dealer service any time that you run into a tough set—even after you have finished your training and are well established in business. You will be money ahead if you do, because your time is valuable. It is far better to break even or take a loss on an occasional job than to waste hours of time for which you cannot fairly charge your customer.

Importance of a Business Card. The first step in establishing yourself as a professional serviceman is getting a business card. This you can hand to clerks at a jobber or distributor to get wholesale prices on parts.

Business cards can also be inexpensive advertising if widely used. Many stores in small towns display such cards under glass counters or on bulletin boards as a courtesy to you and as a service to their own customers. Libraries, post offices, and other places may have bulletin boards on which business cards are permitted. Be sure, however, to make the rounds regularly and put up clean cards. A dirty card is poor advertising.

Your biggest and most profitable use for business cards is as a reminder in every set that you repair. Knowing the card is there, the customer can easily look up your phone number on it when some other set in the house goes bad or when that same set needs attention again. Attach a card neatly in a permanent position inside the cabinet or on the back cover of the set. On wood cabinets, use a thumbtack, small carpet tack, or a hand stapler. On plastic cabinets, attach the card with speaker cement or Du-Pont glue.

Design of a Good Business Card. Since so much depends on the impression made by your business card during the critical beginning months of your business, do not skimp on its cost. Stay away from cheap cards. Locate a good printer who will design the entire card, using the most effective styles and sizes of type for your particular purpose.

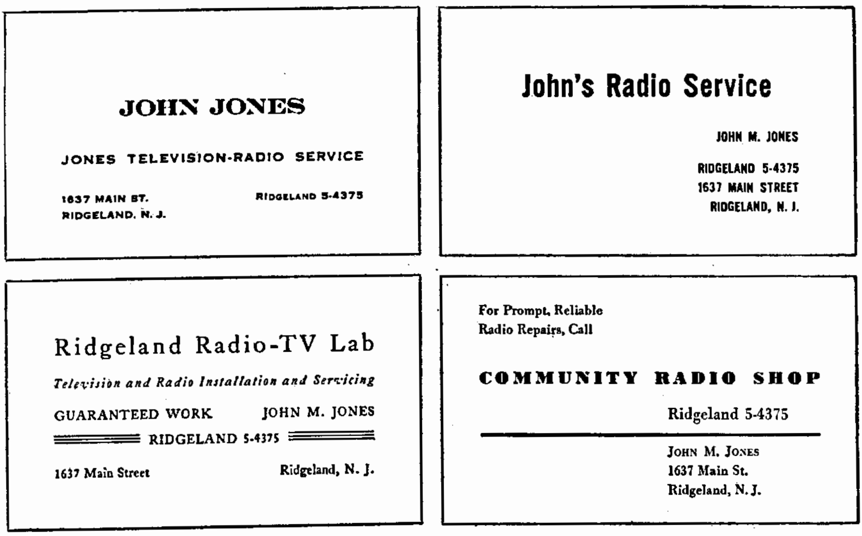


Fig. 8. Ideas for your business card. A good printer can make up one of these with your own name and address, for use in establishing yourself as a professional serviceman so you can get wholesale prices on tubes and replacement parts

For television and radio servicing, a business card should have the following information:

1. Your name.
2. The name of your business, if you decide to use one.

3. Your address.
4. Your telephone number.
5. A line telling what your business is.

Keep your card simple and dignified, as in the examples shown in Fig. 8. Stay away from anything unusual. In the beginning your card should express a feeling of dignity and responsibility. Use high-quality plain white cards and a rich dark-colored ink. Dark green, dark maroon, dark blue, or dark brown are good colors. Black ink is also acceptable.

Many printers offer free use of illustrations for cards, but you will be better off without these. The illustrations are generally out of date anyway and do more harm than good.

Certain manufacturers of radio tubes offer to print cards for servicemen at very attractive prices. These cards always contain an emblem and sometimes other advertising of the manufacturer, which detracts from your own name and message. Also, the cards drop in value when used by a number of servicemen in the same town.

Getting Business Know-how. When you decide to start earning money from servicing, spend a few weeks studying the business side of servicing. Books on this are available from most jobbers. Get this business training and then come back to your study of practical servicing. You then will not ruin your future by making the business mistakes so many other beginners fall into. With a professional attitude right from the start, you will gain and hold the respect of customers and fellow servicemen alike. You will never have to live down such gossip as, "Oh, he'll fix your set for nothing—he's just learning."

Building Self-confidence. When you decide to fix receivers for a fee—now, next month, or next year—act as if you definitely know how. Act as if you cannot possibly fail to fix any set. Your customers will not know how much time you spend on their sets at the beginning, nor will they care. Likewise, your customers will not know or care whether you have the set fixed by a dealer. All this is behind the scenes and should be kept there for business reasons.

Remember also that a little knowledge can be dangerous. Do not be too positive in telling a customer what is wrong, because even the best servicemen make wrong estimates of troubles sometimes. Play safe—merely suggest possible troubles and say that further tests in your shop will be necessary to confirm your suspicions.

QUESTIONS

1. Why are inferior bargain-sale parts usually more expensive to you in the long run?
2. What two types of firms specialize in selling replacement parts to servicemen?
3. Why are overdue charge accounts at jobbers bad for your business?
4. How long do manufacturers usually keep spare parts on hand for large, expensive sets?
5. If you pay $3.50 for a replacement part, how much should you bill the customer to make a 40 per cent profit?
6. Tell how you would set up and use a reminder system for reordering parts taken from your stock.
7. From what two well-known firms can you obtain circuit diagrams for orphan sets?
8. What essential information should be on your business card?

2

Tools Needed for Servicing

Choosing Tools. Only a few tools are needed to get started in servicing. These are a soldering gun, long-nose pliers, diagonal cutters, combination

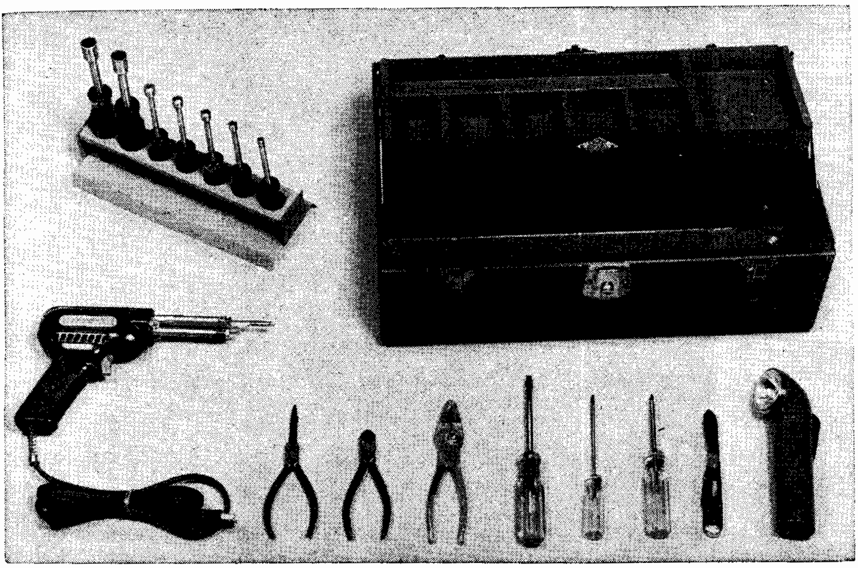


Fig. 1. Tools needed for getting started in servicing and making home calls. Top row—set of spin-type socket wrenches with stand; toolbox. Bottom row—Weller soldering gun; long-nose pliers; diagonal cutters; combination pliers; ¼- by 4-inch screwdriver; ⅛- by 4-inch screwdriver; No. 2 Phillips screwdriver; two-blade pocketknife; flashlight

pliers, three screwdrivers, a flashlight, a set of socket wrenches, a knife, and a toolbox, all shown in Fig. 1.

Suggestions for choosing and using each of these basic tools will be given first. Additional tools for speeding up repair work at the shop bench will then be described. Suggestions will also be given for building a good workbench.

It pays in the long run to buy high-quality tools. They may cost more, but they will last a lot longer, do better work, and give you a feeling of pride.

Soldering Gun. Since practically all connections in television and radio sets are made with soldered joints, a soldering tool comes first on your tool list. For this, a soldering gun is strongly recommended in place of an ordinary soldering iron. A soldering gun is ready to use a few seconds after being turned on, whereas ordinary soldering irons take several minutes to heat up. A soldering gun has a long, thin tip that is ideal for working in a crowded television chassis. Ordinary soldering irons are large and clumsy in comparison and may burn or damage adjacent parts when used in crowded locations.

Additional information on the selection of a soldering tool is given in the chapter on soldering, along with complete instructions for making soldered joints.

Long-nose Pliers. Next to a soldering tool, you will need most often a pair of long-nose pliers. These are used for pulling on a wire when unsoldering a joint, for prying a loop of wire apart when unsoldering, for threading wire through a hole in a soldering lug, for bending hooks or loops in wires, for squeezing loops together to get tight joints, and for crushing insulation on wires so it can be removed easily.

Diagonal Cutters. For cutting hookup wire of all kinds in all locations, diagonal cutters are used. These are also known as side-cutting pliers. The most useful type has flat jaws between the handles for squeezing insulation on wires.

Diagonal cutters can also be used for snipping off loose ends of insulation and rubber on wires, for cutting dial cord, for cutting thin soft metal such as soldering lugs, and for cutting insulating tape.

Diagonal cutters for television and radio work range from 5 to 7 inches in length. Choose the size that fits most conveniently in your own hand.

Cheap diagonal cutters get dull quickly, and for this reason are a waste of money. Spend at least $2 right at the start to get a good pair.

Combination Pliers. These are the commonest pliers of all, so you probably have them already. They are used for holding, bending, and squeezing, for breaking off old connections and old mounting brackets, and for loosening and tightening nuts. The name comes from the two-position pivot that gives a combination of two different sizes of jaws. Slipping the pivot to the other hole permits opening the jaws wider for gripping larger objects.

If buying a new pair of combination pliers for service work, get one of the thin, lightweight types. Sometimes they are called slip-joint pliers or gas pliers.

When using combination pliers for loosening or tightening nuts, grip the pliers tightly, with the jaws squarely on the nuts. This prevents the pliers from slipping and rounding off the corners of the nut.

Screwdrivers. Screwdrivers have just one purpose—to loosen or tighten screws and slotted-head bolts. In emergencies, however, they can be used as a substitute for everything from a crowbar to a chisel. Of course, such misuse is only for real emergencies when the correct tool is not at hand.

You can get along nicely at the start with three screwdrivers. Get a medium-size standard screwdriver with a ¼- by 4-inch blade for all-round use. This will be used chiefly for removing chassis-mounting bolts, tightening the bolts used for mounting new parts, and removing wood screws.

A small standard screwdriver with a ⅛- by 4-inch blade is needed for loosening the tiny setscrews that hold some types of control knobs on their shafts.

A No. 2 Phillips screwdriver with a 4-inch shaft takes care of practically all sizes of the special Phillips screws that are encountered in television and radio sets. These screws have four-cornered depressions in the heads, to speed up inserting the screwdriver and to minimize chances of having the screwdriver jump out of the screw when tightening or loosening.

Get the best quality in screwdrivers right from the start, since even these cost less than a dollar apiece. The best types have shatterproof plastic handles that fit comfortably in the hand. Plastic handles also serve as insulation, permitting safe use in high-voltage circuits.

Knife. You will need a good two-blade pocketknife for scraping wires, cleaning soldering lugs, and cutting insulation off wires. Choose a strong knife that has two good blades. Keep the smaller blade razor sharp all the time for cutting insulation. Use the larger blade for rougher work, such as scraping.

Spin-type Wrenches. A set of spin-type socket wrenches is needed for removing and replacing chassis-mounting bolts, speaker-mounting nuts, and other nuts and bolts used for mounting new and replacement parts in a television or radio set. These wrenches have handles like screwdrivers. Each has a different size of hexagonal socket at the tip. Sometimes they are called hex nut drivers. One manufacturer uses the trade name Spintite for them.

Get a high-quality set of these wrenches at the start because you will use them a lot. They should have hollow shafts that fit over the projecting ends of long bolts to reach the nuts. Cheap wrenches are a waste of money because they wear out quickly, do not fit accurately enough, and do not usually have hollow shafts. Plan to spend at least $4 for a set of seven wrenches.

Spin-type wrenches are handled much like screwdrivers, and are far better and faster than pliers. The socket cannot slip off once it is held over a nut or a bolthead. Once a nut is loosened, you can spin it off quickly by rolling the shaft of the wrench between your fingers.

Typical sizes in a set of spin-type wrenches are $\frac{3}{16}$, $\frac{7}{32}$, $\frac{1}{4}$, $\frac{9}{32}$, $\frac{5}{16}$, $\frac{11}{32}$, and $\frac{3}{8}$ inch. The $\frac{1}{4}$- and $\frac{5}{16}$-inch sizes will probably be the most used, so paint colored bands or dots on the handles of these two sizes if they are not made in different colors already.

Flashlight. A small flashlight is badly needed on home calls to light up dark corners inside the cabinet when replacing tubes, when loosening or tightening mounting bolts, or when looking over the chassis for defects like broken wires. An ordinary two-cell flashlight will give you the most value per set of batteries, but almost any flashlight will do. If you have one already, by all means use it.

Choosing a Toolbox. The only tools that you ordinarily need to take along on service calls to homes are those just described. For carrying these tools and an assortment of small parts and supplies, get a good-looking toolbox right from the start. Choose this box carefully because it is the first piece of equipment that your customer sees when you enter the house. Get a fairly large toolbox, attractively finished in a bright baked-on enamel. It should have an automatic lift-up tray that makes the bottom of the box accessible immediately when you lift the cover.

The better models of fishing-tackle boxes are ideal for your purpose. You can remove some of the tray partitions to make a few large partitions for tools. All-aluminum boxes are particularly attractive.

A large box is desirable so that it will hold at least half a dozen new tubes in cartons. An 18-inch-long box is a good size. On radio calls you often know beforehand the make and model number of the set and can take along a set of new tubes for it. The odds are almost 50–50 that new tubes will clear up the trouble in radio sets, allowing you to do the whole job on one call.

Toolbox Supplies. The big temptation is to pack a toolbox full of things that are seldom if ever needed on service calls in homes. Your customer's home is not a workshop. The receiver chassis should always be taken to the shop when special tools are needed.

When cleaning up in the customer's home, put all scraps of excess solder, small bits of wire, and fragments of insulation in a compartment of the toolbox. Carefulness in cleaning up will make a good impression. Be sure to remove the scraps when you get back to your shop, for otherwise your next customer will get a poor impression when studying the contents of your toolbox.

Care of Tools. Plan the arrangement of your toolbox carefully so that you have a definite place for each tool. Keep the box alongside you when working, as shown in Fig. 2. Put each tool back when you are finished

Fig. 2. Example of another good toolbox for home calls. On television calls, many servicemen carry the required large number of spare tubes in a traveling bag like that directly behind the picture tube on the floor here

with it. This minimizes chances of leaving tools in homes or losing them, especially when working outdoors on television antennas. Screwdrivers are particularly likely to roll under furniture where they are overlooked.

Several of the small partitions in the toolbox tray should normally be left empty. Use these for bolts, knobs, and other hardware taken off a set when you remove a chassis for shop work.

Do not toss tools into your toolbox. You might miss and dent a valuable piece of furniture, making your customer unhappy. The clatter will also be annoying. Your customer does not understand the things you do to the receiver, and hence he judges you on the basis of little things like handling of tools.

Put a drop of oil on the pivot of each pair of pliers occasionally to keep them working smoothly. Good clean tools inspire good work. Dirty tools, on the other hand, seem to encourage slipping and carelessness that often damages radio tubes, parts, and even your own skin.

Workbench Tools. The tools described so far are used both on service calls and on your workbench. The additional tools you will need on your workbench at the start for replacing defective parts are three files, a hacksaw, a drill, a hammer, a center punch, a cold chisel, and a vise.

Files. Three files will take care of your minimum requirements when getting started.

A slim-taper fine-cut triangular file 8 or 10 inches long is used for filing a screwdriver blade to shape and for filing small parts. Do not use this for filing a soldering-iron tip or for filing soldered joints, as soft solder will quickly fill in the fine grooves and make the file useless.

A flat second-cut machinist's file $\frac{3}{4}$ or 1 inch wide and 8 or 10 inches long is used for rougher work, such as filing the tip of an ordinary soldering iron and filing mounting brackets of new parts when they are too big.

A second-cut round or rat-tail file $\frac{5}{16}$ inch in diameter and 8 or 10 inches long is handy for enlarging round holes in a chassis when you do not have the required large drill or reamer.

After a file has been used for a while, the grooves between the teeth become clogged with metal, and the teeth themselves become dull. You can clean a file by scraping out the metal from each groove in turn with a needle, but this does not sharpen the teeth themselves. It is far better to discard a clogged file in favor of a new one.

With files, as with so many of the other tools you will use, it is better to pay a few cents more to get a well-known make having a quality you can rely on.

Hacksaw. Replacement volume controls and some types of switches come with extra-long shafts that must be sawed to the correct length. For this you will need a hacksaw on your workbench right from the start.

Here, however, you can get along with a cheaper tool, since you will use it only occasionally and for light work. It does not even have to be adjustable in length. Blades with 24 teeth to the inch are most useful and are easily obtained.

Always keep a few extra blades on hand, as they break easily. New hacksaw blades are cheap, so replace the blade whenever it gets dull. You will save time and do better work with a sharp blade.

To replace a hacksaw blade, unscrew the wing nut at the far end of the saw or unscrew the handle, according to the type of saw you have, until the blade slides off the holding pins. Put the new blade over these pins, with the blade teeth pointing *away from the handle,* and tighten.

Take long, slow strokes when sawing, to distribute the wear over more teeth and to make the blades last longer. Apply steady pressure on the pushing-away stroke so you can see filings fall down. Ease up the pressure on the pullback stroke.

To start a hacksaw when cutting metal, nick the work with a fine triangular file at the correct point and start the saw in the nick.

When using a hacksaw, put the work in a vise whenever possible. If the work slips when held in the hand, the saw blade may break and cut your hand.

Drill. When replacing defective parts, it is frequently necessary to make new mounting holes. An ordinary breast or hand drill that will take up to $\frac{1}{4}$-inch-diameter round-shank drills is quite adequate to start with. Both types are shown in Fig. 3.

A breast drill has a curved top piece that fits against your chest for applying pressure when drilling, but usually the work must be placed on a chair or on the floor to take advantage of this. A hand drill is easier to use at bench height, but here all pressure must be applied with the left hand while turning the drill with the right hand. Many servicemen get extra pressure on a hand drill by using their chin also, on top of the handle.

You can get along with only five drill points at the start, because the sizes of bolts used for mounting parts are pretty well standardized. These five drill sizes are No. 4, 10, 18, 28, and 33. If ordering drills by diameter in inches, get the next larger equivalent of each, such as $\frac{7}{32}$ inch for No. 4, $\frac{13}{64}$ inch for No. 10, $\frac{11}{64}$ inch for No. 18, $\frac{9}{64}$ inch for No. 28, and $\frac{1}{8}$ inch for No. 33.

The cheaper carbon drills are satisfactory for a breast or hand drill. Keep at least two of each size of drill on hand, so that you can replace dull drills frequently. Since the two smaller sizes break frequently, it is even better to start with four of each of these. Carbon drills cost so little that it is cheaper to replace them than to pay for sharpening.

Sharp drills are desirable from a safety standpoint also. With a dull drill you have to apply so much extra pressure that the drill may break and damage parts in the chassis and may cut your hands as it skids.

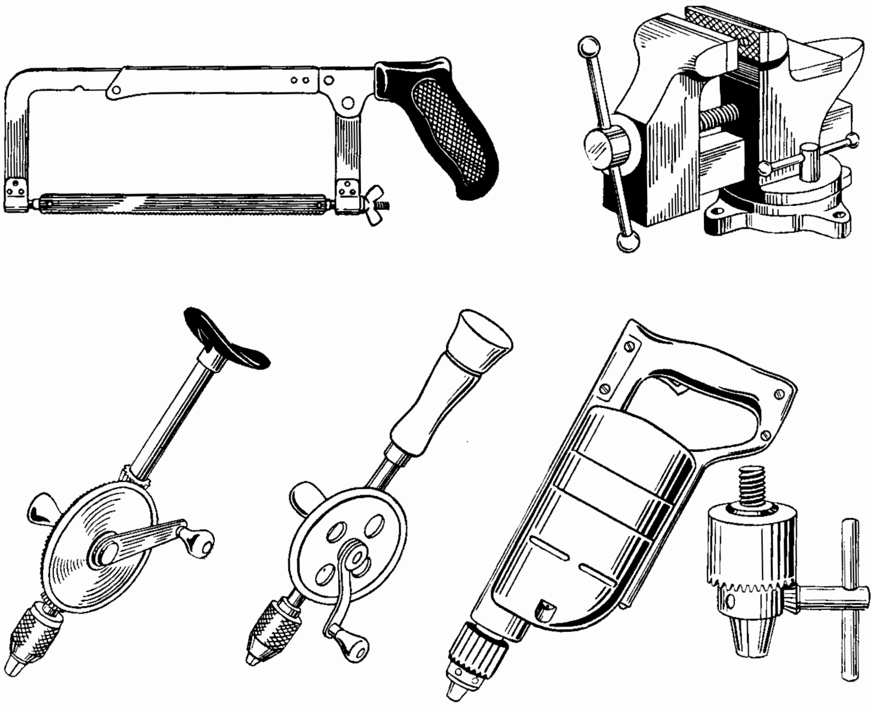


Fig. 3. Hacksaw, vise, breast drill, hand drill, electric drill, and Jacobs chuck with key, all suitable for bench use in a servicing shop

When drilling, especially when using the smaller sizes of drills, be sure your work is rigid. All drills are highly tempered hard steel and will snap viciously when they break, producing sharp-edged pieces that can cut your hands. Never let anyone hold the work for you when drilling, because of this danger. Support the work in a vise if possible, so it cannot slip or move when you apply the required drilling pressure.

Apply enough pressure to a drill so that the cutting edges bite into the metal instead of sliding over it. If drilling on a chassis, put a block of wood under the drilling location so you can apply pressure without risk of damaging other parts. Ease up on the pressure just before the drill bites through, and turn slowly from then on. If the point of the drill jams in the last big shaving, back out the drill to get clear, then turn still more carefully to break up the shaving.

When drilling hard material such as a steel chassis, or when a large hole is required, make a small hole first. You can then change to the larger final drill and easily enlarge the hole.

Electric Drill. A ¼-inch electric drill is a highly desirable substitute for a breast or hand drill. A type designed for light, intermittent duty is adequate if of a reliable well-known make. A drill with a key-type Jacobs chuck like that shown in Fig. 3 is best for your use.

A good electric drill can now be obtained for $20 to $25. It will soon pay for itself in time and energy saved if doing full-time servicing. With electric drills, use high-speed drill points rather than the carbon type.

Larger electric drills taking up to ½-inch drills are not recommended for routine service work because they are heavier and clumsier, and generally run at slower speeds that require too much pressure when working on a chassis.

Hammer and Punch. A drill will skid on a smooth piece of metal when starting, unless you first punch a depression at the correct point. For this you need a hammer and a center punch. The hammer need not be expensive, but be sure that its head is firmly anchored to the handle. An ordinary carpenter's hammer, of medium weight such as 16 ounces, is best as it can be used also for installing antenna systems.

Spend a few pennies extra to get a really good center punch. Chrome-vanadium steel center punches are swell, and cost only about 50 cents each.

Before using a punch or chisel on a chassis, remove all the tubes. If possible, place a block of wood on the opposite side from where you plan to punch. The larger the drill point, the larger must be the starting depression and the harder you will have to hit the punch with the hammer.

Drilling Out Rivets. The easiest way to remove rivets is to drill them out with an electric drill or hand drill. Use a drill slightly larger than the body of the rivet. Sometimes it is easier to start with a small drill, and then enlarge the hole. Make a starting hole for the drill point with a center punch. You can drill out either the head or the flattened end of the rivet, depending on which is easier to get at.

If the rivet begins to turn with the drill after you have drilled awhile, try to break off the rest of the rivet with side-cutting pliers or a sharp cold chisel. A rivet usually does not start turning until the drill has almost cut through. Always remove tubes before doing any heavy pounding on the chassis.

If the rivet persists in turning yet cannot be cut off easily, move the chassis so the undrilled end of the rivet is against a bench vise or other heavy metal part. Now drive a center punch into the partly drilled hole. This tightens the rivet and prevents it from turning, allowing you to finish the drilling. If a helper is available, it may be easier to have him hold a heavy hammer against the other end of the rivet while you tighten it with the center punch.

Replace rivets with conventional nuts and bolts. Always use a lock washer under the nut. Vibration set up by the speaker or power transformer may loosen the nut if the lock washer is omitted.

Cold Chisel. A cold chisel is used chiefly for cutting off the heads of rivets. Get a high-quality chrome-vanadium steel chisel, with a ½-inch-wide cutting edge.

Heavy work with a chisel on a chassis can damage other parts and loosen soldered joints. For this reason, when enlarging a chassis opening for a power transformer or other part, drill holes first along the cutting line, as close together as possible. Light taps on a sharp cold chisel are then enough to cut out the metal between the drilled holes. Finish with a file to get a neat straight or curved edge.

Vise. A hacksaw can be used best when the object being sawed is held in a vise. One with jaws somewhere between 2 and 3 inches wide is adequate for service work. It can be the type that clamps onto the bench and is readily removed, provided your bench top projects enough to give room for the vise clamp.

Some bench tops are flush with the sides or are too thick for clamping on a vise. In this case, fasten a 1½- by 1½- by 4-inch block of hardwood to the side of the bench at a convenient location for clamping on the vise when needed, or get a vise that can be fastened with screws, as shown in Fig. 3.

Workbench Suggestions. At the start you can get along quite well with a simple bench or even a plain table. Eventually, however, you will want to build something that looks impressive and provides convenient places for all your equipment. Study the benches used by other servicemen, and make notes of the ideas and designs that appeal to you.

The construction features and dimensions given in Fig. 4 can serve as a starting point or even as the complete building plan for your own bench. The complete bench in Fig. 5 illustrates how bench dimensions and features can be changed to suit personal preferences.

The working surface of your bench should be somewhere between 36 and 40 inches high, depending on your height. This is about 10 inches higher than a carpenter's bench. The extra height is needed so you can work comfortably on sets while standing up, as well as while sitting on a high stool.

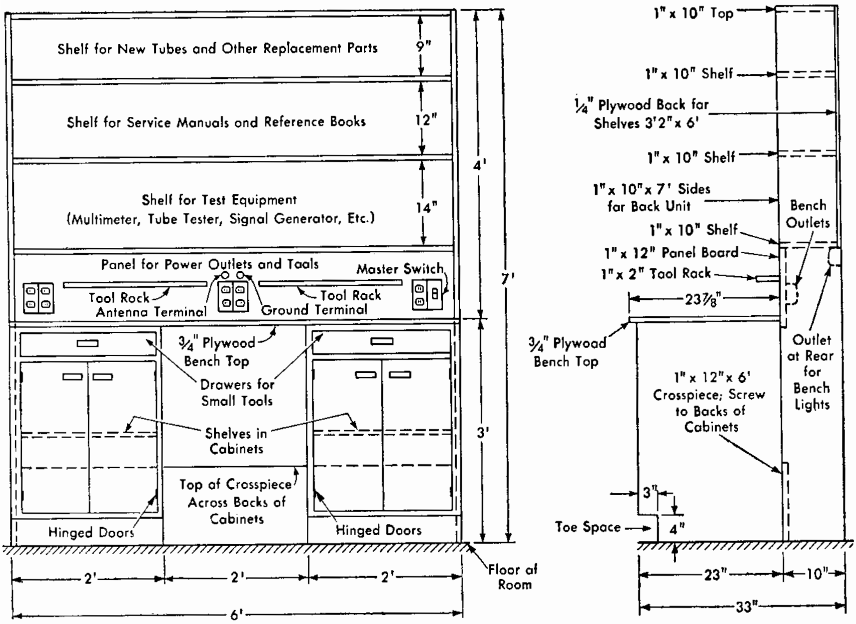


Fig. 4. Suggested construction of easy-to-build television and radio service bench. Shelves at rear are made separately and attached to bench with angle brackets and wood screws. Base units can be purchased assembled but unpainted, simplifying carpentry work

A one-man bench does not have to be more than 6 feet wide and 2 feet deep on the working surface. If you make a bigger bench, it merely becomes a storage shelf for sets and parts, and it never looks good. Build extra shelves elsewhere in your shop for storing sets.

The working surface of a bench can be a piece of linoleum, ¼-inch or thicker plywood, or ⅛- or ¼-inch Masonite Presdwood laid over ordinary boards. Cracks and joints are undesirable in the working surface because small screws get lost in them. Most servicemen prefer Masonite for the top. Never use a metal top, because it can be a shock hazard. For the same reason, do not place decorative metal edging across the front of your bench.

Fig. 5. Example of good service bench having many of features described in this chapter. Bench should be located for shortest possible path to car or truck, so heavy television sets will not have to be carried too far. (Sylvania photo)

Bench Supports. Leave the center portion open under the bench so you can get your knees under when sitting on the stool. Shelves or drawers can be built on each side for storage of spare parts. Drawers are best, though more difficult to make. With drawers, you can easily see everything in them. With cabinets or shelves under the bench, you can only see things that are stacked in front.

Kitchen-cabinet base units with drawers are ideal for the base of a service bench. These units come completely cut and sanded, but are sometimes unassembled and unpainted. You need only a hammer, screwdriver, and glue to assemble them. Cabinet units can be obtained from some mail-order houses, department stores, or furniture stores at way less than a carpenter's charges for making them.

Mail-order firms and lumber yards sometimes will sell ¾-inch plywood that is cut in 2-foot-wide strips for use as sink tops. The cost is about $1 per foot of length. These strips can be placed on top of the drawer units to give you a complete workbench base with a minimum of carpentry work.

Individual drawers in housings are also available, ready to be screwed in position under the center of the bench. These drawers can also be set into the tool board at the back, for holding small tools and hardware.

Bench Back. At the back of your bench you will want a rack for holding power outlets, tools, test equipment, service manuals, and reference books. Keeping the top of your bench 2 feet deep or less makes it easy to use these instruments without taking them off the shelf. At the beginning and for spare-time servicing, a simple shelf for test instruments is entirely adequate.

Bench Tool Rack. There should be a place for every single tool on your bench or in drawers underneath. Spring-type holders for tools can be obtained in hardware stores. Another way, used on the bench in Fig. 5, is to drill holes of various sizes in a 1- by 2-inch strip of wood and to screw this strip to the back of the bench. Screwdrivers, pliers, and many other small tools fit nicely into a rack of this type.

Bench A-C Outlets. Your bench should have plenty of electric outlets. You need one for the soldering tool, one for the tube tester, and one for the set being worked on. Additional outlets are desirable for letting sets run a few hours after they have been repaired, for the electric drill when you get one, and for a host of other purposes. Eight outlets are none too many. These can be on the back of the bench, arranged two on each side and four at the center as indicated in Fig. 4. Put another outlet box behind the bench back, for plugging in the overhead lights of the bench.

All of these outlets will take a lot of punishment, so stay away from the bargain counter and dime store when buying them. Get the very best grade obtainable, at an electrical supply store, and be prepared to pay about three times the price of corresponding cheap units. Spring contacts in cheap outlets lose their tension quickly and fail to grip or even touch the prongs of plugs.

Regular wall outlets with plastic mounting boxes and plastic surface plates are ideal for benches. With plastic boxes, you can connect the outlets together with nonmetallic-sheathed cable or even ordinary lamp cord instead of hard-to-handle BX.

Use a line cord and plug for the electrical system of your bench and plug it into an existing electrical outlet in the room. If bench wiring is permanently connected to the wiring system of a building, the job must be done by an electrician or at least pass official inspection if fire insurance is to remain valid.

Master Switch for Bench. It is a good idea to have one master switch on your bench. This is connected to the line cord serving the whole bench, including bench lights, as indicated in Fig. 6. The master switch then turns off the lights along with everything else on the bench. The lights are a reminder for you to turn off the switch when you leave the bench. This arrangement eliminates the fire hazard of leaving a soldering iron and other devices plugged in all night with power on. The master switch can be a standard toggle switch on a wall plate, mounted alongside the right-hand pair of outlets.

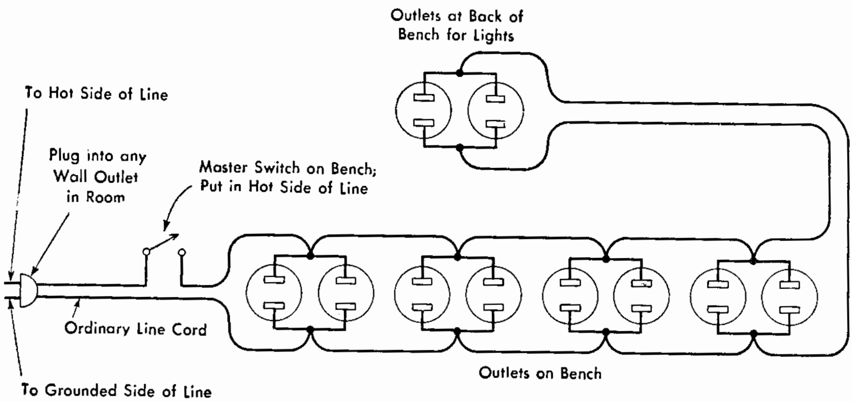


Fig. 6. Suggested wiring arrangement of a-c outlets and master switch for service bench

Workbench Lighting. Provide plenty of light for your workbench. Two or preferably three 100-watt lamps in reflectors will serve nicely for overhead lighting. Aluminum reflectors made for photographic use are ideal here because they can be adjusted to the most effective angle. They come complete with socket and line cord for about $2. This cost is about the same as that of individual sockets and enameled metal shades, but sockets require a lot of installation work.

Photographic reflectors can be clamped to ceiling rafters in a basement or to any supporting rod mounted horizontally above the bench for this purpose. When more light is needed for close work, you can easily take one of the reflectors down temporarily. A reflector designed for No. 1 photoflood lamps will hold a 100-watt bulb perfectly.

Better still for close work on the bench is a gooseneck-type desk lamp that can be moved around and adjusted easily to give light exactly where needed on a chassis.

Fluorescent lights for a bench are expensive and at times also a nuisance. These lights can cause electrical noise interference in the radio sets on which you are working, unless well made and completely shielded and grounded. If you prefer fluorescent lighting, get high-quality two-lamp fixtures that have the proper built-in ballasts and filter condensers to give steady light with a minimum of electrical interference.

Reference Library Shelves. Shelves are needed on a bench for service manuals, reference books, tube manuals, and catalogs. The shelf dimensions shown in Fig. 4 give room to get your fingers over the top of the largest service manual when taking it down. Stocks of new tubes and parts can be kept on these shelves also.

Assembling a Bench. When building a bench, bear in mind that you may some day have to move it. Assemble it in sections that fasten together with wood screws and angle brackets. The working top can be fastened to the base sections with metal brackets. Fasten these underneath the top with short wood screws, so no screwheads show on the top surface of the bench.

Make sure that each section of your bench will go through all doors. Benches represent a large investment of time and money, so preserve your investment by planning for portability.

After assembling your bench, spend at least 2 hours sanding it smooth and rounding off all sharp edges and rough corners. Get half a dozen large sheets of 1/0 garnet paper, which cuts faster and lasts much longer than ordinary sandpaper. Tear the sheets into convenient smaller sizes to fit around a sanding block. Thorough sanding can do much to give a professional appearance to your bench.

Fill in all cracks and holes with plastic wood if they are in locations that show. Overfill each hole since plastic wood shrinks a bit when drying. Sand down all filled areas after the plastic wood has dried.

Painting the Bench. Most service benches are finished in colored enamel. Use enamel undercoater first, then either one or two coats of the desired color of enamel.

Spar varnish also gives an attractive finish on new wood, and is easier to apply. For the first coat, thin out by adding 25 per cent turpentine, and sand this down lightly after it dries. This varnish is particularly good for the working surface of your bench if you are using plywood or Masonite. Another easy-to-apply finish that is good-looking on well-sanded new wood is a combination stain and wax such as Minwax.

Hardware and Supplies. Many different kinds of screws, bolts, washers, fasteners, springs, and other small parts are used in television and radio sets. These occasionally need replacement, but they can be obtained in convenient small assortments from your jobber as needed.

Assortments of machine screws, nuts, and lock washers are used for mounting new parts. The 6-32 and 8-32 sizes are the ones you will use most. The first number in the screw size refers to the diameter of the screw and is proportional to the diameter; thus, 8 is thicker than 6. The second number tells the number of threads per inch; most radio screws have 32 threads per inch.

Many different kinds of cements and chemicals are available for servicing work. Here again you can order as needed. Speaker cement will be used most of all. Get one tube of this for your toolbox and either a tube or a jar for the bench. You can use it for cementing practically anything that gets loose on a receiver.

Cement solvent will be needed on the bench for loudspeaker repairs and for getting speaker cement off your fingers. The chapter on loudspeakers covers its use fully.

A can of fine machine oil can be obtained from any gas station and is used for lubricating shafts and tuning mechanisms.

Carbon tetrachloride is used for cleaning metal parts. You can probably buy this cheaper from your local drugstore than from a radio jobber.

Furniture polish and some form of scratch remover are needed for freshening up wood cabinets, as described in the chapter on cabinet repairs.

Start out with a 1-pound spool of rosin-core solder, as specified in the chapter on soldering. Unwind a few feet from this to roll up separately for your toolbox. Get the fine solder made especially for television and radio work.

Get a 25-foot coil of solid tinned insulated hookup wire for the bench. Take off a few feet of wire for your toolbox. You do not need much wire for repair work, so this is plenty for a start.

Cheater Cord. Practically all television sets are made in such a way that the receiver end of the line cord comes off with the back cover. This is a safety precaution for users, so they cannot get a shock if they touch the high-voltage terminal inside the set. For servicing, however, you have to be able to operate the set with the back cover removed. Television-receiver line cords made for this purpose are called cheater cords. Get one from your jobber when you start working on television sets. Put it in the toolbox whenever going on home calls for television, as it is needed even for replacing tubes.

Workbench Antennas. For testing radio receivers, run about 25 feet of insulated wire of any type from your workbench up to the ceiling of the shop and then along the ceiling in a straight line. It is best to run the wire crosswise to pipes and other wiring, but even this is not critical. Attach a small battery clip to the end of the wire at the bench, to speed up connecting this wire to a receiver. Do not use more than about 25 feet of wire, because a longer antenna can overload some radios and cause distortion that did not exist for the customer.

For testing television receivers, you will eventually need a good rooftop television antenna, with a twin-lead transmission line running down to the workbench. Instructions for installing television antennas are given in a later chapter.

QUESTIONS

1. Name two advantages of a soldering gun over a soldering iron.
2. What three types of tools are needed for bending, holding, and cutting wires?
3. Why should one blade of your toolbox pocketknife be kept razor sharp?
4. Why is a flashlight an essential servicing tool?
5. What type of drill requires high-speed drill points?
6. If a rivet starts turning after it is partly drilled out, what should be done?
7. What length of bench gives enough working space for one serviceman?
8. Why is a master switch desirable for a workbench?
9. What type of finish will you use on your own workbench?
10. What is a cheater cord used for?

3

How Television and Radio Sets Work

Extra Knowledge Pays. In servicing, your interest in broadcasting begins at the receiving antenna, where the desired radio wave is picked up and fed to a television or radio set. To fix the set, you do not need to know how the program was produced, how it was changed into a radio wave, or how that radio wave got through the sky. You just need to know how to find, test, and replace the bad parts, as illustrated by Fig. 1.

To make top money in servicing, however, it helps to know a little more than how to fix sets. When a customer asks questions about television and radio, simple answers will boost your reputation and your income.

The average person knows little about what is inside a television receiver, so his questions are more likely to be about simple things outside the receiver. He may ask why television antennas have to be aimed carefully in some locations. He may ask why f-m radio is supposed to be better than ordinary a-m radio.

Questions like these will be easy to answer if you have a conversational knowledge of the three kinds of broadcasting systems that are being used today. This chapter gives you the whole story, so you can satisfy your curious customers. They will be impressed because they can understand your answers, and will give you credit for knowing so much. They will respect you as a professional serviceman. They will recommend you to others. Best of all, they are much more likely to pay your bill without questioning or quibbling.

Whenever servicemen discuss television or radio, the word *frequency* is heard many times. Frequency is actually one of the most important technical terms you will use in servicing. For this reason, the meaning of the word will be explained before the three kinds of broadcasting systems are taken up.

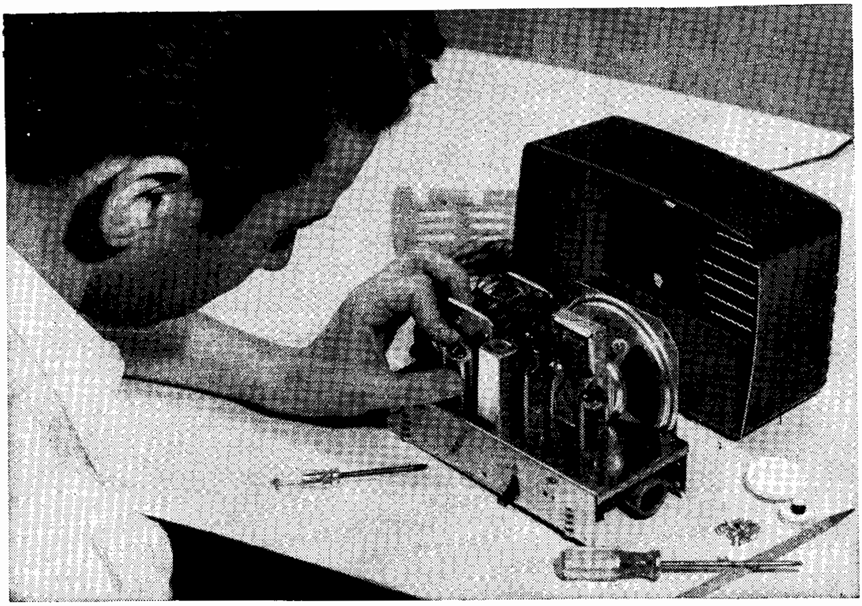


Fig. 1. This radio set was fixed by replacing one bad tube, without even thinking about how the set actually works. It pays to know more than is needed, however, because curious customers often ask semitechnical questions

Frequencies of Sounds. The number of times per second that anything vibrates is called its *frequency*. A big bass drum might vibrate 30 times a second when hit. This means that it goes through 30 complete back-and-forth movements of its stretched skin in one second. Each of these back-and-forth movements is called *one cycle*. The drum would thus have a frequency of 30 cycles per second.

You can actually feel the compression parts of a sound wave when the drummer goes by in a parade. If you are holding an opened newspaper, you will feel the sound waves still better because the air compressions move the newspaper back and forth. Sound waves can thus make other objects vibrate.

When you strike the key for middle A on a piano, a hammer inside hits a wire string having exactly the correct length to vibrate 440 times per second. The resulting sound has a frequency of 440 cycles.

When the musician draws his bow across the thinnest string of his violin, a much higher frequency is heard—perhaps as high as 4,000 cycles. Each sound in this world has its own frequency. The shriller the sound, the higher is its frequency.

The human ear has definite limits on what it can hear. The lowest frequency that the normal ear can detect is about 16 cycles. The highest is somewhere around 20,000 cycles. The frequencies between these limits are known as *audio frequencies* because they can be heard.

The term audio frequency is often abbreviated as a-f. When you use abbreviations like this in conversation, just pronounce the letters.

Frequencies of Electricity. The electricity flowing through power lines to homes has a frequency also. This electricity goes through 60 complete cycles of change in the direction of flow each second, so its frequency is 60 cycles per second. For convenience, the expression *per second* is usually dropped.

For every frequency of a sound wave, an electrical signal can have the same frequency. Signals like this are called *audio-frequency signals* or *a-f signals*. The range of a-f signals is about 20 to 20,000 cycles per second, the same as for sound waves, as shown at the left in Fig. 2.

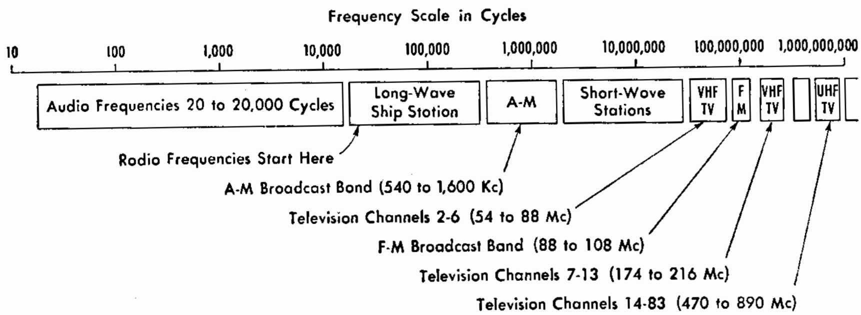


Fig. 2. Frequency chart. Frequency limits for the five bands in which home receivers operate are listed below the boxes. Remember that 1,000 cycles is 1 kc, and 1,000,000 cycles is 1 mc

Electricity can easily be made to go through way more than 20,000 complete cycles of change in direction per second. Electrical signals whose frequencies are higher than about 20,000 cycles per second are called *radio-frequency signals,* abbreviated as *r-f signals.*

The radio frequencies from 20,000 up to 540,000 cycles are not used for commercial broadcasting and cannot be picked up by ordinary radio sets. Merchant marine and military stations use these frequencies, chiefly for communication with ships at sea.

Kilocycles and Megacycles. It is awkward to write strings of zeros after numbers when dealing with radio frequencies. For this reason, two larger units are used in places of cycles.

Kilocycles means *thousands of cycles*. You will use *kilocycles* most in your work on a-m receivers. Kilocycles are abbreviated as kc. One kilocycle is equal to 1,000 cycles.

Megacycles means *millions of cycles*. You will use *megacycles* chiefly when working on f-m and television receivers. Megacycles are abbreviated as mc. One megacycle is equal to 1,000,000 cycles. Also, one megacycle is equal to 1,000 kilocycles.

Broadcasting Systems. The three distinct types of broadcasting systems in use today for bringing entertainment to homes by way of the air are a-m radio, f-m radio, and television. Each type will be taken up in turn in this chapter, after a quick look at the frequencies used by the stations in the three systems. The receivers used with each system will be emphasized, to prepare you for the practical servicing instructions that come later.

Station Frequencies. The diagram in Fig. 2 shows all of the frequencies that you will deal with in servicing television and radio receivers.

The regular a-m radio broadcast band extends from 540,000 to 1,600,000 cycles. To change these values to kilocycles, drop the last three zeros. The broadcast band thus is 540 to 1,600 kc. This is the range over which ordinary home radio receivers can be tuned.

Tuning dial scales of a-m broadcast receivers are seldom marked with the full frequency value in kc, because of lack of room for the zeros on the dial. Instead, one or even two zeros are dropped from each value.

Above the broadcast-band frequencies are the ranges covered by two-band, three-band, and all-wave receivers. Here you can pick up international broadcast stations, police calls, code stations sending messages in dot-and-dash form, and amateur radio conversations. This is commonly known as the *short-wave region*. It extends from 1,600 to 54,000 kc, or up to 54 mc, which is the first television station frequency.

Television station frequencies are in three bands. The first, called the *low vhf band*, or simply the low band, contains television channels 2, 3, 4, 5, and 6. The second, called the *high vhf band*, or high band, contains channels 7, 8, 9, 10, 11, 12, and 13. The third is called the *uhf band*, and contains 70 more television channels. The abbreviation vhf means very-high frequency; uhf means ultrahigh frequency.

Originally, 13 television channels were assigned in the vhf band, but the first one has since been dropped without renumbering the other 12 channels. The vhf television channel numbers and their frequency ranges are as follows:

	Channel No.	Frequency, mc
Low VHF Television Band	2	54–60
	3	60–66
	4	66–72
	5	76–82
	6	82–88
F-M broadcasting		88–108
High VHF Television Band	7	174–180
	8	180–186
	9	186–192
	10	192–198
	11	198–204
	12	204–210
	13	210–216
UHF Television	14–83	470–890

Between the f-m band and the high band for television are communications station frequencies of no interest to servicemen. Similar communication stations operate between the high vhf band and the uhf television band. Above the uhf television band are more communication stations, radar stations, and other special services that have no importance to home receiver servicing.

Frequency values alone are not enough to identify stations, as two or more stations may be assigned to the same frequency. Call letters are therefore assigned to each station for identification.

Call Letters of Broadcast Stations. Each television and radio broadcasting station is identified by its own call letters. Call letters beginning with K are assigned to radio and television broadcast stations located west of the Mississippi River and in U.S. territories such as Hawaii and Alaska. Call letters beginning with W are assigned to stations east of the Mississippi River. A few old stations, such as KDKA in Pittsburgh, are exceptions to this rule.

A-M Broadcasting System. The major units of an a-m broadcasting system are shown in Fig. 3. When the announcer speaks before the microphone in the studio, he produces *sound waves* that act on the microphone.

Microphone. A thin metal sheet or diaphragm in the microphone moves back and forth when a sound wave hits it. Attached to this moving diaphragm is an electrical device that changes the movements into a corresponding electrical signal called the *audio signal.*

The device inside the microphone may be a piece of crystal, a coil moving between the ends of a permanent magnet, or simply a corrugated metal ribbon moving between the poles of a permanent magnet. All types of microphones produce the same result—they change the sound waves into audio signals.

Microphone Cable. The audio signal produced by a microphone is an alternating electric voltage. To transfer the voltage from one place to another, wires are needed.

The wire that comes out from a microphone is called the *microphone cable.* This cable provides a path for transferring the audio signal to the audio amplifier that is the next part of the a-m broadcasting system shown in Fig. 3.

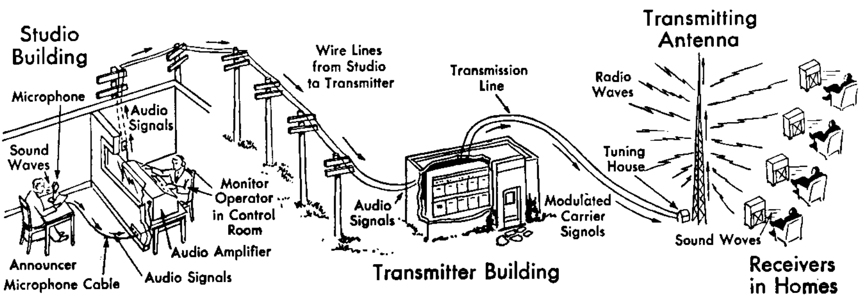


Fig. 3. Signal paths from microphone to receivers in typical a-m broadcasting system

Audio Amplifier. The audio signals coming from a microphone need to be strengthened many thousands of times. This electrical strengthening process is called *amplification.* It is done with radio tubes and radio parts in an audio amplifier.

A meter on the amplifier panel shows the strength of the audio signals. There is also a volume-control knob for changing the strength of the signals. The man at the control desk must keep the signal strength nearly constant, even though the singer or speaker in the studio moves around a lot.

From the control room, the strengthened audio signal travels over wire lines for miles to get out to the transmitter building. This transmitter is usually located outside the city.

A-M Transmitter. As soon as the audio signal gets inside the transmitter building, it is boosted in strength some more. The audio amplifier that does this is much like the one in the control room, only a lot more powerful.

The amplified audio signal is combined with the special radio-frequency signal needed to carry it through space. This radio signal is known as the *carrier signal*, and has the frequency that was assigned to that station by the U.S. government.

Why a Carrier Signal Is Needed. An audio signal, no matter how strong, would not travel more than a few hundred feet through space if fed to an antenna. This is why the audio signal must be combined with a higher-frequency signal that is capable of traveling great distances through space.

The carrier signal is generated in a vibrating quartz crystal, and is amplified by radio tubes to build up its strength or power. Next, both audio signal and carrier signal are fed into the same tube and combined. The result is known as the *modulated carrier signal*.

In smaller stations the modulated carrier signal is fed directly to the antenna tower. In larger stations, the modulated signal is usually amplified still more by huge power tubes.

The modulated carrier signal coming out of the transmitter building is still an electric current, so it travels through wires to the transmitting antenna. These wires can be one inside the other to give what is known as a coaxial cable. Occasionally the two wires are side by side, forming a transmission line.

There is usually a boardwalk alongside the wires going out to the antenna tower. Station operators use this when they have to adjust coils and condensers mounted in the little house at the base of the tower. Technically this house is called the tuning unit, but operators usually speak of it as the doghouse.

A-M Antenna Towers. Many different kinds of antenna towers are used by a-m broadcast stations. Some are tall and some are short. Some are thick and some are thin. Some stand up by themselves, while others require guy wires to hold them erect.

The height of the tower for an a-m station is carefully tailored to match the frequency assigned to the station. The higher the assigned frequency, the shorter is the tower needed. You will find that this simple rule holds true for everything in radio and television. Remember—the higher the frequency, the shorter is the antenna needed. Both f-m and television stations use much higher frequencies than a-m stations; hence their transmitting and receiving antennas are much shorter than for a-m.

A transmitting antenna tower changes the modulated carrier-signal current into *radio waves* that travel away from the tower in all directions. These radio waves travel with the speed of lightning but are invisible.

What they actually are does not matter now, because even scientists are not too sure about it today.

A-M Receiving Antenna. The radio waves that carry an a-m radio program away from the transmitting antenna are changed back to sound waves by a receiver. The first part of a receiver is the antenna on which the radio waves act.

Many different kinds of receiving antennas are found in homes. In modern radios, loop antennas mounted at the back of the cabinet are the commonest. No matter what the receiving antenna looks like, however, it has just one job. It changes the radio wave back into an electric current. This carrier-signal current is exactly like that which flowed up the transmitting antenna tower, except for being much weaker.

A-M Superheterodyne Receiver. All television receivers, all auto and portable radios, and practically all the radio receivers used in homes today are superheterodyne receivers, usually called *superhets.* These sets have four main sections between the receiving antenna and the loudspeaker, as shown in Fig. 4.

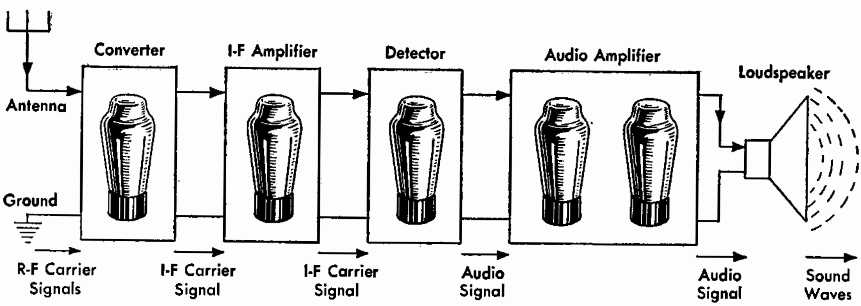


Fig. 4. Circuit arrangement in an a-m superheterodyne radio receiver

The converter in a superhet changes the carrier frequencies of all incoming signals to a fixed lower carrier frequency known as the intermediate frequency, or i-f. In modern radio sets the fixed i-f value is 455 kc.

Most of the amplification in superhets is done in i-f amplifiers. The i-f carrier signal still contains the original audio signal. The detector separates this audio signal from the now-unwanted i-f carrier.

In the audio amplifier are tubes that boost the strength of the audio signal enough to operate the loudspeaker. The first tube in this section is called the first a-f tube. The last tube is called the a-f output tube or the power tube. If there are three a-f tubes, as in some large radios, the second is known as the second a-f tube.

The loudspeaker has a large paper cone or diaphragm that moves back and forth to produce sound waves when a strong audio signal is fed into it. In this way a loudspeaker gives back the original sounds produced in the studio.

How a Superhet Converter Works. The converter section of a superhet receiver contains two separate stages: the *r-f oscillator* and the *mixer–first detector*. Both of these stages have tuning circuits that are controlled by a single tuning knob on the front panel of the receiver.

Whenever you tune a superhet to a new station, you are tuning the r-f oscillator so it generates a frequency 455 kc higher than that station's frequency. The mixer–first detector combines these two signal frequencies to produce a new carrier signal whose frequency is exactly the desired 455-kc i-f value.

The mixer stage in a superhet receiver is also called the first detector because it has the job of detecting or separating out the i-f signal. The detector stage that does the real job of separating the audio signal from the rest in a superhet is therefore usually called the second detector. You will be using all of these terms a lot in your work, so it is a good idea to get familiar with them now.

Tuning Action. A receiving antenna intercepts radio waves from many different stations and changes them all into carrier-signal currents, each having a different carrier frequency. Tuning action is needed to separate the one desired station frequency from all the others.

When a coil and condenser are connected together, the combination works best at one particular frequency. Changing the electrical value of either part changes the frequency at which they work best. This is tuning action, found in every television and radio receiver. Usually the condenser value is changed by means of a variable condenser like that shown in Fig. 5.

When the plates of a variable condenser are fully closed or meshed, the combination tunes to the low-frequency end of the band. When the plates are fully unmeshed, the combination tunes to the high-frequency end of the band. This is illustrated for the a-m broadcast band in Fig. 5.

Modern receivers use two or more variable condenser sections mounted on the same shaft. Each section has its own coil. With a two-section or two-gang tuning condenser, one section tunes the mixer circuit to the desired station frequency. The other section then tunes the oscillator to a frequency 455 kc higher.

With a three-gang tuning condenser, the extra section tunes an r-f amplifier stage located between the antenna and the mixer. This one-tube stage has two jobs. First, it amplifies a weak desired signal before this signal gets changed to the i-f value. Second, the r-f stage provides additional tuning action (improved selectivity) to keep undesired signals out of the receiver circuits.

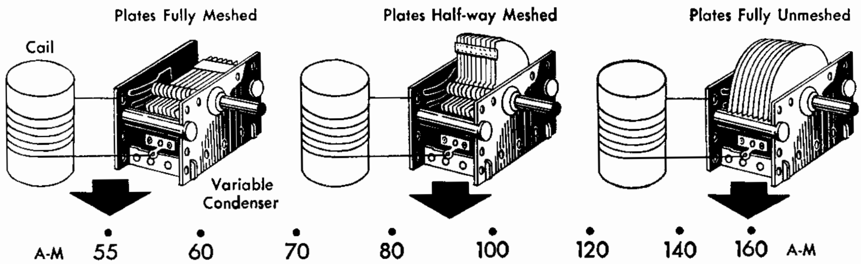


Fig. 5. Positions of tuning condenser rotor plates for three different frequencies in the a-m broadcast band. Remember that fully meshed plates give the lowest frequency

Getting Power for Receivers. When radio tubes are used to boost the strength of a signal, power is added to the signal. This power has to come from somewhere—either from power lines or from batteries. Practically all television receivers and home radio receivers get their power from the power lines that serve homes.

In the early days of radio, batteries provided the power required to operate the tubes. When engineers learned how to make radio sets operate directly from power lines, batteries went out of the picture for a while. Today batteries are back again in portable receivers, in auto radios, in tiny new vest-pocket receivers, and in farm radios for homes that do not yet have electricity.

F-M Broadcasting System. Just before World War II an entirely new system of radio broadcasting, called *frequency modulation* or simply f-m, was introduced. This system uses transmitters of its own, operating on an entirely different principle from a-m transmitters, and requires special receivers. Older sets intended for reception of standard a-m broadcasts cannot pick up f-m programs. Many of the newer sets have an extra band for f-m so that they can pick up either type of program.

Frequency-modulation broadcast stations operate in the frequency band between 88 and 108 mc. This is very much higher in frequency than ordinary all-wave a-m receivers tune to, so special short antennas are needed for f-m. The signals of an f-m station cannot ordinarily be heard farther than about 100 miles from the station.

Within the service radius of an f-m station, the signal obtained is almost entirely free from static. The f-m signal is usually also better in fidelity (naturalness) than that of an a-m station. An f-m station can legally broadcast a much wider range of audio frequencies than a-m broadcast stations are allowed to do. This means that f-m stations can broadcast such high-frequency sounds as the tinkle of bells, the squeak of a door, and the highest notes of string musical instruments, such as the violin. Of course, f-m receivers must be better technically to take advantage of this higher fidelity. Poorly designed or poorly adjusted f-m sets can sound horrible.

F-M Transmitter. Up to the point where the audio signal arrives at the transmitter building, f-m and a-m systems differ only in quality of equipment. Higher-quality amplifiers and microphones are used in the f-m studio to provide the higher-fidelity program. Now let us see how f-m really differs from a-m.

In an a-m transmitter, the process of modulation (mixing the carrier signal with the audio signal) is done in such a way that the *strength* of the carrier signal is varied by the audio signal. In f-m, however, it is the *frequency* of the carrier signal that is varied or modulated by the audio signal. This is where the name frequency modulation comes from.

F-M Transmitting Antennas. The range of an f-m station is limited essentially to the line-of-sight distance from the transmitting antenna to the horizon. The higher a tower is, the farther you can see from it. The higher an f-m transmitting antenna is, the farther the f-m radio wave can travel in a straight line to points on the earth. For this reason, the antenna of an f-m transmitter is located at the highest conveniently available point in a community. Sometimes the antenna is on top of a mountain or hill. Sometimes it is on top of a tall steel tower that is also used by an a-m transmitter.

Line of sight means that, if you can see the f-m transmitting antenna with your eyes or even with a telescope on a clear day when standing alongside your f-m receiving antenna, you can receive the program with an f-m receiver. The higher the transmitting antenna, the greater is the distance from which it can be seen.

There is some bending of f-m radio waves along the curved surface of the earth, so good reception can often be obtained beyond line of sight.

The higher and better the f-m receiving antenna and the more sensitive the f-m receiver, the better will reception be. Similarly, the higher the power of the f-m transmitter and the higher its transmitting antenna, the greater will be the distance at which its signals can be regularly picked up.

Many f-m sets will work with built-in antennas if located within about 10 miles of stations. Some f-m sets have a simple connection to the power line for signal pickup. Other sets have built-in loops containing only one or two turns of wire. Best f-m reception is obtained with a television-type antenna located in the attic or on the roof of the house, however.

F-M Receiver. Except for just one stage, an f-m receiver is about the same as a superheterodyne a-m receiver. This different stage is the discrimi-

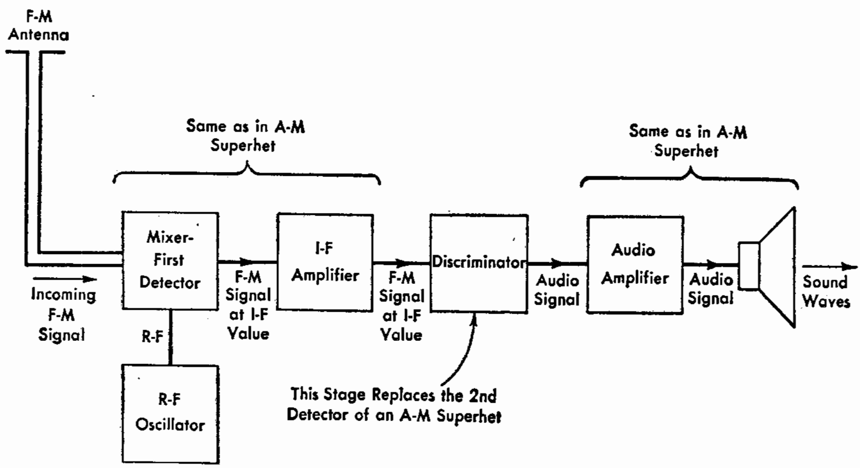


Fig. 6. Circuit arrangement in an f-m superheterodyne receiver

nator, which replaces the second detector as shown in Fig. 6. The r-f oscillator signal still combines with the incoming signal in the mixer to produce an i-f signal, just as in an a-m superhet. The i-f value will usually be 10.7 mc, which is much higher than the standard 455-kc value for a-m radios.

The job of the discriminator is to remove the audio signal from an i-f carrier signal that is swinging back and forth in frequency at an audio rate. The discriminator delivers the desired audio signal to the audio amplifier, just as does the second detector of an a-m receiver. From there on, f-m and a-m receivers are identical in operation.

An f-m superheterodyne receiver tunes over a band ranging from 88 to 108 mc, and f-m tuning dials are generally marked directly in these megacycle values.

Variable condensers are used for tuning in some f-m sets. Other f-m sets employ a variety of unusual tuning arrangements involving sliding bars, moving plungers, or adjustable coils. You will find, however, that all are quite easy to fix once you get acquainted with them.

There will usually be more i-f amplifier tubes in f-m receivers than in a-m receivers. Sometimes the last i-f amplifier tube is called a *limiter*. This tube passes only signals that are *below* a certain strength. It is adjusted to pass the desired constant-amplitude f-m signal. It then blocks or limits any undesired noise peaks that are stronger than the signal. This limiting action is what removes static crashes from f-m programs. An f-m receiver gives enjoyable listening even during thunderstorms, whereas a-m radios are so noisy in storms that they must usually be turned off.

Some f-m sets have two limiters, to give still further suppression of undesired noise. On the other hand, there are f-m sets that have no limiters at all. These sets use a ratio detector in place of the discriminator. The ratio detector is the same tube connected in a slightly different way, so that it suppresses noise at the same time that it detects the audio signal.

Television Broadcasting System. Television is a combination of the two broadcasting systems you have just covered, along with some new techniques. Television uses f-m to bring in the sound portion of a program and uses a-m for the picture portion.

Sound System for Television. A complete television broadcasting system is really two systems in one. The sound portion is already familiar to you, so a brief review will take care of it for now.

In the television studio, the microphone on the boom over the performers picks up the sounds and converts them to audio signals. These signals travel through the microphone cable to the control room where they are amplified. The audio signals then go over wires to the transmitter in another room in the building.

In the transmitter room, the audio signals are fed to the f-m transmitter that broadcasts the sound portion of the program. This transmitter operates at the high-frequency end of the 6-mc-wide channel assigned to that television station. The picture transmitter operates at the low-frequency end of the channel. Thus, for a station on channel 2 (54–60 mc), the sound carrier is on 59.75 mc and the picture carrier is on 55.25 mc.

The sound- and picture-carrier locations within a 6-mc-wide channel are the same for all television channels, so the two carriers are always 4.5 mc apart. By keeping all channels alike in this way, it is possible to build television receivers in which both sound and picture of any television station can be tuned in accurately with one knob.

The sound carrier for a television station is changed to radio waves by the transmitting antenna. These radio waves travel through space to the receiving antenna.

The f-m receiver portion of the television receiver changes the resulting f-m signal current back to the sounds picked up by the microphone. Sound for television programs is thus handled very much as in the standard f-m broadcasting system.

Television Camera. The picture portion of a television program starts at the television camera. Here, lenses focus the desired scene onto a coated plate inside a large camera tube. This tube is known as the iconoscope, the orthicon, or the image orthicon, depending on which particular type is used.

The camera tube changes the picture at the studio into a corresponding picture signal. The job of the television camera thus corresponds to that of the microphone in a sound system.

Many elaborate electronic circuits are needed along with the camera tube. Each tiny speck of the projected picture image inside the camera tube must be changed into an appropriately weak or strong electrical signal. This must be done in the correct sequence so that every part of the picture is transmitted. This orderly sequence is also necessary so that the picture tube in a television receiver can reverse the process and paint the picture back on the viewing screen electrically.

Here are a few technical figures. The picture is transmitted as 525 separate horizontal lines. The process is repeated 30 times a second, which means that 30 complete snapshots of the scene are transmitted per second. The human eye sees these 30 glimpses of the scene as a continuously moving picture, because the eye is able to retain the impression of each glimpse for a fraction of a second. In medical language, this is called persistence of vision.

There is actually only one tiny dot of brightness on a television receiver screen at any given moment. This bright dot is varying continually in brightness. It moves along the lines of the screen so fast, however, that our eyes see only the complete picture.

From the television camera, the picture signal goes to the master control desk in an adjoining room. Here operators watch viewing tubes and switch from one camera to another as called for by the program director.

The picture signal must be accompanied by various synchronizing signals that will keep receivers in step with the transmitter. These synchronizing signals are broadcast along with the picture signal. They are sent out during the intervals when the screen is momentarily dark after the end of each line and after the end of each complete picture.

From the control room, the picture signal goes through special electrical cable to the picture transmitter in another room nearby. Here the picture signal is amplified and then combined with its own carrier signal.

After more amplification, the resulting modulated carrier signal travels over another cable to the transmitting antenna high above the transmitter building. This antenna serves for both the sound and picture transmitters.

Television Receiving Antennas. The same receiving antenna serves for both the sound and picture portions of a television program also. In locations close to television stations a built-in loop antenna in the set or a simple two-rod antenna in the attic can be used. Usually a more complicated antenna arrangement above the roof is needed for good television reception, however. A later chapter in this book tells how to install and adjust television antennas.

The reliable reception range of television signals is limited to about 150 miles because of the high frequencies involved, and is normally about 50 miles. This is much the same as for f-m. In hilly country, the range is less if hills block the straight line-of-sight path between transmitting and receiving antennas.

Television Receiver. The picture carrier signal from the television antenna is boosted in strength and tuned in much as for an ordinary a-m superheterodyne receiver. Because of the higher frequencies involved, the circuits and parts look different, but they work in the same way.

The second detector in the picture portion of a television receiver is often called the video detector, because it separates the picture or video signal from the picture carrier. This video signal is boosted in strength by the video amplifier tubes and fed to the television picture tube, as indicated in Fig. 7. There it causes the spot on the screen to vary in brightness from instant to instant.

The synchronizing signals that are transmitted to keep receivers in step come out from the video amplifier. These sync signals are used to drive horizontal and vertical sweep circuits.

The horizontal sweep circuit feeds a coil that makes the spot on the screen move back and forth over each of the 525 horizontal lines into which the picture is divided.

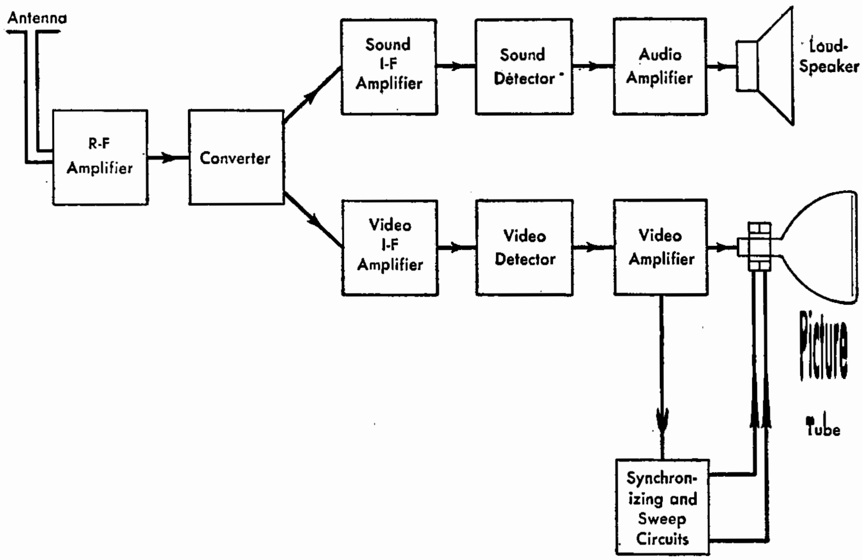


Fig. 7. Circuit arrangement used in older television receivers, in which sound and picture signals take separate paths right after the converter

The vertical sweep circuit feeds a coil that makes the spot move down to the next line when it reaches the end of one line. The vertical sweep also makes the spot move up to the top of the screen for a fresh start each time it reaches the bottom of the picture. Both the horizontal and vertical deflecting coils are mounted around the neck of the picture tube.

In the arrangement of Fig. 7, the television sound carrier signal travels with the picture carrier signal through the converter. At some point after this, the picture and sound i-f carrier signals are separated. The sound i-f carrier signal then goes through its own i-f amplifier, its own f-m discriminator or ratio detector, an audio amplifier, and a loudspeaker just as in an f-m receiver.

In another widely used television-receiver arrangement, known as the intercarrier system and shown in Fig. 8, the sound signal is not separated from the video signal until both reach a point just ahead of the picture tube. In passing through the video detector, the sound and picture i-f carriers mix with each other to produce a new sound carrier signal of 4.5 mc. The sound system of the receiver amplifies this 4.5-mc frequency-modulated carrier, separates the sound signal from it in an f-m detector, then amplifies the sound signal in the audio amplifier that feeds the loudspeaker.

Television receivers usually have somewhere between 15 and 30 tubes. Despite all these tubes, television-receiver troubles are very much the same as those of f-m and a-m receivers. Actually, it is often easier to find the

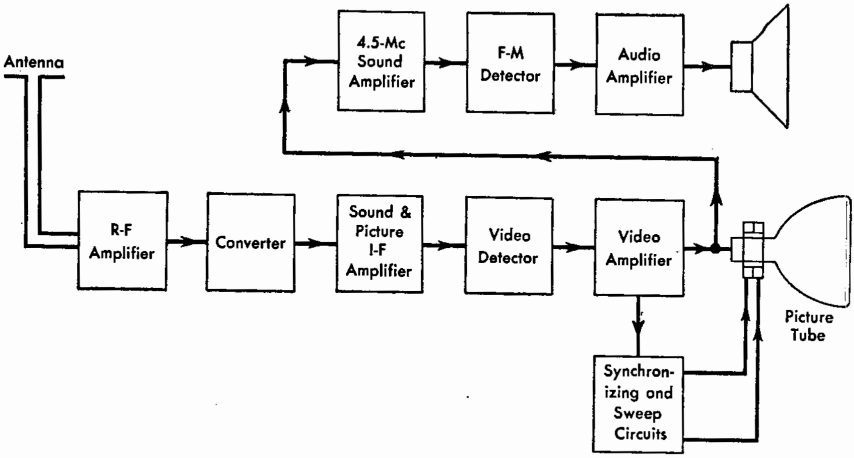


Fig. 8. Circuit arrangement used in modern television receivers. This is known as the intercarrier system. Sound and picture signals take the same path up to the picture tube

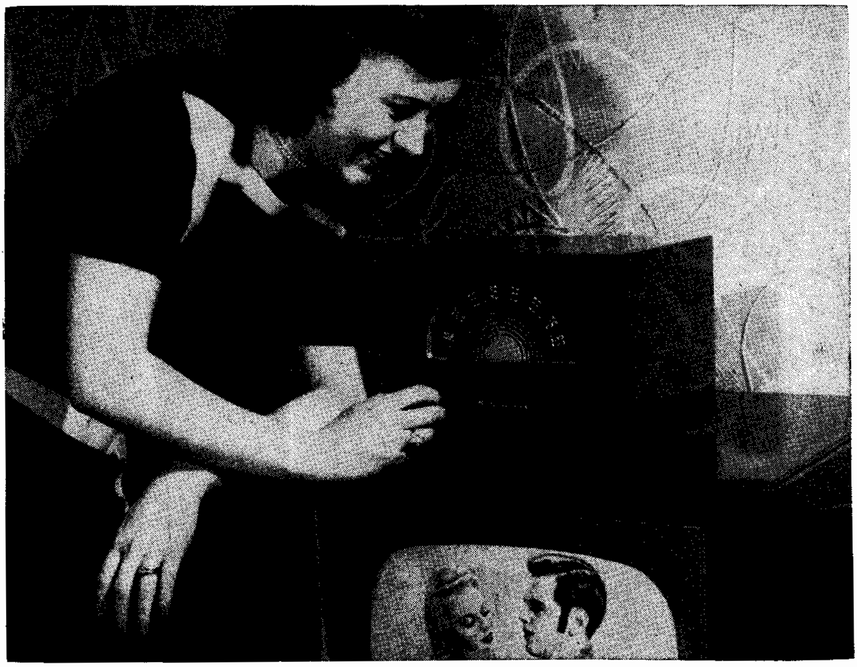


Fig. 9. Converter unit being used with vhf television receiver to bring in uhf stations. Dial is marked in uhf channel numbers from 14 to 83. (RCA Victor photo)

defective part in a television receiver because the picture itself gives clues to the trouble.

UHF Television Reception. One of the early converter units used with an ordinary vhf television receiver to bring in uhf television station programs is shown in Fig. 9. The dial on this converter is marked in uhf channel numbers from 14 to 83.

A converter changes the incoming uhf carrier frequencies to an unused vhf channel frequency in the locality. The vhf receiver is tuned to this unused channel whenever uhf reception is desired.

Simpler and less expensive converters provide a choice of only one or two uhf stations, for use in localities having only one or two uhf stations.

Newer television receivers have provisions for receiving all 82 television channels and hence require no converters.

QUESTIONS

1. Is 1,250 kc in the regular a-m broadcast band?
2. How many cycles are there in 2 mc?
3. What are the three types of broadcasting systems?
4. What type of broadcasting can be tuned in around 100 mc?
5. In what band is 198–204 mc and what is the channel number?
6. Do call letters of television stations in Los Angeles, California, start with K or W?
7. Why are television receiving antennas much shorter than outdoor a-m radio antennas?
8. How many megacycles apart are the sound and picture carrier signals in every television channel?
9. How many horizontal lines are transmitted in a television picture?
10. About how many tubes are there in a television receiver?

4

Making a Service Call

Nature of a Service Call. When a television set or console radio goes bad, the average customer will pick up the telephone and call a serviceman. A few will do this also for table-model sets, but most of these small sets will be brought into your shop. In both cases, however, your goals will be the same—to *make a good impression* on the customer, *confirm* the customer's complaint by trying out the set, check it over carefully for *obvious defects,* test the *tubes,* and then *remove the chassis* from the cabinet for troubleshooting if these preliminary checks fail to locate the trouble.

This chapter takes you through this entire sequence, from your first contact with the customer right up to the time you start troubleshooting underneath the removed chassis. You learn what to ask and say when a phone call comes in for service, what to take with you on a call, how to look your best, how to act to make a good impression, and how to carry on conversation with a customer while you work.

You learn to look and listen first, so you will not overlook a simple and obvious defect that does not even require removing the chassis. You learn how to try out a television or radio set you have never seen before, without letting the customer know that the knobs are all strange to you. You learn what troubles to look for in each type of set before removing the chassis.

Finally, you get practical step-by-step instructions for removing the chassis from even the most complex television-radio-phono console. The entire chapter is thus in exactly the same order as the events of a typical service call, right up to the final paragraph on collecting the money. So—let us assume now that you hear the telephone ringing in your shop.

Handling Telephone Calls. Always answer your telephone with a cheery hello, as if greeting the prospective customer personally with a smile on your face. If doing spare-time work from your home, you will not know whether the call is a personal or business one until the other person asks, "Is this the man who fixes radios?" Your answer would then be, "Yes, this is John Jones. Can you tell me a little about your set?" This, of course, is what the customer wants to do most of all.

Listen patiently and carefully even though the detailed description is technically worthless. Just remember that from this phone conversation you must obtain the customer's *name, address,* a definite day-and-hour *appointment* for looking over the set, and if possible the *make and model number* of the set. This last information is desirable because you can then take along spare tubes of the types used in that set, by looking up the circuit in your service manuals.

Equipment for Home Calls. Your toolbox, along with the tube tester and multimeter described in later chapters, is all that you ordinarily take into a customer's home. Your own car will be entirely all right for business use at the start, but eventually you will want a business car or truck of some kind.

Spare tubes are carried in your toolbox, along with the tools and supplies suggested earlier. Additional new tubes for television sets are kept in the car or truck.

Set down your toolbox and tube tester before ringing the doorbell. When someone opens the door, take off your hat and identify yourself by giving your name and the purpose of your call. Keep the hat off from then on. You can easily carry it in the same hand as your toolbox when you go into the house. Of course, you are not smoking when you go in.

The next question is: What sort of an impression do you make as the customer opens the door in answer to your ring?

Your Personal Appearance. One highly important factor in your success as a serviceman is the impression that you make on your customer. To make a good impression, you must always appear neat and clean, and you must always be courteous.

Your appearance, your professional attitude, and your technical ability all determine whether people will call you regularly or just use you as a last resort when their set goes bad.

How to Make a Good Impression. What you do in the customer's home has a great deal to do with the impression you make, as Fig. 1 clearly shows. Your customer regards his home as his most valuable possession. Any damage that you do through carelessness—any disrespect you show toward his home and his furnishings—will not be overlooked or forgotten.

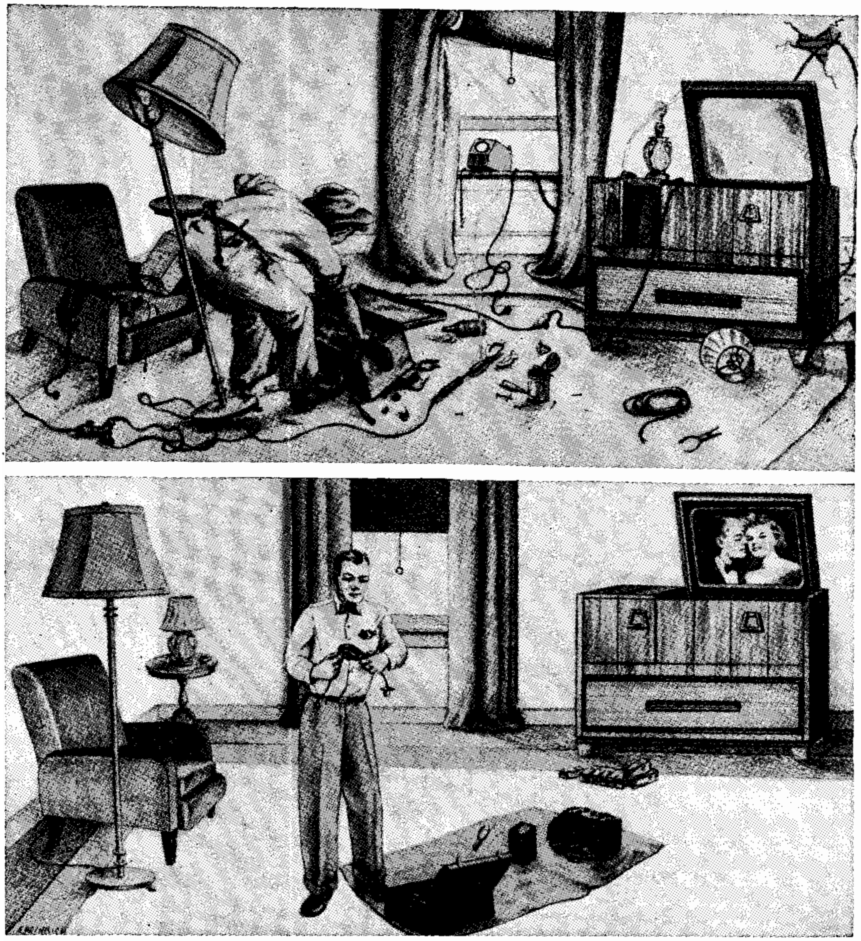


Fig. 1. Top—How to make a bad impression in a customer's home. Bottom—How to make a good impression. Note use of cloth under toolbox to protect rug. Television receiver shown is early model in which picture tube is mounted vertically, face upward, and picture is viewed in mirror fastened under cover of set. (Philco illustrations)

Here is one way to make a good impression immediately when you enter a home. Spread out a large, clean piece of cloth on the rug or floor alongside the console before you even touch it. Place your toolbox on this cloth, never on the furniture. The cloth will prevent the toolbox and tools from soiling the rug or scratching the floor.

Whenever it is necessary to move furniture in order to get at the television or radio set, be careful not to scratch either the furniture or the floor. If any floor lamps are near the set, ask the customer's permission to move them away temporarily, since they are so easily knocked over.

Conversation. In answering questions, never give a lecture on technical subjects just to show how much you know. The customer always appreciates a simple and definite answer. Let him ask more questions if he wishes. Answer each one briefly as best you can. Remember that you are going to have to charge somebody for the time you spend in idle conversation with a customer if you are going to earn a good living from servicing. On the other hand, no customer is going to pay willingly for talking time. Therefore, you yourself have to keep the lost time at a reasonable minimum.

In conversation with a customer, avoid mentioning *politics, religion,* or obvious *personal* matters. Many servicemen have got into trouble and lost customers by commenting on these three dangerous topics. Let the customer give his own opinions if he wishes, but stay neutral yourself always.

Look and Listen First. Records show that in five to seven calls out of ten there is no need to remove the chassis of a television or radio set from its cabinet to find the trouble. Bad tubes are the commonest trouble. Other troubles that can be fixed without removing the chassis are:

1. Improper adjustment of the operating controls for the receiver.
2. Power-supply trouble, such as a defect in the line cord, house wiring, house fuses, dead batteries and loose battery connections for portable radios, blown fuses, and faulty battery wiring for auto radios. All these are covered in the chapter dealing with power supplies.
3. Trouble in the antenna system that picks up signals and brings them to the set.
4. Obvious above-chassis trouble, such as tubes loose or out of their sockets, loose or missing tube shields, broken wire, or toys jammed in the set by children.
5. Man-made or natural interference that is noted for the first time on a television receiver and blamed on the set by the customer.

All of these troubles can be recognized and eliminated or explained without removing the chassis. Many of them can be checked while you are trying out the set to confirm the customer's description of the complaint.

Trying Out a Radio Set. Whenever possible, *let the customer turn on the set and demonstrate it for you.* Watch closely and note what each knob is for, so you can operate the set with confidence yourself even if you have never seen that particular model before. Only a few sets have lettering on the panel or knobs to identify each knob.

No serviceman is able to identify all the control knobs at a glance on a strange set, since controls are arranged in so many different ways. Despite this, customers often think their set is the only one in the world and feel insulted if you ask which knob turns on the set. Watch carefully while the customer tries the set. Ask him to try certain things, such as the tone control and band-changing switch, if you cannot tell which they are.

Sometimes you will have to find out for yourself what each knob does. On table-model sets there will usually be only two knobs. One will be for tuning, and can be identified by a glance at the tuning dial while turning it. The other will be a combination on-off switch and volume control. Turning this knob clockwise until a click is heard turns on the set. Further clockwise turning then increases the volume or loudness of the program.

Radio sets having an f-m band or a short-wave band in addition to the broadcast band will also have a band-changing switch or knob. Check performance on each tuning band. If the set works on one band, the trouble is in the parts for the other band.

Many radios have a tone-control knob. This can be in any position when trying out the set.

Larger table models and most consoles will also have a radio-phono switch. A receiver that is set to the phono position will sound just as dead as if there were trouble, unless it is connected to a phonograph and a record is playing.

When trying out a radio set, your ears will tell you whether performance is satisfactory. Local stations should come in loud and clear. Larger sets should bring in a few distant stations as well. On local stations there should be no hissing or static noise.

Hum heard along with the program should not be objectionably loud. On most sets some hum is normally noticeable during moments of silence in a program if your ear is close to the loudspeaker.

There should be no raspiness or severe distortion. The amount of distortion will depend on the size, quality, and cost of the set, so listen to new sets whenever possible and note how they sound. You will quickly learn what to expect in tone quality from various sets.

Trying Out a Television Set. With television sets it is particularly desirable to let the customer show you how the set behaves or misbehaves. By watching, you can identify all the controls and at the same time see if the customer is tuning in the set properly.

The controls found most often on the front of a modern television receiver are the on-off switch, the station-selector switch, the fine-tuning control, a contrast control or a brightness control, and the sound-volume control, as shown in Fig. 2. These will have large knobs, generally arranged

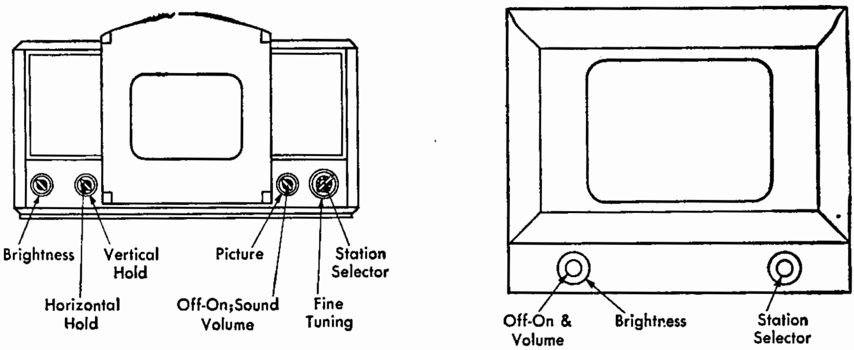


Fig. 2. Locations and functions of controls on two different early models of television sets

in pairs one behind the other on concentric shafts. The on-off switch is combined with the volume control on one knob just as in radio sets.

Other controls often found with large knobs on the front panel will have such names as horizontal hold control, vertical hold control, focus control, and sound-tone control. When not visible on the front panel, some or all of these additional controls have small knobs, and may be concealed behind a hinged or sliding portion of the front panel or may be at the rear of the chassis along with other semiadjustable controls. When a receiver is working properly, only the large-knob front-panel controls are needed for tuning in and adjusting picture and sound.

Many different special controls will be found at the rear of a television set. Sometimes these have small knobs or have knurled shafts that can be turned with the fingers like a knob. More often the ends of the control shafts are slotted so they can be turned with a screwdriver. Examples of at-rear controls are given in Fig. 3.

Before adjusting a screwdriver control, mark or measure its original position as shown in Fig. 3, so you can return exactly to the original setting if changes have no effect on the trouble.

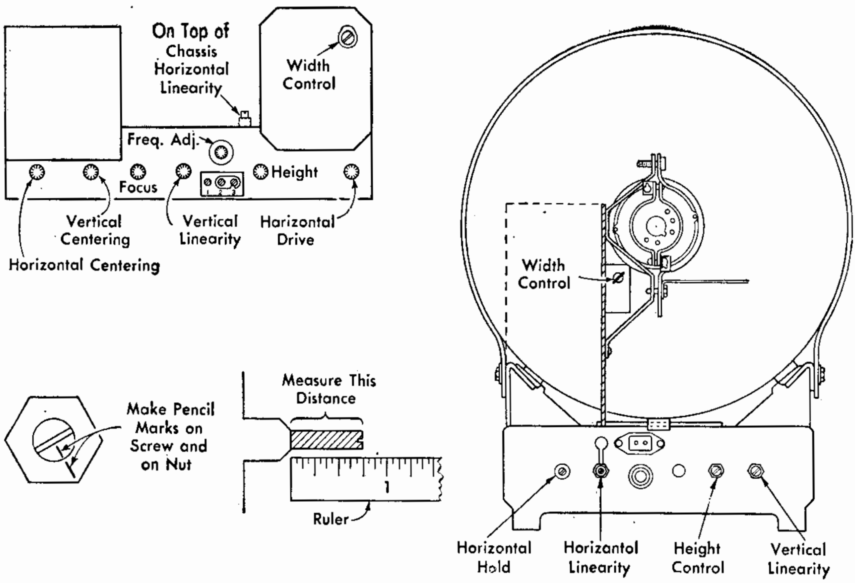


Fig. 3. Examples of rear controls on two different sets, and methods of marking positions of these screwdriver controls so you can go back to their originol settings if necessary

What Television Controls Do. Picture trouble in a television receiver can often be cleared up by adjusting one of the small-knob controls at the front or rear of the set. Once you learn what each of these controls does to the picture, you will be able to select and adjust the correct control for the particular trouble. This knowledge of control action is important, because careless tuning of some of the controls can throw the set way out of adjustment.

Effects of some of the controls on the picture are shown in Fig. 4. For each of these picture troubles, the controls that may need adjusting are listed. In each case, the first control listed is the one that ordinarily fixes the trouble, but the others listed may need slight adjustments because they interact with the first one.

The following paragraphs give in alphabetical order the common names of the various controls found both at the front and rear of television sets, tell what each control does, and give adjusting instructions where needed. Study this list carefully now, and use it for reference whenever in doubt about some control.

AGC CONTROL: Back-of-set control that varies the level at which the automatic-gain-control circuit works. Used on only a few sets. Adjust for

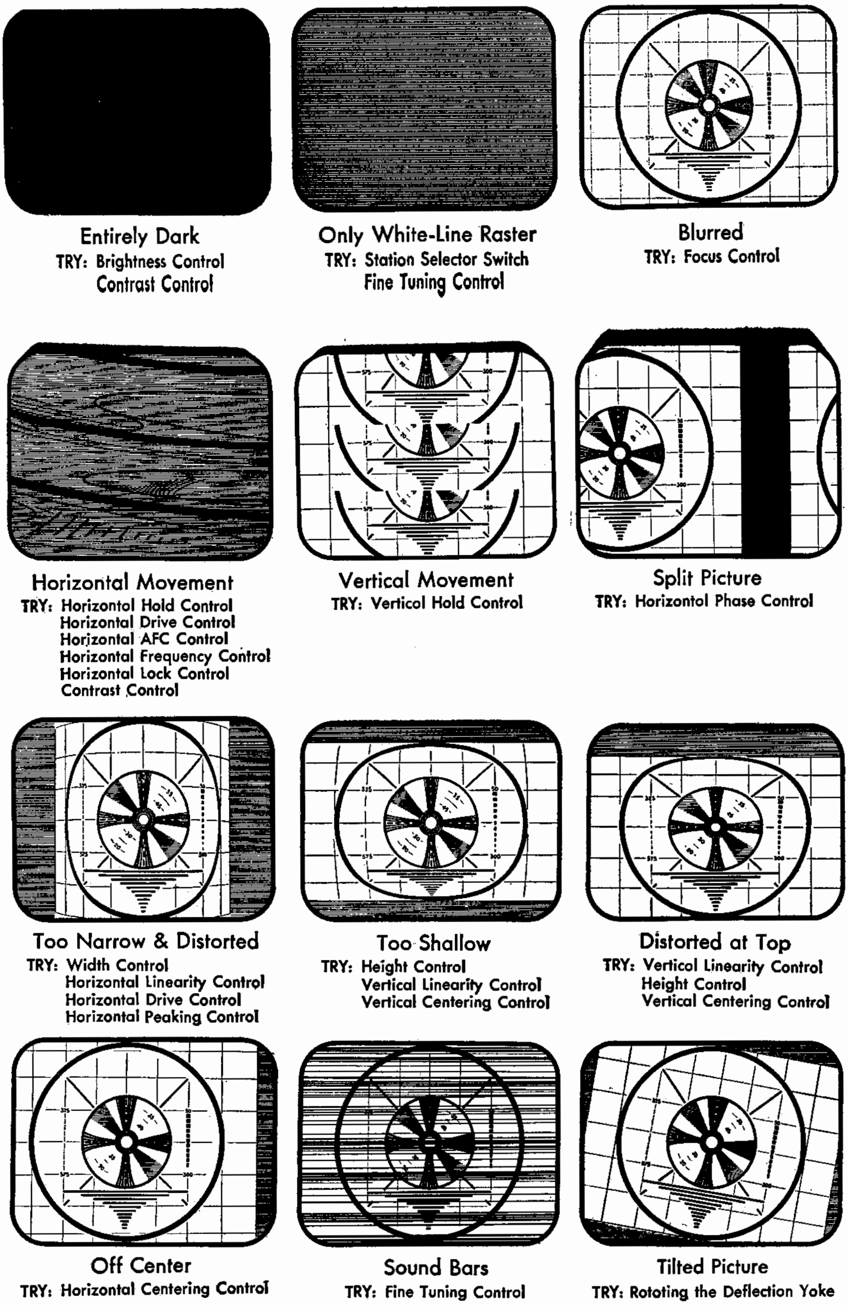


Fig. 4. Examples of television picture defects that can be due to improperly adjusted controls. To get experience in recognizing troubles like these, try adjusting each front and rear control in turn on a receiver that is working properly. Be sure to mark the position of each screwdriver control before changing it

clearest picture when tuned to the strongest local television station. Picture may vanish when this control is way out of adjustment.

AGC SWITCH: Permits disconnecting a special automatic-gain-control (agc) circuit of the receiver when maximum sensitivity is required, as for receiver locations far away from television transmitters. For most locations, leave this AGC SWITCH in the ON position, where it serves to make all station programs come in with approximately the same picture and sound signal strength.

BACKGROUND CONTROL: Same as BRIGHTNESS CONTROL.

BEAM-BENDER CONTROL: Same as ION-TRAP CONTROL.

BRIGHTNESS CONTROL: Varies the picture-tube operating voltage that determines the brightness of the spot produced by the electron beam. When the BRIGHTNESS CONTROL is adjusted, the CONTRAST CONTROL will usually need adjusting also. Adjust the BRIGHTNESS CONTROL for the dimmest acceptable picture, as excessively bright pictures mean shorter picture-tube life.

BRILLIANCE CONTROL: Same as BRIGHTNESS CONTROL.

CHANNEL-SELECTOR SWITCH: Same as STATION-SELECTOR SWITCH.

CONTRAST CONTROL: Varies the strength of the video signal, just as a VOLUME CONTROL varies the strength of an audio signal. In one extreme setting the CONTRAST CONTROL makes the picture all harsh blacks and bright whites like pen-and-ink drawings. In the other extreme position it makes the picture a dim, muddy gray all over. The correct setting gives blacks, whites, and many tones of gray. The effect of the control is best seen by watching gray panels on a test pattern while adjusting the control. When the CONTRAST CONTROL setting is changed, it is usually necessary to readjust the BRIGHTNESS CONTROL also.

FINE-TUNING CONTROL: Often provided on front panel of sets having a STATION-SELECTOR SWITCH, to permit correcting for tube and circuit variations when the coil and condenser values placed in the circuit by the switch are not exactly right for a particular station. The FINE-TUNING CONTROL generally adjusts a small variable condenser. For conventional receivers having a separate sound system, adjust for loudest and clearest sound. Generally needs readjusting each time the STATION-SELECTOR SWITCH is set to a different channel.

Some receivers with switch-type tuners have a fine-tuning adjustment, accessible with a screwdriver when the tuning dial is removed, for each of the 12 channels. These 12 adjustments should be adjusted for maximum sound in sets having conventional sound systems. Start with channel 13 and work backward, as sometimes there is interaction between the controls.

With intercarrier sound receivers, adjust the FINE-TUNING CONTROL for clearest picture. One way is to adjust for maximum sound and then turn away from this point enough to eliminate the sound bar pattern and ragged appearance of the picture on the screen.

FOCUS CONTROL: Changes area of spot made by electron beam on screen. May be either a chassis control or a mechanical means for moving a ring-type permanent magnet located on the neck of the picture tube, both of which are covered in later chapters. Adjust the FOCUS CONTROL for sharpest possible picture. When picture is in correct focus, horizontal line structure of picture will show clearly when viewer is close to screen. Adjust so these scanning lines that make up the picture are as sharp and distinct as possible. Best viewing position is just far enough away so these lines blend together and cannot be seen. Blurred picture generally means that FOCUS CONTROL needs adjustment.

FRAME LOCK CONTROL: Same as VERTICAL HOLD CONTROL.

HEIGHT CONTROL: Determines the vertical distance occupied by the picture on the screen. Adjust so the height of the picture is just a little greater than the height of the mask opening on the screen, tune to all channels in turn, and readjust if top or bottom edges of picture show on any channel. VERTICAL CENTERING CONTROL may need readjustment also after HEIGHT CONTROL is changed.

HI-LO BAND SWITCH: Changes tuning circuits. When set to LO position, channels 2 through 6 can be received. When set to HI position, channels 7 through 13 can be received. Rarely found on modern television sets, which do this switching automatically with the STATION-SELECTOR SWITCH.

HORIZONTAL AFC CONTROL: Generally serves to assist the HORIZONTAL HOLD CONTROL by adjusting an automatic-frequency-control circuit that acts on the horizontal sync system. Adjust only when you cannot stop tearing or zigzagging of the picture with the HORIZONTAL HOLD CONTROL.

HORIZONTAL AMPLITUDE CONTROL: Same as WIDTH CONTROL.

HORIZONTAL BALANCE CONTROL: Use for same purposes as HORIZONTAL PEAKING CONTROL, adjusting only as last resort.

HORIZONTAL CENTERING CONTROL: Moves entire picture sidewise on screen. If it is a chassis control, it applies centering voltage to the horizontal deflection coils. More often, horizontal centering is obtained by readjusting a lever or wing nuts that change the position of the focus coil. If the first adjustment made moves the picture in the wrong direction, adjust in the opposite direction. Several makes of sets have magnetic centering rings, one just in front of the focus coil and the other just behind it on the neck of the tube; rotate these to center the picture.

HORIZONTAL DRIVE CONTROL: Affects strength of output voltage of horizontal sync system. Generally needs adjustment only after a new tube is put in set. When out of adjustment, diagonal zigzag line pattern cannot be eliminated by any HORIZONTAL HOLD CONTROL adjustment. If set has no HORIZONTAL LINEARITY CONTROL, the HORIZONTAL DRIVE CONTROL may be used for the same purpose of improving the shape of a circular test pattern. If the set has a linearity control, try it first before disturbing the drive control. If the HORIZONTAL DRIVE CONTROL makes the picture brighter, do not turn it any farther than absolutely necessary.

HORIZONTAL FREQUENCY CONTROL: A secondary control that assists the HORIZONTAL HOLD CONTROL, usually by adjusting an automatic-frequency-control circuit acting on the horizontal sync system. Adjust the frequency control only when you cannot stop tearing or zigzagging of the picture with the HORIZONTAL HOLD CONTROL.

HORIZONTAL HOLD CONTROL: Makes the horizontal sync system operate at a frequency close to that of the horizontal sync pulses that are put in the television signal by all station transmitters, so that these pulses can more easily control the receiver. If incorrectly set, weird zigzag diagonal moving patterns appear on the screen. Adjust the control so the complete picture is restored, then check all channels. Adjust further if the zigzag patterns reappear on any channel. Best position for this control is usually about midway between the two points at which the picture locks in and becomes steady, when turning toward the lock-in region of the control first from one direction and then from the other.

The HORIZONTAL HOLD CONTROL also has a centering effect on the picture. If the correct final setting of this hold control leaves the picture off center, make the necessary correction with the HORIZONTAL CENTERING CONTROL; this usually means adjusting the focus coil.

HORIZONTAL LINEARITY CONTROL: Makes spot move across screen at uniform speed when properly adjusted. Can be adjusted properly only when test pattern is being broadcast by some station. Rarely needs adjustment. Adjust so vertical lines in picture or test pattern are exactly straight.

HORIZONTAL LOCK CONTROL: Serves the same purpose as a HORIZONTAL HOLD CONTROL in some sets. If there is a HORIZONTAL HOLD CONTROL also, the HORIZONTAL LOCK CONTROL is intended to assist it. Try adjusting the lock control only when you cannot stop tearing or zigzagging of the picture with the HORIZONTAL HOLD CONTROL.

HORIZONTAL OSCILLATOR CONTROL: Same as HORIZONTAL FREQUENCY CONTROL.

HORIZONTAL OSCILLATOR PHASE CONTROL: Same as HORIZONTAL PHASE CONTROL.

HORIZONTAL PEAKING CONTROL: Same as HORIZONTAL DRIVE CONTROL in some sets, and a separate control in others. Adjust this peaking control only as a last resort to improve roundness of circles on test patterns if the correction cannot be made satisfactorily with the HORIZONTAL LINEARITY CONTROL. If the peaking control makes no improvement, return it to its original position.

HORIZONTAL PHASE CONTROL: Adjusts horizontal sync system to make each horizontal line start and stop at sides of picture tube. Adjust this only if picture is split into two parts divided by black vertical line on screen, with the two halves of the picture reversed in position.

HORIZONTAL POSITION CONTROL: Same as HORIZONTAL CENTERING CONTROL.

HORIZONTAL SPEED CONTROL: Same as HORIZONTAL FREQUENCY CONTROL.

HORIZONTAL SYNC CONTROL: Same as HORIZONTAL HOLD CONTROL.

ION-TRAP CONTROL: Found in sets having ion-trap coils along with or in place of ion-trap magnets. Adjust current through the coils. To adjust, turn up BRIGHTNESS CONTROL so picture is the brightest normally used for viewing, then adjust ION-TRAP CONTROL for maximum brightness.

LOCAL-FRINGE SWITCH: Permits choice of best possible picture quality for reception of nearby stations, or greater sensitivity but slightly poorer picture quality for locations over about 25 miles away from television stations.

ON-OFF SWITCH: Turns television set on and off. Generally combined with the VOLUME CONTROL, just as in radio sets.

PHASE DETECTOR BALANCE: Generally the same as HORIZONTAL PHASE CONTROL.

PICTURE CONTROL: Same as CONTRAST CONTROL.

PICTURE-CONTROL SWITCH: Gives choice of giant-circle picture filling entire circular screen or conventional picture. Found chiefly on some Zenith sets.

PICTURE-SIZE CONTROL: Same as WIDTH CONTROL.

SHARP-TUNING CONTROL: Same as FINE-TUNING CONTROL.

SOUND CONTROL: Same as VOLUME CONTROL.

SPEED CONTROL: Same as HORIZONTAL FREQUENCY CONTROL.

STATION-SELECTOR SWITCH: Serves to switch into the receiver circuits the pretuned coil and condenser combination required for reception of the particular channel desired.

SYNC CONTROL: Same as HORIZONTAL HOLD CONTROL.

TILT CONTROL: If the picture is tilted on screen, loosen wing nuts or other nuts that hold deflection yoke in position, and rotate deflection yoke until picture is straight.

TONE CONTROL: Changes tone of sound portion of television program, just as in radio sets.

TV-PHONO SWITCH: Serves to remove power from all but the audio amplifier tubes when using a phonograph with the television set.

VERNIER-TUNING CONTROL: Same as FINE-TUNING CONTROL.

VERTICAL AMPLITUDE CONTROL: Same as HEIGHT CONTROL.

VERTICAL CENTERING CONTROL: Moves entire picture up or down on screen. If it is a chassis control, it applies centering voltage to the vertical deflection coils. More often, vertical centering is obtained by readjusting a lever or wing nuts that change the position of the focus coil.

VERTICAL HOLD CONTROL: Adjusts frequency of vertical sync system. When this control is far out of adjustment, several pictures are seen overlapping each other vertically and moving up or down on the screen. When the control is slightly off in one direction, the picture will roll upward. When the control is slightly off in the other direction, the picture will roll downward. The rolling movement may be faster in one direction than the other. Best adjustment is obtained by approaching the correct setting from the direction in which the picture movement is slowest. Adjust until the picture is stationary. After adjusting, reduce the CONTRAST CONTROL setting until the picture is just barely visible; the picture should still be stationary if the VERTICAL HOLD CONTROL is correctly set.

VERTICAL LINEARITY CONTROL: Affects vertical spacing between horizontal lines of raster. Can be adjusted properly only when test pattern is being broadcast by some station. Adjust so circles on test pattern are true circles, with no flattened or peaked portions at top or bottom. Improper adjustment makes people's faces or legs look either too long or too short. The HEIGHT CONTROL usually requires readjustment whenever the VERTICAL LINEARITY CONTROL setting is changed.

VERTICAL POSITION CONTROL: Same as VERTICAL CENTERING CONTROL.

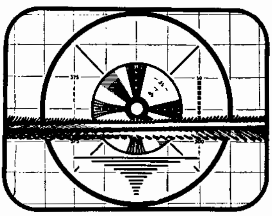
VERTICAL SIZE CONTROL: Same as HEIGHT CONTROL.

VERTICAL SPEED CONTROL: Same as VERTICAL HOLD CONTROL.

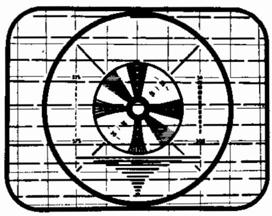
VOLUME CONTROL: Adjusts loudness of sound portion of television program.

WIDTH CONTROL: Determines how far electron beam moves horizontally from side to side on screen; hence it controls width of picture. Adjust so width of picture is just a little more than width of mask opening on screen. Check adjustment on all channels, and readjust if sides of picture show on any channel. HORIZONTAL CENTERING CONTROL may need readjustment also when WIDTH CONTROL is changed. The HORIZONTAL LINEARITY CONTROL may also need readjustment, since this often interacts with the WIDTH CONTROL. Keep going back and forth between these two controls, adjusting first one and then the other, if you have trouble getting the correct size of true circles on the test pattern.

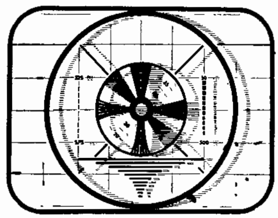
Identifying Television Interference. Television-receiver interference troubles are easy to recognize but hard to cure. Each has its own characteristic sound in the loudspeaker and pattern on the screen, as shown



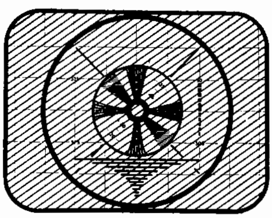
Diathermy
Seen Only When Doctor in Vicinity is Using His Diathermy Equipment. May be Much Lighter Smear, or Heavy Black Smudge



Auto Ignition
Seen as Flashing White Horizontal Dashes Only When Auto Without Ignition Noise Suppressors is Passing Nearby. Dashes are Shown in Block Here for Clarity



Ghost
Two or More Patterns are Seen, the Fointer One Being Due to a Signal Arriving Over a Longer Path After Reflection from a Hill, Building, or Other Large Object. Turning Antenna May Help



R-F Interference
Commonest Type of Interference. Caused by Another Transmitter, Such as Local F-M Station, a Local Television Station Operating on Another Channel, a Police or Fire Radio Station, or an Amateur Radio Station. Can also be Caused by Radiation from Oscillator of Another Television Receiver Up to Several Blocks Away

Fig. 5. Examples of interference troubles most often seen on television pictures

in Fig. 5. With experience you will know which troubles must be endured.

Diathermy interference is one that you cannot do much about, other than suggest that the local doctor buy new well-shielded equipment. Signals from police radio stations, amateur radio stations, and other legal types of radio service can produce r-f interference patterns because of inferior circuit design in the customer's own television set. Here you can try connecting an interference filter to the antenna terminals of the television set. These filters are sold by jobbers, and serve to block signals of all stations operating on frequencies below that of television channel 2.

You will learn later how to adjust the direction and position of a television antenna to reduce or eliminate the effect of a particularly troublesome interfering signal.

Removing Back Cover of Set. So far, you have found out exactly how the set is misbehaving. You have noted whether the trouble occurs on some or all channels or band-switch settings. You have become familiar with the receiver controls and have found that adjustment of receiver controls will not clear up the trouble. You have also made sure the trouble is actually in the set and not due to transmitter trouble or interference. The next step, then, is to remove the back cover of the set so you can see the top of the chassis clearly.

Removing Back Cover of Radio Sets. The cardboard or wood back cover of a table-model radio set will be fastened either with screws or snap fas-

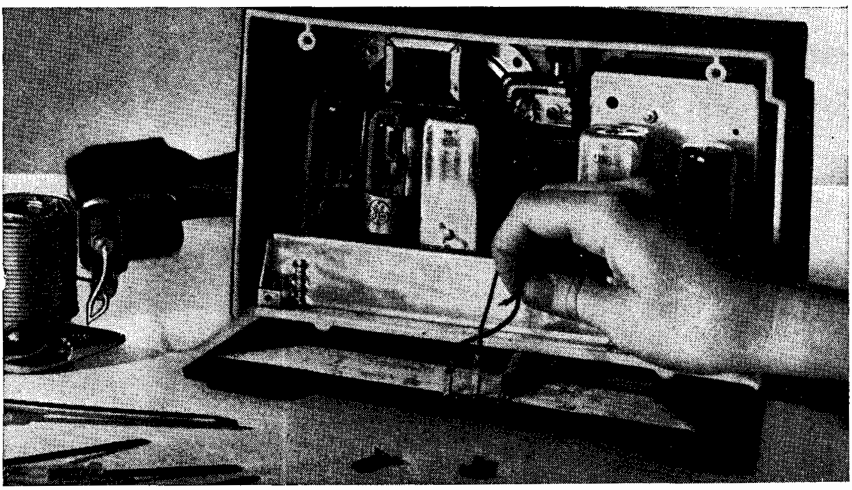


Fig. 6. Leads going to back-cover loop antennas of small radios break easily, as shown here, so handle loops carefully. Resolder the joints when leads are frayed or broken.

teners. The screws are easily removed with an appropriate size of screwdriver. The snap fasteners are pried out with a small screwdriver.

In many radio sets, a loop antenna is attached to the back cover on the inside, with leads going from the loop to the chassis. Be careful not to break these connecting leads. Leave the loop connected to the chassis as shown in Fig. 6, because the loop is needed for testing the set while working on it. Loop antennas are an actual part of the radio circuit, so a broken wire here will cause trouble.

If the loop antenna is connected by means of plugs and jacks, make a diagram identifying where each antenna lead goes, before removing any of them. Accidental reversal of loop-antenna leads is a trouble that is very difficult to locate. Play safe and make a connection diagram first. This precaution also applies when the loop-antenna leads go to terminal screws, unless both leads and terminals are color-coded.

Back covers with loops are sometimes fastened to the chassis as well as to the cabinet. Just remove the cabinet fastenings, leaving the loop attached to the chassis.

Removing Back Cover of Television Set. If adjustments of the television-receiver controls do not clear up the trouble, return all controls to their original settings and remove the back cover of the set. A screwdriver will usually serve for loosening the screws in the cover. On a few sets, a spin-type socket wrench of the correct size may be needed. The cover will stay in position after the screws are removed, because of the line-cord plug.

To remove the cover, pull it back firmly by gripping near where the line cord goes through the cover. This disconnects power from the set. To operate the set without the back cover, use a cheater cord.

Do not start testing tubes and do not remove the chassis from the cabinet of a radio or television set until you have carefully looked over the top of the chassis for obvious defects.

How to Look and Listen. The types of trouble that can be fixed without removing the chassis will now be taken up one by one. Examples of common causes for each trouble will be given, along with suggestions for making the necessary repairs. This practical information applies to all types of sets, radio as well as television, from the tiniest table models to huge consoles.

Identifying Power-supply Trouble. Look for trouble outside the receiver chassis when the set is stone-cold-dead, with no hum, no pilot lamps lit, no tubes warm or glowing, and nothing at all on the screen if a television set. An entire later chapter covers these troubles.

Identifying Antenna-system Trouble. With all types of sets, form the habit of checking antenna connections to the set while waiting for tubes to warm up after you have turned the set on. Look for loose terminal screws. Look for bare antenna lead-in wire touching the chassis. Look for a lead-in wire that has slipped off the antenna terminal of the set. Look for any other obvious defects like these.

If there are two lead-in wires as on f-m, television, and short-wave sets, be sure the bare ends of the wires are not touching each other at the set. Follow the lead-in wire around the room as far as you can conveniently do at the time.

In a television set, if the sound is weak and noisy and the picture is gray, with a lot of white spots called snow on all stations or on all but the strongest, a possible cause is antenna trouble. Of course, ask the customer first if all the stations came in clearly before. Some sets are so poorly made or so carelessly installed that they bring in only one or two of the strongest television stations properly even in a large city like New York.

In a home radio set, outdoor antennas are rarely used today. Most sets have built-in loop antennas. Careful examination generally shows up trouble in loops. On small table-model sets you will often find a hank antenna, which is a few feet of insulated wire coming from the set and running under a rug or around a window frame. Check this to make sure the bare end of the wire is not touching a radiator or other grounded object. Signs of a poor or defective radio antenna are noisy reception, no distant or weak stations, and the need to turn the volume all the way up.

In an f-m set, there will usually be an antenna tacked to the back of the set (if a console) or mounted somewhere in the house. This antenna is connected to the set with two-wire line like that used with television antennas. If the set is noisy and gets only a few stations, look for a break in the wires and see if the antenna is still in position.

In an auto radio, few stations and a lot of noise may mean that the antenna has become grounded to the frame of the car. Examine the antenna mounting carefully. Look also for breaks in the lead-in wire that runs from the antenna to the radio set.

In a battery portable, loop antennas are used. They have the same types of trouble as loops on home radios.

More information on troubleshooting and repair of antennas is given later in this book.

Obvious Above-chassis Troubles. When you look over the top of the chassis, make sure all tubes are firmly pushed down in their sockets. Make sure all tube shields are in position and pushed down. If any of the tubes have top caps, make sure the connecting leads are not touching anything else. Examine the loudspeaker for damage to the cone. Be sure the loudspeaker connecting plug and all other plugs are firmly pushed in. Look carefully for broken wires.

Look also for things that should not be in the chassis, such as children's toys poked through holes in the back cover. Be on the lookout for damage by insects and mice. These pests are attracted by the warmth of a set.

If you can locate the trouble by careful inspection in this way, troubleshooting procedures become unnecessary. You can immediately replace the bad part according to instructions given in later chapters.

Testing Tubes. Almost 50 per cent of all radio-set failures and up to 75 per cent of all television-set failures are due to bad tubes. In most sets you can reach all the tubes from the rear of the cabinet, without removing the chassis. Instructions for testing tubes are given in following chapters.

Tube testing is one of the most important things you do in the presence of the customer. When the trouble is only a bad tube, you can complete the repair job quickly by putting in the required new tube. After you have proved that all tubes are good and the trouble is elsewhere, you are in a much better position to get paid for a thorough troubleshooting and servicing job. The customer feels that the trouble must be serious and hard to find, and becomes resigned to the larger bill that troubleshooting jobs deserve.

Removing the Chassis. When all tubes check O.K. and no troubles can be found above the chassis, the next step is getting that chassis out of its cabinet as quickly as possible, because time means money to you. Equally important is getting the chassis back again correctly after the repairs are made.

In the customer's home you must handle a chassis with confidence and assurance, even though you have never seen that particular set before. You have to make a good impression so the customer will allow you to take the chassis to your shop for repairs if this becomes necessary.

This chapter covers the commonest mounting methods and chassis-removal procedures. You will learn what to look for and what to do on any set. You will acquire the knowledge and confidence to tackle big combination television-radio-phono consoles. On these, it often takes longer to get out the chassis than to make the actual repair.

Table-model sets will be covered first since they are most common and usually easiest to work on. After that, special instructions will be given for handling large consoles and television-radio-phono combinations.

Table-model Sets. The steps in removing the chassis of a table-model television or radio set are:

1. Unplug line cord.
2. Remove control knobs.
3. Remove back cover of cabinet if present.
4. Remove tuning dial pointer or dial scale if necessary.
5. Disconnect cables going to chassis, such as from separate speaker.
6. Remove chassis-mounting bolts or screws.
7. Slide chassis carefully out of cabinet.

Unplug Line Cord First. Always pull the receiver line-cord plug out of the power outlet before removing or putting back a chassis. This eliminates the possibility of getting a bad electrical shock. The ends of the line cord under the chassis are soldered to exposed terminals, and your fingers can easily slip under the chassis and touch one of these.

More important still, the chassis is connected directly to one side of the a-c power line in many universal a-c/d-c television and radio sets. In one position of the line-cord plug in the wall outlet, the entire chassis is electrically energized or hot, even when the set itself is turned off. In the other position of the plug, the chassis is electrically hot when the set is on.

Touching a hot chassis is exactly the same as touching a bare power-line wire. The jolt you would get from touching a hot chassis or terminal might well make you drop the chassis on the floor, with resulting damage. Furthermore, if your other hand happened to be touching a metal wall-outlet plate, radiator, pipe, or other grounded object when you had a finger on the hot chassis or on the line-cord wire, the resulting current flow through your heart could well prove serious.

How to Remove Control Knobs. Having unplugged the line cord, the next step in getting a chassis out of its cabinet is removing the knobs that fit over the ends of the control shafts. These come off either by loosening a setscrew or by pulling. Sometimes these knobs are jammed on and require quite a bit of force, but you will not be afraid to use force once you identify which type of knob it is.

Removing Knobs Having Setscrews. The older method of fastening a knob on a shaft is with a setscrew. The slotted end of this screw can be reached with a small screwdriver through a hole in the side of the knob. Therefore, turn the knob completely around or inspect all sides of it, to see if it has a hole for a setscrew. If you find such a hole, insert a small screwdriver in it. Gently turn the screwdriver between two fingers until you feel it drop into the slot of the screwhead, then apply force and pressure to loosen the screw. After about one full turn of the screw counterclockwise, the knob should slide readily off its shaft.

Some table radios have mechanical pushbutton tuning systems. These rotate the tuning condenser to a new position each time a button is pushed. In these tuning systems, the tuning knob is usually fastened by a screw going through the end of the knob. This screw must be removed to get the knob off so the chassis can be slid out. Removing this screw releases the locking mechanism for the pushbuttons, making it necessary to reset the pushbuttons after replacing the chassis in its cabinet again. This is a fairly easy job, however. Instructions for setting up pushbuttons are given in a later chapter.

Removing Friction-grip Knobs. The commonest method of fastening a knob on a shaft is by friction. The friction for holding the knob on the shaft is obtained either with flat springs or with serrations or grooves inside the knob and on the shaft. All friction-grip knobs are removed by a firm, steady pull.

Double controls on television sets have two knobs. The smaller knob is on the inner shaft. The larger knob is next to the front panel and is on the outer metal sleeve. These knobs are removed one at a time, usually by pulling straight off.

Sometimes small knobs are difficult to grip tightly enough to pull off. For these, a simple knob puller is worth many times the few dimes it costs. The prongs of the puller fit behind the knob and the cabinet, giving a firm grip on the knob without risk of damaging the brittle plastic knob or the equally fragile cabinet.

A handkerchief looped behind a tight knob is often recommended, but does not work too well in practice because the handkerchief usually tears before the knob comes loose. A length of insulated hookup wire looped behind the knob gives a better grip for pulling. Two loops, one on each side of the shaft, are still better.

Prying off a knob with a screwdriver is risky business because of possible damage to an expensive and oftentimes irreplaceable cabinet. If a knob will not come off, it is far better to crush it with pliers and then put on a whole new set of knobs. The new knobs need not be exactly the same shape as the old ones, as long as they look good on the set and are made to fit the type of shaft at hand.

Pushbuttons for automatic tuning usually slip through the holes in the cabinet and come out with the chassis. Only in a few older sets is it necessary to remove the pushbutton caps before sliding out the chassis. Pushbutton caps are generally held on by friction, and come off with a firm pull.

What to Do with Knobs. To avoid losing knobs, always put them in an empty compartment of your toolbox or some other equally safe place as soon as you take them off. If at your bench, use trays, cans, boxes, or dishes for the same purpose. If the chassis will be out of the cabinet more than a few minutes or is scheduled for a trip to your shop, put the knobs back on their shafts after removing the chassis.

You will realize the importance of using containers the first time you have to spend an hour or more hunting on the floor for a tiny setscrew that somehow got wedged into a crack under your workbench. Neatness both at your bench and in customers' homes can really save you time and money.

A cloth mailing bag with tie strings is ideal for holding knobs and hardware. Tie the bag to the chassis after all loose parts have been put in.

Removing Dial Pointer and Scale. In a few table-model radio sets the dial pointer is outside the cabinet and must be removed before the chassis can be slid out of the cabinet. The pointer is held in place on its shaft by friction. It can usually be pulled off easily by grasping the center cap with your fingers. Sometimes gentle prying with a small screwdriver will help get the pointer loose. Be careful not to scratch the dial face.

Some sets have a slide-rule dial with a pointer that comes through a slot in the cabinet. This pointer rides on the dial cord, and must be disconnected from the cord before the chassis can be removed. Examine the pointer to see how it comes off. Usually the pointer will have spring clips that grip the dial cord. This type of pointer can be pulled off the cord with your fingers.

If the pointer is fastened to the cord with cement, apply speaker cement solvent or acetone and wait a few minutes for the cement to soften before pulling the pointer off the cord.

Disconnecting the Speaker. On some sets you will find a connecting plug in the speaker cable, either at the loudspeaker or on the chassis. This plug is removed by a firm, steady pull. It disconnects the loudspeaker for convenience in working on the chassis. Do not turn on a set when its loudspeaker is disconnected.

Removing the Picture Tube. The commonest method of mounting the picture tube of a television receiver is by means of brackets and strips attached to the chassis. The chassis and picture tube then come out together.

In some sets, the picture tube is held by brackets attached to the cabinet, as in Fig. 7. Before removing the chassis here, pull the socket off

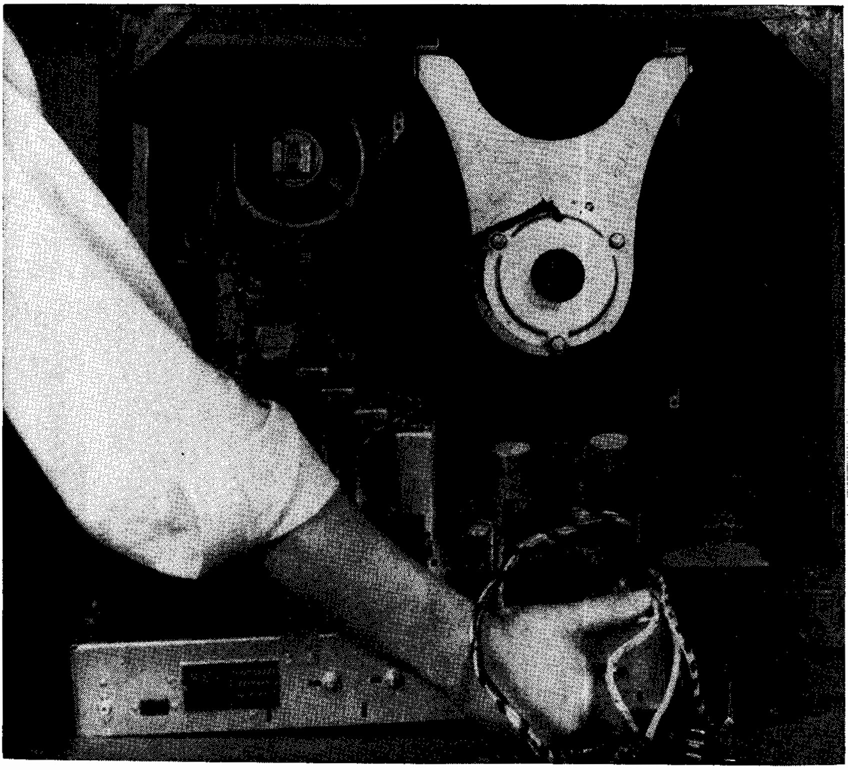


Fig. 7. Removing chassis from television set in which picture tube is supported from top of cabinet. The three plugs at the bottom, which must first be removed, go to the loudspeaker, to the picture-tube deflection yoke, and to a separate high-voltage power supply that has already been removed from the cabinet. (Du Mont photo)

from the base of the picture tube and disconnect the plugs in the wires going to the deflection and focus coils.

Removing Chassis Bolts. The chassis of a table-model set is bolted to the bottom of the cabinet. Turn the set on its side, being careful not to damage the loosened loop antenna, and remove the lowest screws or bolts first. Hold your hand under the chassis when removing the last of the uppermost screws, so the chassis cannot drop down and be damaged. Another way is to remove all but one screw, place the set upright so that this screw projects over the edge of the bench, then remove it.

For older table-model sets, an ordinary screwdriver or a socket wrench will serve for removing mounting bolts. Some of the newer sets have bolts with special heads that cannot be removed with tools generally available to nontechnical owners. This is done to meet Underwriters' requirements for safety from electric shock. The required special wrenches can be obtained from the local distributor of that set. Usually your hexagonal socket wrenches will remove these special bolts that do not have screwdriver slots.

Sliding Chassis out of Table-model Cabinet. With the cabinet right side up and its back toward you, hold the cabinet in position with one hand, and pull the chassis slowly out of the cabinet by grasping one of the metal shield cans or some other rigidly mounted part. Be careful not to damage the loop antenna of a radio set or the picture tube of a television set as you take out the chassis.

In smaller radio sets the speaker will be attached to the chassis. In larger table-model radio sets and in television sets the speaker may be fastened to the cabinet and connected to the chassis with wires or a cable. Usually these wires are long enough so that you can get the chassis out of the cabinet and turn it upside down for troubleshooting without removing the speaker. If the wires are not long enough to permit this, remove the nuts around the back of the speaker rim with a socket wrench, leaving one of the top nuts for the last. Hold the speaker in place with your hand while spinning off this last nut with your fingers, then grasp the speaker magnet frame and pull straight back to remove the loudspeaker. Place the speaker face down on a clean piece of paper on your workbench. Be careful not to puncture the fragile paper cone with any sharp object.

Do Not Use Force. A chassis should slide out easily. If it does not, stop pulling and look carefully to see what is still holding it. The chassis may have feet that rest in holes or depressions in the bottom of the cabinet. There may be rubber shock-absorbing washers under the chassis that have become stuck to the cabinet. Gently lift or pry the chassis upward and then slide it out.

Sometimes the tuning dial may be fastened to the back of the cabinet. You may even find a loudspeaker that is fastened both to the chassis and the cabinet.

In the years to come, receiver designers will undoubtedly figure out still-different ways to arrange and mount parts, so do not worry about details of these things now. By using your eyes as you gently pull on the chassis, you will always be able to figure out where it is still holding and what to do about it. Remember—never use force.

Removing the Chassis from a Console. A receiver that rests directly on the floor rather than on a table is known as a console. The simplest consoles have a television or radio chassis exactly like that used in table models but generally have a larger loudspeaker that is attached to the cabinet rather than to the chassis. Larger consoles will have a larger chassis for television, f-m, and a-m, larger and fancier tuning dials, more control knobs, larger radio loop antennas that are sometimes rotatable, and one or even two automatic record changers.

The instructions already given for handling table-model sets apply also to consoles. With this basic knowledge, plus careful inspection of a console, you should have no trouble in removing the chassis from any console. The suggestions and examples given here will speed up your work, however, by helping you to recognize special mounting and connecting schemes.

A console cabinet is ordinarily too large to be carried conveniently by one man. The handling involved in hauling a console to your shop involves risk of scratching the cabinet finish, so you will invariably go to the customer's home to fix a console. This is especially true for television sets. If troubleshooting and major repairs seem necessary, take to your shop only the chassis and other parts needed to operate the set on your bench. For radio sets the chassis and loudspeaker are all you need, as shown in Fig. 8.

Precautions for Consoles. A console is a more complicated and more expensive set, and the customer is usually watching to see how you handle it, so do your work even more carefully than on table-model sets. Be especially careful never to let a tool slip and scratch the cabinet. Be thinking always about getting each part back again correctly. It may be days or even weeks before you will be putting the chassis back. You will find from sad experience, just as every other serviceman has, that your memory cannot be trusted that long when working on a lot of different sets.

Make careful notes of the positions of knobs, pointers, screws, wires, and everything else you loosen or remove, whenever there is the slightest possibility of getting things back wrong. Thus, if some knobs are different

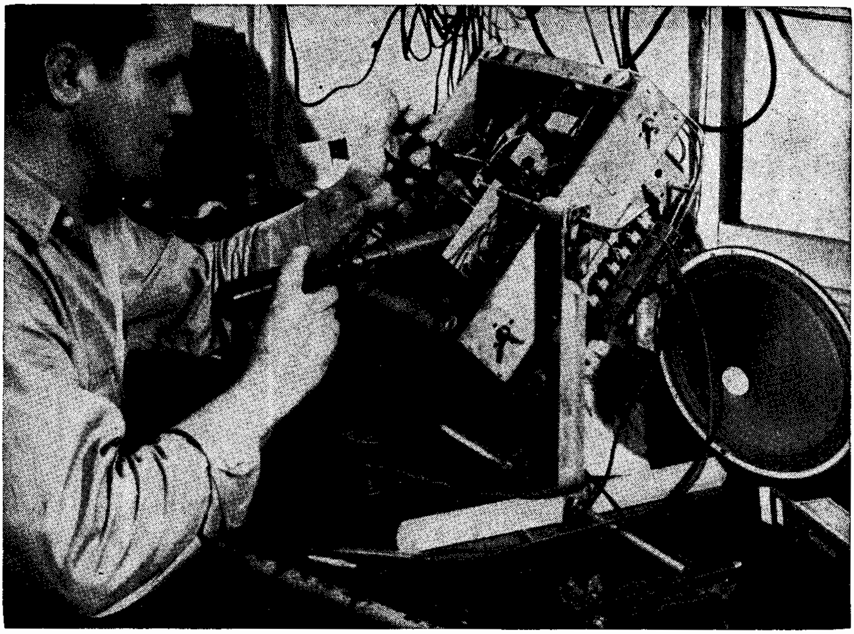


Fig. 8. Only the chassis and loudspeaker of a console were brought to this shop for repairs. Chassis jack, available from jobbers for around $5, holds chassis at any convenient angle. Most servicemen prefer to keep loudspeaker face-down on bench so dirt and iron filings cannot get into the air gap at the center of the cone. (Centralab photo)

from others yet all shafts are alike, make a sketch showing where each knob goes. If pushbuttons must be removed and the call letters are set into the buttons, jot down the order in which the buttons should be.

If there is any chance of getting leads mixed up, as there usually is, make a sketch before disconnecting a single one. In the set shown in Fig. 9, for example, sketches may be needed for the wires going to both loudspeakers, for the f-m antenna terminal strip, and for the a-m loop connections. All the other leads here have plugs and receptacles that are practically impossible to get back in wrong.

Scotch tape and china-marking crayon are good to carry in your toolbox for labeling leads. Keep a supply of 3- by 5-inch index cards and a pencil in your pocket foı making diagrams and jotting down information. Put the customer's name or the make and model number of the set on each card at the same time, because loose cards easily get mixed in a shop.

Never lay your tools or even knobs and screws on top of the cabinet. You run a serious risk of scratching the cabinet. There is also the risk that screws and knobs will roll off the cabinet and get lost under furniture without your realizing it. Remember that you are responsible for any damage that you do to the cabinet, as well as to any other furniture in the customer's home. Even a small scratch that you are unable to fix satisfactorily may become the customer's excuse, and rightfully, for not paying your bill.

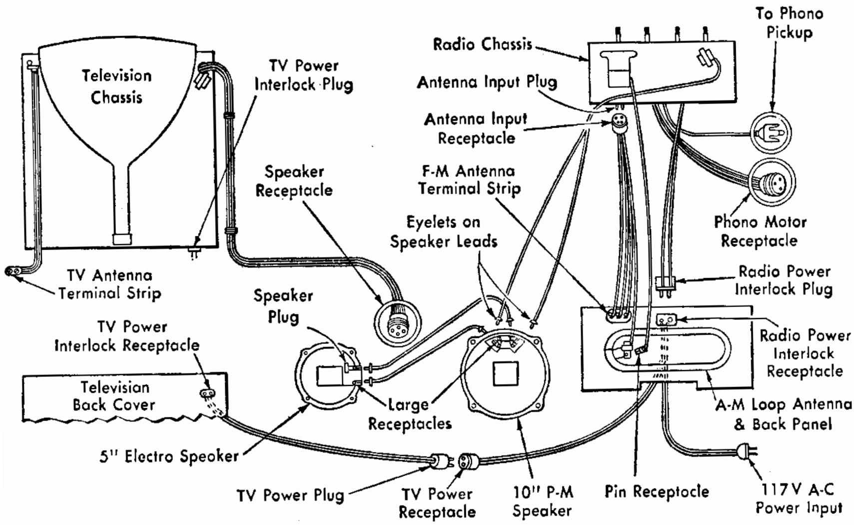


Fig. 9. Example of connection diagram for television-radio-phono console

Simple troubles like loose wires and bad tubes are even more common in consoles than in table-model sets, so do not remove the chassis until you have made a thorough inspection for obvious defects and have checked tubes.

Disconnecting Console Antennas. A modern radio-television console can easily have as many as three separate built-in antennas and one or more outdoor antennas, all connected to screw or plug terminals on the chassis. These antenna leads must usually be unplugged or disconnected to get the chassis out. Just as with table sets, make a careful sketch to ensure that you will get the leads back again correctly. Handle these antenna leads carefully, because rough handling often makes them weaken or break near the point of connection.

A loop antenna is an actual part of the radio circuit. It should therefore be taken to your shop along with the chassis and loudspeaker whenever possible. You can then check performance of the set in the shop after you have located the trouble and repaired it. If the loop antennas are mounted on the back cover of the set, they present no problem. Just take the entire cover with you.

If the loop antenna is separately mounted and is rotatable, it can generally be lifted out easily by removing a few screws on the upper mounting bracket. Study the installation carefully until you find the screws provided for this purpose.

There are unfortunately a large number of consoles in which the loop antennas are stapled to the inside of the cabinet or to its back edges. In general, it is unwise to remove antennas of this type. Instead, make a sketch of the stapled antenna and put estimated dimensions on the sketch. You can then roughly duplicate the antenna on your bench with the same length of ordinary hookup wire.

Disconnecting Record-changer Leads. Never cut a wire or cable that passes through a hole in the cabinet framework. Look carefully for a disconnecting plug or terminal screw somewhere along the length of that wire.

The power leads to the phonograph motor are soldered to terminals inside the chassis in a few receivers, instead of being plugged into a socket. If there is no plug for these leads on the chassis or at the motor, you will have to cut the leads before you can remove the chassis from the cabinet. Stagger the cuts, so the joints cannot touch each other even if your insulating tape falls off.

In some sets the phonograph motor plugs into an outlet on the chassis. This outlet is wired so power to the phonograph motor is cut off when the set is turned off.

In the commonest type of cable used to connect the phono pickup of a record changer to a radio receiver, the insulated wire is connected to a metal prong. The braided metal shield around the wire is connected to a metal cup that surrounds the prong. This plugs into a single-hole jack that is generally located at the back of the chassis. If there is only one such jack, you can safely pull out the lead without any worry about getting it back right. If there are two or more identical jacks, make a sketch first before disconnecting the record changer. Extra jacks are sometimes provided for plugging in a microphone, recording equipment, a television tuner, or an f-m tuner.

Removing Record Changers. If poor radio reception is the complaint of your customer, there is no reason to touch the record changer once you have disconnected its leads. Only where the customer mentions record-changer trouble would you take this to the shop.

Removal of the record changer usually involves lifting it directly out of the cabinet, because the changer floats on springs. Look first for shipping bolts inside the springs, however. Usually these bolts will be loosened rather than completely removed. Shipping bolts should never be tightened except for shipping purposes.

Disconnecting Speaker Leads. When a disconnecting plug is provided for the speaker, one or two of the pins in it are thicker than the others or are unequally spaced, to serve as a guide for inserting the plug correctly in its socket. There is not very much difference in thickness or spacing, however. It is possible to get the plug in wrong by applying a little force. Therefore, make a habit of examining plugs and sockets like this carefully before inserting the plug. Use your eyes rather than your sense of touch to get the pins in the correct holes. Incorrect insertion can cause damage when the set is turned on.

Avoid turning on a set when the speaker is disconnected. This is particularly important with consoles, since they usually have more power and there is more likelihood of serious damage. The speaker is the load for the audio amplifier, and holds voltages down to their normal values. With the load removed, the voltages shoot up much higher and can cause breakdowns of parts.

Pilot-lamp Connections. Console radios quite often have one or more pilot lamps in the record-changer compartment. In sets having solid doors that close to hide all controls, there is usually a pilot lamp behind a red glass button or jewel above or below the doors. This glows to indicate that the set is on.

Sometimes the pilot lamps that illuminate elaborate tuning dials are mounted on brackets attached to the cabinet rather than to the chassis. Pilot-lamp sockets in consoles are usually screwed or bolted to the cabinet and have soldered wire leads running to the chassis. Leave the wires connected and remove the sockets when preparing to remove the chassis.

Some pilot-lamp sockets are held in place by spring clips that fit over brackets attached to the cabinet. To remove a spring-type pilot-lamp socket from its bracket, grasp the socket firmly with your fingers and pull.

Use your flashlight for examining pilot-lamp socket-mounting arrangements deep inside the cabinet. One good look is generally enough to tell you which way a socket comes off.

Rubber bands are handy for fastening pilot-lamp wires and other cables to some part of the chassis, to prevent the wires and sockets from flopping around while carrying the chassis to your shop.

Removing Chassis Mounting Bolts. In most consoles the chassis rests on a shelf or framework very much like the bottom of a table-model radio. The chassis is attached from underneath with bolts or screws just as in small sets. Getting at and seeing these screws is sometimes just as much of a problem as working on wires behind the dashboard of an automobile. In both cases the best method is to forget your dignity and lie on the floor on your back, with your head inside the cabinet. Again a flashlight comes in handy for speeding up the work.

Sets having the chassis mounted on its side are more of a problem. The upper mounting screw closest to the front is usually hardest to get at, so remove it first. Leave the easiest screw for the last, and hold the chassis with one hand while removing it. You will soon develop your own tricks for getting out these side-hung sets painlessly.

There are many other ways of fastening a chassis to the inside of a console cabinet. Careful inspection with a flashlight will always reveal the locations of the mounting screws or bolts.

Getting the Chassis Out. Rubber vibration-absorbing washers will usually be found under the chassis on big sets. Lift the chassis to get clear of these, then slide it out through the back. Get a firm grip on the chassis when doing this, and pause for inspection whenever something sticks. Be prepared to tilt the chassis to get it past the back framework on some sets.

The chassis is sometimes mounted on a square of ½-inch plywood. This baseboard in turn is screwed to the cabinet. Here you remove the baseboard mounting screws first, lift out the chassis and baseboard as a unit, then lay the chassis on its side or back so you can get out the bolts that fasten the board to the bottom of the chassis.

Tuning dials of consoles are oftentimes mounted on the chassis and also screwed to the front of the cabinet for greater rigidity. If the chassis does not slide out easily, look for screws at the back of the dial.

Removing the Speaker. Practically all speakers in consoles are fastened to the cabinet with mounting bolts, the nuts of which are accessible from the rear. These nuts are easily removed with a hollow-shaft socket wrench of the correct size. Remove the bottom two nuts first, and hold the speaker with one hand while spinning off the last of the upper nuts with the socket wrench or your fingers.

It is generally best to take the speaker to your shop along with the set. Do this unless you are certain that you have located the trouble and can fix it without trying out the set at the shop. Be careful not to damage the speaker cone when handling it. Keep the speaker *face down* in a clean location to minimize chances of iron filings getting into it.

Inspecting the Chassis. After removing any chassis in a customer's home, place it on a cloth or newspapers that you have spread out to protect the rug and floor. Now turn the chassis upside down or on a side so that you can inspect the parts underneath. Look for obvious defects, such as burned-out resistors, paper condensers from which all the wax has run out, bad wiring, and bare leads or terminals touching each other.

If you want to go a bit farther and can operate the set outside of its cabinet, plug in the set and turn it on. With volume well advanced and a station tuned in, try tapping each tube in turn with the handle of a screwdriver. If proper operation is restored or noise is produced when a particular tube is tapped, that tube is probably intermittently defective and needs replacement. Next, poke or wiggle each under-chassis part in turn with a stick of wood, with the handle of a small screwdriver, or with plastic tongs made for this purpose, as shown in Fig. 10. Do this also for tube-socket terminals and other soldered joints. Many simple defects can be located in this way.

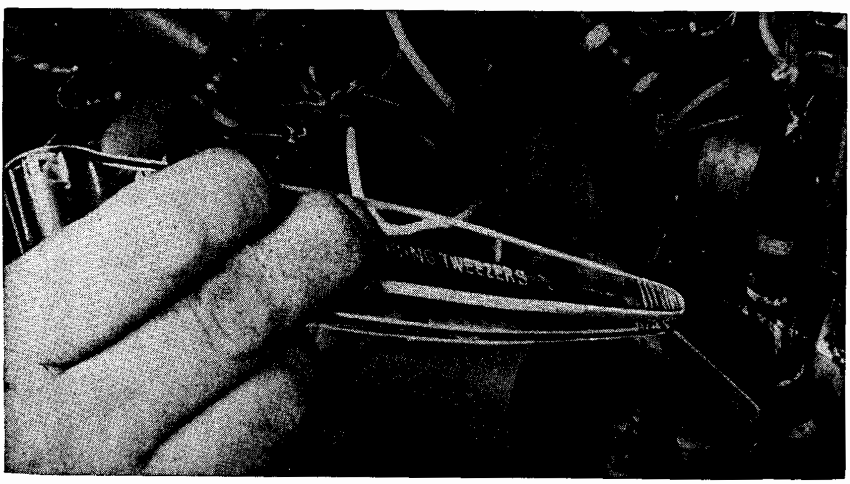


Fig. 10. These probing tweezers, made of insulating plastic, are handy for wiggling suspected parts and wires while a set is on, as well as for picking up small parts that are accidentally dropped into a chassis. (Hytron photo)

Troubleshooting. It is usually impractical to operate the chassis of a large console on the floor, because antenna and speaker leads are not long enough. Also, the home is by no means an ideal place for troubleshooting. Once you have gone this far, your best bet is to take the chassis and all other needed parts to your shop. Customers will invariably permit this when you explain that you will call them for approval of your estimate of the charges before you go ahead with the actual repair work.

As you acquire experience, you will occasionally do some chassis troubleshooting in a customer's home. Usually there will be special circumstances, such as a rural location 25 miles or more from your shop where the mileage cost of an extra trip would be pretty high. Another situation justifying work in the home is where the customer is extremely eager to have the set fixed immediately for use at a party or other event.

Do not tackle a repair job in a customer's home unless you are sure you can finish it, however. Your workbench is the only place where you can really do justice to the customer's receiver under normal circumstances.

Taking the Chassis to Your Shop. When leaving the customer's home with a chassis, make several trips from the house to the car, to avoid the risk of dropping something. Put the chassis on the floor of the car rather than on the seat. Put the loudspeaker face down on the floor, on newspapers.

The chassis is always safest on the floor of the car. On spring seats or on a cushion there is more danger that it will flip over when hitting a bump.

Always have the customer's name and address on a card that is firmly wedged between parts on a set or is tied to the set. This is particularly important when you pick up several sets on the same trip. Otherwise, sets can easily get mixed up.

Be just as careful with each chassis in your shop. Shelves keep sets out of danger. Keep your bench clear except for the set on which you are working.

Cleaning the Chassis. Always expect to find a lot of dust and dirt on the chassis and inside the cabinet of a receiver. A housewife is not supposed to clean the inside because of the possibility of damage and sometimes of shock. Therefore, never comment on the amount of dust that you find inside a set. Consider a thorough cleaning as a regular part of every job that comes on your service bench. Do not do this cleaning in the customer's living room, however. Leave the dust on or take the chassis outside for cleaning.

A cloth is used for removing dust. A few drops of liquid furniture polish on the cloth will make it hold dust better. A small, clean paint brush with soft bristles is handy for getting between crowded parts on top of the chassis. Later you may wish to get a small vacuum cleaner or use an attachment with your regular home vacuum cleaner.

Use a system when wiping the chassis of an old radio that may have a 10-year layer of dust. Remove a tube and wipe it, wipe the chassis area and socket made accessible by removal of that tube, then replace the tube. Repeat for each other tube in turn. This is better than removing all the tubes at once, unless you are going to do this anyway for tube-testing purposes. The important thing is to avoid getting the tubes mixed up and replaced incorrectly.

After wiping off the tubes and chassis, take a good deep breath and blow out the dust from between the gang tuning condenser plates. A feather or pipe cleaner can be used between individual pairs of plates if the dust sticks stubbornly.

Any grease or dirt on top of the chassis that cannot be removed by simple wiping should be rubbed with a cloth dipped in cleaning fluid such as carbon tetrachloride.

Do not use cleaning fluid on any plastic material such as cabinets, dial windows, or plastic safety windows of television sets, as cleaning fluid will soften and ruin some plastics. Wipe the tuning dial and its transparent window, if present, with a soft dry cloth. There is nothing underneath the chassis that needs to be cleaned.

Caution. In looking over a set and cleaning it, do not touch the adjusting screws for coils and condensers even if their bolts or nuts appear to be loose. These adjustments are often critical, and special test equipment is needed for realigning the receiver if the adjustments are changed.

Cleaning Television Glass Surfaces. With television sets, the face of the picture tube and the plate-glass or plastic safety window in front of it should be cleaned carefully without scratching the highly polished surfaces. First dust each surface lightly with a soft dry cloth to get off as much dust as possible without grinding it in. Next soak a chamois or soft cloth in warm water and wring nearly dry, to clean the surfaces thoroughly.

Putting the Chassis Back. Replacing a chassis in a console cabinet is the reversal of the steps followed in removing the chassis. Replacement is even easier than removal if you have been observant and have made careful notes.

If any screw holes in a wood or plastic cabinet are stripped or too large, insert a small piece of rosin-core solder in the hole before putting in the screw.

When the entire job is finished, plug in the set and check its performance yourself carefully. If something is wrong, check the installation again step by step to see what you have overlooked. Remember that band-changing and radio-phono switches must be set for radio reception. When you are satisfied with the performance of the set, ask the customer to check it also because this is good business.

Before you leave the customer's home, make one quick search to see if you have left any tools. Next, clean up all dirt and scraps of insulation that are left on the rug or floor. Put back in position any lamps or chairs that you moved. Do everything else needed to make the room as neat and clean as when you came into the house.

Collecting the Money. To complete the service call after returning and installing the repaired chassis, you would next hand the customer a bill that was carefully prepared beforehand in your shop. To make sure the customer has the money ready for you, in check or cash, call the customer beforehand and ask for an appointment to install the chassis at a time when it would be convenient to pay the bill.

Television and radio repairs must be on a cash-and-carry basis if you are to stay in business for long, because the time spent on extra calls to collect money is an expensive loss to you.

When you put your first chassis back in a console in a customer's home, when you hear him say it looks and sounds good, when you get paid—then you will have completed your first real service job. It is one of which you can well be proud—and the forerunner of many more because you will be on the right track to success in servicing.

QUESTIONS

1. What information should be obtained over the phone when a customer calls for service?
2. What topics should be avoided during conversation with a customer?
3. What is the commonest cause of trouble in all receivers?
4. Name three other causes of trouble that can be fixed without removing the chassis of a receiver.
5. Why should the position of a screwdriver-type control at the back of a television set be marked before changing the setting?

6. What does the contrast control do in a television set?
7. Which hold control should be adjusted when the picture changes to diagonal zigzag patterns?
8. Which hold control should be adjusted when the picture rolls up or down on the screen?
9. Why should the receiver line-cord plug be pulled out of the wall outlet before removing the chassis of a table-model set?
10. How are most control knobs removed from receivers?
11. When a built-in antenna is stapled to the inside of a console receiver that requires shopwork, how is an antenna obtained for shop use?
12. Is cleaning fluid safe to use on plastic safety-glass windows and on plastic masks of television sets?
13. How can service calls be kept on a cash basis?

5

Getting Acquainted with Electricity and Magnetism

A Foundation for Your Training. All television and radio circuits depend on simple basic things like voltage, current, resistance, power, and magnetism for correct operation. More important still are the volt, ampere, ohm, and watt units for measuring these things in circuits. You will use one or more of these units practically every time you look for bad parts or order new parts. Thus even the foundation training in this chapter is highly practical.

Introducing the Electron. When you poke a finger into an electric lamp socket, that unpleasant throbbing feeling is due to electrons flowing through the fingertip. What are these electrons? Where do they come from? Where do they go? Why do they go? And most important of all, what can they do? The simple answers to these questions will be for you the practical story of electricity at work in television and radio.

Electrons are everywhere, in everything. The electron is one of the smallest particles of matter, so small that it has never been seen by human eyes. Despite this smallness, an electron's behavior is well known. Think of the electron as a tiny ball, smaller than the smallest ball bearing you ever saw. Imagine it to be so small that it can travel through the invisibly small pores of metal objects, just as easily as water flows through the pores and holes in a sponge.

Electrons are everywhere because they are in each one of the atoms that make up everything in the world. An atom is bigger than an electron but still is too small a particle to be seen even in the most powerful new microscope.

An atom has a central core around which are whirling one or more electrons. Over 90 different kinds of atoms are known today. Each kind of atom has a different number and arrangement of electrons.

Some atoms are able to hang onto their own electrons pretty well. Other atoms have trouble keeping their full quota of electrons. An electron that gets away and wanders from atom to atom is called a *free electron.*

An atom is normal when it has its full quota of electrons—no more and no less—whirling around it. When an electron gets away, the atom has a way of attracting another electron to complete its quota again.

Negative Charges. An electron is technically known as the *unit negative charge of electricity.* The minus sign of arithmetic is used to represent the negative charge on the electron, as shown in Fig. 1. The same minus sign

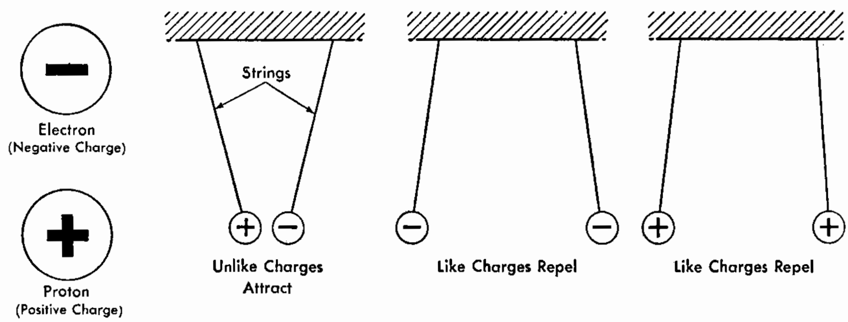


Fig. 1. Kernels of puffed cereal hung from silk threads will act like this if charged as indicated, demonstrating the law of electric charges on which the action of every tube depends

is also used to indicate a negative charge produced at some point in a circuit by a group of electrons. An example of such a point is the negative terminal of a battery.

Nature seeks to maintain a balance at all times. Therefore, for every unit negative charge there must be an equal and opposite positive charge. This positive charge is represented by the plus sign of arithmetic. The unit positive charge is called a *proton.*

A normal or neutral atom has the same number of electrons as it has protons. If an electron wanders away from a neutral atom for any reason, there will be one positive charge in the atom that is no longer canceled by a negative charge. The atom will then have a positive charge. This is all it needs to attract the next stray electron that comes along.

It is a basic law of nature that *unlike charges attract each other.* The diagrams in Fig. 1 will help you remember this. When objects with unlike charges, one positive and the other negative, hang side by side on strings, they are attracted to each other.

When both objects have positive charges, they repel each other. Likewise, when both objects have negative charges, they repel each other. These repelling actions illustrate the other part of this basic law of electric charges, that *like charges repel each other.*

The operation of every tube depends on this law of electric charges, so memorize these six words: *Unlike charges attract; like charges repel.* An easy way to remember is to think about the same natural law in the moonlight, where girls attract boys.

What Is Electricity? Whenever electrons travel toward a positive charge, they form a current of electricity. With the lamp socket as an example again, the action of the power company's generators is such as to produce at one instant a strong positive charge at one terminal in the socket. At the same instant, there is an oversupply of electrons (negative charges) at the other terminal. The electrons cannot travel through air to get to the positively charged terminal, but they can and do travel through the path provided by your finger inserted in the socket. What you feel is electrons in motion—a current of electricity.

Voltage Sources. Anything having the ability to produce a surplus of electrons at a terminal is a source of electricity, usually called a *voltage source.* Such a source will always have two terminals. There will be a surplus of electrons at the negative terminal and a corresponding shortage of electrons to provide a positive charge at the positive terminal. The greater the surplus of electrons, the higher is the voltage between the terminals.

Whenever an electrical path is completed between the terminals of a voltage source, the surplus electrons at the negative terminal will travel over this path to the positive terminal, as indicated by the arrows in Fig. 2. This travel of electrons along a path is called *electric current.* The current will flow just as long as the voltage source can continue replenishing the supply of electrons at the negative terminal.

Batteries are voltage sources that use up their supply of electrons and hence run down. Power-line voltage sources will not run down because the huge generators at the power station can keep up the supply of electrons.

Voltage Is Electrical Pressure. The higher the voltage, the more electrical pressure there is at the negative terminal of a source. This electrical pressure urges the electrons to take some path—any path—from the nega-

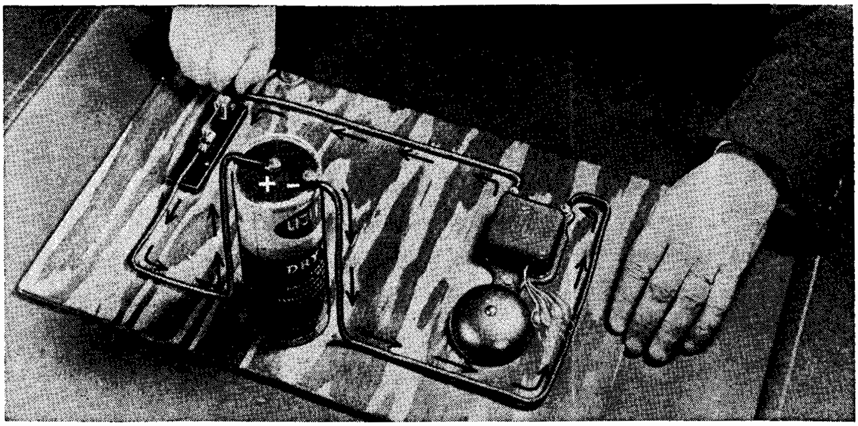


Fig. 2. When the switch is closed, the electron flow around this simple circuit makes the bell ring. The outside terminal of the standard No. 6 dry cell is negative, so electrons flow out from it through the wire as indicated by the arrows. (GE photo)

tive terminal to the positive terminal. If the voltage gets high enough it can even make the electrons jump through air. This can be seen as a spark, as an electric arc, or as lightning in nature.

Volts and Millivolts. The answer to any question about how much voltage exists between two terminals is expressed in *volts*. Voltages of some of the devices you will encounter in your work are indicated in Fig. 3. The shock that you feel becomes more violent as the voltage goes up.

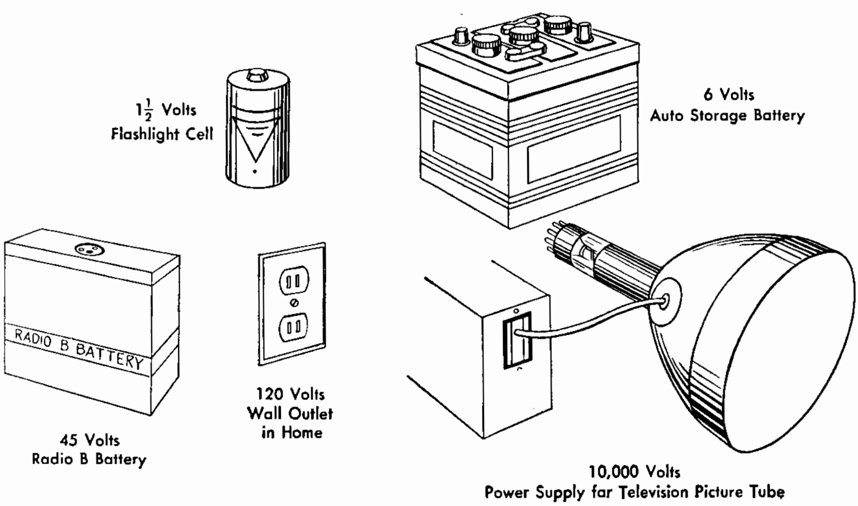


Fig. 3. Examples of voltages encountered in servicing work

Voltages below about 50 volts cannot usually be felt, but all voltages encountered in servicing can be measured with meters called voltmeters. In servicing work, you will be measuring voltages frequently because they are an important clue to causes of trouble. The abbreviation used for volts is *v*.

The smallest battery used in portable radios is rated at about 1½ volts. Much smaller voltages are quite common in circuits, however. To eliminate the decimals required to express small voltages in volts, the *millivolt* unit is used. One millivolt is equal to a thousandth of a volt; instead of writing 0.001 volt, you write 1 millivolt. The abbreviation for millivolts is *mv*.

Voltages of signals in receiver circuits are often even lower than 1 millivolt. For such small voltages a still-smaller unit called the *microvolt* is used. One microvolt is equal to a millionth of a volt; this means that 1 microvolt is the same as 0.000001 volt.

In television receivers, voltages of thousands of volts are needed for the picture tubes. To eliminate writing zeros for these high voltage values, a larger unit called the *kilovolt* is often used. One kilovolt is equal to 1,000 volts. The abbreviation for kilovolts is *kv*.

What Is Current? Voltage is a measure of the strength of electricity. But what can that strength do? Just one thing: It can push a certain number of electrons over a given path during each second of time after the path is provided. This flow of electrons is called *current*.

The more electrons flowing per second, the higher is the current. More electrons can do more work, so higher currents mean greater results. Current, electric current, electron flow, and current flow all mean the same thing—all are the result of a voltage that is making electrons move through a wire or other path.

The strength of a current could be expressed in terms of the actual number of electrons flowing per second. This is such a tremendously large number, however, that several more convenient units of current flow are used in television and radio servicing.

Amperes and Milliamperes. The basic unit for measuring current flow is the *ampere*. One ampere of current is flowing when 6.28 million million million electrons are flowing past a given point per second. This figure is given merely as a matter of interest, because you will never bother to count electrons. You will always deal with amperes and related smaller units for current flow. Ampere is abbreviated as *amp* or *a*.

In television and radio work, the unit of current that you will use even more than the ampere is the *milliampere*, abbreviated *ma*. One milliampere is equal to one-thousandth of an ampere. A still smaller unit is the *microampere*, equal to a millionth of an ampere.

The meters used for measuring current will always indicate which unit is intended. A meter that reads in amperes is called an *ammeter*. One that reads in milliamperes is called a *milliammeter*. One that reads in microamperes is called a *microammeter*.

It is unnecessary to have a separate meter for each current range. Instead, you will use a single instrument called a *multimeter*. This has one meter and a switching arrangement that permits changing the meter circuit so it can be used to measure several different current ranges.

What Is a Conductor? Electricity can flow freely only through materials known as *conductors*. In a good conductor, like copper, silver, or aluminum, there are many free electrons wandering aimlessly from atom to atom at all times. When a voltage source is connected to a conductor, these free electrons are attracted to the positive terminal of the source. This movement of electrons is the current that flows whenever a conductor is used as a path for electricity.

The more free electrons there are in a material, the greater is the current that flows when a voltage is applied. Most metals are good conductors, though some are better than others. The human body is a conductor, especially when the skin is wet.

What Is an Insulator? A material that has only a few free electrons is called an *insulator*. Examples of good insulators are glass, plastics, mica, dry air, and a vacuum.

There is no definite dividing line between conductors and insulators. Everything will conduct electricity to a certain extent, particularly if the voltage is made sufficiently high. Thus, with voltages of about 15,000 volts, electricity will flow through air between the points of spark plugs in automobiles. At the lower voltages encountered in radio sets, however, air is a good insulator.

Insulating materials are used between the terminals of all television and radio parts, to prevent electrons from taking short cuts. Sheets of brown or black Bakelite or a similar plastic are perhaps the commonest insulating material. This plastic insulation has a peculiar characteristic odor when cold. When seared by a hot soldering iron, its pungent smell is unforgettable.

What Is Resistance? You have learned that voltage is the force which makes electrons move. Current is the movement of electrons resulting from this force. You also know that materials called insulators offer almost complete opposition to the movements of electrons. This opposition to the flow of electrons is called *resistance.*

The resistance of an electron path through a good insulating material is extremely high. The resistance of a path through a copper wire or other good conductor is very low.

In television and radio circuits, in-between resistances are frequently needed for certain electron paths. Special parts called resistors are inserted in the electron path to provide a desired amount of resistance to current flow.

Ohms and Megohms. The unit used to specify the amount of resistance offered by a particular path for electron flow is called the *ohm.* Just to give an idea of its meaning, a 1-foot-long piece of copper wire about as fine as a human hair has a resistance of about one ohm. This is the kind of wire used in some types of television coils.

Thick copper wire, such as that used in wiring houses, has almost zero ohms of resistance per foot. The No. 18 copper wire that is so widely used for making connections in television and radio sets has a resistance of 0.006 ohm per foot. This resistance is so small that for connecting purposes we think of it as zero ohms.

Wire made from a metal alloy called Nichrome has a much higher resistance than copper wire. For this reason, Nichrome wire is often used to make resistors.

By winding a long length of fine Nichrome wire on an insulating form, resistance values as high as 10,000 ohms and even more are readily obtained. By using less wire or a thicker wire, any desired value of resistance between zero ohms and 10,000 ohms can be obtained.

High values of resistance, as high as 10,000,000 ohms, are widely used in television and radio sets. It would take too much Nichrome wire to get such high resistance values. This is why carbon is used in resistors instead of wire when higher values are needed. The carbon is mixed with clay in varying amounts and molded into rods of various lengths and thicknesses to get the desired resistance value.

It takes a lot of zeros to specify resistance values above 100,000 ohms. Therefore, a larger unit of resistance called a *megohm* is also used. One megohm is equal to 1,000,000 ohms. You will often find megohm abbreviated as meg.

What Is an Electric Circuit? Whenever a complete electron path contains the three things shown in Fig. 4A, it is a useful electric circuit.

First, a circuit must have a voltage source. This source can be a battery, a power line, a transformer, or a generator.

Second, a circuit must have a load through which electrons can flow to do useful work. This load can be a loudspeaker in which electrons can produce sound, a picture tube in which electrons trace out a picture, or simply a resistor that passes on a signal to the next tube.

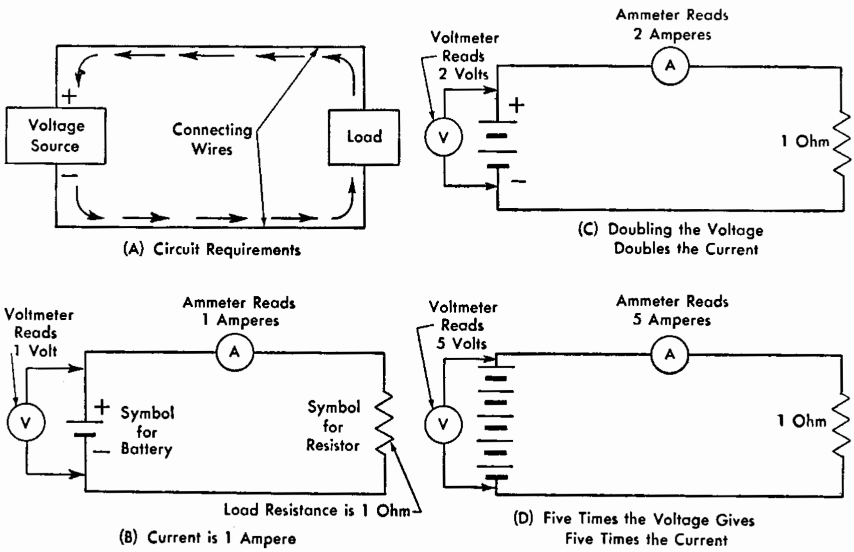


Fig. 4. These diagrams show that when you increase the voltage in a circuit, the current increases correspondingly. Study each note on each diagram

Finally, a circuit must have connecting wires. These provide a complete path through which electrons can travel from the negative terminal of the voltage source through the load and back to the positive terminal. The voltage source can be thought of as a pump that keeps the electrons circulating around this path.

Predicting How Much Current Flows. You already know that a high resistance cuts down the amount of current flowing in a circuit. Zero resistance allows the largest possible current to flow. Also, the higher the voltage, the more force there is to push electrons around a circuit, and hence the larger is the current.

There is actually a simple relationship between voltage, current, and resistance. This is illustrated in Fig. 4*B*. Here, a voltage of 1 volt produces 1 ampere of current in a circuit containing 1 ohm of resistance.

When the voltage is increased to 2 volts in Fig. 4C, the ammeter shows 2 amperes. Similarly, 5 volts gives 5 amperes, as in Fig. 4D, and 35 volts gives 35 amperes. The important thing to remember is that, when you double the voltage in a given circuit, you double the current.

Now suppose the voltage is left at 1 volt and the resistance of the load is doubled, as in Fig. 5. Again an ammeter will show how much current is flowing. Note that doubling the resistance cuts the current in half, to 0.5 ampere. In like manner, a resistance of 10 ohms passes only one-tenth of the current that 1 ohm passes.

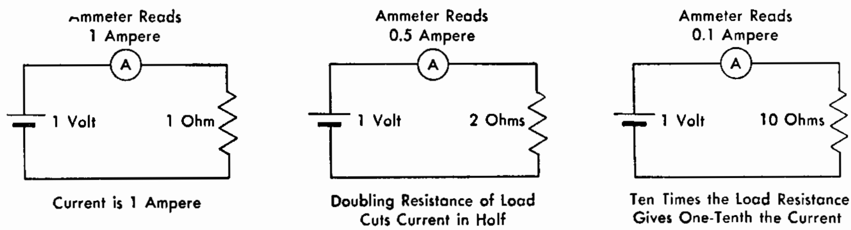


Fig. 5. Increasing the resistance in a circuit makes the current go down

To find what other values of voltage and other values of resistance would do to the current in this simple circuit, just divide the voltage value *in volts* by the resistance value *in ohms*. This gives the current value *in amperes*. Engineers call this rule Ohm's law, in honor of the man who first figured it out. You do not need to remember the law, however, as such figuring is not necessary for the practical servicing techniques covered in this book.

Heat and Power. Whenever electrons flow through something, it gets hot. For example, an electric lamp gets hot because electrons are flowing through its filament. An electric stove gets hot because electrons are flowing through the Nichrome wire in its heating element. Similarly, many resistors in a television set get hot or at least slightly warm when electrons flow through them. In each case, the heat means that electric power is being used.

There is a limit to how much electric power a device can take. Too much power means too much heat, and too much heat can make any device go bad. For this reason, resistors and many other parts in a television or radio set have a power rating.

The larger the physical dimensions of a resistor or other part, the higher will be its power rating because it has more surface area for getting rid of heat. The units used for expressing power rating are already familiar to you if you have electricity in your home.

Watts and Kilowatts. The unit of electrical power is the *watt.* Electric lamps have ratings ranging from 15 to 300 watts in the commonest sizes. The resistors used in television and radio sets have much lower ratings, ranging from 0.1 to 3 watts for carbon resistors and on up to about 20 watts for wire-wound resistors.

In servicing you will not need to use the larger and more familiar unit of power called the *kilowatt,* which is equal to 1,000 watts. It is good to know this relationship between watts and kilowatts, however. Your customers pay their electric bills on the basis of how many kilowatts of power they use each hour of the month.

Power is charged for on the basis of *kilowatt-hours,* abbreviated kwh. A special motor called a watt-hour meter is needed to measure this. Every home with electricity has such a meter. The meter is read by a power-company employee once a month to determine how much power was used. A 1,000-watt electric heater that is on for 1 hour draws exactly 1 kilowatt-hour of power. For 2 hours it would be 2 kwh; for 5 hours it would be 5 kwh. A 100-watt heater could be run for 10 hours to use up 1 kwh, however, because you multiply power in kilowatts by hours of use to get kwh.

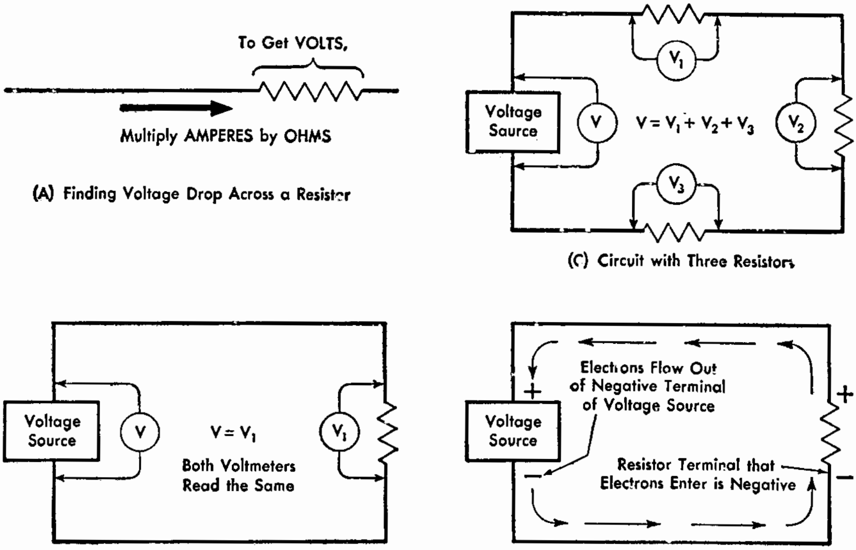
You may sometimes wish to explain that television and radio sets cost very little to operate. For example, suppose a television set draws 200 watts, as indicated in the service manual for the set. In an hour, then, the power used is 200 watt-hours, or $\frac{1}{5}$ kilowatt-hour. If the customer pays 5 cents per kilowatt-hour for electricity, the operating cost per hour is $\frac{1}{5}$ of 5 cents or 1 cent per hour.

In servicing, you will rarely if ever have to figure out power values. You simply order the same size of resistor that was in before.

Voltage Drops. Whenever current flows through a resistor, it produces a voltage drop across the resistor. The resistor value in ohms multiplied by the current value in amperes gives you the amount of this voltage drop, as illustrated in Fig. 6A.

As you get farther along in your study of circuits, you will find that resistors are often inserted intentionally in circuits to produce voltage drops. These voltage drops are often used to act on following circuits. The thing to remember now is that, whenever current flows through a resistor, there is a voltage drop across that resistor.

When there is only one resistor in a circuit, as in Fig. 6*B*, the voltage drop across the resistor is equal to the voltage of the source or power supply. When there are two or more resistors in the circuit, the voltage drops across the individual resistors always add up to the voltage of the source, as in Fig. 6C. This is useful to know when troubleshooting in circuits.



(A) Finding Voltage Drop Across a Resistor

(C) Circuit with Three Resistors

(B) Circuit with One Resistor

(D) Polarity of Voltage Drop

Fig. 6. Voltage drops across resistors in a circuit are useful troubleshooting clues. Study each diagram in turn carefully as you read the associated text

Polarity of Voltages. You already know that a voltage source has polarity, wherein one terminal is negative with respect to the other source terminal. Electrons, which are negative charges, flow out of the negative terminal when the circuit is completed. Once you identify the negative terminal of any voltage source, you know that the other terminal is positive.

The voltage *drop* across a resistor likewise has polarity. The direction of electron flow determines what this polarity is. The resistor terminal that electrons enter is ***negative*** with respect to the other resistor terminal, as indicated in Fig. 6*D*.

Polarity must always be expressed with respect to something. Thus, the polarity of one resistor terminal is expressed with respect to the other resistor terminal. The polarity of one battery terminal is expressed with respect to the other battery terminal. The polarity of one point in a circuit is usually meant to be with respect to ground, unless otherwise specified.

You do not even need to figure out the direction of electron flow through the resistor if you can trace the circuit from the resistor to the voltage source. The resistor terminal that connects to the negative terminal of the voltage source is always negative. Study Fig. 6*D* and you will see that this is quite logical.

Direct Current. Voltage sources that have a definite polarity at all times are known as direct-current sources. Batteries are an example. Direct-current sources make electrons flow in one certain direction through a circuit. This direction of electron flow, you will remember, is away from the negative terminal of the voltage source.

The term *direct-current source* is often abbreviated as d-c source, or simply as d-c. The voltage of a d-c source is similarly abbreviated as d-c voltage, or simply d-c. Thus, d-c can stand for direct current, for the voltage that sends direct current through the circuit, or for the source that has the voltage that sends the current through the circuit.

This sounds complicated, but do not worry about it; from the way the abbreviation d-c is used, you will always know what is intended. Most generally, you will find that d-c is used to indicate that electrons are flowing in the same direction at all times.

There are still quite a few thousand homes in this country, chiefly in the older sections of large cities, that have d-c power lines. The number is gradually dwindling, however.

Alternating Current. In most homes today, the current flowing through the power lines is *alternating current,* abbreviated a-c. This alternating current is produced by an alternating voltage, abbreviated a-c voltage or simply a-c.

An alternating voltage is produced by a generator that reverses its polarity many times a second. Each time the polarity reverses, the electrons flowing in all connected circuits must change their direction, too. The current is changing or alternating in direction many times a second, and is thus logically known as an alternating current.

In the United States, practically all a-c power stations generate power at a frequency of 60 cycles per second. During each cycle a given terminal will change from negative to positive in polarity and go back to negative again.

Most of the tubes in television and radio receivers require both a-c and d-c voltages. For this reason, each a-c set will have a power-supply circuit that changes the a-c voltage to a d-c voltage by a process known as rectification. As a result, you will be working mostly with d-c voltages. You will not have to worry a bit about the rapidly changing polarities of the a-c power-line voltage.

Alternating Voltage. At first thought it might seem impossible to specify the value of a voltage that is continually increasing or decreasing and even reversing in polarity regularly. Actually, this is no problem at all. A d-c voltage of 1 volt will produce a certain amount of heat when applied to a given resistor. The a-c voltage which produces *the same amount of heat* in that resistor is also 1 volt.

The a-c voltage value that produces this equivalent heating effect is called the *effective value*. Unless otherwise specified, a-c voltage values are assumed to be effective values. The meters you will use in troubleshooting read these effective values.

Magnets and Magnetism. Anything that attracts iron or steel is called a *magnet*, and this attracting ability is called magnetism. The operation of every transformer, practically all television picture tubes, every standard loudspeaker, many types of phonograph pickups, and all types of electric phonograph motors depends on magnetism.

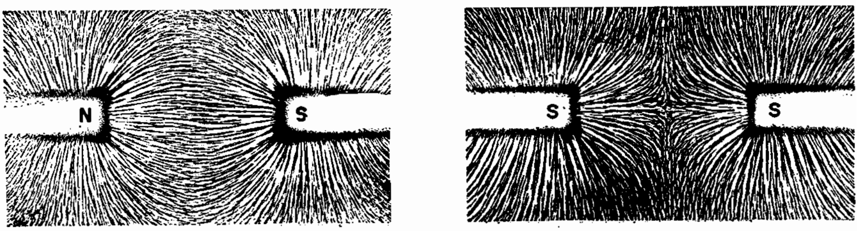
In service work you will be dealing with two types of magnets. A *permanent magnet* holds its own magnetism and cannot be turned off. An *electromagnet* has magnetism only when current is flowing through its coil. An electromagnet can therefore be turned off by stopping the current flow. A few practical facts about these two types of magnets will definitely prove useful.

Poles of Magnets. The attracting power of any magnet is generally greatest at its two ends. These ends are called the poles of the magnet. Iron filings sprinkled over a permanent magnet will cling to these two poles.

Both poles of a magnet have equal ability to attract iron filings and hence have equal magnetism, but actually the two poles are different. This difference can be demonstrated with two straight bar magnets by covering them with cardboard and sprinkling iron filings on the cardboard. If identical poles are brought together, the magnets will repel each other, and the pattern of iron filings will show a repelling action. On the other hand, if unlike poles are brought together, they will attract each other, and the iron filings will form lines going straight across between the two poles. A simple basic rule expresses this: *Unlike poles at-*

tract, and like poles repel. This rule, illustrated in Fig. 7, is exactly the same as for electric charges.

If a straight permanent magnet is hung or pivoted at its center so that it can rotate readily, one pole will always point in the direction of north. This is because the earth itself is a huge magnet. For convenience in identifying the poles of a magnet, the pole that swings to the north is called the *north pole.* The other magnet pole is called the *south pole,* because it is then pointing in a southerly direction. Every magnetic compass is based on this simple principle.



Unlike Poles Attract **Like Poles Repel**

Fig. 7. This is what happens when iron filings are sprinkled on cardboard placed over permanent magnets. The filings arrange themselves in lines corresponding to magnetic lines of force. Here the magnets are arranged to demonstrate the rules of magnetism

The letter N is often used in place of the word north to identify the pole of a magnet. The letter S is similarly used for the south pole.

Electromagnets. Any ordinary piece of iron or steel can be made into a magnet by winding insulated copper wire around it and sending direct current through the wire. When current flows, the ends of the iron or steel rod will be poles and will attract iron filings. As soon as the current is interrupted, the rod will lose its magnetism, and the filings will drop off. Any magnet that depends on electricity in this way is called an electromagnet.

The more current that flows through the coil of an electromagnet, the stronger will be the magnetism and the more iron will be attracted to the poles. Electromagnets used in large loudspeakers can easily hold a pair of pliers or a screwdriver. These powerful magnets therefore attract iron filings like honey attracts bees.

Even a single iron filing in a speaker can ruin the moving coil and cause distortion. It is extremely important to keep iron filings away from speakers. Good modern speakers are carefully sealed, and the magnets are covered with dust caps to keep out filings, but the magnets of many older speakers and cheaper modern units are exposed. You will learn more about what iron filings do to speakers later. You will also learn how to get out the filings.

Permanent Magnets. Certain types of steel can hold magnetism permanently. These pieces of steel continue being magnets after the magnetizing force of the current-carrying coil is removed. Such magnets are called permanent magnets and are now used extensively in speakers.

Modern permanent magnets are made from alloys that hold much more magnetism than steel alone. The most widely used of these alloys for speakers is Alnico V, which contains ALuminum, NIckel, and CObalt.

Magnetic Fields. Magnetism is the same, no matter whether produced by permanent magnets or electromagnets. Magnetism is considered to be a magnetic *field* made up of magnetic *lines of force*. All magnets are surrounded by magnetic lines of force, arranged much like the lines formed by the iron filings in Fig. 7.

Magnetic lines of force occur for any coil that is carrying current. Even a wire has magnetic lines of force around it when carrying current. The more complete loops or turns there are in a coil, the more magnetic lines of force there are, as shown in Fig. 8. This means that more turns of wire give more magnetic effect.

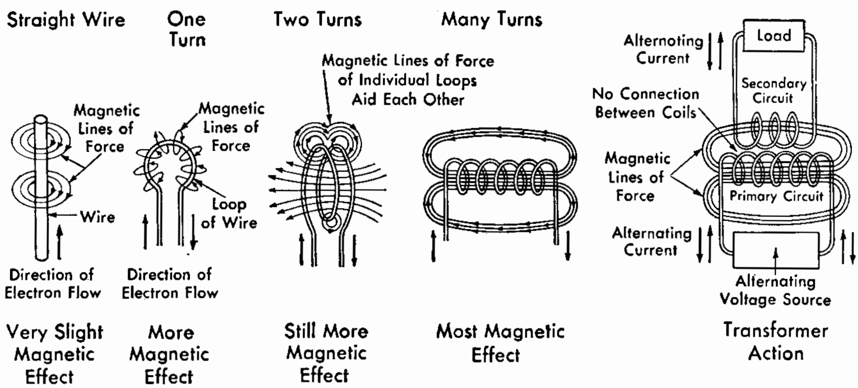


Fig. 8. Coil and transformer actions. The more turns of wire there are in a coil, the greater is the magnetic effect

The actions of all transformers depend on this magnetic field around a current-carrying coil. If another coil encloses part or all of the magnetic field, the two coils can act on each other even if not touching. Any change in current through the first coil can make a current flow through the second coil when the two coils are connected into a circuit.

Since alternating current is continually changing, it can easily be transferred from one coil to another by a magnetic field, as in Fig. 8. You thus already know the operating principle of a transformer, even before studying this important part.

Interference from Magnetic Fields. The power transformer in an a-c receiver and the motor of a record changer both have coils that carry fairly large alternating currents. These coils therefore produce strong and continually changing magnetic fields that can affect other nearby parts. For this reason, parts whose performance might be affected by these magnetic fields must be kept well away from the troublemaking coils or shielded from them by iron or steel housings or partitions.

Even a single wire can pick up hum from the magnetic field of a motor or transformer, if this wire is in a part of the receiver circuit that is followed by a number of amplifier tubes. Here the wire itself must be enclosed in a shield. Insulated wires inside a braided wire shield will often be found in receivers.

Iron or steel is required to shield parts from the magnetic fields of coils that carry 60-cycle alternating current. Aluminum or copper shields are used for coils and transformers carrying signal currents at higher frequencies. Even tubes are sometimes shielded, to prevent stray magnetic fields from affecting them.

QUESTIONS

1. Will a positive charge attract a negative charge?
2. The television power supply in some sets delivers 14 kv; how many volts is this?
3. What unit is used to specify the amount of resistance?
4. If the voltage of the power supply in a circuit is increased, will the current increase?
5. What is the approximate cost of electricity for operating a television set one hour?
6. What is the power-line frequency in your locality?
7. How can the magnetic effect of an electromagnet be stopped?
8. If the N pole of one magnet is brought near the N pole of another magnet, will they attract each other?
9. Why are iron or steel housings used for some receiver parts?

6

How to Use a Multimeter

Getting Acquainted with a Multimeter. In servicing, you need to measure d-c volts, a-c volts, ohms, and occasionally amperes when testing to locate the defective part in a receiver. The instrument used for this purpose is called a *multimeter*. With it, every part in a television or radio receiver can be checked for internal faults, such as breaks in wires, changes in resistance, short circuits between wires, and grounds.

A multimeter is sometimes called a volt-ohm-milliammeter, a multitester, a set tester, or a multirange tester. Multimeters having only volt and ohm ranges are also called volt-ohmmeters.

A multimeter has a number of different ranges for each type of measurement, to cover all testing and troubleshooting requirements in servicing. These voltage, resistance, and current ranges are obtained by combining special switching circuits and plug-in terminal jacks with a single meter.

To use a multimeter, you set the range switch of the multimeter to the kind of meter you want, plug the test leads into the correct pair of jacks, clip the test leads to the terminals of the part being checked as in Fig. 1, and read the meter.

In troubleshooting, you measure voltages while the set is on or measure resistances while the set is off. By comparing your multimeter readings with the normal values given in service manuals, you get clues to the location of the trouble.

Consider the multimeter as a tool for indicating what your eyes, ears, and nose cannot do. For example, if you suspect the defective part to be a resistor yet the resistor is not charred or burned in any way, use the ohmmeter range of the multimeter to test the resistor.

As another example, suppose all the tubes in a receiver test good and all the parts look good, yet the set is dead. Here you would use the d-c voltmeter ranges of the multimeter to measure voltages in the set. You then compare these values with those given in the service manual for the set and look for trouble in the section where measured and printed voltages do not agree.

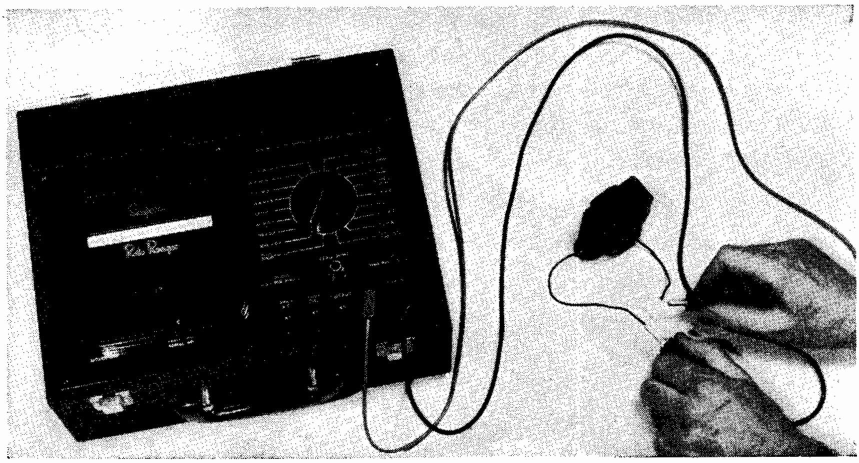


Fig. 1. Measuring the resistance of a choke coil with a multimeter. This Simpson model 221 Roto Ranger has an ingenious mechanism that automatically changes the meter scale when the range switch is changed. This minimizes meter-reading mistakes because the meter scale is always read directly

In this chapter you will learn how to use a multimeter correctly for practical servicing tests. You will find that reading the meter is just as easy as reading length on a ruler. You will get simple instructions for choosing the correct multimeter range for any test. Most important of all, you will get advice on how to choose a good multimeter for your servicing work.

Choosing a Multimeter. Many different sizes and styles of multimeters are available at an equally great variety of prices. Choosing the best one for your particular requirements can be a real problem if you have only catalogs to go by.

Examples of good multimeters for servicing use both in the shop and home are shown in Fig. 2. If you choose one of these, there is no need to worry about what to look for in a multimeter. Both are designed and constructed properly for practical television and radio servicing, and will get you started right. Each has a convenient handle for carrying into homes and at the same time meets all requirements for bench use in your shop. Each has the required high sensitivity for television testing. Prices of both are about the same, in the range of $40 to $50.

The construction and design information in the following sections will help you to get acquainted with the important parts and features of your multimeter. This information will also serve as a buying guide if you want to consider some other make or model of multimeter.

Meter Sensitivity. Multimeters are rated according to their sensitivity in ohms per volt when used as voltmeters. The higher this rating is, the more sensitive is the multimeter and the more accurate it is.

Multimeters with a sensitivity of 20,000 ohms per volt are widely used by experienced servicemen. The recommended multimeters in Fig. 2 both

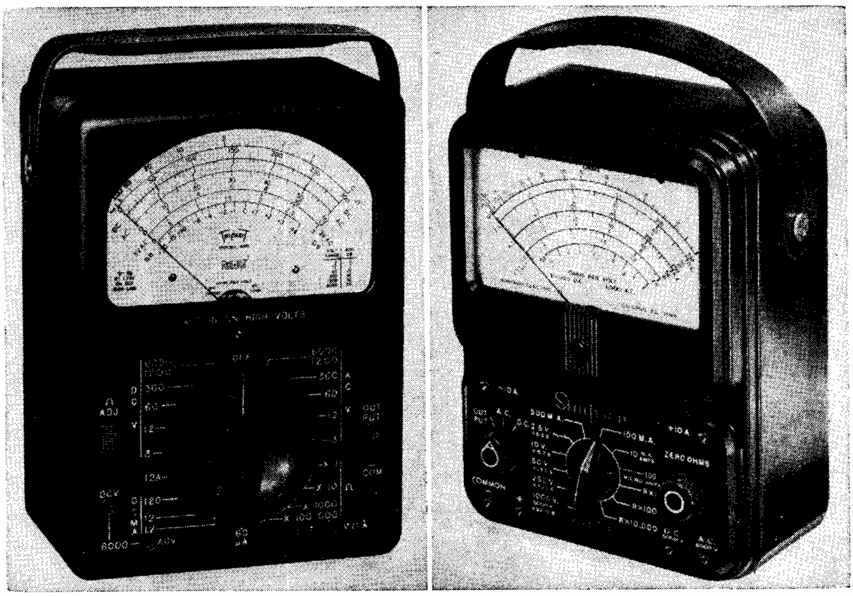


Fig. 2. Two excellent high-sensitivity multimeters recommended for anyone getting started in servicing work. Left—Triplett model 630. Right—Simpson model 260

have this sensitivity. Pocket-size multimeters with sensitivities of 1,000 or 2,000 ohms per volt may be cheaper but are no good for you, because they cannot measure the higher resistance values encountered in modern receivers.

Meter Scales. A neat and simple arrangement of scales on the meter of a multimeter helps prevent mistakes in reading. The three most important scales are for ohms, a-c, and d-c values.

The ohms scale is usually at the top on a multimeter, because its divisions are unequally spaced, and require more identifying numerals for easy reading. The d-c scale comes next, and the a-c scale is under it.

The a-c scale is often printed in red to distinguish it from the d-c scale. Extra sets of numerals are usually printed below the a-c and d-c scales, to make it easier to read other ranges of values on these scales. Sometimes the same numbers serve for both the a-c and d-c scales. In a good multimeter the scales are carefully planned for easiest possible reading on all ranges.

One requirement for easy reading of resistance values is the use of *multiplying factors* for the higher ohms ranges. With this system, the ohms scale is read directly when the switch on the instrument is set to $R \times 1$. The designation $\times 1$ means multiply by one. When the switch is set to $R \times 10$, the ohms scale readings are multiplied by ten. Similarly, for settings like $R \times 100$, $R \times 1{,}000$, $R \times 10{,}000$, and $R \times 100{,}000$ the scale values are multiplied by the designated number.

One excellent higher-cost multimeter for servicing use is that shown in Fig. 1, which has an automatic scale-changing mechanism. Whenever the selector switch is changed, the scale on the meter changes also. With this feature, the multimeter is much easier to read, and there is no danger of reading the wrong scale. Though costing almost twice as much as the multimeters shown in Fig. 2, it is no more accurate or useful. Consider it only if you can afford to pay that much extra to get an easy-reading scale. Many servicemen do find that it is worth the extra money.

Why Extra Ranges Are Needed. Several ranges are needed on a multimeter for each type of measurement so the pointer can be read more accurately. The effect of using just one high-range scale would be like using a 300-pound bathroom scale to weigh a letter. You cannot read small fractions of a pound on a scale made for hundreds of pounds. Likewise, you cannot read a 1½-volt battery voltage on a 5,000-volt scale designed for television power-supply measurements. For such low measurements a 0-to-3-volt range, 0-to-5-volt range, or even a 0-to-15-volt range is needed to give the accuracy required. The same holds true for resistance and current measurements. Several ranges are therefore provided on a multimeter for each type of measurement.

Controls. Simplicity of operation is important in a multimeter. It helps to speed up testing and reduces chances of damage by using the wrong range.

Most multimeters require only one operation to change a range for most of the settings. The extra jacks for high voltage and for high current (amperes) are not serious objections, as these ranges are not used very often. These extra jacks are required because the range-selector switch is not ordinarily made to handle such high voltages and currents.

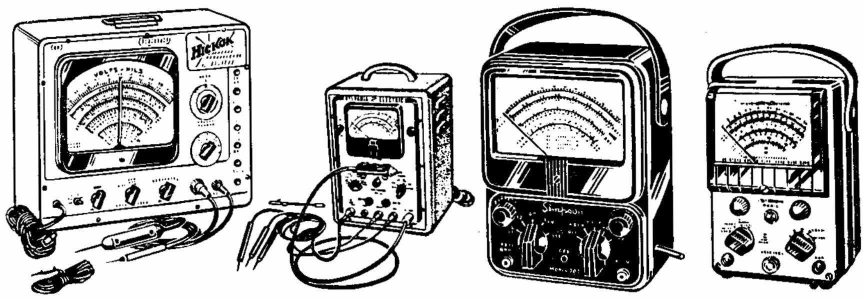
Test Leads. Two leads, one red and the other black, are generally furnished with a multimeter. Each lead has a short probe at one end for plugging into a jack on the multimeter panel. The long probe at the other end of the lead is held in the hand when measuring. In addition, two removable alligator clips are often furnished with test leads. These can be pushed onto the metal tips of the probes when semipermanent connections are desired. Some probes have permanently attached clips.

Carrying Case. Although you can get a leather or plastic carrying case for either of the recommended multimeters, the extra cost is rarely justified. These multimeters are made well enough to withstand ordinary handling on your bench, in your car, and in homes. The case can actually be a nuisance, since it takes time to take the multimeter out of the case and put it back.

Combination Multimeter and Tube Tester. A double-purpose instrument may be a bit cheaper than a separate multimeter and tube tester of the same quality, but it is definitely not recommended for you at the start. Accidental damage to the meter when using the multimeter section puts the tube tester out of action, since the same meter serves for both. This leaves you without your two most important instruments for the two or more weeks needed for shipping the instrument to the factory and getting it repaired.

Electronic Multimeters. Another type of multimeter you may want to consider later for bench use and even for television work in homes is one of the electronic multimeters shown in Fig. 3. These are also called electronic volt-ohmmeters, vacuum-tube voltmeters, and vacuum-tube volt-ohmmeters. Each has one or more vacuum tubes and hence must have a source of power for filament and plate voltages. Some of these electronic multimeters operate from the a-c line, while others have batteries for portable use just as in portable radios.

The advantage of the electronic instrument is that it has practically no effect on the circuit to which it is connected. Ordinary multimeters draw enough current to reduce the voltage appreciably in high-resistance circuits. Electronic multimeters draw very little current, as they use the amplifying ability of the tube to increase the strength of this current enough to operate the meter. Such a characteristic is especially useful in television servicing. Another advantage of electronic multimeters is that they are not likely to burn out when overloaded by mistake. Chief drawbacks of electronic multimeters for you at the start, however, are higher cost and more complicated operation.



Hickok Model 209A   Sylvania Polymeter   Simpson Model 303   RCA Voltohmyst

Fig. 3. Examples of good electronic multimeters, well worth considering after getting established in a servicing business

Instruction Booklet. With each multimeter comes the manufacturer's booklet of operating instructions. This tells how to set the multimeter for the desired range and how to connect the test leads to the part or circuit being tested.

Some multimeter instruction booklets are small, and contain only the barest minimum of operating instructions. Others are larger, well prepared, and fully illustrated. The more complete instructions can be a real help to you in getting the best possible results from your multimeter. Good instructions also reduce chances of damaging the meter accidentally during use.

The general instructions in this chapter cover all common precautions against damage, but multimeters differ greatly in design. Do not take chances in operating your multimcter—read its instruction book first, before trying to use the meter. Remember that you can burn up a ten-dollar bill (the usual minimum price of a multimeter repair job) faster with improper use of a multimeter than with a match!

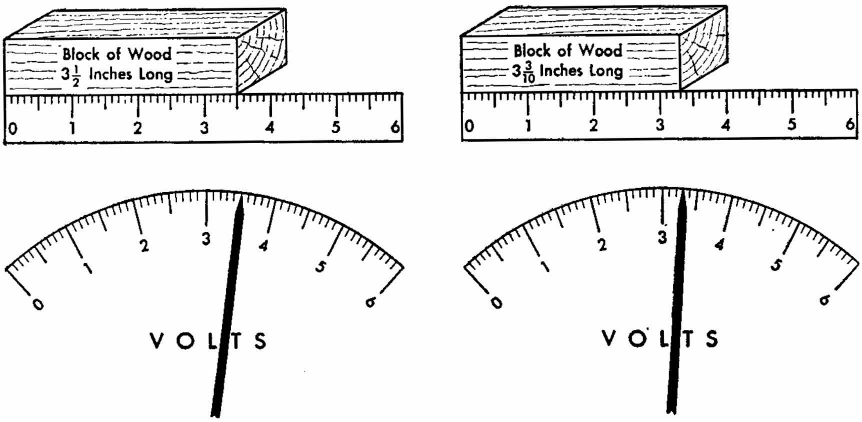
If a registration card is included with your new multimeter, fill it in and send it back to the manufacturer as soon as possible. This will give you full benefit of the manufacturer's guarantee on your instrument.

Measuring D-C Voltages. Measurements of d-c voltages in receivers provide extremely valuable information when hunting for the troublemaking section. Learn the correct procedure now, to avoid possible damage to your new multimeter.

1. If the multimeter has an a-c/d-c switch, turn it to the d-c position. If no such switch is used, proceed directly to the next step.
2. Set the range switch to a d-c voltage range, usually marked D-C V. If you know about how many volts to expect at the place you intend to check, set the range switch to the range next higher in voltage. For example, if you expect to measure a voltage around 180 volts, then set the range switch to 250 or 300. If you have no idea how many volts to expect, set the range switch to 1,000 or 1,200. If working on the high-voltage section of a television set, start with the 5,000- or 6,000-volt range.
3. Put the short black test-lead plug in the common black jack, generally marked COM, —, or COMMON.
4. Put the short red plug in the red jack identified by V-O-MA or a similar voltage designation.
5. Hold the long-handled black probe on the negative voltage terminal of the set. This is generally the chassis. If you are making several voltage tests, push an alligator clip over the end of the probe and clip it to the chassis.
6. Turn on the set if it is not already on. Touch the tip of the long red probe to the terminal you want to check. Make this connection lightly so you can remove the probe quickly if the pointer goes off scale or reads backward.
7. Read the meter on the correct scale for the range being used.
8. If the reading is way down near zero for the range you start with, lift the red probe off the terminal and switch to a lower range, then repeat the measurement. Always disconnect the multimeter in this way before changing ranges, to prevent arcing at the range-switch contacts inside the multimeter.

Reading D-C Scales. Reading the d-c scale of a meter is very much like reading a 1-foot ruler. The zero end of the meter scale is at the left, just as on the ruler. The full-scale end of the meter scale corresponds to the other end of the ruler.

The place at which the meter pointer comes to rest corresponds to the point at which you read a ruler when measuring something. For example, in Fig. 4A the block measures 3½ inches long, and the meter pointer indicates 3½ volts. If the block of wood were 3³⁄₁₀ inches long and the voltage were changed to 3³⁄₁₀ volts, the two indications would again match as shown in Fig. 4B.



(A) Meter Reads 3½ Volts **(B) Meter Reads 3 3/10 Volts**

Fig. 4. Reading a meter is exactly like reading a ruler

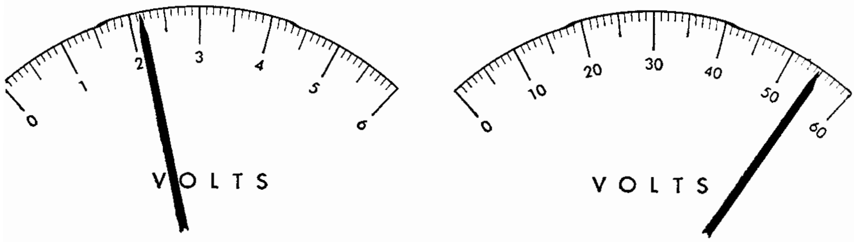
The ruler used in the illustrations is one commonly used by machinists. It differs slightly from the conventional ruler in that it is divided into tenths of an inch instead of eighths or sixteenths.

When reading a meter, look straight down on the pointer. If your head is off to one side, you may see an entirely different division line under the pointer and thus get a wrong reading. This is called a parallax error.

A horizontal position, flat on the bench, is best for a multimeter. A meter resting on end or propped at an angle will give essentially the same accuracy, but is more easily knocked over or damaged.

Meter Scale Divisions. The space between two adjacent lines on a ruler or meter is called a division. Several different lengths and thicknesses are used for division lines to make them easier to read.

If you measure a block of wood with a ruler and find that the end comes exactly halfway between division lines, as shown in Fig. 5A, you would read 2 inches plus 1½ tenths of an inch. This is expressed as 2.15 inches. Actually, a reading of 2.1 is close enough for most troubleshooting.



(A) Meter Reads 2.15 Volts (B) Meter Reads 55 Volts

Fig. 5. Examples of how meters are read when the pointer is between division lines

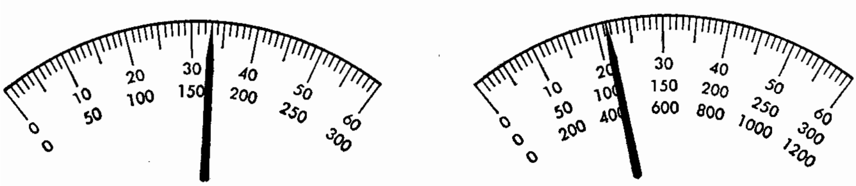
In many tests the pointer does not fall right on a division linc nor does it fall exactly halfway between two lines. When this happens, read the value of the nearest division line, as shown in Fig. 5*B*.

Reading Higher D-C Ranges. A meter in a multimeter will usually have two or more rows of numbers for the d-c scale. Thus, in the example of Fig. 6*A* there are numbers for a 300-volt range as well as for a 60-volt range. Read only the row of numbers for the range being used, just as if the meter had only that one scale.

As an example, the pointer indication is read as 165 volts when using the 300-volt scale in Fig. 6*A*. This reading is figured out by noting first that the pointer is three divisions past 150. Since there are ten divisions between 150 and 200, each division is 5 volts. Three divisions past 150 is therefore 15 past 150, or 165.

If you were using the 60-volt scale for the pointer setting of Fig. 6*A*, you would ignore the 0–300 row of numbers and simply read 33 volts directly.

An example of reading a three-range scale is given in Fig. 6*B*. Here again, you read only the numerals for the range being used. Note that



(A) Read 165 on 0-300 Range
Read 33 on 0-60 Range

(B) Read 430 on 0-1200 Range
Read 107.5 on 0-300 Range
Read 21.5 on 0-60 Range

Fig. 6. Multimeter scales are easy to read if you look only at the row of numbers for the particular multimeter range being used for troubleshooting or testing

for the 60-volt range the smallest scale division represents 1 volt. For the 300-volt range this smallest division represents 5 volts. For the 1,200-volt range the smallest division represents 20 volts.

In most servicing measurements it is not necessary to read more than three digits. A reading of 107.5 volts would therefore be called 107 volts or 108 volts. Accurate readings are not necessary, because in troubleshooting you are looking for a very large change from the value given in the service manual.

The number opposite each switch position on the multimeter is the right-hand or full-scale value for voltage and current ranges.

Reading Extra D-C Ranges. Multimeters often have voltage ranges for which there are no rows of scale numbers. However, there will always be a row of numbers that can be multiplied mentally by 10 or occasionally by 100 to get the range of values required. For example, when a 6,000-volt range setting is used, you can read the 60-volt scale and multiply the reading by 100. A reading of 33 volts on a 60-volt meter scale would then indicate a voltage of 33 multiplied by 100, which is 3,300 volts. Here, 100 is the multiplying factor.

Off-scale D-C Voltage Readings. If the pointer goes off scale to the left, the polarity of the d-c voltage is opposite to what you thought it would be. Disconnect the test leads quickly and reverse them at the receiver. The pointer cannot go far to the left of zero because of stops inside the meter, so ordinarily no damage is done.

If the pointer goes off scale to the right, the voltage you are trying to measure is more than the full-scale value of the range you are using. When this occurs, lift off the long-handled test probe, turn the multimeter range switch to the next higher range, and repeat the test.

If the pointer moves violently across the scale, lift off the long-handled test probe quickly and check your multimeter settings. You may have the multimeter in a milliampere or ohms position or in way too low a d-c voltage range.

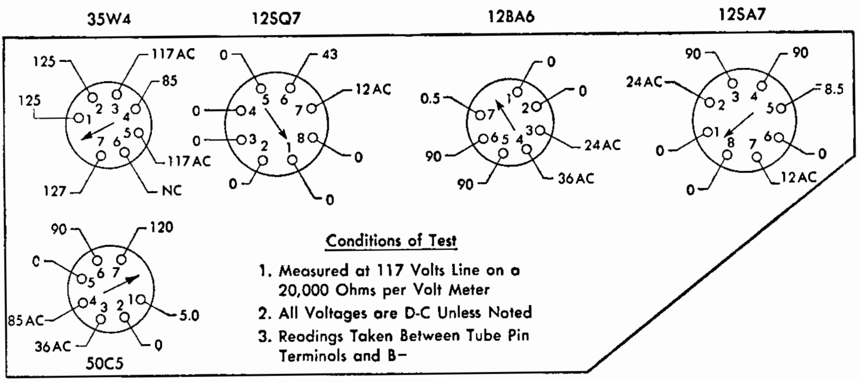
If the meter pointer jumps around intermittently, you probably have a defective part in the circuit being measured.

If the pointer vibrates on a d-c voltage measurement, there probably is a-c present along with the d-c voltage being measured. For some circuits, this may be normal, but in most cases it is a clue to trouble.

Accuracy of D-C Voltage Readings. When a multimeter is used to measure d-c voltages in a receiver, some current is drawn from the receiver circuit by the meter. In getting to the meter, this current flows through resistors in the receiver and produces voltage drops across them that rob from the voltage being measured. The voltage indicated by the meter will therefore be slightly lower than the actual voltage.

With a 20,000-ohm-per-volt multimeter, the meter current is so small that its effect cannot be noticed for most measurements. Only with lower-sensitivity 1,000-ohm-per-volt multimeters does the error in voltage readings become appreciable.

When voltage values are given in service manuals, the ohms-per-volt sensitivity of the meter used is generally specified. If using the same meter sensitivity, you can forget about errors due to meter current when measuring voltages. Most service manuals today give the voltages obtained with a 20,000-ohm-per-volt multimeter sensitivity. An example of one way used in service manuals to specify correct voltages is shown in Fig. 7.



Viewed from Bottom of Chassis

Fig. 7. Example of voltage data given in a service manual (for GE model 509 clock-radio)

Precautions When Measuring High Voltages. Observe the following precautions when measuring the high voltages of television receivers and even the plate circuit voltages of radio sets:

1. Use extreme care in working with all voltages over 100 volts! Do not let the first few low-voltage shocks fool you into thinking you can take it! You may get by with just a sharp, tingling sensation when you lightly touch a 250-volt terminal on a dry day. However, if your hands are wet or you happen to grab these same wires with more firmness on a damp day, *you can get killed!*

2. Do not work on high-voltage circuits in a place where the floor is wet, such as a basement workshop, unless you are wearing a good pair of

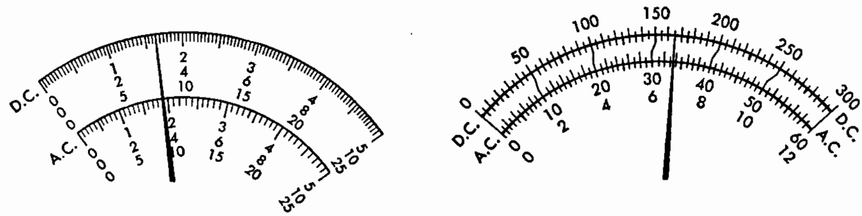
rubbers. A wooden platform spaced off the floor helps in wet or damp locations.

3. Do not work on a set if you are overly tired. You can easily ruin yourself or your test equipment or both! No job is important enough to take chances. Get some rest and come back to it in the morning.

4. Keep one hand in your pocket when working on dangerous high-voltage circuits. This leaves only five fingers, instead of ten, that can carelessly or accidentally slip onto a high-voltage terminal. Having one hand in your pocket also eliminates the dangerous hand-to-hand path through your heart for electricity.

5. Keep your fingers well away from the metal tip of the test probe.

Measuring A-C Voltages. To make a-c voltage measurements, follow the same procedure as for d-c voltages, except switch to the a-c volt positions on the range switch and read on the a-c meter scale (generally printed in red).



(A) Read 1.9 on 5-Volt A-C Range
Read 3.8 on 10-Volt A-C Range
Read 9.5 on 25-Volt A-C Range

(B) Read 170 on 300-Volt A-C Range
Read 34 on 60-Volt A-C Range
Read 6.7 on 12-Volt A-C Range

Fig. 8. Examples of a-c and d-c scales of multimeters, with the pointer reading for each a-c range. The 25-volt d-c range at A and the 60-volt d-c range at B are about the hardest to read that you will find on any multimeter. If you can read these, any other meter will be easy

Some multimeters have separate rows of numbers for the a-c scale, as shown in Fig. 8A. Others use the d-c range numbers, as in Fig. 8*B*. Examples of readings are given for each type.

The a-c scale divisions are spaced closer together at the left end of the scale. This is due to the rectifying characteristics of the copper-oxide rectifier used in the multimeter to change the a-c to d-c so it can be measured by the meter.

To read the value of the a-c voltage at a particular pointer indication, follow the same procedure as for reading a d-c scale, except use the a-c scale.

Measuring Audio Output Voltages. An important use for a multimeter is measuring the strength of the audio signal that a receiver feeds to its loudspeaker. This is done when aligning the receiver; hence you will not need to know the procedure for a while.

Output measurements are made with a-c voltage ranges by moving the red test lead to the OUTPUT jack on the multimeter panel. Some multimeters have a switch setting for OUTPUT which makes it unnecessary to move the test lead. Switch the output ranges the same as a-c volt ranges, using the highest range first.

The a-c audio voltage measured across a loudspeaker changes continually, in step with the volume and frequency of the sound coming from the loudspeaker. The louder the sound, the higher the voltage indicated by the pointer. For music, the pointer moves up and down in time with the music.

Measuring Resistance. The ohmmeter ranges of a multimeter are used to test parts that may have become defective because of overload, natural aging, moisture, or mechanical failure of the mounting. Practically every television and radio receiver part can be tested quickly and easily with an ohmmeter. Detailed instructions for making these ohmmeter tests are given in later chapters of this book; hence only general instructions for measuring resistance will be given here.

The ohmmeter section of a multimeter uses different combinations of resistors and a battery with the meter to obtain the different ranges of resistance. The battery, located inside the multimeter, makes the meter pointer swing over to zero on the ohms scale when the test leads are touched together.

A variable zero-adjust resistor in the ohmmeter circuit compensates for the drop in battery voltage as the battery is used. A well-designed ohmmeter requires very little if any readjustment of this control in going from one range to the next. With poorly designed ohmmeters, the control must be adjusted every time you change to another ohms range.

Procedure for Measuring Resistance. Several precautions must be observed when using the ohmmeter, to prevent damage to the multimeter or excessive drain on the ohms range battery.

1. Be sure the receiver is turned off whenever measuring resistance. As a further precaution, unplug the line cord. On battery sets, disconnect all batteries before making resistor checks. The on-off switch for these sets generally controls only the filament circuit, leaving the plate voltage still connected. Be sure to disconnect the B battery as well as the A battery.
2. Discharge any large or high-voltage condensers before testing them

for shorts. An easy way to do this is to grasp a screwdriver by its insulated plastic handle and hold the metal blade against the condenser terminals. This usually produces a loud but harmless spark as the condenser discharges. It needs to be done chiefly to the high-voltage condensers in television power supplies, for otherwise these condensers may discharge through the meter and damage the meter coil.

3. If you know the approximate value of the resistor to be checked, set the range switch to an ohms range which has that value somewhere near the center of the scale. If you do not know the approximate resistance, set the range switch to the highest ohms range.

4. Plug the test leads into the ohmmeter jacks of the multimeter. These are generally the same jacks used for d-c voltage measurements. One is the COMMON or – jack, and the other is marked +, V-O-MA, or V-Ω. The symbol Ω here means ohms.

5. Hold the tips of the long probes together and check the zero-ohms adjustment. If the lowest ohm range is used, it is a good idea to clip the leads together to ensure a good low-resistance contact. If the meter pointer is not at zero on the ohms scale, adjust the Ω ADJUST or ZERO OHMS knob to bring the pointer to zero.

6. Hold or clip the long test probes on the leads of the part under test, and read the ohms scale. If the pointer indicates too close to the highest-resistance mark to give a good reading, switch to the next lower range. For resistance measurements it is not necessary to disconnect one test probe when changing ranges. Switch to a still-lower range if necessary, until the reading is near the center of the scale.

If you cannot get a reading (if the pointer does not move noticeably from the highest-resistance or infinite end of the scale), either the part you are testing is open or its resistance is higher than the full-scale ohms range of your tester.

Reading an Ohmmeter Scale. The zero is at the right end of an ohms scale on most multimeters, so that values increase to the left.

The divisions of an ohms scale are definitely not of equal value across the scale. You must therefore figure out the value of the scale divisions each time the pointer rests in between numbered lines on the scale. For example, in Fig. 9A there are five divisions between 0 and 1. The value of each of these divisions is therefore 1 divided by 5, which is 0.2 ohm. Between 5 and 10 on the scale there are also five divisions, but here they cover a scale distance of 5 ohms, so each of these divisions is 1 ohm.

The same procedure is followed for all other portions of the ohms scale, as indicated by the reading for each pointer position in Fig. 9A. This procedure applies for the three divisions between 50 and 200, even though the divisions are very unequal at this crowded end of the scale. The scale distance between 50 and 200 is 150, which means that each of the three divisions is 50. The first division line to the left of 50 is therefore 100.

Some ohms scales, chiefly on electronic volt-ohmmeters, have the zero at the left. This ohms scale is read the same as ordinary ohms scales, remembering that numbers increase to the right rather than to the left.

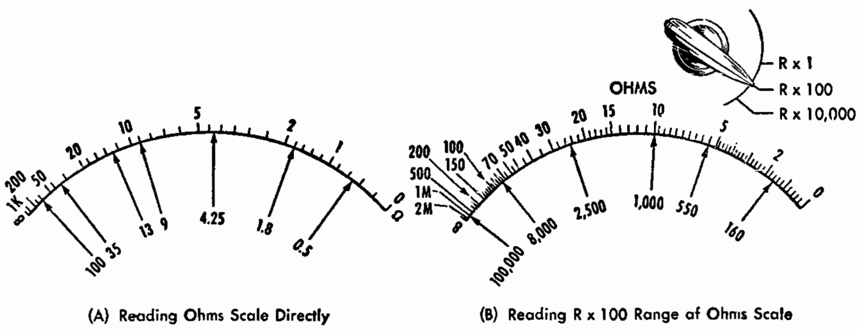


Fig. 9. Examples of ohms-scale readings on two different multimeters. Check each reading

Reading Ohmmeter-scale Abbreviations. The ohms scale of a multimeter often has special markings and abbreviations not found on other scales. A few of these are listed below for your reference.

Ω is the symbol for ohms. It is the Greek capital letter omega. The lower-case letter omega, written as ω, is also used, mostly in wiring diagrams, as an abbreviation for the word ohms.

∞ is the symbol for infinity. It is usually used at the high-resistance end of the ohms scale. It means an infinite amount of ohms or an open circuit. The meter pointer indicates at this mark when the ohmmeter leads are not connected to anything.

K is the symbol for 1,000. It is often used after a number to indicate that the number has three more zeros after it. For example, 500K means 500,000 ohms.

M is often used in place of meg to designate that the number is in megohms. Add six zeros to change it to ohms.

M is sometimes used instead of K for 1,000. Its position with respect to other numbers on the ohms scale or the range switch will usually tell you at a glance what M stands for, so do not let this confusion of abbreviations worry you.

Reading Higher Ohms Ranges. Most multimeters have two or more ohms ranges. The commonest and most convenient method of reading higher ohm ranges is with multiplying factors that only involve adding zeros to the scale value, as in Fig. 9B. Here there is only one easy-to-read set of numbers on the ohms scale, and the range switch setting gives the multiplying factor. Just multiply the scale reading by the switch setting. Thus, a scale reading of 15 is 15 ohms for R × 1, 1,500 ohms for R × 100, and 150,000 ohms for R × 10,000.

Getting Accurate Resistance Readings. Several cautions must be observed in using the ohms ranges to get the most accurate reading and to protect your multimeter.

1. Disconnect one lead of the resistor, condenser, or coil being checked, whenever other parts are also connected between the two measuring points. Any shunt path around the part being checked could cause a lower resistance reading than normal or even hide a defect. A shunt path may also indicate a false leakage resistance, a short in an actually good condenser, or some other nonexistent defect.

2. Keep your fingers off the bare test prod tips, and keep your fingers off the terminals of the part being tested, because your own body provides a shunt resistance path. This body resistance can cause a considerably lower resistance reading than normal, especially if your hands are moist and the resistance being measured is around a megohm or higher. You can easily measure your body resistance by holding one test probe tip in each hand. Body resistance can be as low as 10,000 ohms if your fingers are moist, though it is usually around 100,000 ohms.

3. Turn the multimeter range switch to an off position or a high-voltage range position when you are through using the ohms ranges. This prevents damaging the ohmmeter if the test probes accidentally touch voltage supply terminals. In addition, this precaution prevents the ohmmeter battery from being run down if the test probes touch each other.

4. Remove worn-out batteries from the multimeter as soon as you notice that you can no longer adjust for zero ohms. If this is not done, the chemicals may leak out of the worn-out battery and corrode wire connections or fine-wire resistors in the multimeter. The battery case may also expand with age and jam the battery in its mounting.

Measuring Direct Currents. Although practically all multimeters have several current ranges, these are seldom, if ever, used for testing or troubleshooting. Voltage or resistance measurements are made instead, since they are much easier to make and give equally useful information about a part or circuit.

To measure the amount of current flowing through a circuit, the meter must be inserted in the circuit so the current can flow through the meter. This involves turning off the set and disconnecting or even unsoldering or cutting a wire so you can connect the multimeter test leads to the two sides of the break in the circuit. The circuit must then be reconnected or resoldered after the measurement has been made. It sounds like a lot of work, and it is.

Detailed instructions for making current measurements are given in the instruction manual for the multimeter you buy. The d-c scales are read exactly the same as for d-c voltage ranges.

Care of Test Leads. Test leads are an important part of your multimeter, so handle them carefully. When using the slip-on alligator clips for receiver connections, wiggle each clip a few times after it is in place to cut through any oxide or dirt on the terminal or the chassis.

Alligator clips can be clipped onto the multimeter handle when not in use. Of course, if your multimeter has a storage compartment, this is the best place of all for the clips as well as the test leads. Your toolbox is another good place for test leads and clips.

When using the multimeter, keep the leads on the bench so they do not get pinched in a drawer or in a cabinet door. When you unplug the leads, grasp the probe handles instead of pulling on the wires. Pulling on test leads can eventually loosen or break the wire inside the probe handles.

If insulation is broken on a test lead so bare wire shows, wrap with No. 33 Scotch insulating tape to prevent the bare wire from touching the chassis while making tests.

Keep test leads free of kinks or knots. These put a strain on the wire and take up valuable lead length.

Keep the test leads away from your soldering iron. Keep them also away from hot tubes in the set. Heat can burn through or damage the insulation on the leads.

Multimeter test leads have a habit of catching on corners and knobs. Pulling on a test lead without looking at it first has many a time pulled a costly multimeter right off the bench. Test equipment does not bounce well!

Testing a Multimeter. To check a multimeter after an accidental overload or bump, measure the voltage of a flashlight cell. A new cell should read fairly close to 1.5 volts on the lowest d-c voltage range if the multimeter is undamaged. Measuring the a-c line voltage is another check; this should read within a few volts of 117 if the multimeter is good and the power-line voltage is normal in your locality.

Meter Zero Adjustment. Practically all meters have an adjusting screw that permits changing the at-rest position of the pointer a small amount. This is used to make the pointer rest exactly at the zero position on the d-c scale when the meter is not in use. From time to time a slight adjustment of this screw may be needed, especially after an overload.

Using a small screwdriver, set the zero-adjuster screw on the front of the meter so that the pointer is on the scale line farthest to the left when nothing is connected to the test probe leads. Tap the multimeter case lightly with your finger while doing this, to offset any slight friction in the bearings. If the multimeter is normally used in a vertical or a 45-degree position, make the zero adjustment in that position.

The pointer may move off zero a slight amount (generally less than one d-c scale division) when the meter is tilted from horizontal to vertical. To eliminate the nuisance of readjusting the zero position, use your multimeter in the same position all the time. If the pointer is bent as a result of severe overload, you can sometimes bring the pointer back to the zero mark with the zero-adjuster screw. Do this only as an emergency measure, however. For best performance, return the multimeter to the factory for repair if the pointer is noticeably bent from overload.

Replacing Ohmmeter Batteries. If the pointer cannot be brought all the way to the zero mark with the ohms adjust control, the ohmmeter battery for that range is probably low and requires replacement. To replace the proper battery if more than one battery is used, check the operating instructions for your tester. Be sure you install the new battery in the same position as the old one, to obtain the correct polarity.

The center post of a 1.5-volt flashlight cell is positive. The corresponding terminal for this cell inside the multimeter will sometimes be marked + or painted red. If you get the battery in backward, the pointer will read off the left end of the scale when you connect the probes together for checking the ohmmeter zero. If two or more batteries are used on a particular range and one is reversed, the pointer will not come up to the zero-ohm mark.

Replace multimeter batteries with new ones having the same number and make as were in before, or use equivalent units recommended in the multimeter instruction book. Batteries may be obtained from the multimeter manufacturer or from your parts jobber. Some multimeters use standard-size flashlight batteries which may be obtained in the dime store.

Be sure the multimeter battery contacts are clean and have good spring tension against the battery. If a screw-in clamp is used to mount the battery, be sure to tighten the screws securely.

Common Troubles in Multimeters. Some of the more common troubles that develop in multimeters are:

1. Meter burned out because of overload. When this occurs, one or more of the resistors may also be damaged. Return the multimeter to the factory for repair.
2. Broken meter window glass due to dropping tools or other objects on it. Return to factory.
3. Smashed case or panel due to dropping the multimeter. This is often the most expensive repair. In addition to a new case or panel assembly, the meter will probably require new parts. Return to factory.
4. Bent pointer due to overload of meter. Try the meter zero adjustment first. If it will not bring the pointer to zero, return to factory.
5. Weak or loose plug or jack contact springs, usually caused by bumping a test prod while it is in the jack. Repair or replace jack or test leads yourself. New test leads and jacks can usually be obtained from jobbers.
6. Frayed or broken test probe wire or broken test probes, due mostly to careless handling of test leads. Buy new test leads.

Getting a Multimeter Repaired. Return a damaged multimeter only to the manufacturer or to an instrument repair shop authorized by the multimeter manufacturer. Before shipping, write to the manufacturer and describe the damage. Be sure to give the model number and tell where you bought the instrument. The manufacturer will then send the necessary shipping instructions and will generally give you a rough estimate of the cost of repair.

Place the multimeter in a small cardboard box first, along with the test leads. Be careful not to jam the leads against the meter glass. Pack the cardboard box carefully in a wooden box. There should be at least a 1-inch thickness of crumpled newspaper or similar shock-absorbing material between the multimeter box and the outer box. Nail on the wood cover of the box with small nails.

Tie the box securely with heavy cord as an extra precaution. Letter the mailing address on it clearly with black ink, so the package will not go astray even if your pasted-on shipping label comes off.

Place a FRAGILE sticker on each side of the box. Generally these stickers and a shipping label will be supplied by the multimeter manufacturer along with the shipping instructions.

Insure your package for its full value if shipping by parcel post. This will protect your investment in case the multimeter is lost or further damaged.

QUESTIONS

1. What should be the sensitivity of a good multimeter for service work?
2. Where is the ohms scale usually located on the meter of a multimeter?
3. If the pointer moves to the left of zero when measuring a d-c voltage with a multimeter, what should be done?
4. When making voltage measurements in a dangerous high-voltage circuit, where should one hand be kept for safety?
5. How is the zero adjustment of an ohmmeter corrected from time to time as the ohmmeter batteries run down?
6. What is usually indicated by a reading of infinity for the highest ohmmeter range?
7. If a reading of 55 is obtained on the ohmmeter scale when the range switch is set to R $\times$ 1,000, what is the resistance value?
8. What value would you read if the pointer is at 200 when using the R $\times$ 100 scale?
9. When the ohmmeter zero adjust control no longer brings the pointer to zero on the ohms scale, what should be done?

7

Removing and Replacing Tubes

What Tubes Do. Tubes are the heart of the modern television or radio set. They have many different tasks. For example, rectifier tubes change a-c to d-c in the power supply. Amplifier tubes increase the intensity of the desired signal. Mixer tubes change the incoming r-f signal to an intermediate frequency which can be amplified more easily. A tube even provides the actual picture in a television set.

Tube Appearance. You will have little trouble spotting the tubes in a set because they look so different from other parts, and because tubes fit into sockets that permit easy removal and replacement. Examples of some of the different sizes and shapes of tubes you may have to replace are shown in Fig. 1.

Other Plug-in Parts. A metal plug-in unit is not always a tube. For example, the ballast resistors used in some of the older a-c/d-c sets to reduce line voltage look exactly like metal tubes, yet they are only resistors mounted in metal housings. They can be distinguished from tubes by the type numbers, which are considerably different from tube numbers. Some of these ballast numbers are 100-70, L4OCT, BK-10-A, M-23-D, and 10-23A. Ballast resistors have no vacuum, and some types even have holes in the metal housing for ventilation. In Fig. 2 there are examples of ballast resistors.

Vibrators in automobile radios look like metal tubes but are larger and usually have a bright aluminum housing, as also shown in Fig. 2. They will be easy to recognize, as they are the only tube-like parts that hum loudly when working.

Parts of a Tube. Though various types of television and radio tubes differ widely in appearance, all have an *envelope* or outer housing. This envelope holds a vacuum for the *elements* or *electrodes* inside.

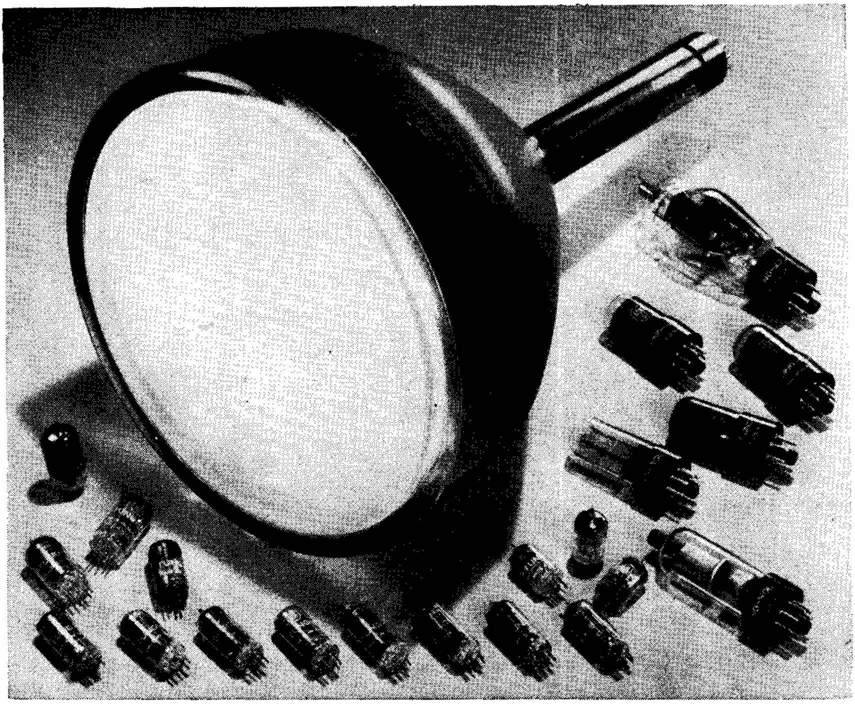


Fig. 1. Variety of tubes found in one older television receiver. The tubes without bases, at the bottom of the picture, are called miniatures. Newer sets have much the same assortment of small tubes but have a much larger picture tube with a rectangular screen. (Tung-Sol photo)

All tubes have either a separate or self-contained base containing the pins that serve as terminals for the tube. These and other external parts of tubes will be taken up one by one before considering what goes on inside the tubes.

Tube Envelopes. The glass or metal housing or envelope that encloses the working elements of a radio or television tube comes in many different sizes and shapes. On glass tubes the envelope is sometimes called a bulb. On metal tubes it is sometimes called a shell.

A glass envelope often has a bright silvery coating on part of the inside surface. This chemical coating is called the *getter* because it is put on during manufacture to get or absorb the last trace of gas and air from inside the envelope after the air has been drawn out with vacuum pumps.

Some tubes may have a dull black coating of graphite over the entire inner surface. This is sprayed on during manufacture to provide an electrostatic shield for the working elements inside. Tubes like this do not ordinarily require separate metal shields.

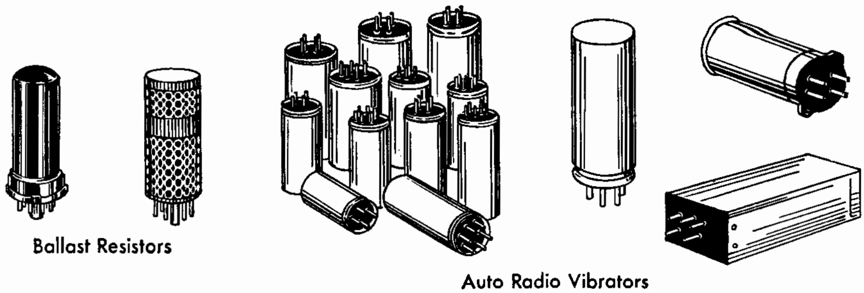


Fig. 2. These parts look a little like tubes, but are easy to recognize

The tube type number is generally etched or printed on the side or top of the glass or metal envelope. On very old tubes the number appears only on the base.

A *metal* envelope will not crack or break like glass when handled roughly, but the elements inside can be jarred out of place if the tube is dropped. The metal envelope acts as a self-contained electrostatic shield.

A metal envelope radiates heat better than glass. This keeps the tube elements cooler and increases tube life. Because it is getting rid of more heat, however, a metal tube will usually feel hotter than the equivalent glass tube. Metal tubes can easily get hot enough to burn bare fingers. Even glass tubes can normally get hot enough to sizzle your fingers. It is a good idea to turn off the set and allow the tubes to cool for a few seconds before touching them.

Tube Bases. All tubes have bases to support anywhere from 4 to 14 metal pins (also called prongs). On some bases, two pins are thicker than the others, or the pins are spaced unequally so the tube can be inserted only the one correct way in its socket, as shown in Fig. 3.

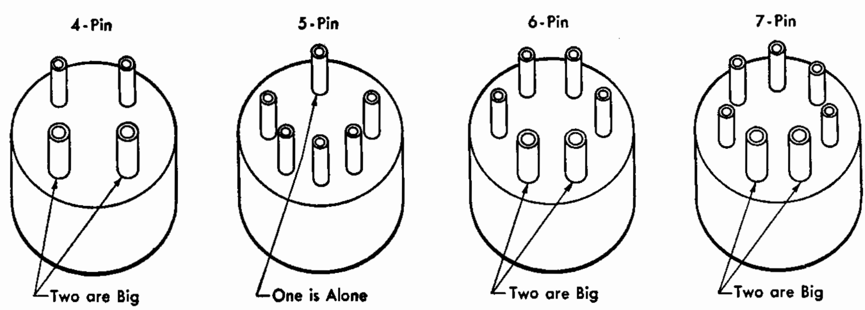


Fig. 3. Pin arrangements used on four older types of tube bases to ensure that tubes are inserted correctly in their sockets in receivers. The 4-pin tube is still in use

When tubes have molded plastic bases, the pins that come through the bases are tubular. The thin wire lead from each element of a tube comes right through the glass envelope and goes through the inside of a base pin. These leads are made of special wire that seals to glass, so no air can leak into the tube around the leads. At the outer end of each pin is a blob of solder that connects the inner lead securely to the pin.

Octal bases, shown in Fig. 4, have provisions for eight equally spaced pins and have a molded plastic aligning key in the center of the base to

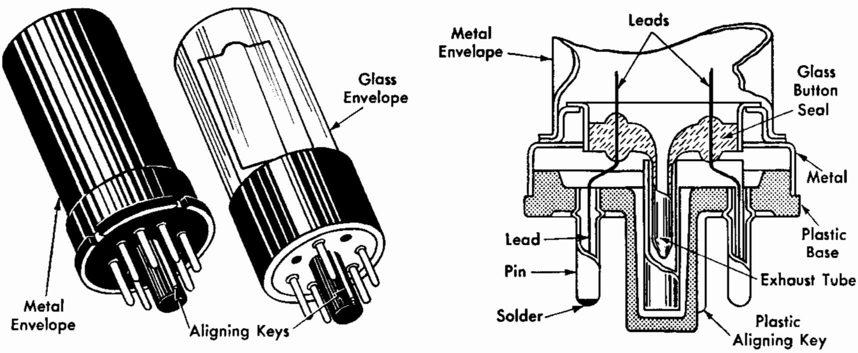


Fig. 4. Metal and glass tubes having octal bases. Pins not needed on certain tubes are omitted during manufacture without changing the spacing of the remaining pins, as shown here for the glass-envelope tube

ensure correct positioning in the socket. The socket has a corresponding notch in its central hole.

In metal-envelope octals, the leads come out of the envelope through glass beads that are sealed into holes in the envelope, in order to insulate the leads from the envelope.

Loktal bases, like that in Fig. 5, have the same equally spaced arrangement of pins as octals but have a metal aligning key that has a lock-in groove which helps to keep the tube in its socket. Loktal tubes have solid-wire pins that go right through the glass to the elements inside.

Miniature tubes have no separate bases. The pins come right out of the glass envelope as in Fig. 6, and the spacing of the pins controls insertion in a socket.

Subminiature tubes are like miniatures except for being much thinner—even smaller than little-finger size. These tiny tubes will usually be found in camera-size portable radios and in hearing aids.

Fig. 5. Example of a loktal tube, showing glass envelope, metal base, metal aligning key, and solid wire pins that go right through the glass envelope. (Sylvania photo)

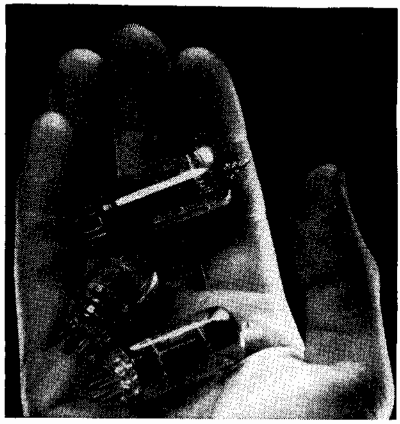


Fig. 6. Examples of miniature tubes, which have no separate bases. Most are 7-pin and have a wider gap between two of the pins to ensure correct insertion. (Sylvania photo)

Diodes. The simplest tube of all is one having only two working elements, a filament and a plate, mounted in a vacuum as shown in Fig. 7A. A tube having just two elements is called a diode. When the filament is cold, no current can be sent through the tube by the B battery because the gap between the filament and the plate is a break in the circuit. The plate is also known as the anode.

When the filament is heated by current obtained from a filament battery connected as in Fig. 7*B*, the filament gets red-hot. The resulting heat boils electrons right out of the wire, just as heat boils particles of steam out of water.

Once electrons are free of the filament, they are attracted by the positive charge on the plate, and travel over to the plate. There is thus a movement of electrons from the filament to the plate inside the tube. This stream of electrons moving through empty space is an electric current, just as are electrons moving through a wire.

If B-battery connections are reversed, the plate has a negative charge. Now the plate repels the electrons that are coming out of the hot filament, and there is no flow of electrons through the tube.

If an a-c voltage source is used in place of the B battery, the plate of the tube is alternately negative and positive. Electrons flow through the tube on the half-cycles when the plate is positive, but not on the alternate half-cycles when the plate is negative. Electron flow is thus always in the same direction, from filament to plate through the tube, even though the plate voltage is a-c. This is called rectifying action and is widely used for changing a-c to d-c.

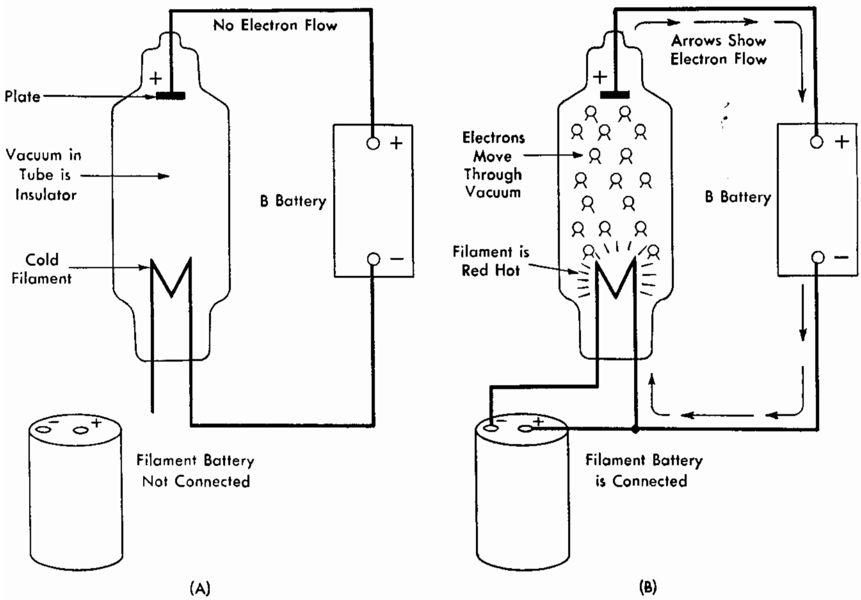


Fig. 7. Operation of a diode tube. Without a filament battery, no electrons flow

Indirectly Heated Cathodes. In any tube the electron-emitting element is called the *cathode.* The commonest type of cathode used in tubes is the indirectly heated cathode. The source of heat for this is an insulated filament of tungsten wire inside a metal sleeve. This filament is called the *heater* because its only job is to provide heat. The metal sleeve is covered with a chemical oxide coating that serves as the cathode. When heated by the heater element inside, this oxide coating gives off electrons much more efficiently than does a bare wire. The cathode has its own lead in these heater-type tubes. Symbols for filaments and cathodes are shown in Fig. 8, along with typical constructions.

Triodes. Diodes are useful in rectifying alternating current, but do not boost the strength of weak signals. In 1906 Lee De Forest achieved amplifying action by placing another element between the cathode and the plate. Since this made three elements in all, the new tube was called a triode. The new element was a winding or grid of fine wire; hence it was called the grid.

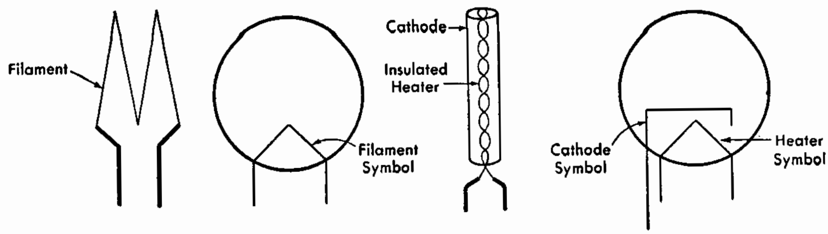


Fig. 8. Construction details and symbols for the two commonest electron sources used in tubes. Filaments and heaters use the same symbol, but a heater will always have a cathode symbol too

How a Grid Controls Current. The number of electrons that travel from the cathode to the plate in a tube can be controlled by changing the electrical charge or voltage on the grid. When the grid has no charge, electrons go through just as if the grid were not there.

When the grid is made more negative than the cathode, the grid repels electrons back toward the filament. The more negative the grid is, the fewer electrons get through the grid wires. A negative grid thus gives less plate current than is obtained without the grid. The grid can easily be made negative enough to block all the electrons, so that the plate current is zero.

In television and radio sets the grid of a triode is generally operated with a small negative d-c voltage called a bias voltage. This allows a certain amount of plate current to flow. When an a-c signal voltage is applied to the grid of a triode, the signal alternately adds and subtracts from the negative-grid bias voltage. As a result, the plate current of the tube alternately increases and decreases just like the a-c signal voltage on the grid. The signal current in the plate circuit can be several thousand times as strong as the signal current in the grid circuit. This means that the tube has amplified the signal several thousand times.

Tube Voltages. A typical triode amplifier circuit is shown in Fig. 9. A dotted-line symbol represents the grid in the tube circle. One battery, called the A battery, provides the current for the heater. Another, called the B battery, provides the plate voltage that places the positive charge on the plate. Note that the B battery connects between cathode and plate, not just to the plate. This is essential to make the plate positive with respect to the cathode.

The third battery, placed in the grid circuit to make the grid slightly negative with respect to the cathode, is called the C battery. With these three voltages, a triode is capable of boosting the strength of a weak input signal, so that a much stronger signal is sent to the load in the plate or output circuit.

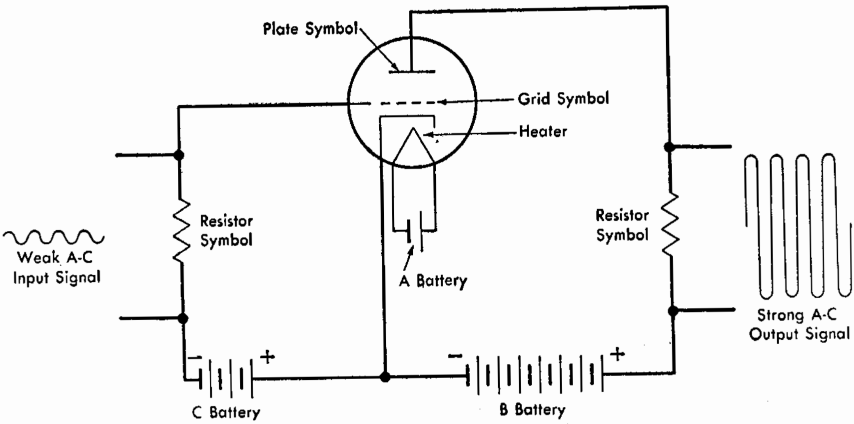


Fig. 9. The three voltages needed to make a triode tube amplify a weak signal can be obtained from separate batteries as shown here. More often, however, these A, B, and C voltages are obtained from an a-c power supply in a receiver

Tetrodes. Adding a second grid to a tube gives four active elements in all. Such a tube is called a tetrode. The extra grid is a wire spiral or a wire screen placed between the control grid and the plate. The extra grid is operated at a positive voltage almost as high as the plate. It is called the *screen grid* because it serves as a screen that prevents the amplified signal on the plate from acting backward on the control grid. Such action in a backward direction, called feedback, would cause howling or other trouble in a set.

Pentodes. When still another grid is added, to give five active elements in all, the tube is called a pentode. This third grid is located between the screen grid and the plate and is connected to the cathode or ground. It serves to suppress secondary electrons that are splattered off the plate when the main stream of electrons hits the plate; hence this grid is called the *suppressor grid.*

Other Types of Tubes. Some tube types have still more grids for special applications. One example, widely used as the mixer–first detector in superheterodyne receivers, is the pentagrid converter which has five grids. Such a tube actually does the job of two tubes.

Two or more tubes are often combined in one envelope. Thus, the type 6SN7 tube has two triode sections, while the 6H6 has two diode sections. Another common combination is the duodiode triode, which has two diodes and a triode all in the same glass or metal envelope. Symbols for some of these tubes are shown in Fig. 10.

Electron-ray or magic-eye tubes are a special type of triode used as a tuning indicator. In one type, the plate is a cone-shaped electrode coated

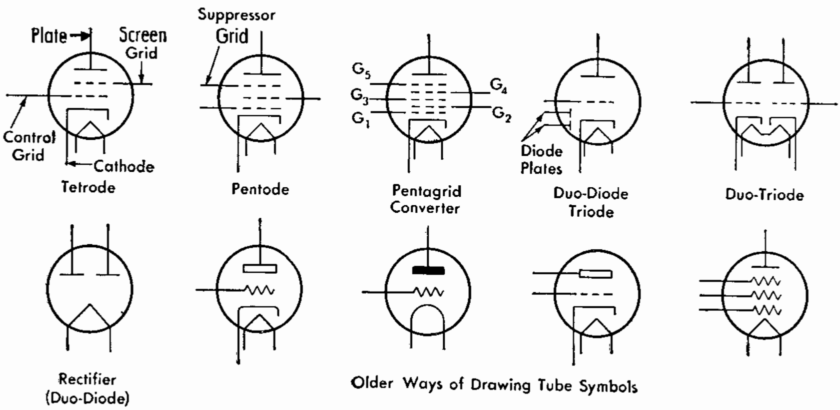


Fig. 10. Symbols for some of the tubes that are widely used in television and radio sets.

with fluorescent material that glows when electrons strike its surface. The amount of surface that glows depends on the grid voltage applied to the tube. When a station is tuned in properly, the grid voltage applied to the tuning eye tube is most positive, and the fluorescent glow covers the maximum area for that station. On very strong signals the glow covers the entire area of the cone.

Crystal Diodes. Many television sets use crystal diodes in place of vacuum-tube diodes. The crystal diode is nothing more than the old-fashioned crystal detector of radio's younger days, modernized to eliminate the adjustable wire catwhisker. Some use silicon crystals, while others use germanium crystals. Examples of crystal diodes are shown in Fig. 11.

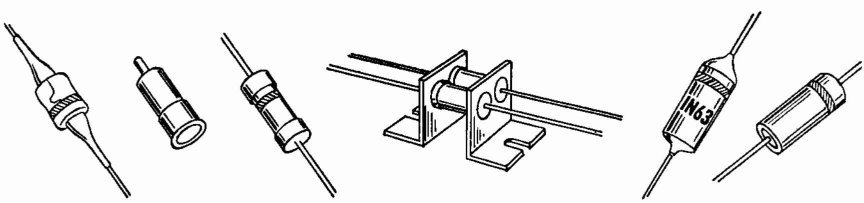


Fig. 11. Examples of crystal diodes, some of which are used in television receivers

Receiving-tube Type Numbers. An identifying type number is etched, stamped, or otherwise marked on the envelope or base of a tube. These type numbers are assigned to tubes by RTMA (Radio-Television Manufacturers Association).

In general, all octal-base tubes follow the RTMA numbering system. Most of the newer tubes do also, but the type numbers of a few special types of new tubes and most old tubes have no meaning.

In the RTMA tube-numbering system, the first number group indicates the filament voltage in 1-volt steps. The number 1 indicates a filament voltage between 0.1 and 2.0; the number 2 indicates a filament voltage between 2.1 and 2.9; the number 3 indicates a filament voltage between 3.0 and 3.9, and so on, to 117 which indicates a filament voltage between 117.0 and 117.9.

One exception to the numbering rule is 7, which is used to designate a 6.3-volt tube having a loktal base. No tubes have a filament voltage in the range of 7.0 to 7.9; hence this causes no confusion.

Another exception to this numbering rule is 14, which designates a 12-volt tube having a loktal base. Table 1 summarizes all this.

Table 1. Useful Data on Tube Filament or Heater Voltages

1S4, 1S5, 1T5, and other types starting with 1 are intended for operation with 1.4 volts on the filament. These are commonly used in portable radios, which use flashlight cells to provide the filament voltage.

2A3, 2A5, 2B7, and other types starting with 2 require 2.5 volts on their filaments. These tubes are seldom used in modern sets.

3Q4, 3S4, 3V4, and other types starting with 3 have a filament center tap that permits use with either 1.4-volt or 2.8-volt filament supplies in battery radios.

5Y3, 5Y4, 5J4, and other types starting with 5 require 5 volts on their filaments. Most 5-volt tubes are power rectifiers, and most power rectifiers have 5-volt filaments.

6SJ7, 6L6, 6SA7, and other types starting with 6 require 6.3 volts on their heaters. This odd value dates back to the days when storage batteries were used as filament supplies for radios. Most 6-volt tubes are indirectly heated.

7B4, 7C5, 7AH7, and other types starting with 7 are also intended for 6.3-volt operation. The 7 indicates they have a loktal base.

12SJ7, 12K8, and most other types starting with 12 correspond to the 6-volt group except that heaters require twice the voltage and half the current of the corresponding 6-volt tubes. There are two exceptions: a 6B8 is similar to a 12C8, not a 12B8, and a 6A7 is not similar to a 12A7.

14B6, 14C7, and other types starting with 14 correspond to the 12-volt group but have loktal bases. Both the 12 and 14 series are widely used in universal superhets.

19BG6G, 19J6, 19T8, and other types starting with 19 have 19-volt filaments and are used chiefly in television receivers that operate the tube filaments in series.

25A6, 25L6, 25Z5, and other types starting with 25 have 25-volt filaments and are used in receivers that operate the tube filaments in series.

32L7GT, 35C5, 35W4, 45Z3, 50L6GT, 70L7GT, and other tubes starting with these numbers are used the same way as the 25-volt tubes but have the higher filament voltages indicated by their first numbers.

117P7GT, 117Z3, 117Z6GT, and other 117-volt tubes have filaments that can be operated directly from the 117-volt a-c power line.

The letters following the filament-describing number serve only to distinguish between tubes having the same set of numerals. Letters for rectifier tubes are issued backward starting from Z; hence tubes like the 6Z5, 5Y3, and 5U4 are rectifiers. Letters for other tubes are issued starting from A and going through the whole alphabet, then continuing with BA, BB, BC, and so on. Thus, a tube with a letter near the end of the alphabet may or may not be a rectifier, but a tube with letters earlier in the alphabet will never be a rectifier.

The letter S ahead of the first letter group indicates a single-ended tube that is otherwise equivalent to one having a top cap. Thus, the 6SA7 has no top cap but is otherwise the same as the 6A7. A single-ended tube is one in which all of the connections are brought out through the bottom of the envelope. On older tubes it was often necessary to bring the grid or plate lead out through the top of the tube for easier shielding and circuit isolation. On new tubes with proper shielding within the tube, this is no longer necessary.

The second number group in the RTMA tube-numbering system indicates the number of useful elements connected by wire leads to the tube-base pins and the top cap. Examples of these elements are the filament, the cathode, each grid, each plate, and the shield or metal envelope. The filament is counted as one element even though it may come out to two or three pins. For example, a 6F6 has six elements brought out by wire leads to the tube-base pins: filament, cathode, control grid, screen grid, plate, and shield.

A second letter group at the end of the tube type number is sometimes used to indicate a special tube characteristic. The meanings of these letters are given in Table 2.

Table 2. Meanings of Letters Used after Tube Type Numbers

G	glass envelope with a molded plastic base and locating lug.
GT	glass envelope smaller in size than type G envelope.
GT/G	tube which can be used interchangeably with either a G or a GT type.
A, B, C, D, E or F	improvement over original type without the letter; for example, the 2X2-A is the same as a 2X2 but will withstand severe shock and vibration.
/	symbol meaning that type numbers before and after it are interchangeable so that either the first or second listing may be followed.
S	external shield; thus, a 6F7S is different from a 6F7.

Television Picture-tube Type Numbers. Cathode-ray tube type numbers also have useful information. The first numbers indicate the over-all diameter of a round screen or the diagonal dimension of the screen on a rectangular picture tube. The first letter following these numbers is assigned in chronological order to distinguish between tubes that would otherwise have the same type number. The last letter and last numeral together specify the color and type of fluorescent screen.

Tube Sockets. Sockets serve to connect the pins on a tube base to the receiver circuits. Sockets also provide a mounting for the tube and a guide for lining up the proper tube pins with the socket holes.

Each socket has spring contacts that make good electrical connections to the tube pins. Each contact has a soldering lug underneath, punched with one or two holes and notches for wires.

Loktal tube sockets have a snap ring in the center hole of the socket to hold the tube in position and serve as a ground connection between the lower metal shield on the tube and the receiver chassis.

Tube sockets are made either from molded plastic or punched-fiber insulating material, as in Fig. 12. The molded socket is generally used in

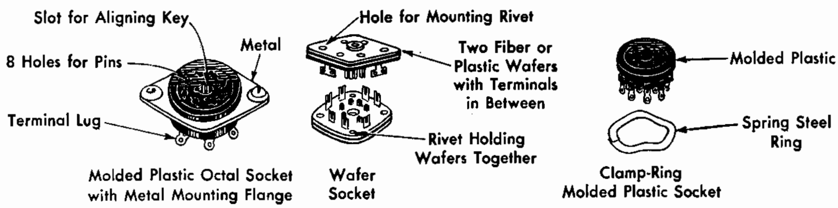


Fig. 12. Common types of octal tube sockets. The wafer socket is most widely used

applications where tubes are plugged in and out a large number of times, such as in tube testers. One type of molded socket is fastened with a split-type clamp ring. This snaps into a recess in the rim of the socket under the panel or chassis.

The punched-fiber wafer socket is most commonly used in television and radio receivers because of its low cost and small size. One style consists of two $\frac{1}{16}$-inch-thick pieces of punched fiber with the spring contacts in between. Rivets hold the two fiber wafers together. Another style consists of one piece of $\frac{1}{16}$-inch-thick fiber with each spring contact individually riveted to the fiber. Wafer sockets are generally riveted to the receiver chassis.

Dip-soldered Sockets. Some radio and television receivers use special sockets that permit making all soldered connections in one operation by dipping the top of the chassis in a pan of molten solder. In place of each lug is a small jack into which leads are pushed from the bottom. The jacks and the ends of the leads project above the top of the chassis. Here a doughnut-shaped metal shield surrounds each tube for protection against shock, as shown in Fig. 13, or a plastic cover goes over the chassis.

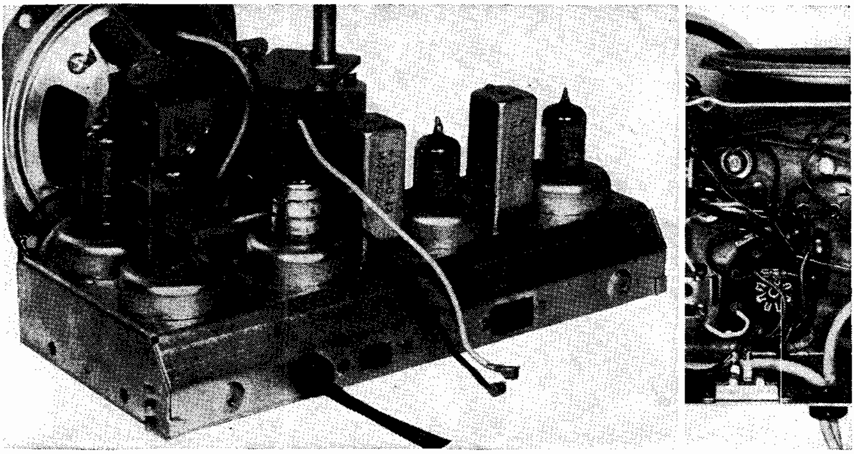


Fig. 13. Chassis of GE clock-radio using dip soldering, and bottom view of one of the special tube sockets used with dip soldering. The soldered joints are above the chassis. (GE photos)

Leads can be unsoldered from dip-soldered sockets by applying the soldering gun to a jack from either the top or the bottom of the chassis while pulling on the lead with long-nose pliers. Leads of new parts can be inserted in the jacks if heat is first applied to melt solder already in the jack.

Some General Electric television receivers have entire insulating subpanels under the chassis on which all connections are made by dip soldering.

Pin Numbers. Tube pin numbers are assigned in a standard manner for each type of tube. These numbers are shown on almost all circuit diagrams and tube-base diagrams. When the numbers on a diagram are arranged in order around the circle of the tube base or socket, they are always shown as viewed from the *bottom* of the base or socket. This helps trace the wiring on the underside of the chassis. The numbers then increase in a *clockwise* direction starting from the identifying guide, as shown in Fig. 14.

A guide is always provided in the tube socket to ensure placing the tube in the socket correctly and to furnish a reference point for numbering the socket contacts and tube pins. This guide may be the space between two large pins, a larger spacing between two or more unevenly spaced pins, or an aligning key, as shown in Fig. 14.

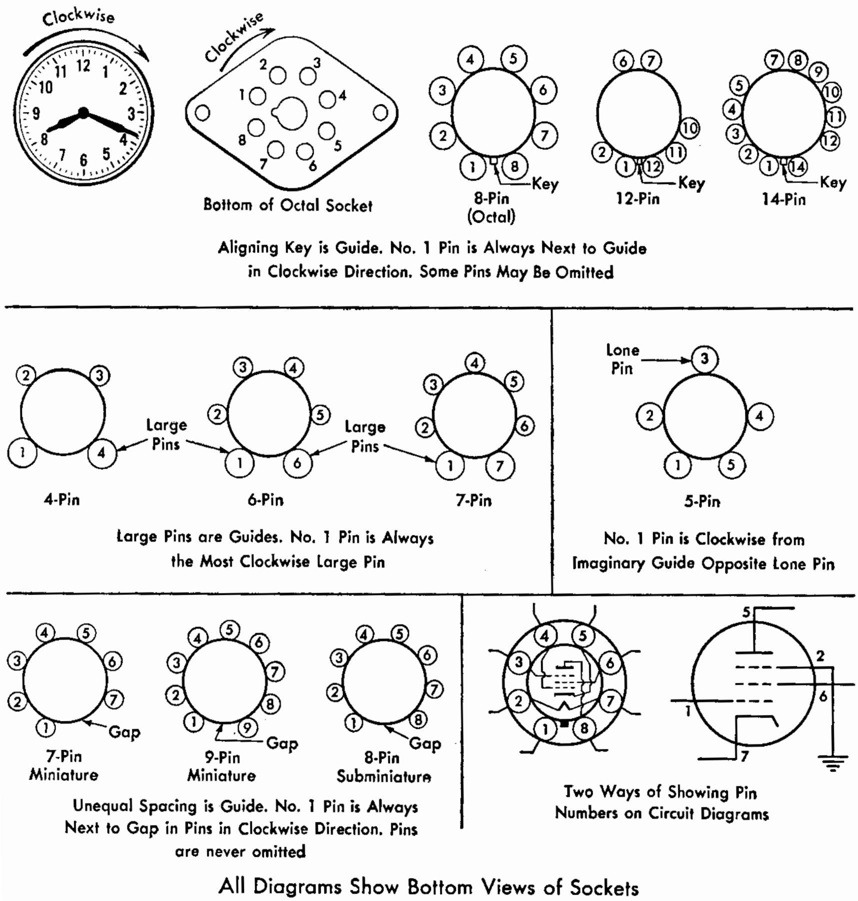


Fig. 14. Chart showing how to find the No. 1 terminal of any tube socket when looking at the bottom of the socket, and methods of showing pin numbers on circuit diagrams

When looking at the bottom of a tube or the bottom of the socket, the first pin in a clockwise direction from the guide is pin No. 1. With octal and loktal eight-pin tubes and sockets, missing pins and terminals are always counted just as if they were there.

Tube-base Diagrams. Socket-terminal connections to the electrodes of a tube are shown in several different ways on circuit diagrams. Tube symbols showing socket terminals in their correct positions are rather rare, as these make the circuit difficult to draw and difficult to follow when trouble-shooting.

Usually, tube symbols are drawn as in the lower right corner of Fig. 14, with each lead numbered. Once you learn how to find any pin number on any tube, you will find this type of symbol entirely adequate. You can also locate socket connections easily with the aid of a tube-manufacturer's handbook, such as the "RCA Triple Pindex" base-diagram guide which is available from jobbers.

When some pins are omitted from octal tubes, the corresponding socket terminals are often used as convenient anchor points for the leads of resistors and condensers.

Socket Troubles. When tube-socket contacts are corroded or dirty, they may be the cause of an intermittent trouble, noise, or an open circuit. To clean the contacts, remove the tubes and run a small piece of wire into each socket hole. Use a wire that is as thick as the tube pins. Roughen the wire a little by nicking it slightly all around with cutting pliers. The sharp edge of a straightened paper clip will often do nicely in miniature sockets. A steel bolt of the correct diameter, an inch or more long and having fairly sharp threads, will work even better as a cleaning tool.

Do not use too large a cleaning tool, as this will spread the socket contacts and do more harm than good. Twist the cleaning tool between your fingers as you move it up and down in the contact.

Insufficient contact pressure may be corrected by getting at the back of the sockets and squeezing the contacts together slightly with a pair of long-nose pliers. Do not exert too much pressure or bend the contacts too far, as you can easily break off the stiff contact material. An ice pick can sometimes be used to tighten a loose socket contact, by working with it from the top of the chassis.

Bad Socket Terminals. A poor connection between a socket terminal and the set wiring is almost always due to a poorly soldered joint. If you suspect a particular socket, push each connection separately with a stick of wood or other insulating material while the set is turned on. Noise or intermittent operation when you press against a socket terminal is an almost certain indication of a bad joint there, even though the soldered connection looks good to the eye.

Before resoldering suspected socket-terminal connections, turn off the set and remove the tube from the socket. Unless the tube is removed, heat from the soldering iron may loosen the wire in a tube pin or even solder the pin to the socket.

Sockets for miniature tubes require still more care because here there is a great tendency for the solder to flow into the tiny contacts on the socket. If you have a dummy tube base with aluminum or steel pins, plug it into the socket while soldering. Dummy bases are made especially for this purpose and are sold by parts jobbers. The solder will not adhere as readily to the aluminum or steel pins as it does to the tinned or nickel-plated pins of the regular tube.

When resoldering a joint, use only a small amount of solder. Generally the solder already on the terminal is sufficient. All that you need do is apply heat and a little fresh solder to get its rosin flux.

If too much solder gets on the contact, hold the set so excess solder can melt and run down the soldering iron, away from the contact. It can then be shaken off the iron easily.

Do not hold the iron on the contact any longer than it takes to melt the solder. Do not allow the iron to touch or get too close to the socket insulation. Heat can char or distort the socket insulation enough to move the contacts out of line or to provide a high-resistance path between contacts.

Socket-insulation Troubles. A short circuit between socket terminals, breakage of contacts, or breakage of socket insulation can often require complete replacement of the socket. This is a rather difficult and time-consuming job, so do it only when you cannot repair the socket. For example, if the socket has arced over between contacts or if you accidentally char the insulation while soldering, first try to scrape off the charred surface with a sharp knife.

Replacing a Defective Socket. Replacing a socket is difficult because of the large number of connections and because of the possibility of damaging other parts of the set.

Most sockets are riveted to the chassis, so you will have to drill out the mounting rivets after first disconnecting all socket leads. Remove one wire at a time. Carefully tag each wire with the socket-terminal number written on a bit of cardboard that is pushed over the bare end of the wire. It is important that you keep track of each lead. If they once get mixed, you may have to put in several more hours of work tracing circuits.

An exact duplicate of the socket in the set is easiest to install. If it is not available, you may have to drill new mounting holes or enlarge the socket hole to accommodate the new socket. Mount the new socket with nuts and bolts rather than rivets. If the original socket is mounted with a snap ring or clamp, mount the new socket by forcing the lock ring over the socket.

Socket insulation may be broken by improperly plugging in a tube. In four-pin sockets this may enlarge some of the socket-pin holes. Such a socket need not be replaced if you mark the socket or chassis in some clear way to indicate the true large holes.

First Steps in Removing Tubes. If removing more than one tube at a time from a set for test, be sure that tube sockets are labeled or that there is a socket layout diagram fastened inside the cabinet, so you can get the tubes back correctly.

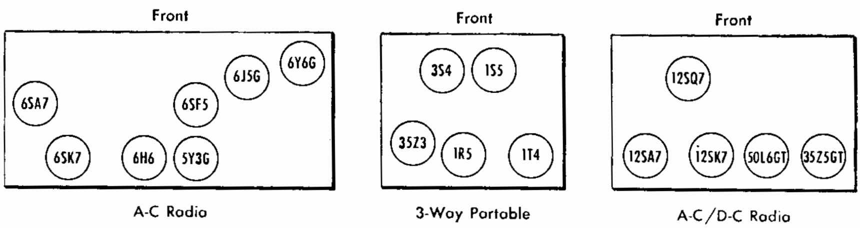


Fig. 15. Socket layout diagrams for radio sets, as given in a handy reference book, "Radio Receiver Tube Placement Guide," published by Howard W. Sams. Similar books of layout diagrams are available for television receivers, to speed up replacement of tubes

Layout diagrams are always *top views* of the chassis, as in Fig. 15, since they are intended as guides for removing and replacing tubes. If no layout is given, make one on a calling card before removing the tubes. Fasten it to the chassis or cabinet with speaker cement.

In sets having two or more tubes of the same type, it is best to mark each tube and socket with a different number or letter so you can get each tube back in its original socket. This will reduce the possibility of circuit unbalance due to small variations in the characteristics of tubes having the same type number. A china-marking pencil, such as the Dixon No. 77 Phano for Glazed Surfaces, works well for marking the glass tube envelope as well as the metal chassis. In television sets it is particularly important to get each tube back in its own socket.

It is always a good idea to turn off the set or unplug the line cord before replacing tubes. Removal of a tube reduces the load on the power transformer and other parts, making voltages go up on tubes remaining in the set. This rise in voltage can sometimes damage tubes still in the set or even affect other parts.

Removing Tube Shields. The commonest type of tube shield is removed by twisting slightly as you pull up on it, as in Fig. 16A. If the shielded tube has a top-cap connection and top-cap shield as in Fig. 16*B*, be sure to remove them both first. If the top-cap lead wire is left on, it may be broken by the sudden loosening of the shield.

Tubes requiring shields generally have metal clips or a raised metal section on the socket or chassis to make secure contact with the shield for grounding purposes.

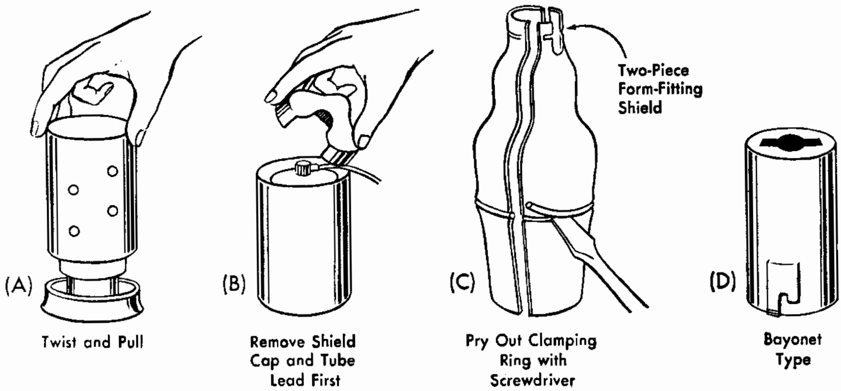


Fig. 16. Methods of removing tube shields. To remove bayonet-type shields, push down and turn just as when removing bayonet-type auto lamps or pilot lamps

To replace a shield, line up the bottom edge of the shield with the raised section on the chassis. Hold the can at a slight angle and place it over one edge, then straighten the can and push it into place.

Two-piece shields generally have a spring clamp wire around the middle to hold the shield in place on the tube. Remove this spring wire by forcing the edge of a screwdriver under the end of the wire or between the two ends, as in Fig. 16C. The two halves of the shield will then fall apart.

To replace a two-piece shield, place both pieces on the tube and hold them together with one hand. Push the spring-wire ring down over the top with the other hand until it seats in the groove about halfway down the side of each shield piece.

Tube shields for miniature tubes are widely used in television receivers. Some of the miniature-tube shields are constructed like bayonet-base auto lamps, as in Fig. 16*D*, hence must be pushed down and turned before they are pulled up.

Removing Top-cap Connectors. The top cap used on some tubes is connected to the set with a flexible insulated wire having at its end a cup-shaped metal connector. This connecting wire is often shielded with wire braid or coiled wire. Be sure this braided or coiled shield does not touch the top-cap connector.

Tube top-cap connectors are of two sizes. The larger one is for the older tubes, while the smaller is for the newer octal tubes.

Remove the top-cap connector by twisting it slightly while pulling up. The connector will normally come off easily, and you can then unplug the tube.

Do not twist the connector too much or pull on it with too much force, as you may break the cap off the tube itself. If the connector does not come off easily, try pushing down on it first. There will often be some play between the tube top cap and the connector, and downward pressure may break the bond that was causing the two parts to stick. If this does not work, pry between the cap and the connector carefully with a very small screwdriver.

To replace a top-cap connector, simply place it in position over the tube top cap and push it straight down into place. Be sure there is ample slack in the lead wire. Make certain the connecting wire cannot catch on the tuning condenser plates.

Tube Clamps. Various types of holding devices are used to hold tubes securely in their sockets. These are found most often in portable sets, where vibration and shock otherwise might cause the tubes to creep out of their sockets.

Miniature tubes are sometimes held in their sockets by a spring-type clamp. The spring is easily pulled to the side when the tube is inserted into the socket. The spring is then placed over the tube to exert a constant pressure on the glass top and hold the tube in the socket.

How to Pull Out a Tube. After removing the top-cap lead and shield, if present, grasp the tube firmly as close to the base as possible, and rock it slightly from side to side as you pull up. Be sure the set is turned off. If you let the tubes cool off for a minute or so after turning the set off, you will not burn your fingers on a heated tube envelope.

The rocking action is particularly essential on loktal tubes, to release the spring catch in the socket. Pulling at a slight angle instead of straight up will often help remove loktal tubes.

Tube-pulling Tools. If the tube does not come out with the above methods, try wedging a screwdriver between the chassis and the edge of the tube base. Before doing this, be sure the power is off and the line cord is unplugged, especially cn a-c/d-c sets; otherwise you may receive a shock.

The screwdriver-type tube-pulling tool in Fig. 17 is particularly handy, as it was designed especially for getting out tight octal, loktal, and other

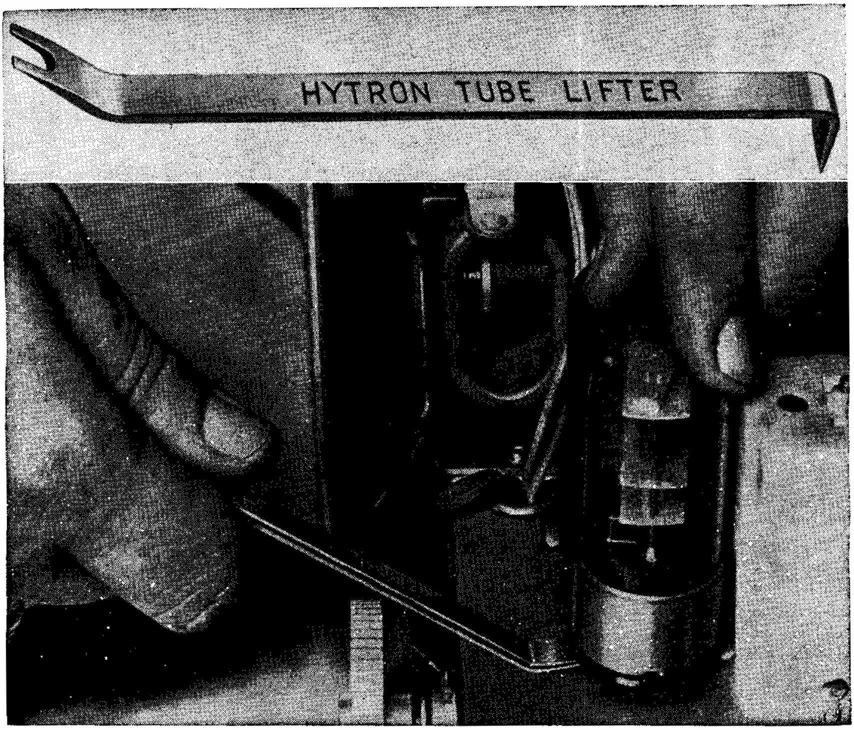


Fig. 17. Handy tube lifter and method of using it. Disconnect set from power line, tip tube slightly, insert tapered end of lifter under base so it goes around one pin, then press lifter handle down while guiding tube vertically with other hand. Use right-angled end when tubes are crowded together, as in television sets and in compact auto radios. (Hytron photo)

large tubes. For miniature tubes the special rubber lifter in Fig. 18 is also available.

Many other types of tube pullers are available. All are useful in removing tubes mounted so close to other parts that you cannot get your fingers around them.

Replacing Tubes. When replacing a tube, plug it back into its proper socket by noting the position of the socket guide key and holding the tube to line up with the guide. Place the tube over the socket and rotate

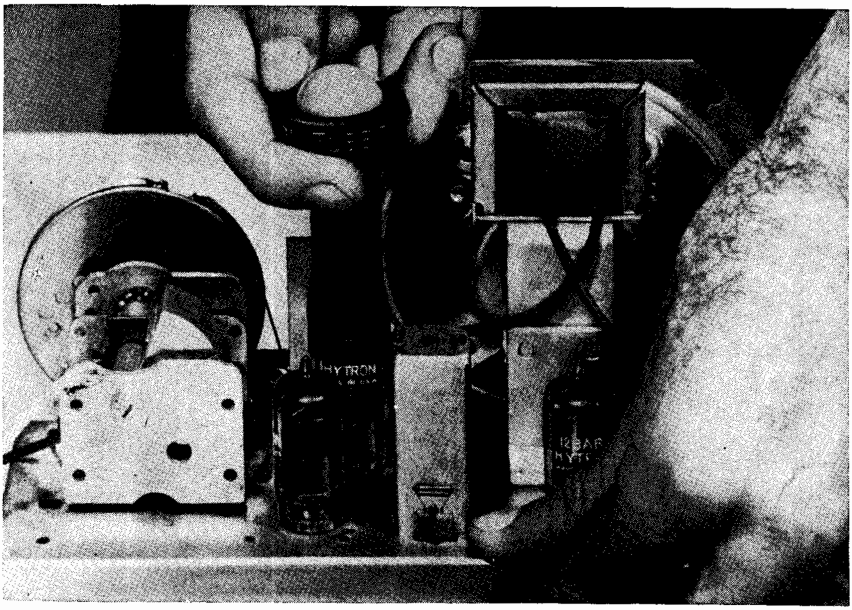


Fig. 18. Handy tube puller for miniature tubes, made from special rubber that resists tube heat and provides both suction and friction for gripping glass envelope. (Hytron photo)

it slightly until the pins fall into the socket holes, then press the tube down into the socket. With octal and loktal tubes, just place the tube on the socket and rotate it until the aligning key drops into position, then push the tube firmly into place.

For miniature tubes in crowded locations, use a small pocket mirror and a flashlight to help locate the tube socket holes. Sometimes tube-location diagrams in service manuals show the key position for each tube.

Four-pin tubes are generally the most difficult to insert properly because the difference in hole sizes is not very great. Note carefully the locations of the two larger socket holes for the filament prongs, and hold the tube accurately so its large pins cannot possibly miss these holes.

Common Troubles in Tubes. The vacuum tube is the most complicated part in a television or radio set. Many of the causes of faulty set operation can be traced to tube failure in one form or another. A tube can fail in many different ways and in many different parts of the set, making a receiver develop hum, noise, distortion, intermittent operation, and a host of other troubles.

Tube-filament Failure. A burned-out filament is one common defect in tubes. The filament or heater is a fine tungsten or alloy wire which is heated by current supplied either by a transformer or battery. This heat is sufficient to make the filament glow bright red in some tubes. In other tubes, the glow may be only barely noticeable.

The filament or heater supplies the heat to boil off the electrons which enable the tube to operate. When the filament breaks, the tube stops working, and so does the set. In rare cases, some of the signal may pass around the burned-out tube and give weak or distorted operation.

The filament of a tube may open for any of the reasons that make an ordinary electric lamp burn out. Expansion of the filament wire with heat each time the set is turned on produces mechanical strains that can eventually break the filament. Sometimes this may occur as an intermittent break, where the filament is good when cold but opens as it heats up. When the filament cools off, it makes contact again, with the process repeating itself at regular intervals of a few seconds or minutes.

Overvoltage on the filament, caused by line-voltage surges or abnormally high line voltage, is a fairly common cause of tube trouble. If the line voltage is appreciably higher than 117 volts for long periods of time, explain to the customer that he must expect tube failures more often than normal.

Burned-out pilot lamps may overload the tapped section of the filament on rectifiers like the 35Z5 and the 45Z5, making the tube burn out. For this reason, urge your customers to have pilot lamps replaced as soon as possible after they burn out in universal a-c/d-c radio sets.

Filament-battery Mistakes. In battery sets, improper connections to batteries can make the filament voltage too high. Interchanging the A and B battery leads is the most drastic mistake of this type, causing almost instant burnout. Some types of farm receivers use 2-volt tubes and have 6-volt battery leads in the same cable with the 2-volt filament battery leads. Check these carefully before connecting them.

Low Emission in Tubes. This is another common cause of tube trouble. It is due mostly to the normal aging of the electron-emitting surface of the filament or cathode. Nothing can be done to prevent this. The remedy is replacement of such weak tubes whenever a new tube gives noticeably improved performance or when a tube tester indicates that emission is low.

Loose Elements in Tubes. When an element in a tube gets loose for any reason, the set may give off a loud rasping noise, a rumble, or a growl when the tube is tapped. The tube is said to be noisy and should be replaced.

If the noise builds up gradually in volume, it is usually because of loudspeaker sound waves acting on the tube, and the tube is said to be microphonic. When this occurs, the howl or hum can generally be stopped by holding your hand on the tube. The tube should be replaced, as it is defective.

Occasionally you may find in television sets a tube having a heavy lead shield over the glass. This serves both as an electrostatic shield and as a suppressor of microphonic feedback, so be sure to replace it on a new tube installed in that socket.

Open Elements in Tubes. Opening of the connection to a tube element can be due to a poorly soldered joint in the tube base, to breakage of a welded connection within the tube, or to breakage of the cap on the top of the tube. These defects may block the signal completely or cause distorted reception. Tubes with poor connections should be replaced.

Loosening of the cement between the glass envelope and the tube base can cause an open element by breaking the solder connection to a base pin or can cause a shorted element by twisting the pin leads together inside the base. Such tubes should be replaced even if they test good, as they will eventually cause trouble.

Opens in tubes may also be due to rosin or dirt on tube pins. Scraping off the rosin fixes this trouble. Sandpaper is also good for cleaning tube pins.

Bent tube pins that do not touch socket contacts also cause opens. Miniature and subminiature tubes give the most trouble, since their pins are simply the wire leads that come through the glass. Bent pins can easily be straightened with a tool made for this purpose, shown in Fig. 19.

Tubes designed for high filament voltages, ranging from 25 to 117 volts, often have intermittent defects because their filaments are wound with finer wire, and give off more heat. This heat can cause the tube elements to expand and open-circuit during parts of the day when the a-c power-line voltage is high, yet the set will operate satisfactorily at other times when the line voltage is normal or low. Such tubes are defective and should be replaced.

Open cathode leads inside rectifier tubes like the 25Z5 and the 25Z6 may be caused by a shorted filter condenser in the power supply of the set. A filter condenser may short because of age, long storage, or excessively high voltage. The cathode lead in rectifier tubes is designed with a small diameter in order to reduce heat flow from the cathode, and will

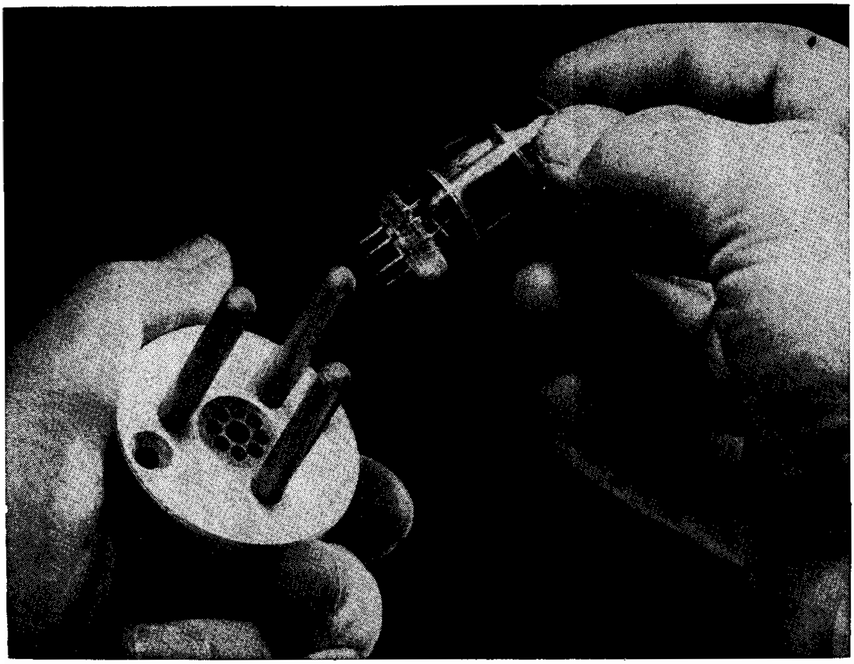


Fig. 19. Pin-straightening tool for miniature tubes. Inserting tube in tapered holes does the straightening job automatically. These pins often break off when straightened with pliers or with a screwdriver. (Sylvania photo)

open-circuit with currents much above ½ ampere. Some of the newer sets have a 50-ohm resistor in series with each rectifier plate or one 25-ohm resistor in series with both plates to limit the current and help prevent burning out the cathode lead.

Shorted Elements in Tubes. Short circuits between the elements in a tube are caused by mechanical failure of a mounting support or insulator. These failures in turn may be caused by excess vibration, excess heat, or continuous operation at higher than rated voltages.

Short circuits between elements are often intermittent and show up as noise when the tube is tapped. Cathode-to-heater shorts are often caused by filament heat.

Insulation Leakage in Tubes. Electrical leakage between elements is caused by cracks or breaks in the insulation separating the various elements. The most common place for leakage to occur is between the filament and cathode of indirectly heated tubes. This will be shown up by a good tube tester. In some circuits this type of tube trouble does not affect receiver performance, so do not replace a tube unless the new tube actually works better in that socket.

High resistance and arcing may occur between the pins on the tube base itself. This may be due to excessive voltage between elements or more often to dust, moisture, or oil on the base. A mark or charred line in the base insulation between two of the base pins is a clue. If you run into trouble of this type, clean off all tube bases with a cloth dipped in carbon tetrachloride or other cleaning fluid.

Gassy Tubes. Gas may develop in a tube because of overheating of one of the elements or actual leakage through tiny cracks in the tube envelope. Gas acts to produce excessive electron flow to the plate. It also reduces the effect of the control grid on the plate current. Two of the effects of gas are noise and distorted reception. Gas gives the most trouble in audio output tubes, so it is a good idea to try a new output tube whenever a radio or television set sounds distorted.

The presence of gas may often be noted by the appearance of blue haze near the plate and filament inside a tube. To find out whether the glow is gas haze or the normal fluorescent glow of some power tubes, hold a magnet near the tube. The harmless fluorescent glow will move as the magnet is moved, while the gas haze will not.

Replacing Tubes. When replacing defective tubes, it is not necessary to get the same make. Tubes from any of the well-known and reliable manufacturers can generally be used interchangeably.

Small variations do occur between tubes of the same type, but these are just as likely to occur in a batch all of one make. These variations are most noticeable on oscillator tubes such as the 6A7, 6J6, 6SJ7, and 1R5, where small variations in electrode spacings can affect the performance of the tubes in some sets.

Television receivers and radio sets with short-wave bands are most affected by small variations in tube construction. If one new tube does not work right, try another one. Save the first tube, however; it will usually work perfectly in some other set.

Try to replace tubes with others of the same size and shape or smaller. For example, some of the earlier 6H6 tubes had a large metal envelope, while later designs use a small envelope. In a set where the 6H6 is mounted near a tuning condenser, the condenser plates might clear the small metal tube but hit the large tube.

If the old tubes are metal, try to replace with metal tubes. If the old ones are glass, try to replace with glass-envelope tubes. This is the safest procedure for avoiding trouble, though nine times out of ten you can interchange glass and metal tubes without affecting performance.

Noise may seem to develop in some sets when you have replaced the tubes with new ones. This is not necessarily an indication of defective tubes. It may be that the new tubes show up set weaknesses which the older less sensitive tubes passed over, such as a poor contact on the rotor of the tuning condenser.

Interchanging Tube Types. Substituting other tube types for those in a set is an emergency practice forced on servicemen when correct tubes are not available. Tube manufacturers and radio jobbers have booklets giving lists of substitutions that are worth trying in such emergencies. An excellent one is "Receiving Tube Substitution Guide Book" by H. A. Middleton, published by John F. Rider Publisher, Inc., and available from jobbers.

Tubes with the same general type number but with a different letter group at the end are interchangeable for most applications. For example, 6C5, 6C5G, 6C5GT, 6C5GT/G, and 6C5MG are usually interchangeable with each other. Even tubes having entirely different type numbers can be interchanged under certain conditions, as explained in the tube-substitution booklets.

When a metal tube is replaced by its glass-tube equivalent, you may sometimes have to use a shield can over the glass tube. The shield stops squealing and howling in the loudspeaker due to feedback. Use the type of shield that grounds itself securely to the chassis through spring clips that you first bolt to the chassis.

Plug-in Adapters for Substitute Tubes. Sometimes two tubes are interchangeable electrically but have different bases. Instead of changing to the required new socket for the substitute, a plug-in adapter is used between the new tube and the old socket. The adapter is simply a tube base for the old tube and a socket for the new tube, fastened and connected together so the combination can be plugged into the socket of the set. The substitute tube is then plugged into the adapter. An example of an adapter is shown in Fig. 20.

Though some assembled adapters are available commercially, it will usually be necessary to assemble your own from parts available at jobbers. The use of a Bakelite socket that fits snugly inside the top rim of the tube base gives a neater finished adapter. Number 20 tinned wire is ideal for connecting the adapter socket to the adapter base. Cut the leads about an inch longer than necessary, solder them to the socket terminals first, insulate with spaghetti sleeving to prevent short circuits inside the adapter, then thread the leads through the correct base pins as indicated in the tube-substitution manual. Pull the leads taut to bring socket and base together, cut each lead flush with the end of its base pin, then solder the end of each pin.

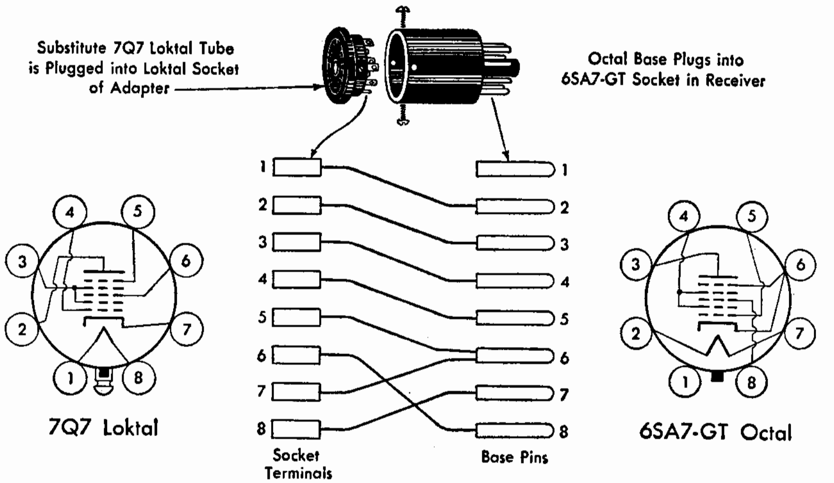


Fig. 20. Example of tube adapter, and method of making connections in it so that a 7Q7 loktal tube can be used in place of an unavailable 6SA7-GT octal tube. This type of work is done only in national emergencies when required tubes cannot be obtained anywhere

If you come across a set that has one of these plug-in adapters and a substitute tube, it is usually better to replace the entire combination with a new original tube when the substitute tube goes bad.

Obsolete Tubes. Old sets using special tubes made for just one manufacturer find their way into a service shop every once in a while. In general it does not pay to repair these antique sets, and the customer should be so advised, tactfully. A new modern set will generally cost much less than the repair charges for the antique and will usually work much better than the old set ever did.

Occasionally you may get a customer who treasures an old set for sentimental reasons and who is willing to pay whatever is required to keep the set operating. You will then have to modify the set to permit use of available standard tubes. One Sylvania "Radio Tube Technical Manual" listed a large number of obsolete and seldom-used tubes, along with enough information to make up replacement adapters or rewire the tube sockets. These data are probably still available from Sylvania.

Foreign Tubes. Information on many foreign tubes and out-of-date American tubes can be found in the book "Vade Mecum," which is sold by many jobbers. You will find it best to turn down repair jobs on foreign sets, however. Foreign tubes are hard to get, and a lot of rewiring is usually needed to change over for American tubes.

Emergency Repairs on Tubes. A loose base or loose top cap on a tube can be repaired in a few minutes, allowing you to get a tube back in service quickly or do a repair job at minimum cost. A new tube is always better than a repair, though. Use the following makeshift repairs only when absolutely necessary.

To re-cement a loose top cap, first scrape the envelope under the cap as carefully as possible with a penknife. Take care not to exert pressure on the top-cap lead wire or you may break the glass seal where the wire lead comes through the tube. Apply a coating of Duco household cement, a good glass or china cement, or speaker cement to the tube surface under the top cap, and push the cap tightly against the tube. The cement should ooze out the side of the cap when it is pushed into place. Set the tube aside to dry for an hour or so. Always handle the top-cap connection carefully after it has been repaired.

To replace and resolder a top cap that has come off, heat the loose top cap by holding a soldering iron against it, then shake excess solder off the cap. Scrape the cap and the tube envelope, apply cement, bring the top-cap lead wire through the hole in the top cap, and push the cap into position on the glass envelope. Now solder the top-cap lead wire to the cap. Do not leave the iron on too long, as the heat may crack the glass seal around the lead.

A broken top-cap connection may usually be repaired. Carefully scrape the short projecting lead. Wind a piece of bare tinned copper wire (about No. 22) around the lead a few times and squeeze the turns gently with pliers. Solder this joint quickly so as not to heat and crack the glass. Remove the cement from inside the top cap to make room for this joint. Complete the repair now just as for a top cap that has come off.

A loose tube base may be re-cemented with speaker cement. Use a stiff strip of paper to poke the cement in around the base, and place a few rubber bands around the tube and base lengthwise to apply pressure until the cement has hardened.

Repairing Tube Pins. An unsoldered tube pin may be resoldered. Scrape the end of the tube pin and as much of the copper wire lead inside as possible with a penknife. Heat the pin for about a minute with your soldering iron, then apply rosin-core solder to the open end of the pin. File or scrape off excess solder to make a neat, smooth pin.

Corroded or dirty tube pins may be cleaned by scraping, filing, or rubbing with fine sandpaper.

Correcting Microphonic Tubes. A microphonic tube that causes howling and squealing can sometimes be made usable by placing a heavy lead cap on top of the tube or by wrapping several turns of solder or lead strip around the tube near the top. Use a little speaker cement to hold the solder in place if necessary. The weight of the lead or solder dampens the vibrations set up in the tube elements by sound waves from the loudspeaker or by jarring, thereby stopping the howling of a microphonic tube. Use this procedure only when you cannot get a new tube.

Reading Faint Tube Markings. One way to make indistinct tube markings visible is by rubbing the glass against the hair behind your ear. Holding an indistinct marking up to the light in different directions, to catch the light reflections, often helps. Putting the tube in an electric refrigerator for about 15 minutes to chill it is another way of making faint markings on glass visible.

Pilot Lamps. Pilot lamps or dial lights are special types of flashlight bulbs used in almost all radios for illuminating the tuning dial and indicating when the set is turned on. Pilot lamps are also used as on-off indicators on record changers and other equipment.

Most of the new sets use the miniature bayonet-base lamp shown in Fig. 21, as this stays tight under vibration. Older sets used miniature screw-base lamps, also shown in Fig. 21.

When replacing pilot lamps, use a new lamp with the same voltage and current rating. The voltage rating is sometimes stamped on the base near the glass bulb. A rating of 6–8, for example, means the lamp will work satisfactorily at any voltage in the range of 6 to 8 volts. The replacement lamp must also have the same bead color, base, and bulb. In fact, if these last three characteristics are known, there is no need to know the voltage. Just use Table 3 to get the type number of the lamp needed.

If you cannot see the color of the bead in a pilot lamp for an a-c set, try a 6.3-volt lamp in the socket first. If this does not light the dial sufficiently, try 3.2- and 2.5-volt lamps in turn until you get just enough light to read the dial. Do not use too low a voltage rating to give extra light, as this means the lamp is being overloaded and will soon burn out.

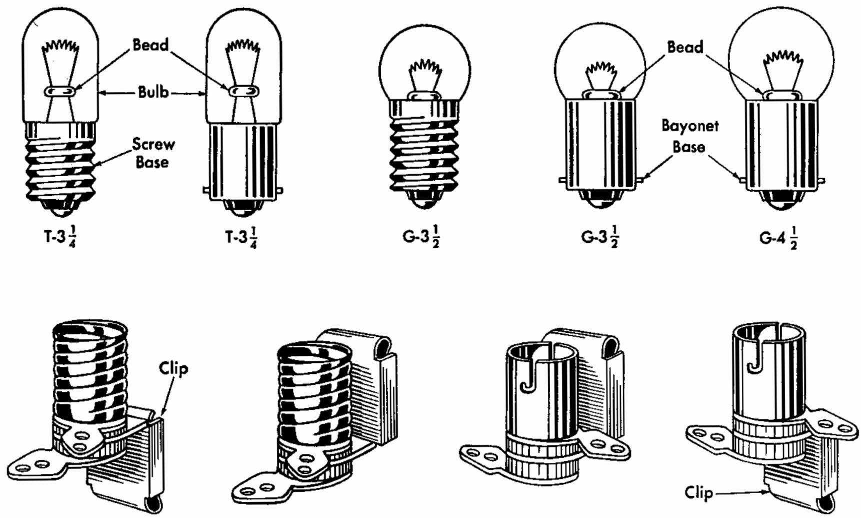


Fig. 21. Types of pilot lamps used in television and radio sets, and typical screw and bayonet sockets for these lamps. Numbers under lamps designate size and shape of glass envelope

Table 3. Pilot Lamps Used in Television and Radio Sets

Type No.	*Rated Volts*	*Rated Amp.*	*Bead Color*	*Bulb Style*	*Base*
40	6–8	0.15	Brown	T-3¼	Screw
41	2.5	0.50	White	T-3¼	Screw
42	3.2	0.35	Green	T-3¼	Screw
—	3.2	0.5	Green	T-3¼	Screw
43	2.5	0.50	White	T-3¼	Bayonet
44	6–8	0.25	Blue	T-3¼	Bayonet
S45	3.2	0.35	White	T-3¼	Bayonet
N45	3.2	0.50	Green	T-3¼	Bayonet
46	6–8	0.25	Blue	T-3¼	Screw
47	6–8	0.15	Brown	T-3¼	Bayonet
48	2.0	0.06	Pink	T-3¼	Screw
49	2.0	0.06	Pink	T-3¼	Bayonet
N49A	2.1	0.12	White	T-3¼	Bayonet
50	6–8	0.20	White	G-3½	Screw
51	6–8	0.20	White	G-3½	Bayonet
55	6–8	0.40	White	G-4½	Bayonet
292	2.9	0.17	White	T-3¼	Screw
292A	2.9	0.17	White	T-3¼	Bayonet
1490	3.2	0.16	White	T-3¼	Bayonet

Removing and Replacing Pilot Lamps. To remove a burned-out pilot lamp, first turn off the set and unplug the line cord. In most sets the pilot lamp can be removed by reaching in from the back of the chassis. If a clip-type socket mounting is used, slide the clip from the chassis and then remove the lamp from the socket. If you cannot get at the pilot lamp easily, remove the chassis from the cabinet first, then remove the pilot lamp.

To remove a screw-base pilot lamp, turn the bulb in a counterclockwise direction the same as you would an ordinary electric light bulb. To remove a bayonet-base lamp, press the bulb down into the socket, turn it a small amount counterclockwise, and release, the same as you would remove an automobile lamp.

If the lamp seems loose when you touch it, tighten it and try the set again before removing the lamp for replacement. If the lamp fits the socket loosely, remove the lamp and squeeze the sides of the socket slightly with the fingers or pliers to provide a little pressure on the side of the lamp base.

If a screw-base pilot lamp is cemented to the socket to prevent its working loose in shipment or in normal operation, try scraping the cement loose with a penknife. If this does not work, apply a few drops of acetone or nail-polish remover to soften the cement before unscrewing the lamp. After the lamp is out, scrape off excess cement on the inside of the socket. Speaker cement solvent is usually acetone.

When replacing the clip-on type of pilot-lamp sockets, be sure you get the socket located in the right way so that the shade or reflector, if one is used, works properly. Also, make certain the clip-on bracket is seated firmly in place, as it usually provides the return path for lamp current.

Pilot-lamp Performance. The pilot lamp in an a-c/d-c set will glow brightly when the set is first turned on, then dim to a proper glow as the set warms up. This is normal and is due to the greater current which flows through the lamp when the tube heaters are cold.

A pilot lamp may flicker with loud signals or when tuning an a-c/d-c set. This is also normal and is due to the change in plate current caused by the loud signal. Part of this increased plate current flows through the lamp filament and causes it to change in brilliance.

Check both sections of the rectifier filament with an ohmmeter or tube tester if a new pilot lamp burns out quickly in an a-c/d-c set. The section of the rectifier filament that parallels the lamp may be burned out. In this case the full tube-filament current flows through the pilot lamp and causes it to burn out again.

If two or more pilot lamps are connected in series, all of them will go out if one burns out. To locate the burned-out lamp, remove the lamps one at a time and replace with good lamps. When you replace the burned-out lamp, all will light up.

If you have a low-range ohmmeter handy, it is sometimes faster to remove all the lamps and check them for continuity with an ohmmeter. An ohmmeter is a good way to test all pilot lamps if you are in doubt about their being burned out. Tube testers usually have provisions for testing pilot lamps, too.

Television Picture Tubes. In ordinary radio tubes the electrons that are emitted from the cathode move outward in all directions to the surrounding cylindrical metal plate or anode. In a cathode-ray tube, however, the emitted electrons are concentrated in a pencil-like beam that is normally aimed at the center of a fluorescent screen on the inside of the tube face, as indicated in Fig. 22. This screen glows wherever the electron beam hits it.

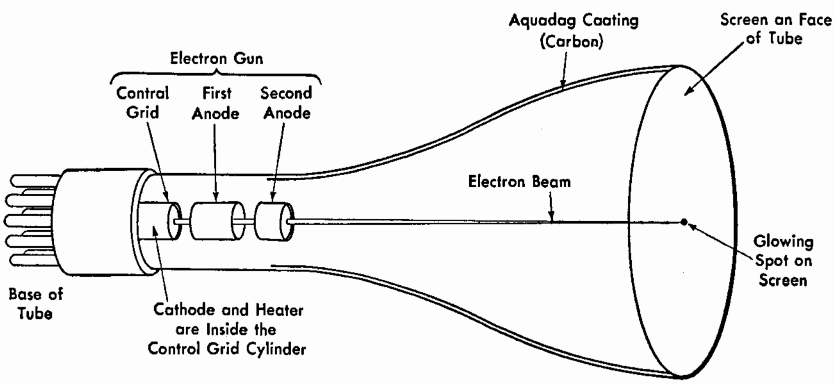


Fig. 22. Arrangement of electrodes in cathode-ray tube

The heater in a cathode-ray tube provides the heat that makes the cathode emit electrons. The control grid determines the number of electrons that get into the beam. A highly negative voltage on the control grid cuts off the electron beam entirely as required for black portions of a television picture. A less negative control-grid voltage lets electrons go out into the beam to produce the bright spots of a picture.

The first plate, called the first anode, works together with the small hole in the control grid to focus the electrons to a small point at the screen. The second anode requires a high voltage, often over 10,000 volts for television picture tubes, to give the electrons in the beam enough speed to produce the desired bright spot on the screen. Together the electrodes just described are called the electron gun.

An electron beam can be deflected by a magnetic field or by an electrostatic field. Practically all television picture tubes today use magnetic fields to deflect the beam. These electromagnetic fields are produced by coils surrounding the neck of the tube. They make the electron beam sweep across a rectangular area of the screen line by line from top to bottom, with the process repeated many times per second. At the same time, the picture signal is applied to the control grid in the electron gun to vary the beam strength, so that the electron beam paints the picture on the screen.

Another coil on the neck of the picture tube, used alone or in conjunction with a permanent magnet, aids the internal anode in focusing the electron beam so as to give a clear picture on the screen. Some of the newer sets use only magnets for focusing. Others have self-focusing picture tubes that do not need external focusing magnets or coils.

Picture-tube Ion-spot Damage. All electromagnetic picture tubes except those with aluminum-backed screens require ion-trap magnets on their necks. The ion-trap magnet, when properly adjusted, prevents the heavy particles called *ions* from getting out of the electron gun and hitting the screen. These ions, being much heavier than electrons, would cause a darkened area near the center of the screen if they hit it. Improper adjustment of the ion trap lets the ions out.

Why Ions Are Troublemakers. There are always some ions in the electron stream issuing from the cathode of a picture tube. Their presence is partly due to gases that cannot be completely evacuated from the tube and partly due to material that breaks loose from the cathode surface.

Positive ions cause no trouble. They are simply repelled back to the cathode by the high positive voltages on the electrodes of the electron gun.

Negative ions have the same negative charge as electrons do and therefore tend to take the same paths. The size of these negative ions, as much as 100,000 times that of an electron, is what makes them cause trouble when they hit the screen. The deflecting coils have little effect on the heavy negative ions, which plow straight ahead to strike near the middle of the fluorescent screen.

The repeated impact of these ions, concentrated in a small area instead of sprayed all over the face of the tube, soon burns a brown spot in the coating. This spot is then permanently dead to any fluorescing effect. Once the damage is done, the only remedy is replacing the tube.

How Aluminum-backed Screens Work. One method of preventing the ions from reaching the phosphor screen is to place a very thin aluminum sheet on the rear of the phosphor coating. The aluminum has thousands of tiny openings through which electrons can pass and activate the fluorescent material, but the larger ions are stopped by the aluminum barrier.

How Ion-trap Magnets Work. The other and most common method of preventing ion-spot damage involves a special electron gun design combined with the use of one or more adjustable external ion-trap magnets placed on the neck of the tube. This combination bends both the electron beam and the stream of negative ions out of line, then bends only the desired electron beam back in line. The heavy unwanted ions do not swerve so easily as the lighter electrons, so the ions hit the sides of the electron gun and are trapped there.

Ion-trap magnet adjustments are necessary to make the electron beam bend back into line exactly, so that practically all the electrons pass out through the hole in the end of the electron gun. The more electrons that get out, the brighter is the picture on the screen. Ion traps are designed so that adjusting for brightest picture automatically ensures effective trapping of ions.

The ion-trap magnet should be adjusted whenever a set is moved to a new location, whenever a new set is first turned on, and whenever a new picture tube is installed. The adjustment of the ion-trap magnet should also be checked after each adjustment of the focus coil.

Adjusting Ion-trap Magnets. Some picture tubes require only a single-magnet ion trap. Other types of picture tubes use two magnets, one larger than the other. Examples are shown in Figs. 23 and 24.

A single-magnet ion trap should be placed on the neck of the tube in such a way that the arrow or other marking on the magnet points to the screen of the picture tube.

With double-magnet types, the stronger magnet of the two should be at the base end of the tube. For the preliminary adjustment, the stronger rear magnet poles should be placed over the two small metal flags mounted on the electron gun inside the tube. The final adjustment is the same for single- and double-magnet types.

With the picture tube operating and the brightness control adjusted for low intensity, the magnet should be moved a short distance forward

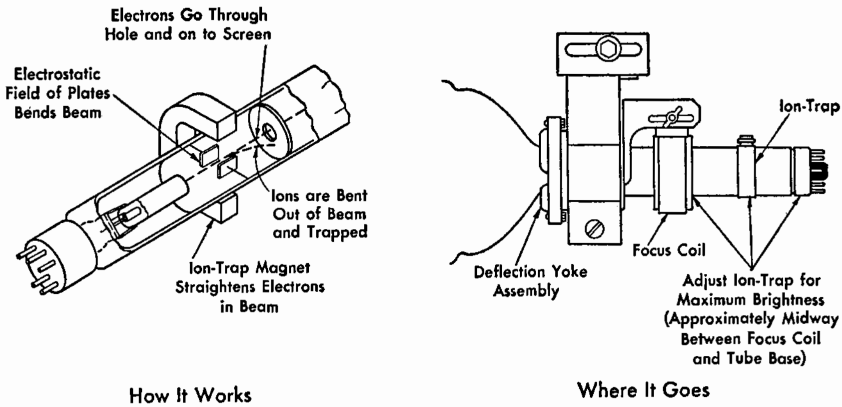


Fig. 23. How an ion trap or beam bender works. Ions and electrons both are bent by the electrostatic field, but the ion-trap magnet is only strong enough to bend back the electrons

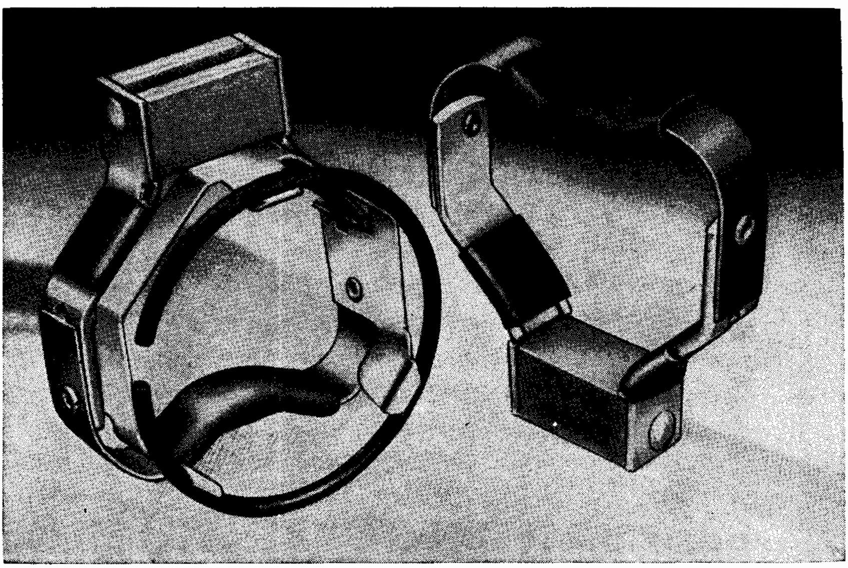


Fig. 24. Examples of ion traps. That at the left has two magnets, one being a block of Alnico and the other a circular piece of magnetized steel wire. (Clarostat photo)

and backward and at the same time rotated to obtain the brightest raster (line pattern).

If, in obtaining the brightest raster, the ion-trap magnet has to be moved more than ¼ inch from the internal flags or if it is pushed against the focus coil, the magnet is probably weak, and a new magnet should be tried.

As a final check, set the brightness control to obtain a raster of slightly above average brilliance. Adjust the focus for a clear line structure to simulate actual operating conditions with a picture. Now move the ion-trap magnet back and forth slightly to the exact position giving maximum brightness.

Never move the ion-trap magnet to remove a shadow from the raster if this decreases the intensity of the raster. The shadow should be eliminated by moving the focus or deflecting coils. The ion-trap magnet should always be in the position to give maximum raster brilliance.

Coil-type Ion Traps. A two-coil arrangement is used as an ion trap in a few older sets. Here the larger coil should be nearest the base. Adjustment for brightest raster is obtained in two ways: by rotating the magnet coil and by adjusting the current through it. The effect of current variation is the same as movement of the permanent-magnet type along the neck of the tube.

Ion-trap Adjusting Precautions. If a raster is not obtained in a few seconds by using the above procedure, turn the set off and check to make sure that the ion-trap magnet is positioned according to the manufacturer's instructions or markings. If the desired results cannot be obtained, try a new magnet.

If the picture tube has just been installed or the set has been moved, it is imperative that the brightness control be kept low until after the initial adjustment of the magnet. The magnet should be adjusted immediately after the set is turned on.

It is important that the intensity of the beam be low when the set starts operating, if the magnet has not yet been adjusted. Tubes have been ruined in 15 seconds of operation with the ion-trap magnet out of adjustment and the brightness control set too high.

Be sure the magnet fits the neck of the tube securely. If it is at all loose, a small piece of rubber placed under the clamps or a piece of friction tape wound around the clamps should prevent the magnet from slipping.

The procedure for aligning the ion-trap magnet should not be omitted just because the set seems to be operating satisfactorily. Even with the magnet poorly aligned a good picture can be obtained, but within a short time darkened areas will appear on the screen.

Removing Television Picture Tubes. Picture tubes should be removed from television receivers only as a last resort. Make absolutely sure first that all the other tubes and parts in the set are good, because it takes a lot of careful work to change a picture tube.

With most television sets, the chassis must be removed from the cabinet in order to get out the picture tube. The procedure for removing the chassis was covered in an earlier chapter. The steps involved in removing the tube from a typical set will now be given.

1. Ground the second-anode connector terminal on the funnel of the picture tube to the chassis for a few seconds with a test lead. Some large cathode-ray tubes have both internal and external coatings on the funnel portion of the tube. These act with the glass to form a condenser that can store high-voltage energy for several hours after the picture tube is disconnected. The amount of energy is so small that there is no danger from electric shock, but it can definitely be felt. An unexpected sudden shock when picking up the picture tube might cause you to drop it.

2. Remove the picture-tube socket by grasping it with your hand and pulling straight back from the base of the picture tube.

3. Remove the ion-trap magnet if one is present on the neck of the tube near the base. Usually the magnet is held in place only by a rubber-covered spring-steel clamp, and can easily be pulled off the neck of the tube.

4. Remove the second-anode connector from the terminal on the funnel of the tube by pulling it straight out from the funnel. On some tubes this is a snap-on cap that requires a bit of force with your fingers to get it off. Note the position of the terminal so you will be sure to get the new tube in this same position.

5. Loosen the special hold-down strap that goes around the widest part of the picture tube, after first studying its anchor screws carefully so you can get them back on correctly. Note also the exact position of the front of the picture tube with respect to the front of the chassis. The new tube must be in this same position, so it fits against the mask for the screen. Two examples of picture-tube mountings are shown in Fig. 25. Be sure to note how tight the straps are originally, before you loosen them.

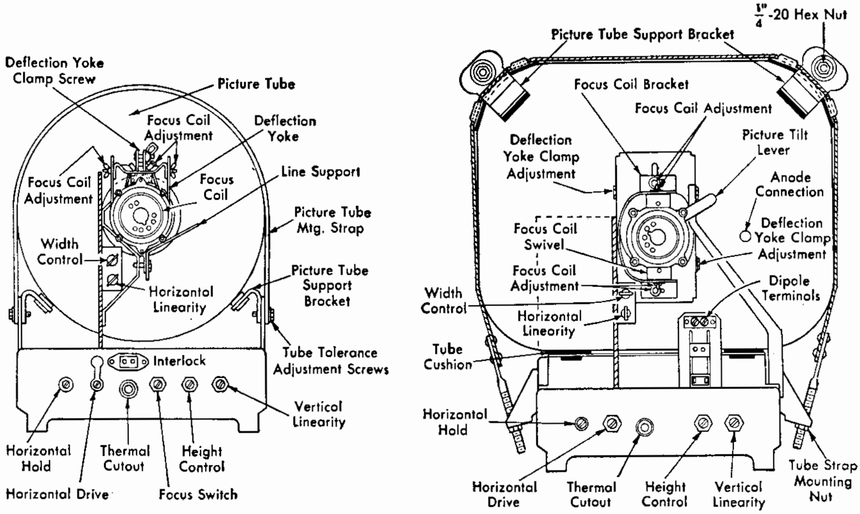


Fig. 25. Two types of picture-tube mounting straps used to anchor tube to chassis

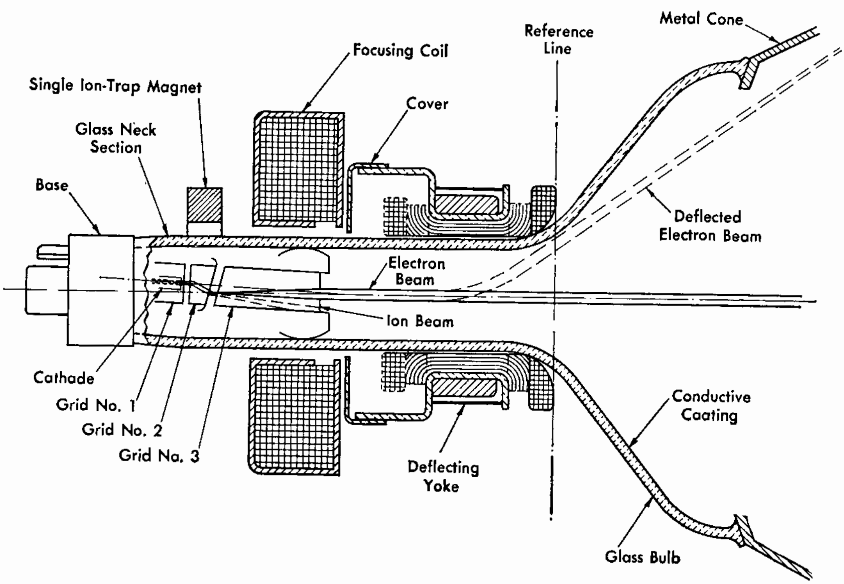


Fig. 26. Locations of deflecting yoke, focusing coil, and ion-trap coil on neck of picture tube having a bent gun. These parts occur in the same order in all picture tubes. The yoke is closest to the funnel of the tube, and the ion-trap magnet is closest to the base

6. Withdraw the picture tube toward the front of the chassis by grasping the widest part of the tube. The deflecting yoke and focusing coil, shown in Fig. 26, need not be disturbed when removing and replacing the picture tube.

7. Place the defective picture tube in a carton for safe handling. Many types of picture tubes can be turned in to your jobber for credit toward a new tube, so check with your jobber. If installing a new tube immediately, put the old tube in the carton in which the new tube was shipped. If setting a tube down temporarily, place it on its face on a soft cloth or pad.

Destroying Defective Picture Tubes. Bad picture tubes that have no credit value should never be discarded without first breaking the vacuum to let in air. This eliminates the danger of an implosion that may cause damage for which you might be held liable. Never give old picture tubes to children.

A simple and safe procedure used in many shops requires only a garbage can and an iron rod. Place the tube in the can, face down. Place the cover firmly on the can. Get an iron rod about ¼-inch thick, and insert it through a hole previously drilled in the side of the can near the top. A wrecking bar will work even better. Move the rod or bar around vigorously inside the can until the rod taps and breaks the neck of the picture tube. There will be a popping sound as air rushes in through the broken neck, but as a rule the large part of the tube will remain intact.

Installing a New Picture Tube. When replacing a defective picture tube, the following steps will apply for most sets:

1. Remove the new tube from its carton, holding the tube only at its widest part. Do not grab the tube by its neck, as that is the weakest part of the tube.

2. Rotate the tube so its second-anode contact on the funnel is in approximately the same position as that for the old tube. With rectangular tubes you have only two choices. The length of the second-anode lead in the receiver will determine which position to use if there is any doubt. The upper position is generally correct. With round tubes the position varies in different sets; in some RCA models, for example, the contact should be about 30 degrees off the vertical toward the high-voltage compartment.

3. Insert the neck of the picture tube through the deflection yoke and focus magnet, while holding the tube by the edges of its face as shown

in Fig. 27. Do not force the tube; if it sticks, investigate and remove the cause of the trouble.

4. Carefully adjust the position of the tube in its supporting cushion at the front of the chassis. Rotate the tube if necessary to get the second-anode terminal at the correct angle for round tubes. Slide the tube for-

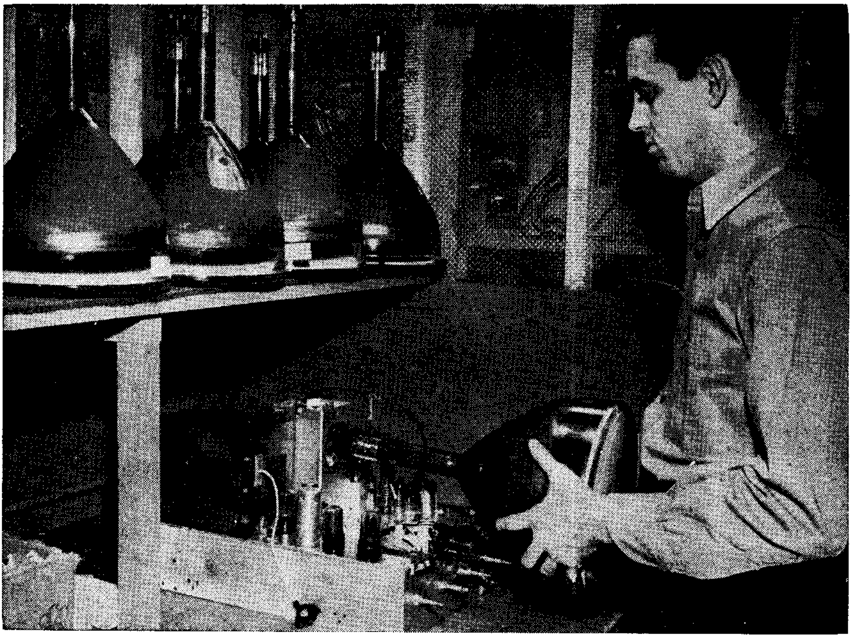


Fig. 27. Correct way to hold a picture tube when inserting it in the yoke. (Admiral photo)

ward or back on the chassis until its face has the same position as for the old tube. Now fasten the hold-down strap.

5. Slip the ion-trap magnet assembly over the neck of the tube.

6. Place the socket on the picture-tube base.

7. Connect the high-voltage lead to the second-anode terminal on the funnel of the tube.

8. Wipe the face of the picture tube and the inside of the front-panel safety glass with a soft cloth to remove all dust and finger marks.

9. Slide the chassis back into the cabinet, insert the chassis bolts, and tighten them. The face of the picture tube should now be against the mask, but should not be touching the safety-glass window. Sometimes the chassis can be slid forward or back enough to get the picture tube in

the right position. If necessary, remove the chassis again and adjust the position of the tube.

10. Push the deflecting yoke cushion as far forward as it will go against the flare or funnel of the picture tube, then tighten the yoke adjusting screws. This adjustment will differ with various sets; its purpose is to get the deflecting yoke as far forward as it will go, so the electron beam will not hit the neck of the tube and cause shadows in the corners of the picture.

11. Replace the knobs on the front-panel controls.

12. Connect the loudspeaker cable and any other cables that were disconnected when removing the chassis.

13. Turn the brightness control down a bit, plug in the set, turn it on, and adjust the ion-trap magnet immediately, as already described.

14. Adjust the deflecting yoke to get a horizontal picture if it is tilted.

15. Adjust the focus coil if necessary, to eliminate corner shadows and get sharpest possible focus. Always check the ion-trap adjustment after adjusting the focus coil.

16. Adjust horizontal and vertical size controls if necessary to make the picture fill the screen without going too far beyond the mask.

Cleaning Picture Tubes. Both new and old picture tubes should be thoroughly clean around the neck and on the face. Use a good window cleaner for the face of the tube, and use carbon tetrachloride to clean the neck. Absolute cleanliness around the neck of the tube is especially important, since greasy smudges might carry leakage currents from the coils surrounding it.

When installing or replacing a picture tube, a photographer's chromium-plated ferrotype plate is better than a mirror for watching the face of the tube while adjusting the receiver from the rear. The highly polished plate provides excellent reflection, and will stand much more abuse than an ordinary mirror.

QUESTIONS

1. What is the name of the electron-emitting element in a tube?
2. What is the filament voltage of a 5U4 tube?
3. Draw a bottom view of an octal socket, numbering each terminal and showing the location of the aligning guide.
4. Why is it necessary to rock a loktal tube while pulling it out?

5. Name three common troubles occurring in tubes.
6. If all pilot lamps in a receiver are out, describe one way of finding the bad lamp.
7. Why is it important to adjust the ion-trap magnet immediately after putting in a new picture tube?
8. When removing a picture tube, what things should be carefully noted so you can get them back correctly?
9. Why should you break the vacuum in an old picture tube before putting it out with the trash?
10. Should the face of a new picture tube touch the safety-glass window of the set?
11. What can be used to clean the inside of the safety-glass window and the face of the picture tube before replacing the chassis in the cabinet?
12. Remove and replace tubes having three different types of bases, and give your own opinion as to which type is easiest to replace correctly.

8

Testing Tubes without a Tester

Three Methods of Testing Tubes. The most common cause of television- and radio-set failure is a worn-out or defective tube. Therefore, it is never a waste of time to test the tubes first when a set is brought to you for fixing. Your customers expect you to do this, because they always hope the trouble is just a bad tube.

Tubes can be tested in three different ways: (1) by checking their performance in the set; (2) by substituting good tubes; (3) by using a tube tester. All three methods are used on radio sets, with the tube tester being most popular among servicemen. For television receivers the first two methods are used most, because tube testers do not reveal the small differences that can affect television pictures.

In this chapter the first two methods of testing tubes are covered in detail. You can actually get started in television and radio servicing without having a tube tester, by following these instructions for testing tubes by *set performance* and by *substitution*.

No matter which way you test tubes, there are a number of things to be done first. These include verifying the customer's complaint, making sure tubes are well seated and in the correct sockets, looking over the top of the chassis for obvious defects, and seeing if any tubes fail to light up or warm up. Procedures for making these preliminary checks will be given first.

Verify Customer's Complaint First. Always verify the customer's complaint of improper set performance before testing tubes. If you are making the check in the home, you may find that the cause of the trouble is something outside the set. There may be a poor antenna connection, a noisy motor in the vicinity, or a blown house fuse. If in your shop, turn on the set in front of the customer so he can demonstrate exactly what is bothering him.

Make Sure Each Tube Is in the Right Socket. If tubes are not in their correct sockets, the set may motorboat (make put-put sounds), squeal, or not operate at all. Tubes can get mixed up easily when they all have the same type of base.

One way to check the location of each tube is by comparing with the tube-layout diagram. This diagram is generally fastened on the inside of the cabinet, pasted on the rear of the chassis, or pasted on the bottom of the cabinet. The diagram is usually in the service manual for the set too. If you cannot find the tube layout diagram, look on the chassis alongside each tube socket for the tube type number. If it is not there, pull out a tube and see if the number is printed in the center of the socket.

If there are no socket markings or diagrams to check against, then assume the tubes are in their right sockets and proceed with the next step. Only once in a while will you find that the customer has removed the tubes and replaced them incorrectly. If you suspect something like this and there is nothing on the set to check against, hold up further work until you can get a service manual containing the tube layout diagram.

Substitute Tubes. On some sets, manufactured during the wartime shortages, a tube type number stamped on the chassis may differ from that of the tube. The tube is probably an emergency substitute if the socket shows signs of rewiring, if the original type number is scratched off the chassis, or if an adapter is mounted between the socket and the tube base. The remaining tubes will generally agree with the chassis type numbers. Leave the tube alone if it is an emergency substitute, unless you have reason to suspect that it is bad. In this case you can either check and replace the emergency tube or restore the set to its original tube lineup.

Make Quick Inspection of Entire Set. Before removing the chassis from its cabinet and before even thinking of testing tubes, spend a few seconds looking for simple, obvious troubles that you can easily see or feel. After you have checked the following list of common external defects a few times, you will find that you can do it automatically while listening to the customer describe how the set went bad.

1. Push each tube down into its socket. Oftentimes a tube creeps up and one of its pins no longer makes contact with its socket terminal.

2. Check the wall outlet. If in the customer's home, and the set is stone-cold-dead (no light or heat from any of the tubes and no hum or

other sounds when the set is turned on), make sure there is line voltage at the outlet into which the set is plugged. You can check the outlet quickly by plugging in your soldering gun or by measuring the a-c voltage at the outlet with your multimeter. If a floor or table lamp is handy, try the lamp in that outlet.

3. Inspect the set's line-cord plug. Look for loose wiring and loose screws.

4. Inspect the line cord. Look for weak, frayed, pinched, or broken regions. Look especially for breaks at the point where the cord enters the plug and where it enters the cabinet and the chassis.

5. Look for a blown fuse in the set. Very old sets often have their own fuses in the line-cord circuit. See that the fuse fits tightly in the fuse holder. Tap the fuse with a pencil to see if it is loose or makes intermittent contact. If the set is dead, pull out the line-cord plug and check the fuse with a low-range ohmmeter even though it may look good. A good fuse should have essentially zero resistance. Small cartridge fuses sometimes develop open circuits at the end of the fuse wires after they have been in use for a number of years.

6. Try the set on-off switch for good snap action. If there is any reason to suspect a defective switch, pull out the line-cord plug first and measure between its prongs with your ohmmeter. The reading should be infinity with the switch off and well below 500 ohms when the switch is turned on.

7. Look for running wax or tar on or near the power transformer. This may mean that the transformer has been overheated or burned out. Note any unusual odors such as that of burned insulation or overheated enamel. Such symptoms are clues to serious troubles, indicating that you should take the chassis into your shop for thorough checking.

8. On a battery set, check the filament battery voltage with the set turned on. Use the lowest d-c voltage range of your multimeter. If the voltage is below 1.1 volts for a 1.5-volt battery, a new battery may be all that is needed. Be sure each battery terminal is clean and is making good contact. See that the battery is installed correctly. The center contact of a dry cell is plus, and its corresponding connection to the set is generally colored red.

Inspecting Tube Filaments in A-C and Battery Sets. In a-c sets the filaments of all tubes except the rectifiers are connected in parallel, as in Fig. 1A. The light from all filaments comes up to brightness gradually, taking as long as a minute in some a-c sets. Only a small amount of light is given off by modern tubes. In some, the only sign of light is a bright red glowing area about the size of the head of a pin.

Some tubes may not appear to light up when viewed from the top, because of the coating of silvery getter material on the inside of the glass. By looking at these tubes from the side, the filament glow can often be seen near the base if the tube is good. If the tube is covered by a metal shield, remove the shield first before checking for a filament glow.

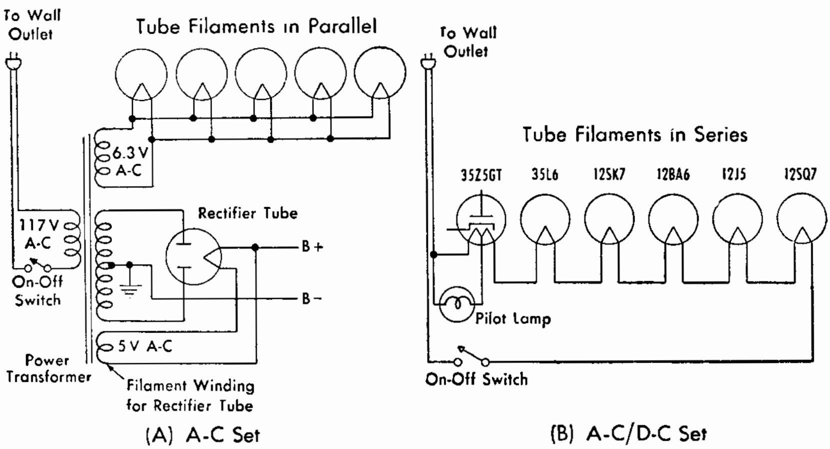


Fig. 1. Parallel arrangement of tube filaments in an a-c receiver, and series arrangement of filaments in a typical a-c/d-c radio set

If the pilot lamp does not light, remove it and examine it. A definite break in the filament shows the lamp is burned out and should be replaced. If you cannot see the open filament, check the lamp further with an ohmmeter. A burned-out lamp will show infinite resistance, while a good lamp will read below a hundred ohms.

Checking Tubes by Touch. If there is no obvious light coming from the center of a tube, leave the set on for a minute or so and then feel the tube to see if it is warm. Rectifier and power output tubes generally run the hottest because heat is generated in the plate as well as in the filament.

Touch each tube carefully. Some of them get hot enough in normal operation to give a bad burn. In particular, watch out for metal tubes like the 6L6 and 5Z5. The black metal shells give no indication that the tube is hot. Your fingers can be severely burned by innocently grabbing one after the set is on awhile.

A tube which does not light up or warm up may have an open filament. This can be checked quickly with an ohmmeter.

Filament Warmup in A-C/D-C Sets. In a-c/d-c sets the filaments are connected in series, as also shown in Fig. 1*B*. When such a set is first turned on, the power-amplifier tube (such as a 35L6 or 50L6), the rectifier tube (such as a 35Z5 or 25Z5), and the pilot lamp will light up quite brightly. The remaining tubes will show just a faint light. After the set has been on about two minutes, the pilot lamp will dim to its normal brilliance.

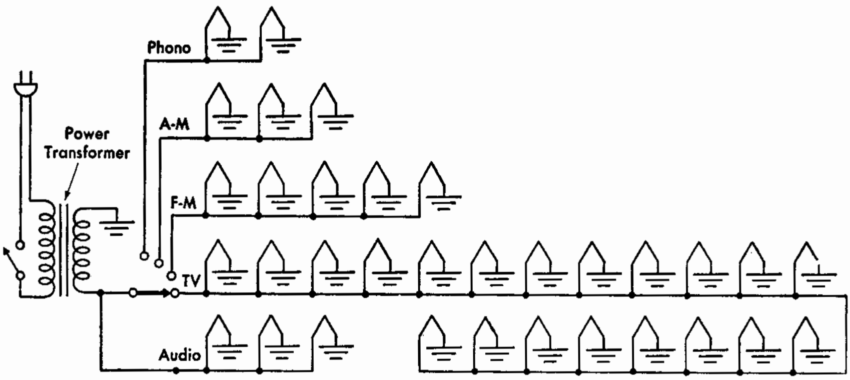


Fig. 2. Arrangement of tube filaments in one television-radio-phono console. Only the tubes in the audio section are heated all the time; the others get filament voltage only when their section of the set is in use

This change in the amount of light as the set warms up is due to the series connection of the filaments. When the set is first turned on, the filaments are cold and their resistance is low. This causes a relatively large amount of current to flow through all filaments. Because the rectifier and the power-amplifier tubes use the greatest amount of filament power and heat up faster, these tubes give off the greatest light.

After the set is on for a while, the slower-heating filaments gradually warm up and increase in resistance. This reduces the filament current flowing through all tubes, so the pilot lamp dims. The power amplifier and rectifier filaments also lose a little brightness, but will still be brighter than the other tubes after the set has warmed up.

Television sets have more tubes but still use either series or parallel arrangements of tube filaments. In a-c/d-c television sets there may be several strings of tubes with filaments in series. In television-radio-phono sets, tube filaments may be arranged in parallel as in Fig. 2, so that a switch applies filament voltage only to the tubes needed for the type of entertainment being used.

Checking for Loose Tubes. The preliminary check of a receiver includes pushing the tubes down in their sockets. It helps to rock each tube sideways gently in its socket when doing this to clean the tube pins and the socket contacts. If any tube seems too loose, remove it and look for broken socket insulation around the keyway and at the tube-pin holes. These broken insulation defects often occur when the tube is forced improperly into the socket, with the key in the wrong position or with the large and small pins reversed.

If the socket looks good, put the tube back in. Be sure it goes into position with some pressure, so that the tube pins fit snugly in the socket contact. If a tube slides loosely into place, the socket contacts may have lost their spring because of age or heat from the tube.

A loose contact on a socket can usually be fixed by removing the chassis and squeezing the bottom of the contact together a little with pliers. Bent pins on tubes should be straightened, as they may be the cause of poor contact in the socket.

Make certain each tube goes all the way into its socket. Sometimes a tube is held away from the socket contacts by solder in the socket or by the socket mounting screws.

Checking for Loose Top Caps. In older radio sets and in high-voltage sections of television sets you will often find tubes that have top caps for connections. Feel each tube top-cap clip and be sure it fits tightly on the top cap of the tube. If the clip is loose, squeeze the sides a little to increase the spring tension. *Warning:* In television sets, top caps may have dangerously high voltage. Do not touch them until the set has been off for several minutes.

Be sure the top-cap lead wire is not frayed or broken. If the wire is covered by a flexible shield, make sure the shielding is back about a quarter of an inch from the cap and is not shorting to the top cap.

Checking Filaments with an Ohmmeter in A-C Sets. In a-c sets, any tube which does not light or get warm after being on for a minute or so is very probably burned out. Remove it from the set, and check the filament for continuity with an ohmmeter by clipping the test leads to the two filament pins. Any ohms range can be used. Replace any tube which reads infinity on the ohmmeter.

Generally, if a tube is burned out, the set will stop operating. In a few instances you may find an a-c set that will continue to operate, although weakly, if one of the tubes is burned out.

Do not attempt to check for filament continuity while the tube is still in an a-c set. The resistance of the transformer filament winding is shunted across the defective tube, along with the filaments of other tubes in the set, as shown in Fig. 1*B*. The ohmmeter will therefore show continuity even though one tube is burned out.

Identifying Sockets from Underneath. When checking tube filaments, you have to know what tube is in a socket before you can find its fila-

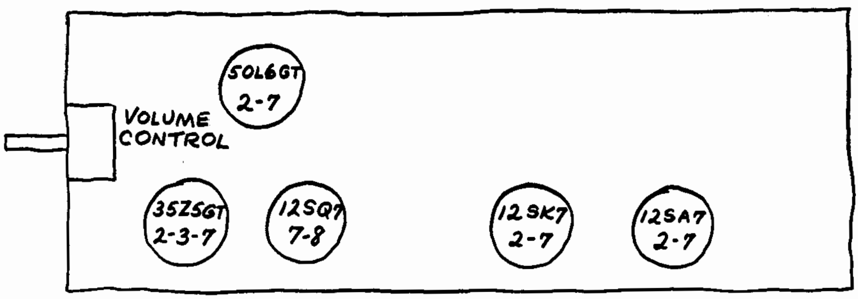


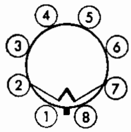
Fig. 3. Example of sketch that can be made to speed up the use of an ohmmeter or a-c voltmeter when testing tube filaments for continuity

ment pins. This means looking at the tube itself or the chassis marking alongside it, which is rather a nuisance when you have the chassis upside down for convenient testing. The solution is to make a rough sketch before you start testing, showing the sockets as they appear when looking at the bottom of the chassis. Mark each socket with the type number of the tube that is in it. Next, look up each tube in a tube manual and jot down the filament or heater pin numbers right on your diagram, somewhat as in Fig. 3. Making this diagram takes only a few minutes, but you will gain this time back through faster testing and will minimize chances of making mistakes. After servicing for a while, you will find that you have memorized the filament pin numbers for the commonest tubes and will not have to look them up each time.

Filament pin numbers for some common tubes are given in Table 1, to show which numbers are used most often for filament connections. Though this list is by no means complete, it will serve as a quick reference for the most widely used tubes, so that you will have to look up only the newer or rarer tubes in the tube manual.

Table 1. Filament or Heater Pin Numbers for Common Receiving Tubes

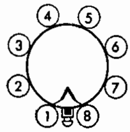
Octals



Except as Follows:

5AX4	2-8	6SL7	7-8
5T4	2-8	6SN7	7-8
5U4	2-8	6SQ7	7-8
5V4	2-8	6SR7	7-8
5W4	2-8	6ST7	7-8
5X4	7-8	6SZ7	7-8
5Y3	2-8	6W4	7-8
5Y4	7-8	12AH7	7-8
5Z4	2-8	12SC7	7-8
6AQ7	7-8	12SF5	7-8
6AS7	7-8	12SF7	7-8
6BL7	7-8	12SL7	7-8
6P7	2-3	12SN7	7-8
6S8	7-8	12SQ7	7-8
6SC7	7-8	12SR7	7-8
6SF5	7-8	12S8	7-8
6SF7	7-8	25W4	7-8

Loktals

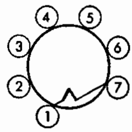


Except as Follows:

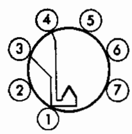
5AZ4	2-8
7F8	2-7
14F8	2-7

7-Pin Miniatures

All 1.5 and 3-Volt 7-Pin Tubes for Battery Sets:



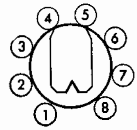
All 6-Volt and Higher-Voltage 7-Pin Tubes:



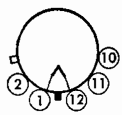
Except as Follows:

6BA7	4-5
45Z3	1-7

8-Pin Miniatures

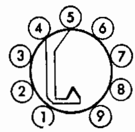


Picture Tubes



All Diagrams are Bottom Views

9-Pin Miniatures



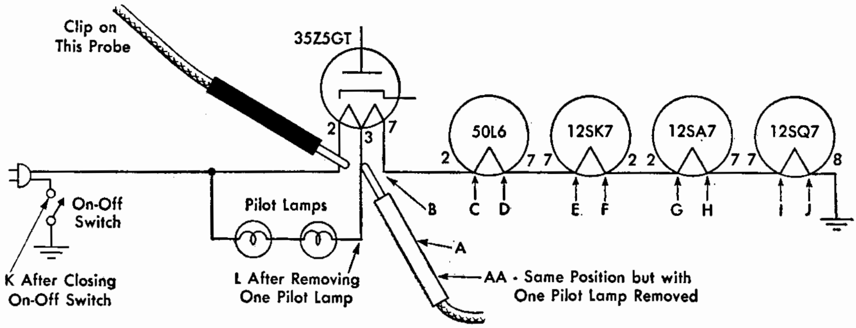
Checking Filaments with an Ohmmeter in Battery Sets. In small battery-type portables, farm battery sets, and hearing aids where the filaments are connected in parallel, follow the same procedure as for an a-c set in locating burned-out tubes, but use the highest ohms range. A low ohms range may draw enough current to burn out a battery-radio tube. Examples of ohmmeter readings for the filaments of good battery tubes are 10 ohms for a 1S4 and 25 ohms for a 1R5.

Checking Filaments with an Ohmmeter in A-C/D-C Sets. In a-c/d-c sets, all the tubes go dark and get cold when one of them burns out, so you have no obvious clues to the bad tube. The filaments of the tubes in a-c/d-c sets may be checked by removing each tube and measuring between filament pins with an ohmmeter, just as for a-c sets. For faster work, tubes can be left in the set and the following procedure used:

1. Unplug the line cord from the wall outlet.
2. Turn the set switch on.
3. Remove the chassis from the cabinet and turn the chassis over so you can see the wiring.
4. Trace the line cord to where it connects to the set wiring. One wire

will generally go to the on-off switch. The other wire will go to one of the tube-socket terminals (generally the filament terminal of the rectifier).

5. Clip one probe of the ohmmeter to the tube-socket filament terminal having the line-cord wire.



Position of Probe	Reading in Ohms	Meaning of Reading
A	35	Section 2-3 of 35Z5GT and/or Pilot Lamps OK
AA	50	Section 2-3 of 35Z5GT OK
	Replace Pilot Lamp After Test AA	
B	235	Section 3-7 of 35Z5GT OK
C	235	Wire from B to C OK
D	565	Filament of 50L6 OK
E	565	Wire from D to E OK
F	645	Filament of 12SK7 OK
G	645	Wire from F to G OK
H	725	Filament of 12SA7 OK
I	725	Wire from H to I OK
J	805	Filament of 12SQ7 OK
K	805	On-Off Switch and Chassis Grounds OK

Fig. 4. Test-probe positions for checking filament circuit continuity of five-tube a-c/d-c radio with an ohmmeter to find a burned-out filament, with examples of readings that would be obtained when all filaments are good

6. Touch the other probe of the ohmmeter to each of the other socket filament terminals in succession, working away from the first probe, until all filaments are checked. An example of how this is done is shown in Fig. 4.

Actual ohmmeter values do not matter here, as they can be different for every set. It is the infinity reading you are looking for, as this means you have just moved through an open circuit.

The last tube in the series string will generally have one of the filament terminals connected to the chassis, and the return path to the other side of the line will be through the chassis. The filament wires are all the same color in most sets, simplifying the tracing of wiring from one tube socket to the next. To find the filament tap for the pilot light, trace the wires from the pilot-lamp socket back to where they connect to the tube socket.

7. In making the continuity check, the first tube you come to which does not show a reading on the ohmmeter has an open filament. To confirm this, remove the tube from the set and connect the ohmmeter directly across the filament pins. On tubes like the 35Z5 and the 45Z5, test the whole filament across pins 2 and 7, and test the tap section for the pilot lamp across pins 2 and 3. On the 35W4 miniature-tube equivalent of the 35Z5GT, pin 6 is the filament tap, and pins 3 and 4 are the ends of the filament. If either set of pins does not show continuity, the tube is defective.

Checking Filaments with an A-C Voltmeter in A-C/D-C Sets. In a-c/d-c sets the filament continuity of each tube may also be checked quickly with an a-c voltmeter. This method of testing has the advantage that it will show up tubes whose filaments are intermittently open. These tubes usually test good with an ohmmeter but open up as the filament heats and expands when the set is turned on. The test procedure is as follows:

1. Remove the chassis from the cabinet.
2. Set your multimeter to the 150-volt a-c range or to the next higher range above 130 volts, such as 200, 300, or 400 volts.
3. Trace the line cord to where it connects to the set wiring. One wire will go to a terminal on the on-off switch. Clip one test probe to this terminal.
4. Plug the line cord into the wall outlet and turn the set on.
5. The second line-cord wire will generally go to one of the tube-socket terminals, such as the filament terminal of the rectifier. Hold the second voltmeter test probe on this terminal.
6. A voltmeter reading of about 115 volts indicates you are getting voltage to the set. Now move this second probe to the other filament terminal of the rectifier tube. If the voltmeter still reads about 115 volts, the rectifier filament is good.
7. Next, trace the filament wire from the rectifier to the next socket and move the second test probe to this socket terminal. Repeat this test for each other filament terminal on the sockets, until you reach a tube socket on which you get no voltage reading. The tube in this socket has an open filament and should be replaced.

The method is based on the fact that full line voltage appears across a break in a series filament string. When the a-c voltmeter probes are both on one side of the break, no voltage is measured.

Caution: Remember that in some a-c/d-c sets the chassis is connected directly to the hot side of the a-c power line for one position of the line-cord plug when the set is on. This line voltage can be dangerous to you. The only way to work safely on one of these sets is with an isolating transformer between the set and the power line. This may cost as much as $10 for power ratings high enough to handle the larger sets, but it is well worth while. An isolating transformer made especially for servicing a-c/d-c sets can be obtained from any jobber.

If you do not have an isolating transformer, keep your hands off the bare chassis whenever the set is plugged into a wall outlet. These a-c/d-c sets can give a dangerous shock even with the switch off, so respect them.

Finding Intermittent Filaments in A-C/D-C Sets. An intermittent filament is one which will show continuity when the tube is cold but will open when the tube is hot.

If the tubes light up normally when an a-c/d-c set is turned on, start to go dim in a few minutes, and then, just before they go out entirely, start to get bright again, look for an intermittent filament. The problem in finding an intermittent tube is to catch the tube in the act of going out. This often calls for patient waiting at each tube in turn.

The a-c voltmeter test works the best for locating intermittents in a-c/d-c sets. When the voltmeter is across the filament of a tube with an intermittent filament, the meter will read the normal filament voltage for the tube under test when the tubes are bright. If the meter is across the bad tube, its reading will go up to the a-c line voltage, generally around 115 volts, when the tubes go out. If the meter is across a good tube, the meter reading will drop to almost zero when the intermittent occurs.

Remember—to find an intermittently open filament in an a-c/d-c set, connect the a-c voltmeter to the filament terminals of each tube in turn, not across the whole string of tubes. For each tube, wait until the set goes intermittent.

Tapping a tube while it is being checked will sometimes hasten the intermittent condition. Rest the chassis on its side so you can hold the probe under the chassis with one hand while tapping the side of the tube with the fingers of your other hand. Be sure to use an a-c voltage range above 115 volts, so you will not burn out the multimeter when you find the intermittent.

Finding Intermittents in A-C and Battery Sets. When tube filaments are in parallel as in these sets, the multimeter will not readily reveal the location of an intermittent tube. Your eyes and fingers will find the fault because only the filament glow in the bad tube will go out and only this tube will get cold.

With three-way portables that operate on a-c power, d-c power, or batteries, first try watching the tubes while on battery operation. Even though the filaments normally glow dimly in these tubes, you may be able to spot the culprit as it goes out. If not, change to a-c/d-c operation and use the a-c voltmeter test. Measure across the filament terminals of each tube in turn, until you come to the tube whose filament voltage shoots up to the power-line value when the intermittent occurs.

Precautions When Installing a New Tube. After replacing a tube having a burned-out filament, watch the set carefully as you turn it on. Be ready to turn it off instantly if the new tube gets too bright or anything else unusual happens, such as a red-hot plate in a tube or a blue haze all through the tube. The cause of the open filament may still be in the set, ready to burn out the new tube too. If the new tube does burn out, a shorted condenser is the most likely cause of the trouble.

Finding Noisy Tubes. If the customer complains of noisy operation, turn the set on, tune between stations, and turn the volume up all the way. Tap on the top and side of each tube or tap the tube shields so as to get motion in all directions. Use a finger or the end of a pencil. Do not hit the tube too hard.

If the noise occurs for all tubes, you are tapping too hard and jarring the chassis. This jars the defective part and causes the noise without revealing the troublemakers. Too sharp a rap may also break the glass or jar the tube elements out of shape.

If a tube produces a loud noise or howl in the speaker when tapped, replace it with a new tube. If this corrects the trouble, discard the old tube as noisy.

Sometimes the tube elements may be loose and vibrate without actually becoming open-circuited. Tubes of this type will set up a howl in the speaker, and are called microphonic. The howl may stop if you touch the tube, but the best remedy is to replace with a new tube.

On shielded tubes, look also for loose shields, for loose top-cap connections, and for shields that touch the top cap lightly enough to produce noise when vibrated by sound waves from the speaker.

A review of the past history of the set is helpful in checking for noise. Noise is more apt to show up in the tubes if the set has just been moved in a van, if the set is subjected to street vibrations produced by subway trains or heavy trucks, or if the customer is in the habit of running the set at high volume. Some common radio troubles due to tubes are listed in Table 2.

Table 2. Common Radio Troubles Caused by Bad Tubes

Observed Effect	*Probable Cause*	*Remedy*
No filament glow on one tube	Open filament	Replace that tube
No filament glow on all tubes in a-c/d-c set	Open filament on one or more tubes	Check filament continuity of all tubes
Low output volume	Rectifier tube weak	Replace rectifier tube
Pilot light out, but set plays	Open lamp filament	Replace lamp
No signal, but tubes light	Dead oscillator	Replace oscillator or mixer tube
Noise when tube is tapped	Loose element in tube	Replace tube that makes noise
Programs sound distorted	Gassy output tube	Replace output tube

Testing Dry-disk Rectifiers. In many modern television and radio sets a dry-disk rectifier under the chassis is used in place of a rectifier tube. The disks do the same rectifying job as tubes and have the advantage of requiring no filament current. Dry-disk rectifiers are often called selenium rectifiers, because most of them use a thin coating of selenium on the metal plates.

The most common fault in dry-disk rectifiers is failure of the stack due to accidental overload from a bad filter condenser, shorted bleeder resistor, shorted bypass condensers, or high line-voltage surge. Before replacing a bad rectifier, check the resistor and condensers, as otherwise the new rectifier may also be damaged. You will learn where to find these possible troublemakers when you study amplifier and power-supply circuits.

When a dry-disk rectifier fails, it conducts almost equally well in both directions. Symptoms of this are reduction in volume and a loud a-c hum. The rectifier disks will get quite hot, and there will generally be sparking around the edges of the disks. The small protective resistor in series with the rectifier will also get hot and give off a wax or tar smell.

A dry-disk rectifier in an a-c/d-c set can be checked quickly by connecting a d-c voltmeter between the radio side of the rectifier and ground. If the indicated voltage with the set turned on is below 100 volts, the rectifier is generally defective and should be replaced.

To make an ohmmeter test on a dry-disk rectifier in an a-c/d-c set, unplug the line cord, turn the line switch off, and remove all tubes, including the pilot lamp. In three-way portable sets, turn the power-selector switch to a-c/d-c. If the set has a phonograph motor, turn the motor switch off. Connect the lowest ohmmeter range directly across the rectifier stacks, measure the resistance, then reverse the leads, and measure again. If the resistance is high with the leads connected one way (over about 1,000 ohms) and is much lower (below 100 ohms) the other way, the rectifier is probably good. To verify, check the resistance of a new selenium rectifier of the same type. When a dry-disk rectifier is bad, the two readings will be more nearly alike, with the lowest one over about 500 ohms. Always use the same ohmmeter range when comparing rectifiers.

Selenium rectifiers for television and radio receivers are usually rated at 130 volts, and vary in their output current ratings according to Table 3.

Table 3. Selenium-rectifier Replacement Data

A-C *Input, Volts*	D-C *Output, ma*	*Typical Applications*
130	65	A-C/D-C radios
130	75	Three-way radios
130	100	Television and radio
130	150	Television and radio
130	200	Television
130	250	Television
130	500	Television

For a starting stock to go in your tube library, you can get along with just one selenium rectifier—the 150-milliampere size. This will replace any of the smaller sizes adequately and will even provide emergency service for a while in sets requiring 200-ma or 250-ma units, until you can get the correct larger size.

Unlike tubes, selenium rectifiers have soldered connections, and are either clamped or bolted to the chassis, so replacement takes a bit more time than does replacing a tube.

Testing Crystal Diodes. More and more germanium crystal diodes are being used in place of vacuum-tube diodes in television receivers. These crystal diodes last much longer than tubes (estimated life is 10,000 hours as compared to perhaps 3,000 hours for the average tube), but do occasionally go bad.

An ohmmeter is the best instrument for checking a crystal diode. Disconnect one lead of the crystal diode, being careful not to hold the soldering iron on any longer than necessary. Measure the diode resistance with an ohmmeter, then reverse the positions of the leads, and measure again. For a good diode the reading should be at least 100 times greater in one direction than the other. For a good 1N34, typical readings are 2,000 and 600,000 ohms.

Advantages and Drawbacks of Substitution Test for Tubes. Trying a new tube is one of the most accurate ways of locating faulty tubes. This method is widely used by television servicemen and is often used by radio servicemen for checking critical tubes such as oscillators and mixers.

The disadvantages of the tube-substitution method are the high initial cost of the tube stock, the space required for storing tubes, the inability to check tubes in the customer's home unless the types needed are determined beforehand and brought in the toolbox, and the inability to check tubes that are brought in by the customer.

Testing Radio-set Tubes by Substitution. To make a tube-substitution test, proceed as follows:

1. Turn off the radio set.
2. Make sure all tube sockets are marked; if not, mark them yourself.
3. Take all tubes out of set carefully and set them aside.
4. Put in an entire set of new tubes from your tube stock.
5. Turn on the set. If it still does not work with all new tubes in place, leave the new tubes in and proceed to check individual parts until the trouble is located elsewhere in the set. When the trouble is found and fixed, put back the old tubes one at a time as described below, and watch for any difference in set performance. It is quite possible to have a number of bad tubes in a set in addition to other defects.
6. If the new tubes correct the trouble and the set starts working again, the fault was in one of the old tubes. To find exactly which tube of the group was defective, put the old tubes back in the set one at a time. Work from left to right or in some other definite order so no tubes are skipped. Turn off the set each time you change a tube. When you come to the tube which makes the set misbehave again, you have located the defective tube. Replace this defective tube with a good tube and continue to put back the old tubes. Be on the lookout for a second tube which might cause the set to misbehave again. A new tube is left in only when it makes the set work better than the old tube.

An alternate to the above method of substitution is to replace each tube one at a time with a new tube. The tube which causes the set to perform again is generally replacing the defective tube. Begin with the rectifier and the audio output tubes as these are the ones most often found defective.

Testing Television-set Tubes by Substitution. It is fairly easy to substitute new tubes for old in a radio receiver having only 4 to 8 tubes. Television sets have anywhere from 15 to 40 tubes, however, so that replacing them all is quite a chore.

Replacing all television tubes blindly is also highly undesirable for technical reasons. A television set may have two or more of one type of tube, differing enough in their characteristics so the set works properly only when these tubes are in their original sockets. Interchanging them just introduces a new trouble to confuse the servicing problem.

Fortunately a television set usually gives clues to the section of the receiver having a bad tube. Some of these clues are listed in Table 4, along with the receiver sections that should be suspected of having bad tubes. For most troubles, this narrows your troublehunting search to half a dozen tubes or less. You then need to find the tubes that are in one particular section. Table 5 is a convenient guide for this at the start.

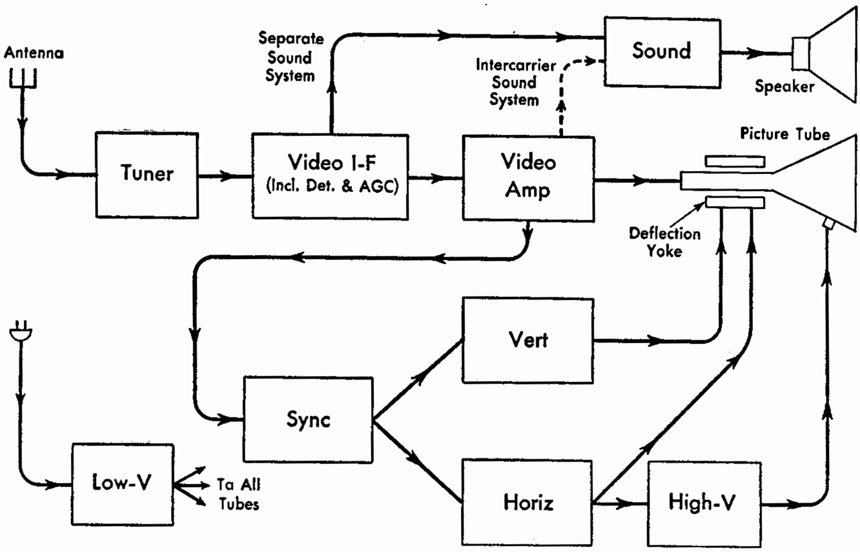
Tube-identification data are generally given on a label pasted inside the cabinet of a television set. The same data are in the manufacturer's service manual for a television set, as well as in Howard W. Sams Photofact Folders and in Rider's Television Manuals. In addition, television tube-placement data are given in handy toolbox-size booklets called "Howard W. Sams Television Tube Location Guide," several editions of which can be obtained from your jobber. Newest sets are not likely to be in these booklets or in Rider's Manuals, since it takes time to publish a book or manual. Hence either Photofact Folders, Rider's Tek-File Packs, or the manufacturer's own manuals are needed for recent models.

The trouble symptoms listed in Table 4 can be caused by defects in many other parts besides tubes. Generally the defect will be in the sections specified for possible bad tubes. The important thing to remember is that tubes are at fault in a television receiver only about half the time. If no bad tube is found, look for trouble in other parts.

Television Tube-substitution Procedure. To test tubes by substituting new tubes in a television receiver, proceed as follows:

1. From the service manual or other data, determine which type of sound system (intercarrier or separate) is used in the set. With the separate sound system there will be separate sound i-f and video i-f tubes. With

Table 4. Television-receiver Tube Troubleshooting Chart



Trouble Symptoms Seen and Heard (Raster is obtained by tuning to channel having no program)	*Probable Sections Having Bad Tube* — *Separate Sound*	*Intercarrier Sound*
No picture; no raster; no sound	Low-V	
No picture; raster OK; no sound	Tuner; Video I-F	Same plus Video Amp
No picture; no raster; sound OK	High-V; Horiz; Picture Tube	
No picture; raster OK; sound OK	Video I-F; Video Amp	Video Amp
Picture weak and washed out, but raster and sound OK	Video I-F; Video Amp	Video Amp
Picture and raster both weak even with brightness control full on; sound OK	High-V; Horiz	
Picture too bright, and contrast control does not work; sound OK	Video Amp; Picture Tube	
Picture all black and white (no grays), and contrast control does not work; sound OK	Video Amp; Picture Tube	
Picture and raster too dim, and retrace lines are visible; sound OK	Vert	
Picture muddy and gray (insufficient contrast); raster OK; sound OK	Video Amp	
Picture wiggles and weaves, lacks blacks, or is very black; raster OK; sound OK	Sync; Video I-F	

Table 4. (Continued)

Trouble Symptoms Seen and Heard (Raster is obtained by tuning to channel having no program)	*Probable Sections Having Bad Tube*	
	Separate Sound	*Intercarrier Sound*
Picture is jittery with double image but not ghost; raster OK; sound OK	Horiz (output tube)	
Picture has engraved effect; raster OK; sound OK	Video Amp	
Picture has maximum brightness, and brightness control has no effect on picture or raster; sound OK	Picture Tube	
Picture has snow on all channels; raster OK; sound is weak	Tuner; Video I-F	Same plus Video Amp
Picture has snow on all channels; raster OK; sound OK	Video I-F; Video Amp	Video Amp
Picture and raster both fuzzy or blooming, and brightness may go on and off; picture cannot be focused; sometimes hissing heard; sound OK	High-V; Picture Tube	
Picture drifts sideways, tears sideways, or breaks up into moving diagonal patterns; raster OK; sound OK	Horiz; Sync	
Picture drifts up or down but not sideways; raster OK; sound OK	Vert	
Picture drifts both sideways and vertically; raster OK; sound OK	Sync; Vert; Horiz; Video I-F	
Picture drifts both sideways and vertically and does not fill screen; raster also too small for screen; sound OK or weak	Low-V	
Picture OK on weak stations but jumps or tears on strong stations; raster OK; sound OK	Video I-F; Video Amp; Picture Tube	Video Amp; Picture Tube
Picture intermittently on and off; raster OK; sound OK	Video I-F; Video Amp	Video Amp
Picture and raster both intermittently on and off; sound OK	High-V; Horiz; Picture Tube	
Picture and sound both intermittently on and off; raster OK	Tuner; Video I-F	Tuner; Video I-F; Video Amp
Picture, raster, and sound all intermittently on and off	Low-V	
Picture and raster both are compressed or squeezed together either at top or at bottom; sound OK	Vert	

Table 4. (Continued)

<table>
<tr><th rowspan="2">Trouble Symptoms Seen and Heard
(Raster is obtained by tuning to channel having no program)</th><th colspan="2">Probable Sections Having Bad Tube</th></tr>
<tr><th>Separate Sound</th><th>Intercarrier Sound</th></tr>
<tr><td>Picture is compressed or squeezed together either at right or left side (not linear horizontally); raster OK; sound OK</td><td colspan="2">Horiz</td></tr>
<tr><td>Picture folds over on itself at side; raster OK; sound OK</td><td colspan="2">Horiz</td></tr>
<tr><td>Picture and raster both have alternate dark and light horizontal hum bars; sound may have hum</td><td colspan="2">Low-V</td></tr>
<tr><td>Picture has alternate dark ond light horizontal bars; raster OK; sound OK</td><td colspan="2">Video Amp; Tuner; Video I-F</td></tr>
<tr><td>Picture and raster both have white horizontal bar at bottom or top; sound OK</td><td colspan="2">Vert</td></tr>
<tr><td>Picture spoiled by white horizontal lines; flashes of white lines in roster; sound OK</td><td colspan="2">Vert</td></tr>
<tr><td>Picture and raster both have faint dark vertical line followed by light vertical area; sound OK</td><td colspan="2">Horiz (output tube)</td></tr>
<tr><td>Picture and raster have vertical bars at right side; sound OK</td><td colspan="2">Horiz (osc tube)</td></tr>
<tr><td>Only thin horizontal line on screen; no raster; sound OK</td><td colspan="2">Vert</td></tr>
<tr><td>Only thin vertical line on screen; no raster; sound OK (can occur only in very few sets)</td><td colspan="2">Horiz</td></tr>
<tr><td>Picture and raster fill screen vertically but not horizontally at sides; sound OK</td><td colspan="2">Horiz; Low-V; Sync</td></tr>
<tr><td>Picture and raster fill screen horizontally but not vertically at top and bottom; sound OK</td><td colspan="2">Vert; Low-V</td></tr>
<tr><td>Picture and raster do not fill screen either horizontally or vertically; sound OK</td><td colspan="2">Low-V</td></tr>
<tr><td>Picture and raster both enlarged, so too big for screen; sound OK</td><td colspan="2">High-V; Horiz</td></tr>
<tr><td>Picture and raster enlarge excessively when brightness is increased; sound OK</td><td colspan="2">High-V</td></tr>
<tr><td>Picture and raster OK; sound is weak, distorted, noisy, raspy, intermittently fading in and out, has howling or squealing, or there is no sound</td><td colspan="2">Sound</td></tr>
</table>

Table 5. Typical Names of Stages Used in Each Section of Television Receivers

TUNER *Also called head end. Generally a separate unit directly back of station-selector switch*

Stage Names: 1st R-F Amp; 2nd R-F Amp; R-F Amp; Converter; Mixer; Oscillator

VIDEO I-F *Includes three or four video i-f amplifier stages, the video detector (often a crystal), and one or more automatic gain control (AGC) stages*

Stage Names: 1st Video I-F; 2nd Video I-F; 3rd Video I-F; 4th Video I-F; Video Detector; AGC; AGC Rectifier; Keyed AGC; AGC Keying; 2nd Detector; AGC Amp; AGC Delay; AGC Detector

VIDEO AMP *Includes the video amplifier stages between the video detector and the picture tube, and the d-c restorer stage*

Stage Names: Video Amp; Video Output; 1st Video Amp; 2nd Video Amp; D-C Restorer

SOUND *For receivers having separate sound system fed from a video i-f stage, includes sound i-f amplifier stages, sound detector, and audio amplifier stages up to loudspeaker. For receivers having intercarrier sound system fed from a video amplifier stage, includes one or more amplifier stages, sound detector, and audio amplifier stages up to loudspeaker.*

Stage Names: 1st Sound I-F; 2nd Sound I-F; Limiter; Intercarrier Sound Amp; Sound Detector; Audio Detector; Ratio Detector; F-M Detector; F-M Follower, Discriminator; A-F Amp; Audio Output

SYNC *Includes all stages between the point in the video amplifier where sync signals are taken out and the point where the vertical sync signal is separated from the horizontal sync signals.*

Stage Names: Sync Amp; Sync Clipper; Pre-sync Separator; Sync Limiter; Sync Level; Sync Clamper; 1st Sync Separator; 2nd Sync Separator

HORIZ *Includes all stages that handle only horizontal sync signals, from the point where the vertical sync signal is separated out to the horizontal output transformer*

Stage Names: Horizontal Sweep Generator; Horizontal Oscillator; Horizontal Oscillator Control; Horizontal Output; Damper; Horizontal Multivibrator; Sync Amp; Pulse Amp; Horizontal Discharge; Horizontal AFC; Sync Phase Inverter; Horizontal Phase Detector; Horizontal Discriminator; Sync Discriminator; Horizontal Control; AFC Discriminator

VERT *Generally has only two stages, located between the sync section and the vertical deflecting yoke of the picture tube*

Stage Names: Vertical Amplifier; Vertical Oscillator; Vertical Sweep Generator; Vertical Multivibrator; Vertical Sweep Output; Vertical Output; Vertical Sync Amplifier; 1st Vertical Amplifier; 2nd Vertical Amplifier

Table 5. (Continued)

HIGH-V	*The stages in the high-voltage power supply are generally inside a separate metal compartment on top of the chassis, required for protection from the high voltages* Stage Names: High-voltage Rectifier; High-voltage Doubler; High-voltage Oscillator
LOW-V	*Two low-voltage rectifier tubes are generally used; one or both may sometimes be a dry-disk rectifier rather than a tube* Stage Name: Low-voltage Rectifier

intercarrier, there will only be video i-f tubes or at the most just one sound i-f tube. No sets made before 1949 used intercarrier, and only GE sets used it in 1949. From 1950 on, intercarrier became increasingly more popular, and today the majority of new sets use it.

2. From the symptoms heard and seen, determine from Table 4 which sections of the receiver could have a bad tube. Use Table 5 as a guide for recognizing the names of the stages in each section, until you become familiar with the variety of names used for the same stage or tube by various manufacturers. Using the service manual, make a list of the suspected tubes.

3. Turn off the set.

4. Remove one of the suspected tubes and insert a new tube of the same type.

5. Turn on the set, wait for tubes to warm up, readjust tuning controls if necessary, and note performance. After changing a horizontal oscillator tube, the horizontal hold control and other horizontal controls will generally need readjustment.

6. If the trouble is still there, repeat steps 3, 4, and 5 for each other tube in the suspected sections in turn. Replace only one tube at a time. Leave the new tubes in for the time being, but keep a record of where they are.

7. When you come to the socket where a new tube restores performance, mark the old tube as defective and set it aside. Now remove your other new tubes and put the good old tubes back, each in the exact socket from which it came.

Television Tube-substituting Precautions. When two or more of the suspected tubes are the same type, be sure to mark them and their sockets with a crayon in some way so you can get each tube back in its own socket.

When putting in a new tube for a substitution test, it is a good idea to place the empty tube carton over or near the tube in the set. This will speed up locating the unneeded new tubes after you have found the bad tube, so you can put your new tubes back in the tube library.

Leaving the new tubes in the set until the trouble is fixed takes care of the rare cases where two or more tubes are bad. Replacing one of the bad tubes then does not clear up the trouble. With a double-trouble set, the trouble will come back when you put the old tubes back in. The old tube that brings back the trouble is, of course, also bad, and should be replaced.

Tube substitution can be speeded up by wearing a lightweight leather glove on your tube-removing hand. With a glove, you do not have to wait until the tube cools enough to touch it.

High-voltage Precautions. Although the safest procedure is to turn off the television set each time you change tubes, experienced servicemen will usually do this for some tubes without turning off the set. From experience, sometimes quite shocking, they have learned how far they must keep their fingers from the high-voltage power supply and the second-anode terminal of the picture tube. For tubes close to the high-voltage points or inside the high-voltage power-pack shield they must always turn off the set first, of course.

There is very little danger of hurting the television receiver by removing tubes with the set on. The real danger is in your getting in contact with the high voltage on the picture tube. This voltage is technically harmless in most modern sets, as the current it can send through you is safely low, but your involuntary muscular reaction to something like 12,000 volts can do a lot of damage.

Touch the spark-plug terminal of an automobile while the engine is running, and you will understand what this means. Entire television sets have crashed to the floor as the victim jerked back; elbows have cracked against pipes or posts as a hand jerked back. Play safe and turn off the television set for each tube swap, until you have become thoroughly familiar with the locations of the high-voltage points in each make of set.

Substituting Tubes in Transformerless Television Sets. In a-c/d-c television sets there is no power transformer, and the tube filaments are connected together in two or more series strings much like series-type Christmas-tree lights. When the filament of one tube in a string burns out, all the tubes in that string will burn out and get cold. Instead of trying to figure out which section has the bad tube, locate the cold tubes by feel and sight, and replace them one by one until the entire string of tubes lights up again. The tubes in a given string may be scattered all over the chassis, so do not overlook any. Transformerless television sets may have a hot chassis, so use the same precautions as for a universal a-c/d-c radio set.

Picture-tube Filament Troubles. The simplest picture-tube trouble to recognize is an open filament. When this happens, there is no light in the electron gun at the base of the tube and no heat at the base. Look at picture tubes that are operating normally and feel their bases, to get an idea of how much light and heat there should be.

One common cause of an open filament is a poor contact inside one of the filament pins of the picture-tube base. This trouble can also be intermittent, so that the picture tube operates normally for a while and then goes dark. Sometimes the trouble can be cleared for a few minutes by slapping the side of the receiver cabinet or by tapping the neck of the picture tube, but this is only a temporary remedy. Therefore, before removing a picture tube because of an open or intermittent filament, try resoldering both filament pins. In all modern 14-inch and larger picture tubes these are pins 1 and 12, which are next to the aligning key. With the exception of the 12AP4, 12CP4, and 12WP4, all 10- and 12-inch tubes likewise have pins 1 and 12 for the filament.

To resolder a picture-tube pin while the tube is still in the set, disconnect the line cord and then pull the picture-tube socket off the tube. Hold the soldering-gun tip under one of the pins and heat it thoroughly, then apply rosin-core solder inside the pin. Repeat for the other filament pin, then scrape off surplus solder outside the pins with a sharp knife.

Shorted Picture Tubes. Another trouble in picture tubes is a partial or complete short circuit between the cathode and the first grid. When this occurs, the brightness control loses control, and the picture has maximum brightness at all times. Since a circuit defect can cause the same symptoms, always confirm your suspicions by making an ohmmeter test.

In all modern picture tubes, pin 11 is the cathode, and pin 2 is the first grid. (The main exceptions are the three 12-inch tubes mentioned above.) Measure between pins 11 and 2 with the highest ohms range of your multimeter while the filament is still warm, so that conditions in the tube have not changed. To do this, operate the set for a while, then pull out the line cord, remove the picture-tube socket, and measure between pins 2 and 11 as quickly as possible. Note the reading, then quickly reverse the ohmmeter leads and read again. The *highest* reading is the one that counts. It should be over 20 megohms if the tube is good. Even 10 megohms indicates excessive leakage between cathode and grid, probably due to Aquadag particles lodged between the cathode and grid. The Aquadag is a coating of carbon used on the glass surface inside the tube. It is also used on the outside of the funnel on most glass picture tubes.

Weak Picture Tubes. Natural aging of a picture tube eventually results in weaker emission of electrons from the cathode and a dim picture. Circuit troubles in the receiver can also cause a weak picture, so always check voltages at the picture-tube socket before blaming the tube.

To check voltages, remove the picture-tube socket. Measure first between socket terminal 10 and the chassis; this is the B+ voltage of the receiver, which should be somewhere between 200 and 400 volts. This voltage is required by the second grid of the picture tube (pin 10 for all tubes except the 10MP4 and the three nonstandard 12-inch tubes). Next, measure between socket terminals 2 and 11 to check the grid-to-cathode voltage. This should be zero when the brightness control is at maximum, and somewhere between 75 and 100 volts when the brightness control is turned all the way in the other direction to its minimum setting. Pin 2 will be negative for this measurement.

The last check to make is the high-voltage supply. Servicemen rarely use a meter for this. Instead, they turn off the set, remove the second-anode lead from the picture-tube funnel and adjust the lead so its end is well away from other parts, then turn on the set and draw a spark from the lead with an insulated screwdriver. Again one hand is kept in the pocket, and the screwdriver is held only by its plastic handle while bringing its metal end near the high-voltage lead. If there is sufficient voltage, it will be possible to draw a spark that is ⅛ to ¼ inch long on an average set. The exact amount of voltage is not critical. After making this test a few times, the serviceman learns to know when a spark indicates ample voltage. Remember—this test is dangerous; be careful.

Another type of cathode trouble makes the white portions of a picture black and the black portions white, as in a photographic negative. The first sign of this trouble is a glimmer or twinkling of tiny spots on the picture. The picture may be usable for many months after this starts, or it may go bad quickly.

If you run into this trouble, check with your jobber regarding picture-tube rejuvenators, to see if he recommends one for this type of trouble. New equipment is being developed at all times. You may be able to get a device that takes care of more than one of the picture-tube troubles just described.

Setting Up a Tube-substitution Library. The first step in testing tubes by substitution is establishing the tube-substitution library or tube stock.

This library is the same as the tube stock you will want to keep on hand anyway for quick replacement.

Go slowly at first. Buy only what you know you need. The best way to know what you need is to service sets for a few months first. You probably will not give the fastest service at the start, but you will learn a lot that will save you money later on. Loading up with stock that may never be needed is one of the best ways to go out of business before you get halfway started!

The perfect tube-substitution library would consist of a complete substitution set of tubes for each type of set in your neighborhood. In addition, it would have at least two extras of each type to help you give fast service on tube replacements without leaving blanks in your library. This could mean something like two thousand tubes, costing close to $2,000 and taking valuable space in your shop, so some compromise must be made.

The practical tube-substitution library is an estimate based on an average of all the tube types in your neighborhood and of the types most often needed. It is well to consider the following factors in setting up your tube library.

In older neighborhoods there will be a few very old radio sets, and you may then want to stock one of each of such old tubes as the 80, 24A, 27, and 45.

In rural areas, stock a few more of the battery-radio tubes, such as 1A7GT, 1H5GT, 1N5GT, 1R5, and 1T4.

In all areas having fairly good broadcast-band radio reception, stock heavily such tubes as the 12SA7, 12SK7, 12SQ7, 35L6GT, 35W4, 35Z5GT, 50A5, and 50L6GT that are used in universal a-c/d-c sets.

In areas having television receivers, the tubes most likely to be needed are the 1B3GT, 5U4G, 5V4G, 6AC7, 6AG5, 6AK5, 6AL5, 6AU6, 6BA6, 6BE6, 6BG6G, 6BK7, 6BQ6, 6C4, 6CB6, 6J6, 6K6GT, 6SK7, 6SL7GT, 6SN7GT, 6SQ7, 6V6GT, 6W4, 12AT7, 12AU7, and 12SN7GT.

Jobbers and distributors can be of real help in selecting the tubes most needed in your locality. Some, such as RCA distributors, can furnish printed tube inventory guides giving actual figures on tube sales. This guide shows, for example, that for every 10,000 tubes sold in a particular year, 530 of them were 35Z5GT, 310 were 50L6GT, 350 were 12SQ7, 300 were 12SA7, 275 were 12SK7, 255 were 6SN7GT, 250 were 6J6, and 200 were 35L6GT. The remaining types were under 200 for every 10,000 sold.

Almost 400 different types were on the list, yet 120 of these were needed so seldom that only 1 was needed for every 10,000 tubes replaced.

The tube inventory list changes each year, so get the latest one from your RCA distributor. Pick out for your tube library those having the highest ratio numbers per 10,000 sold.

You may decide to build up your tube library in several steps. Thus, you might buy 50 tubes the first time, 75 the second time as your cash on

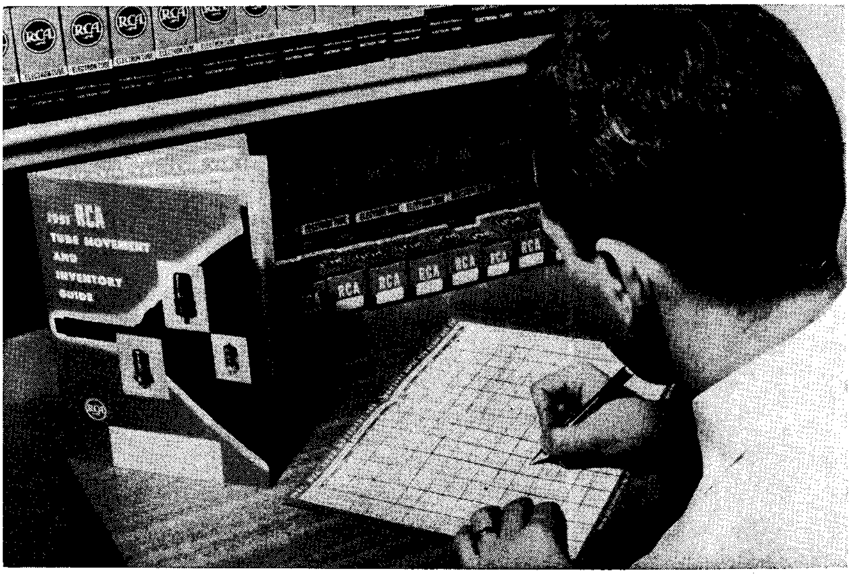


Fig. 5. Example of tube inventory guide sheet available from RCA distributors

hand increases, and 275 the third time when you go into full-time servicing. For the first order you would get one of each of the 50 most needed types. On the second order, however, get one each of 30 types you do not have, plus extras of the most needed types. For the third order you could choose about 120 new types that you do not have, and get still more extras of tubes already in your stock. This would give you about 400 tubes in all, of 200 different types. This is more than enough variety for a full-time servicing business. From then on, build up your stock of the tubes that you use most often, until you have at least a week's supply of each of these.

The important thing to remember is to get expert advice from a tube distributor when you start to build up a tube library. Ask also for their inventory guides, like that in Fig. 5, to help you keep the library stock up to date. When tubes are taken out, they should be replaced every time you go to the distributor, or at least once a week.

Stocking Picture Tubes. There are now many different sizes and types of television picture tubes in use, and few cost less than $25 each. For this reason, picture tubes had best be left out of your tube-storage library at the start. Wait until you know which types are most needed by your customers.

Keep a record of the type of picture tube in each set that you work on. Study the list from time to time, to see which ones are the commonest. These you can safely order for your stock. Valuable time is saved by having new picture tubes on hand for test purposes or replacement when needed.

Taking Tubes on Service Calls. As a rule it is impractical to take along on a service call even one tube of each type in your entire service library, though this is the ideal practice if you have room for them in your car or truck. If you can find out from your customer the make and model number of the set, look up its tube quota in Sams "Red Book" or some other directory.

Give some thought to providing a carrying case or racks in your car for a portion of your tube library, to take care of your needs for service calls in homes. Special tube-carrying traveling bags are available from your jobber and from some tube manufacturers at reasonable prices. Be sure to keep a record of all tubes used on calls, so you can replace these from your stock after returning from each call.

Tube Storage Shelves. Your stock of new tubes may be stored in drawers under the workbench, on shelves alongside the bench, or on shelves at the rear above the bench. Regardless of the method used, arrange the tubes in order of type numbers. Start with the lowest type number (0Z4, 1A3, etc.) at the top left section of your storage space. Add higher and higher type numbers as you go toward the right. When the first shelf is filled, start the next shelf on the left and again proceed toward the right. Repeat this process until all the tubes are stored. Leave empty spaces on each shelf for tubes which you plan to get later.

If the tubes are stored on 10-inch-deep shelves like those used for books, place the tube cartons near the front edge. If you need space for several tubes of one type, stack them in a second row in back of the first.

If you are building shelves specially for tube storage, space the shelves about 6 inches apart vertically and make them about 6 inches deep. Even 3/8-inch-thick wood boards will serve well, though thicker lumber may be easier to get. Build shelves in sections so you can easily move them around later as your business and your work warrant. A convenient width is 3 feet.

Where wall space is scarce, drawers under the workbench or a separate chest of drawers may be used for tube storage. Drawers may be divided into compartments with heavy cardboard strips having cut slits so they interlock like the partitions in an egg crate.

Drawers should have stops on them to prevent pulling a drawer out too far. A nail hammered part way into the upper edge of the rear board of the drawer will generally be sufficient to keep the drawer from coming out.

One coat of aluminum paint on tube storage shelves or drawers costs very little and gives the units a more finished appearance.

Using Tube Stock. As you use tubes, try to take those which you have had in stock the longest. This will keep your stock of tubes fresh. It will also eliminate having to sell a tube in an old carton. Old, dirty, or dusty cartons give the customer the impression that you are selling him an inferior tube.

A shelf arrangement is handy for taking tubes down to make a substitution check. When you are through, though, be certain to put all tubes back in their cartons and return these to the correct positions in the shelves. Be careful also not to mix new tubes with the old tubes you just took out of the set.

Whenever you use or sell a tube, make some record of it as a reminder to order a new tube of that type. Some tube cartons have a tear-off tab with the type number printed on it for this purpose. With other tube cartons, the cover itself can be torn off for this purpose. Keep a box on your tube storage shelf to hold these tabs, with a blank card in it for jotting down type numbers when you do not have a carton tab. Once a week, or whenever you order replacement parts, you can sort out the tabs and order all the tubes needed to replenish your tube library.

Buying Tubes. Build up your tube stock from well-known makes that will result in long-time customer satisfaction. The tube brand names most commonly known are GE, Hytron, Ken Rad, National Union, Raytheon, RCA, Sylvania, and Tung-Sol. Tubes with the brand name of the receiver manufacturer on them are generally equally good, since they are made by one of the large tube manufacturers.

Once you pick a tube manufacturer, try to stay with that one. It pays to know your supplier and have him know you. Not all tube manufacturers make all brands, so you will have to make exceptions once in a while. For example, Raytheon makes most of the subminiature tubes. Sylvania makes practically all of the loktal types. GE makes most of the metal tubes.

Most territories are covered by tube sales representatives who come around every two weeks. This man could also be the representative of some jobber or distributor from whom you buy replacement parts. If you are a regular customer, he will bill you once a month for all your tubes and parts. This type of service may cost you a few cents more, as you will not be able to take advantage of large-quantity discounts, but it is usually more convenient to order this way.

Most tube suppliers usually allow you 40 per cent off list price, with an additional 2 per cent if your bill is paid promptly.

Selling Tubes. Selling new tubes is a big part of a servicing business. Charging list price for a replacement tube is the fair and only way you can cover expenses of getting, storing, and selling tubes, including your time.

Testing tubes free is a profitable way to get to know your potential customers and to advertise. It is not necessary to advertise the free service because the public has come to expect this type of service courtesy as part of a serviceman's job. Give the customer's tubes an accurate and careful check. Do not rush the job. Above all, be honest. Remember that the man getting his tubes checked is a potential customer for a new tube now and for a repair job later.

Guaranteeing Tubes. When you sell a tube, you can safely guarantee it for 90 days against every trouble except glass breakage. Tube manufacturers in turn generally guarantee you a tube life of about 1,000 hours, which is about 11 hours of operation a day for the 90-day guarantee period. Few sets are operated this much. Most tubes actually last much longer than 1,000 hours.

Test new tubes before you sell them. Most tube packages are made so that this can be done without taking the tube from the package. It is possible for a new tube to develop a short or an open heater due to shock during shipment or handling.

When you find a new tube that is defective, keep it for your tube salesman. He will replace it with a new tube.

Occasionally a new tube works all right for a while and then burns out. In cases like this you have to size up your customer. It is possible in rare cases for a tube to be defective in such a way that it will only work for a few hours and then go out. Before you give the customer a second tube, however, try to get permission to check his set. Ask him to bring it in or stop by to see it. This will take a little time, but is advisable because the set may have a defect that will make the second new tube burn out also.

In cases where you feel the tube was at fault, explain that once in a while even the best-quality tubes will fail prematurely. Replace the tube free with a smile.

QUESTIONS

1. State three ways of testing tubes.
2. Why should each tube be pushed down in its socket while a set is on, before removing the chassis?
3. What power troubles outside of the receiver should be looked for if a set does not work at all?
4. What two human senses can be used for finding a tube having an open filament in an a-c receiver?
5. What two types of multimeter measurements can be used to find an open filament in an a-c/d-c set?
6. How can a noisy tube be located?
7. Tell how you would test tubes by substitution in a specific radio set, such as one of your own. (List every move you would make, starting from the time you turn on the set and find it does not work.)
8. Based on what you already know, prepare a list of the first 25 tubes you would buy for your own tube stock.

9

Using a Tube Tester

Reasons for Using a Tube Tester. A tube tester is needed in a servicing business for the following purposes:

1. To make a quick check of all tubes in a radio set.
2. To test tubes brought in by a customer.
3. To make reasonably certain the new tubes you sell are good. Sometimes new tubes are damaged in shipment or otherwise become defective after leaving the tube manufacturer's plant.
4. To check radio tubes in the customer's house.
5. To make a tube check before the customer so as to prove to him that the tubes are in good condition and that your charge for replacing some other part is legitimate.
6. To make a more complete check of a radio set even after you have located and repaired a fault. In this way you may uncover a weak tube which could cause trouble after the set was back with the customer for a couple of months.

How a Tube Tester Works. The switching system of a tube tester applies the proper test voltages to the tube under test. This system consists of a group of sockets (generally one for each type of tube base) plus lever, circular, or pushbutton switches for connecting the socket terminals to the various power-supply voltages and the quality-indicating meter in the tester.

Lever switching generally consists of eight or more switches arranged in a row, with one switch for each tube pin, as shown in Fig. 1. Toggle switches or slide switches are sometimes used in place of levers.

Circular switching consists of two or more multicontact rotary switches. An example is given in Fig. 2. Each of these switches is generally quite complicated. In some testers, the switch positions correspond to the tube pin numbers. This type of switching is widely used in tube testers.

Pushbutton switching, illustrated in Fig. 3, involves a number of push-buttons, generally arranged in one or more rows, that are pushed down

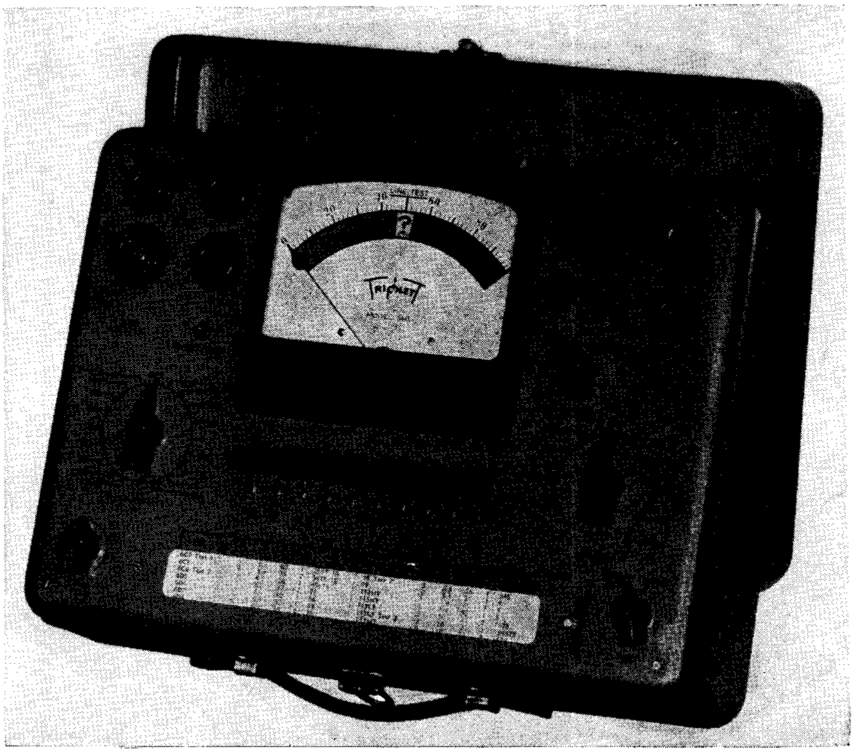


Fig. 1. Example of good tube tester using lever switching. In this Triplett model 3413 tester, the roll chart is visible through a window at the bottom of the tester panel and is moved by spinning the knurled wheel projecting up through the panel at right of chart. (Triplett photo)

in various combinations, depending on the tube being tested. A master release button is provided at the end of each row to release the other buttons at the end of a test, so as to clear the decks in readiness for testing some other tube.

The tube-quality indicator on most tube testers consists of an indicating meter for the quality check. Most testers have a neon lamp for the shorts and continuity test, but a few use the quality-indicating meter for this purpose also.

The quality-indicating meter is generally a d-c microammeter or milliammeter. The meter scale is divided into three parts to indicate the over-all condition of the tube under test as GOOD-?-BAD.

Some testers also have a secondary scale marked 0–100 or 0–1,000 to indicate the condition of tubes more precisely than does a GOOD-?-BAD

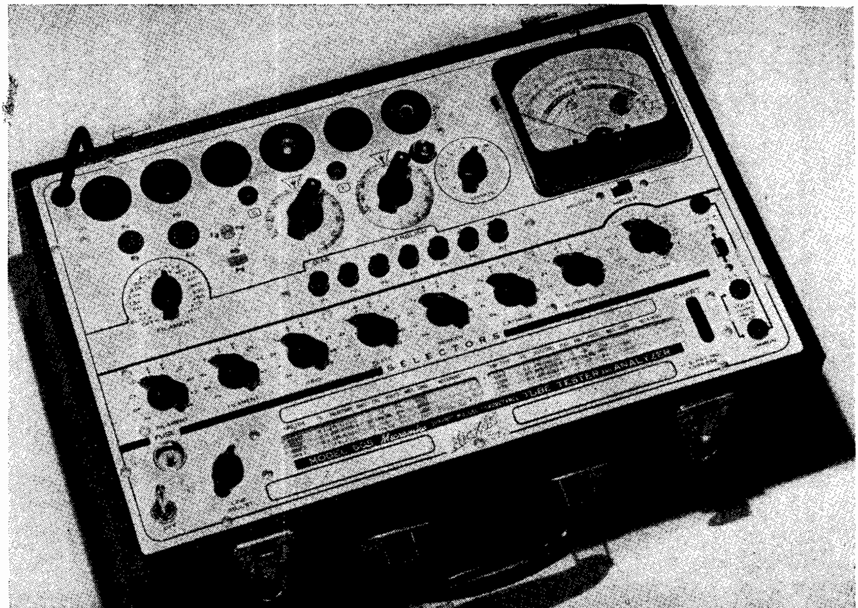


Fig. 2. Good tube tester having circular switching (Hickok model 605). The roll chart here is printed in two sections, so that it need be turned through only half the distance of a one-column chart to find a particular tube. (Hickok photo)

scale. The numerical scale also serves for diodes that cannot make the meter read GOOD even when new. A few testers also use a numerical scale to indicate the equivalent of the tube quality in micromhos. This is a technical unit for grid-to-plate transconductance, but is rarely needed in service work.

Choosing a Tube Tester. For the beginning serviceman, the tube tester is next in importance to the multimeter. A tube tester should meet the following requirements:

1. Give a reasonably accurate test of all the common receiving tubes. This means it should have a shorts-test circuit, a line-voltage adjustment, and a tube-quality meter. False assurance that a tube is good can make you waste hours looking in other parts for trouble that is in the tube.

2. Have a useful life of at least 5 years.

3. Be easy to operate, permit rapid setup for each tube, and minimize the possibility of a mistake in setup. This calls for uniformly arranged controls and large, easily read panel markings.

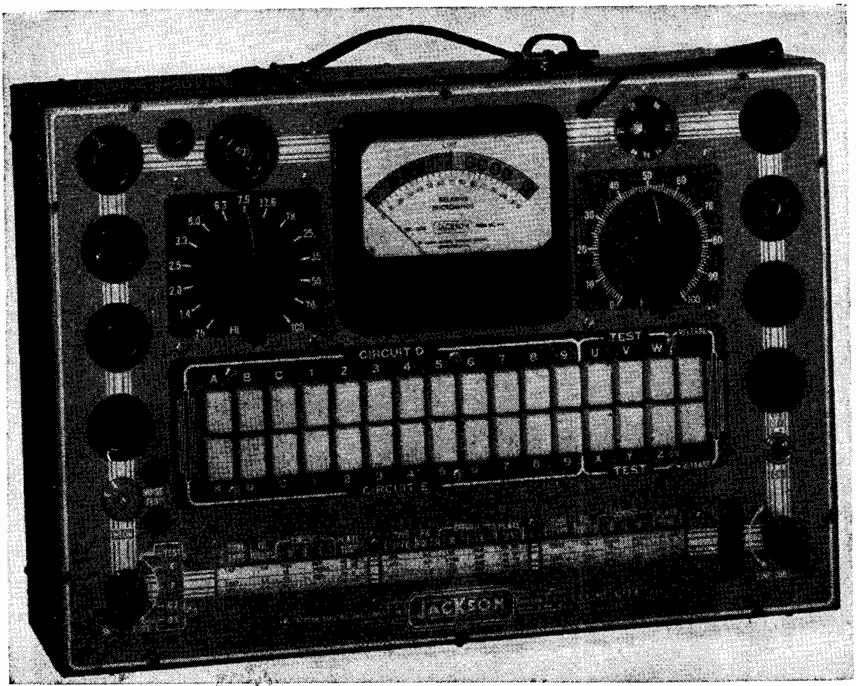


Fig. 3. Good tube tester having pushbutton switching and three-column roll chart. In this Jackson model 648 tester the ? section of the meter scale is above GOOD, where it means the tube is probably gassy, particularly if it is an old tube. (Jackson photo)

4. Have a built-in roll chart or other equally convenient means of determining the correct settings for each tube. A separate booklet of tester settings is not good. It takes time to thumb through the pages, and such a booklet is easily misplaced on a crowded bench.

5. Have a rugged, neat-looking combination portable and counter-type case, with some color for customer eye appeal so that it can be used equally well in the shop, on the counter, or in the customer's home.

Operating-instructions Booklet. Clear, well-printed, and well-illustrated operating instructions are important to understanding your tube tester. Too many tube-tester manufacturers try to cut costs by putting out poorly written and poorly printed instruction books. Look for a tube tester with a good instruction book, both as a help to you and as an indication of a careful manufacturer.

Read the operating instructions carefully before you try to use the tester. This is the best practice to follow with all test equipment. Hold

Fig. 4. Example of good portable tube tester having operating instructions printed directly on inside of cover where they cannot get lost. This is a Sylvania model 220 tester, having lever switching and a three-section roll chart. (Sylvania photo)

back the urge to plug it in and try it out as soon as you get the tube tester. Too many pieces of test equipment find their way back to the manufacturer because of such overeagerness. Go through the procedures for setting up controls for various types of tubes while you read the instructions, but do not connect the tester to the line.

After you have used the tester for several tubes without the power line connected, read through all the instructions again. You will find them clearer now since you are familiar with the controls and some of the settings.

Keep the operating instructions with the tester at all times, even when you think you have them memorized. If they are on a card, place it in a protective celluloid or cellophane cover to keep it from being torn or spotted. If they are in a booklet, keep it in a large envelope fastened inside the tester cover. As in Fig. 4, one good make of tester has complete instructions printed right on the inside of the cover where they cannot be lost.

Roll Chart. A smooth-operating roll chart with large numbers and rapid roll movement is a sign of a good tube checker. The chart should list all the tubes in common use in television and radio receivers. A separate chart or card may contain the settings for obsolete and less used tubes.

The roll chart should be mounted to permit regular replacement with a new chart giving settings for the latest tubes. Some tester manufacturers make up new charts for this purpose, generally at least once a year. Other manufacturers issue lists of new settings from time to time. These lists may be published in a company magazine or sent directly to every registered owner of a manufacturer's tube tester. Sometimes a nominal charge is made for up-to-date charts or lists of tester settings.

The roll chart should not catch or bind when used. It should easily index against a reference line on a heavy glass or plastic cover.

The roll chart should be located so that you can run your finger along the columns as you set the controls. The controls should be located along the space above the chart in approximately the same sequence as the columns on the chart. In this way you can read the chart and set the controls from left to right for ease of setup.

If the tube chart has more than one column of data, it is highly desirable that the first tube type number in the second column be shown clearly on the panel. This saves time in spinning to the start of the second column for a tube type which is actually at the end of the first column. When testers do not have this indication, letter it on a small tab of paper and fasten it to the tester panel with transparent adhesive tape.

Line-voltage Adjustment. Almost all tube testers have an adjustment to compensate for variations in line voltage and tube load. It is generally either a potentiometer or a rotary selector switch marked LINE ADJ. on the tester panel.

The line voltage may be different at various locations in your neighborhood, and may change from hour to hour at your service bench. For this reason, make a rough adjustment of the line-voltage control when the tester is first turned on. This compensates for line-voltage variations due to your location and to the load on the line.

Make a final line-voltage adjustment after the tester is set up with the tube in its socket and warmed up ready for test. This final adjustment compensates for the load placed on the transformer in the tube tester by the heater and plate circuits of the tube under test.

The correct line-voltage setting is generally indicated by a mark on the tube-tester meter scale. The meter is converted to an a-c voltmeter for this test by a rectifier inside.

Tube-quality Tests. Several types of quality tests are used in tube testers. The emission test is the simplest. It indicates the ability of the heated filament or cathode to supply electrons. Emission drops off with the life of the tube; hence low emission means that a tube is near or at the end of its useful life.

Other types of quality tests have various names, such as transconductance test, mutual conductance test, and power-output test. All serve to check the ability of the cathode to emit electrons and the ability of the tube to amplify signals. Because these tests combine an emission test with a test of some of the other properties of a tube, they usually come closer to measuring the tube's actual performance.

Numerical Scale for Diode Tests. With some tube testers, the GOOD-?-BAD scale of the tube tester cannot be used for some of the smaller diodes because the tube plate current is much lower than the lowest current range of the tube tester. Diodes such as the 6H6 and diode sections of multipurpose tubes such as the 6SF7 are examples.

For these, a tube-tester chart may have a special notation such as GOOD ABOVE 10. This means the tube is good if the pointer goes above 10 on the 0–100 scale, even though 10 is in the BAD region of the GOOD-?-BAD scale.

Tube-life Test. A filament-activity test switch is provided on some testers. This switch reduces the filament voltage 10 per cent while keeping all the other voltages constant. The purpose of the switch is to give a rough indication of the probable life of the tube being tested. If the reading on the numerical scale drops to three-fourths of its normal reading when the filament-activity test is made, the tube is presumed to be near the end of its useful life. The accuracy and usefulness of this type of life test are questioned by some engineers, however.

Testing Pilot Lamps and Ballast Resistors. Ballast tubes and pilot lamps can be given a simple continuity test with a tube tester to determine whether they are open or not. Since a ballast tube is simply a wire-wound resistor mounted in a tube housing, the test is usually easier and quicker to make with an ohmmeter. The tube tester is used for this purpose only if its chart provides test settings for ballasts. The advantage of a tube tester is that it gives a hot-continuity test, whereas an ohmmeter does not send enough current through the ballast to heat it up. A ballast resistor can test good when cold yet open up as soon as it gets hot.

Because of the wide variety of ballast-tube pin connections and type numbers, ballast tubes are not always included on the tube chart of a tube tester. Some television sets and modern radios do use ballasts, but you will find them mostly in older radio sets.

To test a pilot lamp, first find the lamp voltage from a pilot-lamp table or from markings on the lamp. Set the filament switch of the tester to this voltage. Hold the pilot lamp in the socket provided on the tester, generally in the center of the large seven-prong socket, and see if the lamp lights.

Magic-eye tubes are checked in a tube tester only for brilliance of glow and for open and closed eye. Voltage-regulator tubes likewise get only a visual check for glow in most tube testers. No meter reading is used on these tubes. Visual checks are only a rough indication of quality, as a tube may have an apparently normal glow and yet be unsatisfactory in its circuit. Trying a new tube is the best test for some of these special types.

Setting Controls for Quality Test. Tube-tester controls are marked with letters or numbers. Considerable care must be used to set these controls exactly as specified on the chart. Pay particular attention to controls with fine markings from 0 to 50 or from 0 to 100. You may often find that a change in setting of only one small division will change the meter reading considerably. An error of a few divisions in a setting can change a GOOD reading to a BAD reading or can make a bad tube read GOOD.

Meaning of Quality Test. After the tube has warmed up and has been checked for shorts, the quality test is made according to the instructions supplied by the tube-tester manufacturer. You will note that some tubes, such as the filament-type 1R4, heat up within a few seconds. Other tubes with indirectly heated cathodes, such as the 35Z5 and the 50L6, may require a full minute to reach a steady indication.

A steady pointer indication on the BAD section of the scale indicates the tube is defective and should be replaced. An indication in the ? section indicates the tube will probably go bad in a short time. Such a tube should be replaced if the customer is willing, even though the tube may still work all right in the set.

Tube manufacturers permit a variation of 20 to 30 per cent in the ratings of a given tube type, so that you can expect differences in the readings for brand-new tubes even though all are the same type. New tubes should all test GOOD, however.

Tube testers are generally made so a tube rejected by the tester is definitely bad. Occasionally a tube testing good on a tube checker may not work in unusually critical circuits of the set.

Unusual Pointer Motion. The way the pointer moves across the scale can tell you something about the tube you are testing.

If the pointer moves rapidly across the scale and hits the full-scale stop with considerable force, pull out the tube quickly or turn off the tester. If the pointer is allowed to stay off scale under these conditions, the tester may be damaged. This behavior generally indicates an improper setup or a defective tube.

If the pointer tip seems to be blurred on a particular tube yet not on all tubes, it is generally an indication that a-c is getting into the meter circuit and causing the pointer to vibrate. This may be due to an improper setup, so turn off the tester and check the settings of the controls. If the tube setup is correct and the pointer still vibrates, it is a pretty good indication of a shorted tube, even though the defect was not revealed by the preliminary shorts test.

If the pointer tip vibrates excessively on all tubes (more than $\frac{1}{32}$ inch) while you make the line-voltage check, the line-check rectifier in the tube tester may be faulty and require replacement. This is a job for the manufacturer of the tester.

If the pointer jumps around considerably and does not settle at a reading, it indicates a bad connection within the tube or at the tube pins in the socket. To check for this, remove the tube, clean off the pins, and straighten them if necessary. If the pointer continues to jump around and appears to move more violently when the tube is tapped, it indicates a defective tube which probably has an internal intermittent short or open due to a loose element.

If the tube has not completely warmed up during the shorts test, the indicating pointer will gradually come up the scale to some steady reading which is the quality indication on that tube tester. If you hold the switch closed, the reading may drop slightly because of heating of the tube elements and tester components. Disregard this lower reading and use the first steady indication as the quality reading.

Slow and small erratic movements of the pointer generally indicate fluctuations in line voltage and not anything peculiar about the tube.

Pointer motion slowly up and down the scale repeatedly indicates a defective tube with an intermittent open or short due to the heat of the filament. For example, when the tube is cold, the heater makes contact. When voltage is applied, the tube starts to warm up, and the pointer begins to move up the scale. Before the tube is completely warm, the expansion of the heater section due to the heat causes the heater wire to open. This removes the source of heat, and the tube starts to cool off. The cathode emission decreases, and the pointer moves downscale. When the tube has cooled sufficiently for the heater again to make contact, the process is repeated. The pointer continues to move slowly up and down the scale as long as the tube is in the circuit. This tube is definitely bad.

Deflection past the GOOD section of the scale does not ordinarily mean that the tube is exceptionally good. Rather, it may also indicate that the tube is defective because of gas or a short, that the tester is set up incorrectly, or that the tube is outside the limits for proper performance in some critical circuits.

If the tube has high emission, the pointer of an emission tester will generally move slowly upscale and may even hit lightly against the full-scale bumper stop. Most emission testers have the GOOD-?-BAD scale calibrated so that a 100 per cent good tube indicates around the ¾ scale mark. An extra-good tube could then indicate near the end scale mark.

A tube for which the tester controls are set up incorrectly, on the other hand, may cause the pointer on an emission tester to move rapidly across the scale and hit the end-of-scale stop rather sharply. A tube that behaves this way should be unplugged immediately. A gassy tube may sometimes also make the pointer hit the stop.

Requirements for a Shorts Test. The most used indicator for shorts between tube electrodes is a neon lamp. This lamp should give a bright glow, visible in normal room light, to indicate a short between the elements of a tube. If the lamp projects from the panel a small amount, it can be seen without looking directly down on it. A plastic protective cover is good protection against accidental lamp damage.

In some testers, the tube-quality meter is connected to an extra switching circuit that makes the meter serve also to indicate shorts. The circuit is calibrated to read BAD for interelectrode leakage below a certain resistance value.

Making a Shorts Test. A check for shorts between tube electrodes is always made before the actual GOOD-?-BAD test. Do not skip the shorts test to save time, as a shorted tube may give false readings or damage the tube tester itself.

If the tube shows a short, it is defective. Do not make any other tests on this tube.

To make a shorts test, rotary or lever switches are moved one at a time as called for in the tube-chart instructions for the tube under test. This connects each element in turn to the shorts-test circuit. With well-designed lever switching, when a certain lever makes the shorts-test lamp glow, the number of that lever is the number of the tube pin that is shorted to some other electrode.

Make the shorts test after the tube has warmed up in the tester. This may take only a few seconds for filament-type tubes like a 1R4 but a full minute for slow heaters like a 35Z5 or a 50L6.

The shorts test on multisection tubes, like the double-diode 6SQ7 which requires three quality tests, is generally made only before the first test. Testers differ in this respect, however, so study the operating instructions for your own tester carefully.

Some tubes may cause the neon shorts test to blink for a moment as the shorts check switch is moved from one position to the next. This is a normal behavior which may be caused by the discharge of the series condenser used in some shorts-test circuits. Do not confuse this momentary glow during switching with the intermittent glow (indicating a defective tube) which you may notice on some tubes while they are being tapped.

For all shorts tests, tap the side of the tube lightly with the fingers or a pencil while watching the shorts-test lamp. The tapping often causes loose tube elements or poor connections within the tube to change position, with a resulting intermittent glow on the shorts-test lamp. Tubes with intermittently shorting elements such as this often cause noisy radio reception or intermittent performance; hence they should be replaced.

Meaning of Shorts Test. Small amounts of heater-to-cathode leakage in power-supply rectifier tubes and output tubes may make the shorts-test lamp glow, but will not usually affect operation of a set.

If a tube is used in an auto radio, considerable heater-to-cathode leakage is permissible.

Most a-c/d-c sets are not critical as to heater-to-cathode leakage, even though considerable voltage may exist between the heater and cathode. This is due to the fact that the speakers used in small sets are generally not responsive to the 60- or 120-cycle hum which might be picked up by a leaky tube.

If a tube is used as a second detector or in the first audio stage, small amounts of leakage current, indicated by a glow of the neon lamp, can cause considerable hum and noise. Such tubes should be used in another part of the circuit and replaced by others which do not show shorts.

Taps and internal jumpers that should show intentional shorts in tubes are designated on the tube chart by a note such as SHOWS SHORT ON 1 AND 5.

Noise Test. Provisions for a noise test are not essential on a tube tester, as most of the noise-test circuits available at present do not tell much. They consist of nothing more than a panel jack connected in series with the plate of the tube under test. When earphones are plugged into this jack and the tube is tapped, noise will be heard only if the tube is very badly noisy. A noisy tube will reveal itself by making noise when in the set.

Gas Test. A sensitive gas test is not essential for your first tube tester. The high-quality tester you eventually get for shop use should have a gas test, however, to give the best possible check of r-f and i-f amplifier tubes.

Most of the present tube testers provide a compromise gas test. Here an off-scale indication beyond the GOOD region or appreciable upscale drifting is an indication of a gassy tube.

If you suspect a tube of being gassy, allow it to heat up first by leaving it in the tube tester for a few minutes before making the gas test. This is especially important on power output tubes. On these tubes, call them gassy when in doubt, and put in new ones.

The number of tubes which are defective because of excessive gas is relatively small with modern tube-manufacturing techniques, except for output tubes where the heat of normal operation may drive gas from the metal tube parts. In the early days of radio, gassy tubes were quite common.

In general, a tube which checks gassy in a tube tester is quite certain to perform poorly in a set. Remember—any tube which reads better than GOOD is probably gassy.

Easy-to-use Tube-tester Controls. For ease of operation the controls for a tube tester should be simple to operate. They should also be well spaced in convenient locations so as to not interfere with the tube or with reading the meter. The ideal tube tester is so clearly marked that it can be used properly without even reading the instruction book. A tester that comes close to this ideal is shown in Fig. 5.

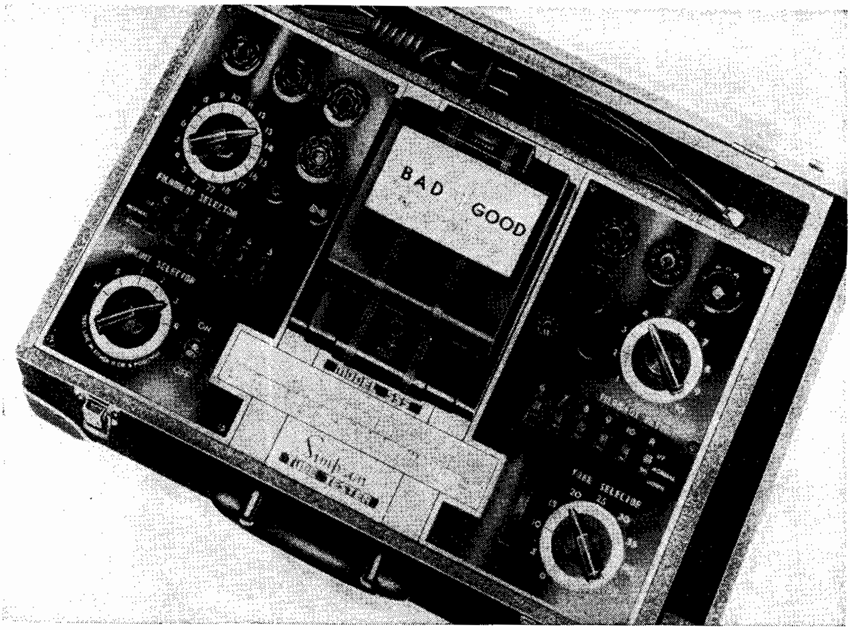


Fig. 5. Simpson model 555 tube tester, having exceptionally clear and simple panel markings that minimize chances for error in setting up controls for a tube test. (Simpson photo)

Ease of operation is important, to keep down the time for running a test. It also helps reduce the possibilities of mistakes in setting controls.

Special buttons or switches with markings like NORMAL PLATE, SECOND PLATE, or RECTIFIER AND DIODES are not recommended, as they are often overlooked and lead to error in reading and to possible tube damage.

The control knobs and buttons should be large enough to be operated easily without fumbling. The controls should be spaced far enough apart to reduce the possibilities of accidental moving while setting an adjacent control. There should be plenty of space for the panel markings associated with each control.

Control knobs should be securely fastened to their shafts, preferably with one or two setscrews in metal inserts, to prevent the knobs from loosening and changing the control settings. Lever switch knobs should be tightly fitted to the switch levers.

The index marker of each control knob should be grooved or molded in the knob or else be securely fastened to it. The index line should be neat and clear and come close to the panel markings.

All switches should have a good snap action to index them into position, yet the motion between positions should be smooth and uniform without any signs of sticking.

The average time required for a tube test on a well-laid-out tube tester should be about 10 seconds to set up the controls, up to 60 seconds for the tube to come up to temperature, and 30 seconds to check for shorts and read the meter.

Filament-voltage Controls. Filament supply voltages should be provided in a tube tester for all tube filament voltages from 0.63 to 117 volts. The filament panel switch should be clearly marked with each of the filament voltages, to minimize chances of putting the wrong filament voltage on a tube. The filament-voltage switch should have at least the following voltage positions: 0.63, 1.1, 1.4, 2.0, 2.5, 3.3, 5.0, 6.3, 7.5, 12.6, 20, 25, 35, 50, 70, and 117.

Tube-tester Sockets. Individual sockets should be provided for each of the popular tube bases, in a logical arrangement on the panel. One of each of the following sockets should be provided: 4, 5, 6, combination small and large 7, miniature 7, subminiature in-line 7, octal 8, loktal or lock-in 8, subminiature circular 8, noval 9. One of the sockets should have a center hole for testing pilot lamps. Other sockets that may be on the tester even though seldom if ever needed today in servicing are those for five-pin bantam, six-pin bantam, and acorn tubes.

Space should be provided for a spare socket, to be used if a new type tube base comes out. The tube-tester manufacturer will then provide instructions for installing and connecting the new socket.

Sockets should make good firm connections to the tube pins and should be securely fastened to the panel. Try a few tubes in the sockets before you buy. See that the tube goes in smoothly with a good snug fit, yet not so tightly that you have to pull the tester off the table to get the tube back out.

Two identical octal sockets are used on some testers because of inadequate switching circuits. These are confusing, so choose only a tester that has only one socket of each type.

Testing Unlisted Tubes. Tubes not listed in the tube chart may often be tested by following the chart listing for similar type designations. Thus, tubes with a G, GT, or other tail-end designation are tested the same as corresponding tubes without these letters. For example, use the 6SA7 settings for testing 6SA7G or 6SA7GT tubes.

New tube types which are not listed in numerical order on the tube chart may be found in supplementary charts supplied with the tester or available from the manufacturer. Sylvania publishes these data in its house organ, *Sylvania News,* which is sent out regularly to servicemen. If you have a new type of tube that is not on the chart or supplement sheet yet is in active tube production, send a card to the tube-tester manufacturer requesting a copy of the latest tube data for your tester and mention the tube you have to test.

Do not write for tube data just because you see the tube type listed in magazines or on some tube-manufacturer's technical sheets. These technical listings often include many experimental types which do not become commercially available until a year or so later. If you cannot buy the tube, either the tube-tester manufacturer has not yet been able to obtain the tube and prepare test data for it, or there is as yet no replacement market for the tube.

Tube-tester Socket Trouble. If a tube seems to require excessive force when plugging in, you may be making one of the following errors:

1. Trying to plug the tube into the wrong socket.
2. Trying to plug the tube into the socket incorrectly. For example, you may not have the guide on an octal tube lined up correctly with the guide in the octal socket, or you may not have the large pins on a four-pin tube lined up with the large socket holes.
3. There may be too much solder on one of the tube pins or the pins may be bent out of shape.
4. There may be something in one of the socket holes of the tube tester. For example, a piece of solder or wire insulation can easily fall into one of the socket holes if you have the tester located near where you are doing set repairs. To remove this obstruction, turn the tester upside down and rap sharply on the back and sides. If the piece will not

fall out, take the tester out of the case and push the obstruction out of the socket from the back.

If a tube drops loosely into the socket or seems loose after it is plugged in, the socket connections may be worn, or they may be out of shape. You may also find the tube pins themselves bent out of shape. Look particularly for bent tube pins on tubes with bases like the miniature seven-pin button base.

Tube-tester Precautions. When you are testing multisection tubes like the 6SQ7, it is usually safe to change the settings for the second and third tests without unplugging the tube. Read your tester instruction booklet carefully beforehand, however, because some testers may require special precautions. Some tubes may be damaged if settings are changed while the tubes are in the tester.

When you are through testing tubes, remove the last tube from the tester, turn it off, and reset all the controls to off or normal. Get the habit of doing this, to minimize chances of burning out tubes or damaging the tester. For example, if you leave the filament switch set at 2.5 volts and absent-mindedly plug in a 1.5-volt tube the next time before checking the settings, the tube will burn out with one quick blast, and you will be out the price of one tube.

Before plugging a tube into the tester, always set the controls to the specified settings first, to avoid burning out the tube.

Most testers have an indicator to show that power is on. A pilot light is the best. It may be by itself or doing some other job also, such as lighting up the roll chart, lighting up the meter scale, or serving as a fuse.

It is not necessary to unplug the tester when you are through making a test. Be sure, however, to turn it off and set the controls to neutral as specified in the individual tester instructions.

Tube-tester Overload Indicators. Most tube testers have some means of protection against overloads. It may be a high-resistance lamp, a fuse, or a fine-wire fixed resistor designed to burn out before any other parts in the tester are damaged.

In normal tube-tester operation, the overload indicator lamp will not glow at all or will be very dim on most tubes. Only rectifier and output tubes normally make the lamp glow brightly.

If the tube-tester switches are not set correctly or if the tube under test has a low-resistance short between some of the elements, such as across the two filament leads, the tube draws high current. This current also flows through the overload lamp, making it glow brightly. When this happens, remove the tube at once and recheck the tester settings. If they are correct, try another tube of the same type. If it tests normally, the first tube is defective. In case of an extremely severe overload, the lamp will burn out. By thus acting as a fuse, it protects the tester from damage.

Do not leave the tube in the tester if the overload lamp glows brightly, as this may seriously damage the tube tester. Only on large rectifier and output tubes is a bright glow normal.

If the tube tester is provided with an overload fuse, this should be located on the panel so it can be replaced without having to remove the panel.

One tube tester uses a 50-ohm resistor in its test circuit as a fuse. In case of severe overload, this resistor burns out. This will prevent serious damage to the tester. Replacing this resistor is a relatively simple and inexpensive operation. Tube-tester instruction manuals tell how to replace these overload resistors, fuses, and lamps.

Even if the tester does not have an overload indicator, you can often tell when excessive current is being drawn. The transformer may hum more than normal when the tube is plugged in, the roll-chart lights may dim, and the line-voltage indicator may drop down the scale.

Do not leave tubes in a tester any longer than is needed to make the test. This particularly applies to rectifier and output tubes.

Tube-tester Case. A rugged, neat-looking combination portable and counter case will provide the best all-round use for your tube tester. If the case is wood or fabric, be sure it has leather or metal corner braces. Rubber or metal feet should be on the back for supporting the tester on a counter. There should also be feet on one side, for keeping the tester upright when you set it down.

A good-fitting cover is important for protecting the panel markings, meter, and controls while you are carrying the tester and for preventing rain from getting in when you are on calls. The cover should have a pocket or straps for the line cord. Slip hinges should be provided, so the cover can be removed when using the tester for benchwork.

Why a Tube Tester May Read Wrong. The voltages applied by a tube tester are rarely the same as those applied to the tube in the set. A tube may read good at the low plate and screen-grid voltages and the low currents of a tester yet distort or otherwise operate improperly at the higher voltages in the set. This variation occurs mostly on power output tubes, where heat in the plate and screen grid at high voltages may release gas or cause secondary emission.

The bias and signal voltages applied to the control grid by the tube tester may differ from those in the set. This can cause a good tube to read bad in a tester because of overload in the grid circuit.

The filament voltage in your tester may be correct, but that in the customer's set may be too high or too low. If too low in the set, a tube that tests good can work poorly in the set because of low emission. If too high in the set, a tube that tests good can short out in the set because of higher filament voltage and greater heat.

Because of all these things, your final decision on any tube should be based on how it works in the set. When in doubt, try a new tube.

Tubes That Rattle. Occasionally a tube will rattle when it is shaken and yet test good in a tube tester. If the rattle is caused by loose material inside the glass envelope, the tube structure has very likely been damaged as a result of mechanical shock or excessive vibration. This tube should be rejected, as it probably will not last its normal life.

If the rattle seems to be inside the base, it is probably just a piece of loose cement between the tube envelope and the base. This will generally have little or no effect on the tube performance. If the tube tests good in the tester and does not behave suspiciously in the set, you can consider it a good tube.

Tube Tester with Built-in Multimeter. A combination tube checker and multimeter is not recommended for the beginning serviceman, because of the increased cost and because accidental damage to the meter would tie up both the multimeter and the tube checker. Loss of these two units at the same time would practically put a serviceman out of business.

About the only justification for getting a combination instrument is that you then need to carry only the one instrument on service calls. Later, when you are well established and have extra money to spend on equipment, you can get one just for outside calls. At the start it is much better to have separate instruments.

The panel arrangement and the meter scale on a combination unit are more complicated because of the added controls and the added scales. This increases the possibility of error and reduces the speed of tube testing and multimeter measurements.

The larger case that is necessary for combination testers makes counter use more difficult.

The addition of a battery checker in combination with the tube checker is worth while if you are in a section where there is considerable portable-radio business, such as near a summer resort. The addition of a few ranges for battery checking does not materially affect the cost of the tester.

Tube-tester Manufacturers. Good quality in components, in their assembly, and in calibration is important to satisfactory performance over the 5-year life of a tube tester. The best over-all criterion of quality is the name of the manufacturer and his experience in the tester business. Experience is important, as quality alone is no assurance that the manufacturer understands the serviceman's angle in tube-tester requirements.

Although every few years all manufacturers of tube testers bring out new models that may be better or worse than previous models, the following manufacturers have established reputations for consistent quality and reliability in their tube testers: Hickock; Jackson; Precision; Simpson; Sylvania; Triplett; Weston. The tube testers shown in this chapter are all good and are highly recommended for you.

There are other good tube-tester manufacturers, generally less known, but if you decide on one, be sure to look the tester over carefully in reference to the many features mentioned in this chapter. There are also some very bad tube-tester manufacturers, selling poor and makeshift testers at enticingly cheap prices yet making absurdly fantastic claims for them. Stick to the well-known makes and you will be safe.

Price. The cost of your first tube tester should be between $75 and $150. The $75 minimum limit is given as protection against inferior construction. If the price is much under that, the manufacturer is skimping in the design someplace or is not expecting to be in business very long! The $150 top limit will keep you from sinking too much into the tube tester at the start. Remember that you will have to do quite a few jobs before you get your tube tester paid for, along with your other expenses. Later, when you are well established, you can get a more elaborate tester in the $150 to $300 range. But not now!

Do Not Buy a Secondhand Tube Tester. Secondhand tube testers are a bad investment, especially if the particular model is no longer in production. Old secondhand tube testers will probably not check new tubes. The socket contacts may be worn, the line-voltage calibration may be out of adjustment, the meter may be damaged, and there may be a host of other faults.

Avoid Bargain Sales. Always buy the latest model of the tube tester you choose, as old models get out of date faster. Buying one that has been on the shelf for a year or more is false economy, even though you get it at a reduced price. Your testers are the tools of your trade. Modern tools promote efficiency in operation and increased profits.

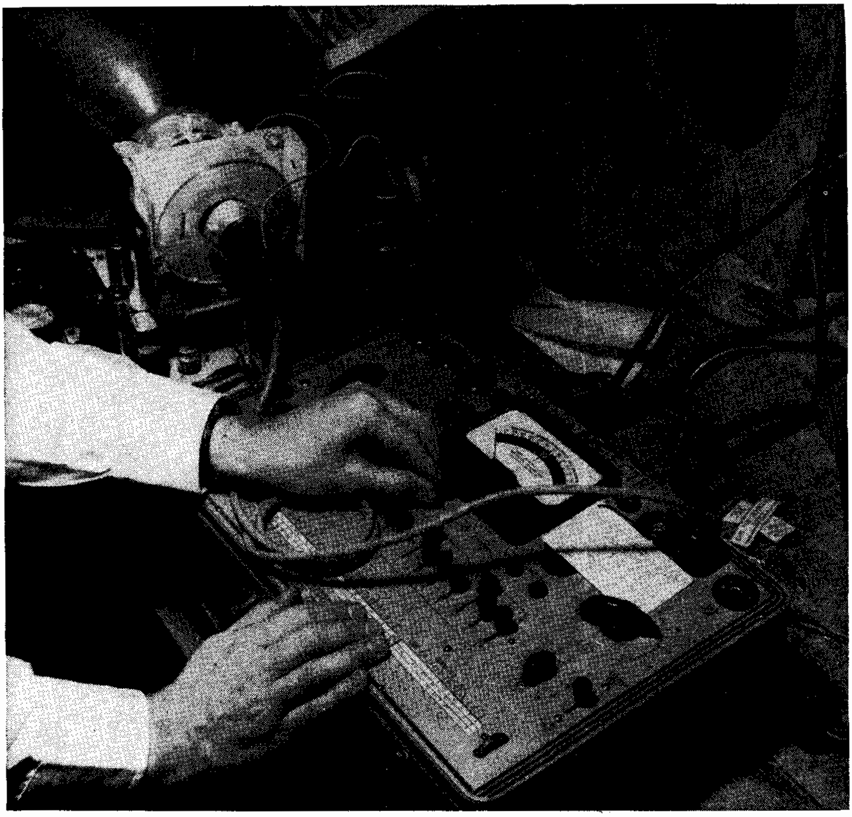


Fig. 6. Example of adapter for testing picture tubes with a Sylvania model 220 tube tester. With this, the picture tube does not have to be removed from the receiver. (Sylvania photo)

Guarantee on Tube Testers. A definite user's warranty and service guarantee are important factors in the purchase of a tube tester. Before you buy, study the manufacturer's printed literature to see just what you can expect in the way of a warranty. Study also the procedures provided for getting data on new tubes and for repair service. Availability of an authorized service station in your locality for a particular make of test equipment is a definite advantage, since even the best of equipment can have an accident or go bad unpredictably.

Most tube-tester manufacturers agree to provide tube-chart data on new radio receiving tubes for 5 years after the particular tube-tester model is discontinued from production. Sometimes a nominal charge is made for these data. The important thing is to be sure the data will be available, for otherwise new tubes would make your tester out of date.

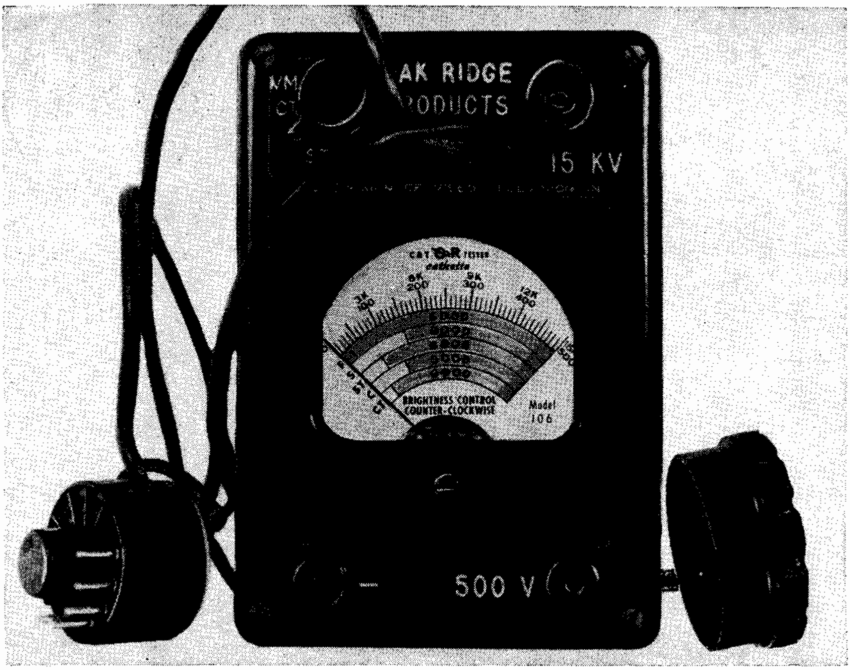


Fig. 7. Pocket-size picture-tube tester. Plug at left goes into picture-tube socket of set, and socket at right is put on picture tube. (Oak Ridge Products photo)

The tube-tester manufacturer generally warrants to the purchaser that any part defective in material or workmanship within 90 days from the purchase of the new tester will be repaired or replaced free of charge.

Testing Television Cathode-ray Tubes. For most service applications the best test of a television picture tube is its performance in the set. Picture tubes cannot be tested directly with an ordinary tube tester.

The arrangement shown in Fig. 6 is one example of inexpensive special equipment you can get for testing the electron gun of a picture tube right in the set. The profit on the sale of just one picture tube will just about pay for the adapter. Picture-tube test equipment saves time when the picture tube is among the suspected items for a particular trouble. The adapter tests for emission, leakage, shorts between electrodes of the electron gun, and open filaments.

Several manufacturers make tube testers designed especially for testing cathode-ray picture tubes. Connections to the picture tube are made with a cable having a socket at the end, as in Fig. 7; hence there is no need to remove the picture tube from the receiver. These testers cannot be used for ordinary receiving tubes. Their purchase can rarely be justified for a small servicing business until a lot of television work is being done.

QUESTIONS

1. Is a tube tester used for checking radio tubes in a customer's home?
2. If a tube tester calls a tube shorted and calls your new tubes of that type shorted too, what would you do?
3. Why is a line-voltage adjustment needed in a tube tester?
4. What does an indication in the ? section of the meter scale on a tube tester mean?
5. Why should a shorts test of a tube be made before the quality test?
6. If a tube reads better than GOOD, is it likely to be gassy?
7. Why should tube-tester controls be reset to their off or normal positions when you finish testing a batch of tubes?
8. Under what condition would a combination tube tester and multimeter be desirable?
9. Why are secondhand tube testers a bad buy?
10. Give the make, model number, and price of one tube tester that meets the requirements set forth in this chapter.
11. About how long can a tube tester be expected to remain useful and up-to-date for servicing work?

10

How to Solder

Importance of Soldering. In general, a television or radio set is fixed by removing the defective part and connecting the new part in its place. Except for tubes and pilot lamps, this involves unsoldering wires from the old part and soldering wires for the new part. Learning how to solder is therefore a highly important part of your training.

Soldering involves melting a lead-tin mixture in such a way that it flows around and adheres to the two or more parts or wires being joined together. The purpose of soldering is to provide a good electrical path that will not loosen or deteriorate with age or rough handling.

It is easy to make good soldered joints. All you need are your regular tools, a good soldering gun or iron, the right kind of solder, and the know-how. By following the few simple instructions given here, you can make smoothly rounded, glistening joints of which any serviceman would be proud.

Choosing a Soldering Tool. Many types of soldering irons are on the market. Each type comes in a number of different sizes and makes, so at first glance the problem of choosing the best iron for your servicing work seems hopelessly confusing. For money-making servicing, however, a new type of soldering tool developed in recent years has proved superior to all the others. This new tool is the soldering gun, so-called because it looks a little like a gun and has a trigger-type switch. You will find at least one of these guns in practically every service shop today.

Soldering Guns. An excellent soldering gun for service work is the dual-heat model shown in Fig. 1. This is rated at 100 watts for low heat and 135 watts for high heat. There are two built-in spotlights for illuminating the joint being soldered. Pulling the trigger switch to the first click turns on the spotlights and gives low heat for routine soldering of joints. Pulling the trigger all the way gives high heat for heavier work, such as for soldering a wire to the chassis.

The main advantage of a soldering gun is that it gets hot enough for use in only about 5 seconds after the trigger is pulled, whereas ordinary electric soldering irons take from 3 to 5 minutes. Such quick heating makes it unnecessary to keep a soldering gun on all day long just so it will be ready for use when needed. Another advantage of the gun type

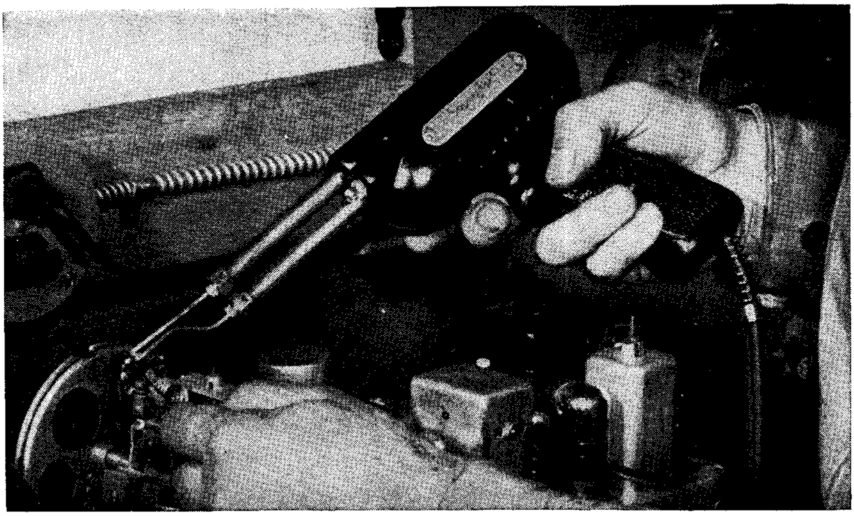


Fig. 1. Using a Weller soldering gun for unsoldering the leads of a defective part in a radio receiver. Spotlight bulb on gun throws needed light directly on joint. (GE photo)

is the long narrow tip, which is ideal for work in a compact, crowded chassis.

A soldering gun is simply a power transformer mounted in a pistol-shaped plastic housing. The primary winding is connected to the a-c power line through the trigger switch. The secondary winding has only a few turns of heavy wire, to send a large heating current through the loop of wire that forms the soldering tip. The voltage at the tip is less than one volt so there is no danger of shock.

Using a Soldering Gun. To solder a joint with a soldering gun, pull the trigger, hold the tip of the gun against one side of the joint, and apply a dab of rosin-core solder between the tip and the joint to aid heat transfer. Next, apply solder to the other side of the joint until it melts and flows freely over the area of the joint. Now take the tip off the joint and release the trigger.

Use the high-heat position only for soldering heavy pieces that require it. This high-heat position is for intermittent duty only. Continuous use on high heat will shorten the life of the tip and may overheat the transformer in the gun.

To unsolder a joint, apply the tip of the gun to the joint and pull the trigger. Apply rosin-core solder between the tip and the joint to aid heat transfer. When the solder on the joint melts, use long-nose pliers to pull the joint apart.

Care of Soldering Guns. The tip of a soldering gun should be kept clean and well tinned. It should be tinned the first time it is heated, by rubbing rosin-core solder over the entire tip. If the tip is not tinned, an oxide will form that is hard to remove and is a poor conductor of heat. The oxide also forms during use, making the tip look dirty and slowing up the transfer of heat to the work. When this occurs, scrape or sand the tip until shiny, then apply fresh rosin-core solder to retin the tip.

The tip of a soldering gun will eventually corrode and break because of heat, but a new tip is inexpensive and can be installed in a few minutes. Simply loosen the nuts on the two studs, slide out the old tip, and cut off the ends of the old tip to get the nuts off. Place the nuts on the new tip, bend the ends of the new tip to fit in the holes in the studs, then tighten the nuts securely with a wrench to finish the job. Check these nuts for tightness occasionally, as loose nuts can cause improper heat or no heat.

Choice of Solder. There is only one correct solder for television and radio repair work—rosin-core solder. The smaller thicknesses, hardly larger than hookup wire, are most convenient for servicing.

Solder is made with several different ratios of lead to tin. The easiest to use and the fastest to cool is 60-40 solder (60 per cent tin, 40 per cent lead), but this is most expensive and not always available. Next best and still in the luxury class is 50-50 solder, which takes just a little longer to melt and cool. Probably the most used type for servicing work is 45-55 solder (45 per cent tin, 55 per cent lead). Even 40-60 solder is satisfactory, though much slower to melt and cool. Recommendation: Get 50-50 if you can.

Rosin flux is essential for cleaning off the thin film of metal oxide that forms on metals. Solder will not adhere to a dirty or oxidized surface.

Although faster-acting acid fluxes are available, they should never be used for servicing. The acid flux will stay on the joint and eat into the copper under the solder, causing corrosion that soon destroys the electrical connection at the joint. Play safe—use only rosin-core solder for electrical joints, regardless of what anyone may tell you. You want your soldered joints to stand up for a lifetime, not for just a few months.

When using solder to fasten metal parts together or to solder a bracket to the chassis during repair work, it is permissible to use a special noncorrosive paste soldering flux, such as that sold under the name of Nokorode. This will clean dirty or oxidized metal surfaces so that solder can adhere, thus speeding up your work.

Electric Soldering Irons. Although a soldering gun is best for professional servicing, it costs about ten dollars more than a good electric soldering iron. Since you may wish to economize at the start, advice on choosing an electric soldering iron is also given. Skip this section if you have already decided on the gun.

For ordinary servicing work, an electric soldering iron rated at somewhere between 60 and 80 watts is large enough. It should have a pointed or wedge-shaped copper tip about ⅜ inch in diameter. This size of tip is small enough to go between parts and wires in a crowded chassis yet heavy enough to hold its heat when applied to large joints.

The tip of an electric soldering iron may screw down over the heating element, but more often it is a rod that fits inside the heating element, as in Fig. 2. The tip should be removable, so that it can be replaced when worn away through use. The iron should have a high-quality cord with woven insulation and a sturdy plug.

A soldering iron takes a lot of punishment; hence it pays to get a high-quality iron right at the start. Also, the heating element may burn out some time, and replacement parts are generally available only for the reliable high-quality makes of irons.

Soldering-iron Holder. With an electric soldering iron you will also need a holder. A simple holder is often furnished with the soldering iron, along with spare tips or different sizes of tips. More elaborate holders can be purchased separately. One type even has a built-in cup of steel wool for cleaning the tip. The chief function of a holder is to provide a place for your hot soldering iron, so that the tip will not burn your workbench.

Tinning an Electric Soldering Iron. The working surfaces of the tip of a soldering iron should be uniformly tinned at all times. Tinning involves applying a coat of solder to the surface. This coating protects the tip of the iron against corrosion due to heat and at the same time aids in the transfer of heat from the tip to the joint being soldered. The first step in tinning is cleaning or filing the tip.

Rest the hot soldering iron against a vise or anything else that will not burn, and file or sand one face of the tip until smooth, as shown in Fig. 2. If your soldering iron is dirty but not pitted, use fine sandpaper for this. Just loop a strip of sandpaper over a flat stick and use like a file.

Only if there are actual holes in the copper should you use a file for cleaning, because each filing removes some copper from the tip. Excessive filing will shorten the tip so much that it will have to be replaced. New

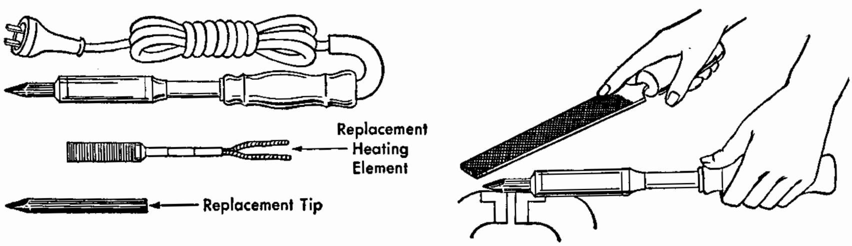


Fig. 2. Electric soldering iron with replaceable plunger-type tip and replaceable heating element. Method of cleaning tip of iron with file is also shown

tips cost only a few cents, however, so use a file when in doubt; it is far better to file your iron clean than to struggle with sandpaper.

When filing the tip of your soldering iron, hold the file flat against the entire face so as not to change the angle of the tip. Too blunt a tip is awkward to use in crowded locations, and blocks your view of the joint while soldering. A tip that is too slim, on the other hand, cools too rapidly at the sharp point and therefore cannot heat the work adequately.

After filing or sanding the tip, apply rosin-core solder immediately to the cleaned face. Wipe off surplus solder with a cloth, then inspect to make sure there is a coating of solder over the entire face. If spots show, repeat the filing and tinning. Do the same for each other face in turn.

Filing a Hot Iron. Filing can best be done while the iron is hot, because with a cold iron you have to file away a lot of solder before you get to the copper tip. This solder clogs the file and shortens its useful life. With a hot iron the solder just rolls on the file without adhering.

Surplus solder can be removed from a soldering iron with a quick downward flip of the iron, if there is no objection to having solder spattered on the floor of your shop. Wiping with a cloth or a wad of steel wool does a more thorough job, however. A cloth also removes any dirt that may have accumulated on the tip, so always keep a piece handy on your bench. Wiping the iron on your trousers is not recommended.

Heating Time. The average electric soldering iron used for servicing requires about three minutes to reach the correct temperature, so always plug in the soldering iron a few minutes before you are ready to use it. Heating time can be speeded up slightly by holding the iron with the tip pointing upward, since heat rises.

Never allow your soldering iron to hang downward by its cord while plugged in; in this position, the heat will travel up to the handle and make it uncomfortably hot. Some irons have disks or fins on the shaft near the handle to radiate surplus heat and keep the handle cool, but even these should not hang by their cord.

Care of Soldering Irons. In a shop, an electric soldering iron is generally left plugged in for the entire working day. A well-designed, high-quality iron is especially important here because the iron gets pretty hot when not used. If improperly designed, it can even get too hot for soldering work; in this case, the molten solder will form in balls and roll right off the iron, and the rosin will boil away before it can do any good.

When an ordinary electric soldering iron is to be left on all day, four things can be done to prevent excessive corrosion of the tip.

First, frequent cleaning and retinning will stop corrosion before it gets too far along.

Second, unplugging the soldering iron and letting it cool occasionally will help a lot.

Third, using a long holder that will radiate heat from the tip prevents overheating. The iron must be laid flat in the holder, so that the bulging part of the heating element is in contact with the holder. The heat that would be drawn away by soldering of joints is then taken by the holder, preventing overheating of the tip.

Fourth, reducing the voltage when the iron is in the holder will reduce corrosion of the tip. Special rather expensive holders are made that do this automatically whenever the iron is set in them. Some have thermostats just as in electric irons for pressing clothes, while others have a switch that is operated by hand or by the weight of the iron in the holder. This switch places a resistor in series with the iron to lower the voltage and make it run cooler when not in use.

Never use your soldering iron as a hammer or crowbar. The heating element is generally insulated with a fragile ceramic material just as in electric stoves and heaters, and this will break if the iron is carelessly dropped or whanged against the bench.

If the copper tip loosens during use, tighten it. On some irons, such as that in Fig. 3, a screw holds the tip in position. In others the tip itself

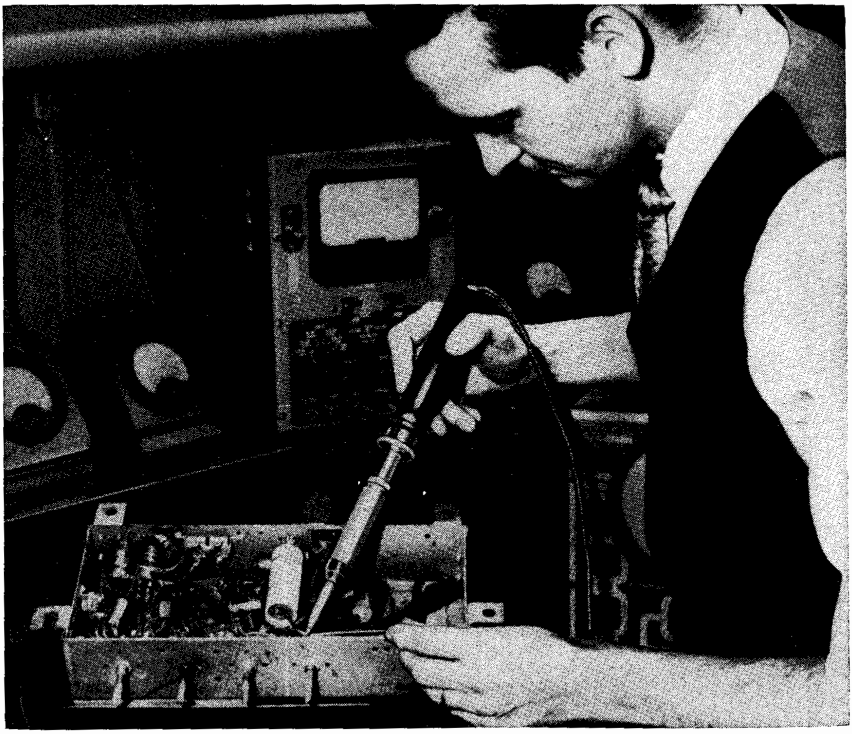


Fig. 3. Using American Beauty electric soldering iron to solder a joint on a new condenser in a radio set. (American Electrical Heater Co. photo)

is threaded and screws into the iron. Loosen and tighten a threaded tip occasionally so the threads do not freeze tight.

How to Solder. The remainder of this chapter, giving instructions for making the various types of soldered joints used in servicing, applies both to soldering guns and ordinary soldering irons. For convenience, only soldering guns will be mentioned, but the same instructions will always apply to soldering irons, too. Study these instructions thoroughly and practice each type of joint as soon as you get the necessary tools and materials. Sloppy soldered joints are a discredit to your reputation among servicemen, so learn to make professional-quality joints right from the start. Just as with cameras, it does no good to have high-quality equipment unless you know how to use it properly.

Unsoldering. The first use you will have for your soldering gun is unsoldering a joint so you can pull out the lead belonging to the defective part. To do this, simply hold the hot tip of the gun against the joint while pulling on the lead with long-nose pliers. If the joint heats too slowly, apply a small amount of solder between the tip and the joint to aid in

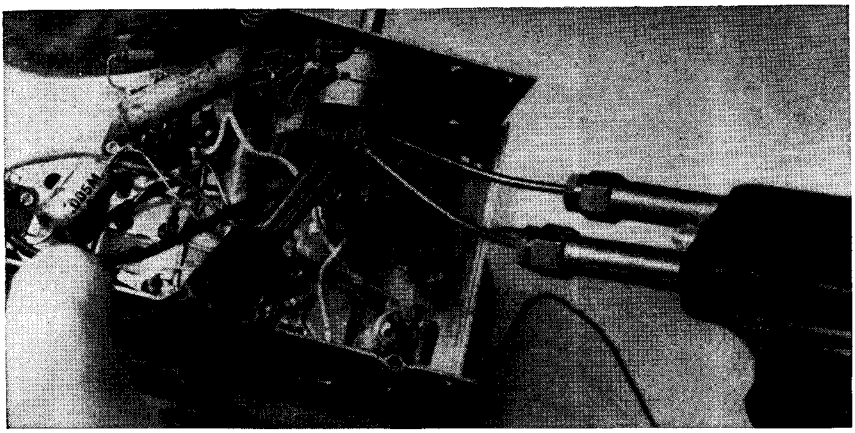


Fig. 4. Using older model of Weller soldering gun for unsoldering one of the connections to an on-off switch that is mounted on the back of the volume control in an a-c/d-c radio set

the transfer of heat. It is just as important to use solder properly for unsoldering as for soldering.

As soon as the solder on a joint has softened, wiggle and pull the lead gently until it comes loose. Use long-nose pliers for this, as shown in Fig. 4. If the joint is too tight for this, pry open the hook in the end of the lead with an ice pick before you pull out the wire. Never use force on a socket terminal lug, as many of them are fragile and will break off easily.

If the joint seems hopelessly tight, as many do, remove the soldering gun and wiggle the lead while the solder on the joint is cooling. Now you have a better chance to pry open the lead or cut off its end before repeating the unsoldering process.

As a last resort, cut off the old lead close to the joint with side-cutting pliers. If the loop of wire remaining is in the way of the new lead, you can easily remove it now with long-nose pliers while holding the iron against the joint.

During unsoldering, the hot solder will often flow down from the joint to a location where it may make trouble. For this reason, always remove surplus solder from the joint after unsoldering. You can easily pick up this solder with a freshly wiped soldering-gun tip. Shake or wipe the surplus solder from the hot tip and repeat the picking-off process as often as necessary to get all lumps of solder off. The cleaner the tip, the more solder it will pick up when doing this.

Unsoldering can often be made easier by removing the excess solder first, before wiggling and pulling on the lead. Practice unsoldering a dozen joints or so in an old set, and you will soon develop your own technique.

When unsoldering or soldering a joint deep down in a crowded chassis, a piece of asbestos paper about four inches square can be used to protect adjacent parts and insulation against being burned by the hot tip of the soldering gun.

Importance of Good Soldering. There is no more difficult trouble to locate in a set than a poorly soldered joint which is causing intermittent reception. The joint may look perfectly good yet have a bad contact underneath the solder. A poor joint can cause many other kinds of troubles also.

Too much solder can cause trouble by flowing to adjacent terminals or wires and producing short circuits. When fixing a set, you certainly do not want to introduce new troubles, because they will be back eventually to plague you.

Preparation for Soldering. For good soldering, all parts of the joint should be clean. In most cases, the wires and terminals will be clean enough or will have been tinned (coated with solder) during manufacture so that cleaning is unnecessary.

Whenever any part being soldered is corroded or dirty, it should be scraped with a knife, filed, or sanded with a small piece of sandpaper until bright. This cleaning is essential for two reasons: so the hot solder will adhere to the metal and so there will be a good electrical path between the solder and the various parts of the joint.

Removing Insulation from Wire. Ordinary cotton or plastic insulation on hookup wire can almost always be split lengthwise by squeezing and crushing with pliers over the length of insulation to be removed. This can be done with the working jaws of long-nose pliers or ordinary gas pliers. Some side-cutting pliers have flat jaws for this purpose between the handles, spaced exactly far enough to squeeze the insulation but not the wire.

Squeezing the wire in a vise is another way of crushing the insulation. The strips of insulation can then be pulled off easily with pliers or fingers, and any loose threads can be cut off with side-cutting pliers, scissors, or a pocketknife.

Pushback hookup wire is designed especially for the convenience of servicemen. It has a loosely woven insulation of cotton threads, held in position lightly by wax. The insulation can easily be pushed back from the end of the wire with fingers to expose the bare wire. You can then hold the wire with long-nose pliers in one hand and pull the insulation down as far as is needed with the thumb and forefinger of the other hand. For an ordinary joint, it is usually sufficient to remove ½ to ¾ inch of insulation from the end of the wire.

Solid insulated hookup wire is easier to use than stranded wire. Both types come tinned, which means that the copper wire has been given a coating of solder during manufacture. Solid wire has one weakness, though; it is more likely to break after being bent back and forth a few times. This bending occurs during normal moving of wires when removing and replacing parts in a crowded chassis. Stranded wire takes a little more time to connect but can withstand this rough handling. For your repair work, therefore, it is preferable to get stranded tinned wire. Either the No. 20 or No. 18 size (No. 18 is a little bigger) will do, with whatever type of insulation you prefer.

Cutting Off Insulation. When insulation cannot be removed by squeezing or pushing back, use your pocketknife. This calls for a sharp knife and extreme care to avoid cutting too far. Even the slightest nick in the copper wire will weaken the wire enough to cause a break eventually at that point. Slice off the insulation, much as you would sharpen a pencil with a knife. It calls for an extremely sharp knife and a delicate sense of touch to avoid cutting the wire.

A safer procedure involves holding the wire flat on your workbench or on a block of wood and rotating it slowly with the fingers while cutting through the outer insulating covering of the wire all around, using a sawing motion of the pocketknife. Slide or pull off this outer covering, first slitting lengthwise carefully if necessary. Now peel off the inner cotton or rubber insulation with your fingers. If a knife is required here, be still more careful than before.

Cleaning Enameled Wire. A coating of hard-baked reddish-brown enamel is widely used as insulation on fine copper wire for coils and transformers, as well as on solid and stranded wire for outdoor antennas. In the smaller sizes, this enameled wire is known as magnet wire because it was originally used in winding coils for electromagnets. The enamel should be removed from the end of such wire before soldering.

Scraping off enamel carefully with a sharp knife is the simplest and most convenient way. Be careful not to nick the copper wire, and be sure to get off all the enamel. If a small piece of fine sandpaper is handy, a faster and better job can be done by folding this over the wire so the grit bites into the enamel on opposite sides. Slide the sandpaper up and down the wire over and around the length to be cleaned while rotating the wire slowly.

Precautions for Plastic Wire. Plastic insulation in bright colors is widely used on wiring in new sets. This wire is thinner than cotton-insulated wire because the plastic coating has excellent insulating qualities. More and more troubles in sets are being traced to this plastic-covered wire, however, because of two weaknesses in its characteristics.

First of all, the plastic covering softens and melts away whenever touched accidentally by a hot soldering iron. The resulting damage to the plastic insulation may go unnoticed, and may not cause trouble until some time later when the wire has shifted so that the bare spot touches a bare terminal.

Second, if a plastic-covered wire presses against a sharp edge of a part or against a sharp corner of a terminal, the plastic will flow. The sharp corner may then eventually cut through the plastic and touch the wire inside. This can cause a short circuit which is extremely difficult to locate because it does not show until the wire is moved.

When working with plastic-insulated wires, do your soldering quickly. Do not hold the soldering iron on the joint any longer than necessary. Be careful not to touch any of the insulation with the iron. Excess heat at a joint can melt and weaken the plastic insulation for as much as an inch away from the joint.

Plastic-covered wire is sometimes called cellulose acetate hookup wire or thermoplastic hookup wire. It is excellent for connections if its two weaknesses are recognized.

Tinning Solid Wire. A wire should be tinned as soon as it is cleaned, before oxides form. Even factory-tinned solid or stranded hookup wire should be given a fresh coat of solder before making a joint.

To tin solid wire, support it over the edge of your workbench so you can hold the tip of the soldering gun under the wire with one hand and apply solder to the top of the wire with the other hand.

Another way is to unroll a few inches of solder from its spool and bend it to project over the edge of the bench. Now hold the wire under the solder with one hand. Bring the hot tip of the gun under the wire with the other hand, so the heated wire melts the solder.

A pair of pliers with a strong rubber band around the handles makes a handy miniature vise for holding a wire being tinned. It can also be used for holding a small resistor or condenser while tinning its lead.

If the solder does not flow smoothly over the area to be tinned, scrape the wire some more. Rubber-covered wire will give the most trouble because the sulphur in the rubber causes a type of corrosion that has to be scraped off completely before solder will stick.

Tinning Stranded Wire. New tinned stranded wire is retinned the same way as solid wire. Old stranded wire usually gives trouble, however. You will have to clean the strands individually if they are enameled or dirty. Untwist the strands for about half an inch from the end and spread them out fanwise. Scrape them all at once with a knife or rub with sandpaper, first on one side of the fan and then on the other. Now untwist a bit more to rotate each strand, and scrape or sand again. Repeat until each individual strand is clean all around. Now tin the strands by heating them from one side with the soldering gun while applying solder to the other side. Shake off surplus solder while it is still molten, or tap the strands quickly with the heated soldering gun so that any molten solder between the strands drops out. After the wire has cooled, twist the strands together again. You can then proceed just as if working with solid tinned wire.

Bare stranded copper wire is widely used in television and radio sets, especially for power-line cords. If the wire is new and fairly clean, it can usually be tinned without untwisting. If it is only slightly dirty, you can untwist and do a quick scraping or sanding job, then twist the cleaned wire together before tinning, to speed things up. You will be doing this a lot when replacing worn-out line cords.

For very dirty stranded wire, you may prefer to use a noncorrosive paste soldering flux. Just insert the wire in the can of paste, remove, apply heat, then apply solder to tin the wire

Burning Off Enamel on Wires. There is one easier way of cleaning enameled wire, if you have an alcohol burner handy. With stranded enameled wire, untwist the strands for about one and a half inches and spread them out so no wires touch. Hold the spread-out strands just below the tip of the inner cone of flame from the alcohol lamp until the wires are red-hot for almost an inch from the end. Now, immerse the heated wires quickly in a little can of alcohol. The enamel will dissolve immediately, leaving a bright and clean copper surface.

Enameled wire can be heated with a gas burner or any other hot flame just as well, then immersed in a pan of alcohol. Solid enameled wire can be cleaned the same way.

Tinning Soldering Lugs. Almost all of the soldered joints made in servicing involve attaching a wire to a small, flat tab of metal called a soldering lug. Fortunately, these lugs are usually tinned during manufacture and do not require cleaning. The lugs are used extensively as terminals for tube sockets and other parts, as anchor points for wires on insulating strips, and for making connections to the metal chassis.

If a soldering lug is dirty, it must be cleaned by scraping, sanding or filing, then tinned. When being tinned, the hole in the soldering lug usually fills up with solder. This solder can be lifted out with a freshly wiped soldering iron, so the wire can be looped through the hole.

Another way of getting a wire into a hole that has filled up with solder is to heat the lug until the solder melts, then poke the wire through. The wire is bent to shape after the solder has hardened, and the joint is then completed in a normal manner.

A handy tool for reaming out solder-filled holes in lugs is an ice pick.

It is possible to make a soldered connection directly between a wire and the metal chassis, but this is not easy, and the resulting joint is usually messy in appearance and lacking in mechanical strength. Always try to make ground (chassis) connections to soldering lugs that are bolted, riveted, or otherwise connected to the chassis.

Joints for Soldering Lugs. The four distinct types of joints used in connecting a wire to a soldering lug are the temporary hook joint, permanent hook joint, wrap-around joint, and lap joint, all shown in Fig. 5.

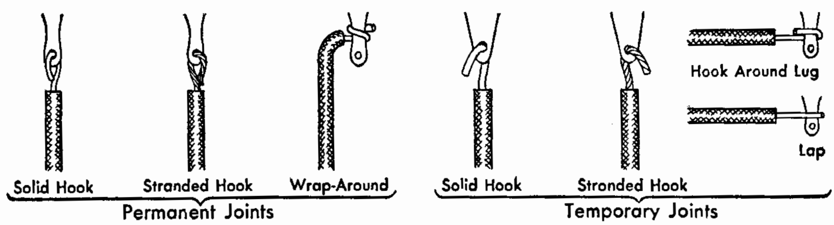


Fig. 5. Types of joints used for connecting a wire to a soldering lug

Each has its own advantages for particular purposes. All four require that both the wire and the lug be cleaned and tinned.

Permanent Joints. The most widely used joint in service work is the permanent hook joint. To make it, the cleaned and tinned end of the wire is pushed into the hole in the soldering lug. The end of the wire is bent back to form a hook, the hook is squeezed together with long-nose pliers, and the joint is soldered by holding the soldering-gun tip against one side while applying solder to the other side. This provides a permanent soldered connection having much-needed mechanical strength as well as good electrical contact.

Another good permanent joint is the wrap-around joint. This is generally used on soldering lugs that have side notches instead of holes, but will work well on any lugs. A wrap-around joint is often the only way you can make a good connection to a terminal that already has a number of wires on it. The wire is wrapped around the lug 1½ times with long-nose pliers, surplus wire is cut off, and the joint is soldered.

The wrap-around joint is widely used in television and radio sets because it can be made faster in production than the hook joint. The wire is simply looped one or 1½ times around the outside of a soldering lug, squeezed tightly with pliers, the surplus wire cut off, and the joint soldered as before.

To unsolder a wrap-around joint, grasp the end of the wire with long-nose pliers and pull while holding the soldering-gun tip against the joint. With a little practice, you will find it easy to keep the solder molten with the soldering gun in one hand, while loosening the wire with long-nose pliers in the other hand. It takes practice to work with both hands in this way, just as it takes practice to play a piano with two hands.

Some prefer to push the end of an ice pick through a wrap-around joint and pry the wire apart while keeping the solder melted. On really tight joints, it is sometimes faster to cut the wire going to the defective part, and wrap the wire lead for the new part right over the old joint.

Temporary Joints. A temporary hook joint is used between a wire and a soldering lug when it may be necessary to remove the wire later, as in making test connections. The procedure is exactly the same as for making a permanent hook joint, except that the hook is not squeezed with pliers before soldering. The hook should be bent together just enough so the wire will not fall out of the hole in the lug, as shown in Fig. 5. Enough solder should be used to get a solid bond between the lug and the hooked wire, but the entire open hook need not be filled with solder.

With temporary joints, be especially careful not to move the wire until the solder has hardened. If you watch closely, you can actually see this hardening process. Molten solder has a shiny, mirror-like gray color, while hardened solder is duller and just a shade whiter in color. You will have to be a living statue for about 30 seconds after removing the gun from a temporary joint, because the slightest bump will move the wire and spoil the joint.

Whenever a joint is accidentally moved during the hardening process, reapply the soldering gun to melt the solder, then try again to hold your breath while it cools. Movement crystallizes the hardening solder, weakening it mechanically and spoiling the electrical connection.

Lap Joint. This is the most temporary of temporary joints. It is made by holding the straight end of the tinned wire against the soldering lug, holding the soldering-gun tip underneath the joint, and applying solder to the top of the joint. Sure, this requires three hands, which is why it is not used much. Actually, you can often bend the wire so that it will stay in the correct position against the soldering lug. You can then solder the joint conventionally with the gun in one hand and solder in the other. Sometimes you can hold both wire and solder in one hand.

Here is another way that often works, even though contrary to good soldering practice. Hold the wire in position on the terminal lug with one hand, press the heated soldering-gun tip over the solder so some will adhere to the lower face of the tip, then apply the soldering gun to the wire so that the solder transfers itself to the wire and the lug. Wire and lug both must be previously tinned, and the wire must be held steady while the solder is cooling. It helps to rest the hand against the chassis while holding the wire.

Dressing a Joint. When making a joint, the wire should be positioned so that the insulation is at least ⅛ inch away from the lug, to avoid burning the insulation. If you are using pushback hookup wire, the insulation can be pushed right up to the joint after the solder has cooled.

In all cases, the joint is dressed after being soldered, by arranging the wires neatly, straightening out kinks with the fingers, and snipping off any surplus wire projecting from the joint. When working with bare leads of parts, dressing also involves moving this bare lead away from other bare leads and away from adjacent terminals.

Good Joints. In a soldered joint, the solder should flow smoothly between the wire and the lug. Such joints are simple and easy to do once you learn them. The important thing is that your joint must be clean and hot enough to melt the solder itself.

Always apply a dab of solder between the gun tip and the joint at the start, so heat will be transferred faster to the joint. After this, apply solder only to the joint. Use just enough solder to get a smooth joint.

Bad Joints. One common mistake in soldering is applying solder directly to the gun tip and allowing it to flow off the tip onto the cold joint like wax dripping from a candle. This joint is messy, requires a lot more solder, and is not good electrically or mechanically. The joint can usually be wiggled loose with your fingers, because hot solder does not stick well to a cold surface.

There are many servicemen in business today who make messy, puddled joints because they do not know any better. These men are continually in trouble with their customers because their repairs do not stand up. You have the edge on these servicemen just as soon as you have mastered the simple trick of making good soldered joints.

Soldering Two Wires Together. The diagrams in Fig. 6 illustrate the different types of joints that can be used for connecting one wire to

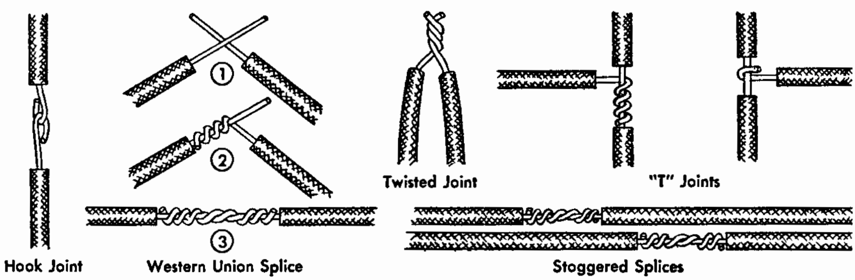


Fig. 6. Types of joints used for connecting two wires together

another, as is required when there is no convenient soldering lug to serve as anchor for the wires. In all cases the wires must be previously cleaned and tinned. The soldering procedure is exactly the same as for soldering wires to lugs: hold the iron on one side of the joint and apply solder to the other side.

The hook joints are used where no mechanical strength is required. Here it is extremely important not to move the wires while the solder is hardening. Squeezing the hooks together with pliers before soldering makes a semirigid and more or less permanent joint.

The Western Union splice is used where mechanical strength is required, as in antenna systems. To make it, clean each wire for at least 1½ inches from the end, grasp one wire in each hand and cross the bared ends, then twist each wire in turn around the other in opposite directions with your fingers. Keep the turns of wire far enough apart so solder can flow between the turns. You can either cut off the ends of the wire with side-cutting pliers or do the final bending with pliers, since the ends will invariably be too stiff to bend with fingers. Straighten the finished joint neatly with your fingers, then solder it.

The twisted joint is frequently used because it is easy to make in crowded locations, but has little mechanical strength. Simply twist the bared ends of the wires together with your fingers, solder the joint, then snip off the projecting ends with side-cutting pliers.

The T joints in Fig. 6 are used for connecting one wire to some point other than the end of another wire. In all cases, remove the insulation at the desired point by cutting or crushing, being careful not to nick the wire. The squeezed hook joint is of course more permanent than the open hook. The twisted-around T joint provides maximum permanence along with mechanical strength.

Insulating Wire Joints. Joints between wires should be taped as a general rule. The best tape for service work is No. 33 Scotch electrical tape or an equivalent plastic tape. This tape should be wound tightly around the joint and well over adjacent insulation, so that there are at least two thicknesses of tape over all exposed wire. Where the joint is out in the open, work with the entire roll. When working in cramped quarters, however, tear off approximately the required length of tape. This tape has sufficiently good insulating qualities for use on line cords or other wires carrying dangerously high voltages.

To wrap the tape, start at one end of the joint. Hold the end of the tape in position against the insulation on the wire with one hand and stretch the tape while wrapping it around the joint with the other hand. Keep your fingers off the freshly exposed surface of the tape as much as possible, because fingerprints will destroy its sticking qualities. Overlap the tape at least half.

When the entire joint has been covered with two thicknesses of tape, the job is done. Before No. 33 tape was developed, rubber tape had to be used first, followed by layers of friction tape to hold the rubber in position. For permanence, the friction-taped joint then had to be coated with shellac, varnish, or a similar material so the end would not get loose.

Always stagger the joints as in Fig. 6 when splicing line cords or other lines or cables having more than one wire. Then, even if the tape on the joints gets loose, the bare joints cannot touch each other and cause trouble.

Soldering Connections for New Parts. Although detailed instructions for installing and connecting new parts are given later in this book, there are a few general rules worth learning now. The actual joints are always made exactly as described in this chapter.

New transformers and electrolytic filter condensers often have insulated leads, and these will usually be longer than are needed. Do not be afraid to shorten leads that are too long; cut them just long enough to leave a reasonable amount of slack for adjusting the position of the wire later, then remove insulation from the ends and proceed exactly as you would when connecting a plain wire to a soldering lug.

Resistors, paper condensers, and mica condensers will invariably have tinned bare copper leads, and these likewise will usually be too long. The lengths of the leads on the old parts can often serve as a guide for shortening the new leads. In general, however, hold the new part approximately in its final position to determine how long the leads need to be. Allow ¼ inch or so for bending back the hook joint, and allow extra length for safety.

If fairly long leads are required and there is danger of their touching other wires or terminals, slip a length of insulating tubing, called spaghetti, over each lead before making the joints. You can get this spaghetti in assorted sizes from any parts jobber or distributor. A bundle of assorted sizes costs little and will last a long time.

Avoid cutting the leads of paper condensers too short, because then the heat from the soldering iron at the joint will travel along the wire and melt the wax in the condenser. It is safer to have the leads too long rather than too short. Do not make sharp-cornered bends in the leads with pliers, as this may weaken the wire. When bending leads with fingers, start at least ¼ inch away from the body of the resistor or condenser.

Do not hold a soldering gun on a joint any longer than is necessary to get solder flowing smoothly over the joint, because heat may travel to delicate adjacent parts and cause damage. Soldering the leads to a new crystal phonograph pickup is an example of this. If the soldering gun is held too long on the terminals of the new pickup, the crystal will be damaged permanently before it is ever used.

The secrets of fast and good soldering are summarized in Table 1. They are well worth extra study right now so you will never forget them.

Soldering without Electricity. When electric power is not available, as might be the case when doing repair work in a remotely located farm home, a flame-type soldering iron must be used. This is much like an

Table 1. Rules for Good Soldering

1. Clean and tin the tip of the soldering gun or soldering iron frequently.
2. File, scrape, or sand the work if dirty.
3. Tin each part of joint separately first if untinned.
4. Make joint mechanically strong first whenever possible.
5. Use only rosin-core solder.
6. Be sure the soldering gun or iron is hot enough.
7. Apply solder between the heating tip and the work first, to speed up heat transfer.
8. Heat the work until it melts solder itself; then apply solder only to the work in completing the joint.
9. Be sure solder flows smoothly over entire joint.
10. Do not use too much solder.
11. Do not move joint until solder hardens.

electric soldering iron except that it is solid metal throughout, instead of having a heating element inside. This iron is heated by placing the copper tip in the flame of an alcohol torch or blowtorch or even by inserting in a coal fire. The most convenient source of heat, however, is a small can of Sterno canned heat, widely used by campers. This can easily be carried in your toolbox for rural calls.

Heating must be carefully watched, and flame-type irons must be retinned frequently to keep the tips clean. As a general rule, heat the iron for about one minute after the tip first begins to melt solder, in order to store up extra heat so that you can make several joints before reheating. Be very careful not to overheat the iron, and never let it get red-hot. It is hard to make a good joint with too hot an iron because the extra heat evaporates the rosin flux before it can act on the joint. Furthermore, excessive heat causes the tip to corrode faster.

When a lot of work must be done with flame-type irons, use a pair of irons. One can be heating while the other is in use. For servicing work, get irons weighing ¼ pound per pair.

In an emergency, an ordinary electric soldering iron can be heated in a flame. Be particularly careful here not to overheat, because this may damage the electric heating element.

QUESTIONS

1. Why should some solder be applied between the joint and the tip of the soldering iron when starting to solder a joint?

2. What is the correct type of solder for television and radio work?
3. Why should the tip of a soldering iron be tinned?
4. Describe one way of removing woven cotton insulation from the end of a wire.
5. Describe one way of removing enamel insulation from a wire.
6. What type of joint is used most for connecting a wire to a soldering lug?
7. When is a temporary soldered joint permissible?
8. Once a joint is heated, where is solder applied to complete the job?
9. What common soldering mistake can be compared to the dripping of wax from a candle?
10. Name and describe the type of permanent soldered joint that gives the greatest mechanical strength.
11. What type of insulating tape is best for service work?

11

Power-supply Troubles

Modern Sets Need Power. The amount of signal power that can be picked up by a radio receiving antenna is just barely enough to operate headphones. Modern television and radio sets use this very weak signal power from the antenna to control much larger amounts of power furnished by conventional electric power sources. This gives amplification of the incoming signal, making it possible to operate loudspeakers that supply room-filling volume. In television sets, much the same power sources are used to provide large, bright-as-day pictures.

The most common type of power supply is the 115-volt a-c power line that enters a customer's home. Second commonest is the storage battery which is the source of power for millions of auto radios. Third is the dry battery, widely used in portable radios and in homes without electricity. In addition, older areas of some large cities still have 115-volt d-c power lines.

If power does not get to a set, the set does not work. It is usually easy to recognize power-supply trouble because the set is then completely dead. There is no sound or even hum, there is no light whatsoever on the screen of a television receiver, and all tubes are cold and dark.

Locating and repairing power-supply troubles is just as easy as recognizing them, once you get familiar with the different types of power supplies. Each will be taken up in turn in this chapter, along with test and repair procedures for common troubles.

A-C Power-line Troubles. In the United States, alternating-current power-line systems operate at a voltage between 110 and 125 volts. The power company tries to hold the voltage to a center voltage plus or minus 5 volts. Thus, if the center voltage in a particular city is 115, the power company will attempt to keep the voltage in each home from dropping below 110 volts or rising above 120 volts. A common center-voltage value is 117 volts.

If the tubes do not light up when you first turn on an a-c or a-c/d-c set, check the connections to the power source. Be sure the power cord is plugged into the outlet and making good contact there. If there is a cube tap in the outlet as in Fig. 1, remove it and plug the set directly

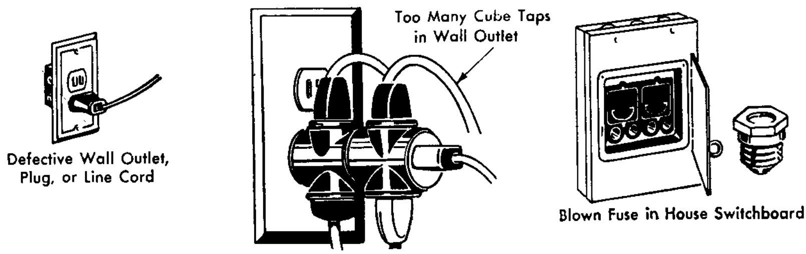


Fig. 1. Three examples of power-line troubles for which a serviceman is often called

into the outlet. These cube taps frequently have poor or loose contacts and are troublemakers in other ways, so urge the customer not to use them on television and radio sets.

House-fuse Trouble. With an a-c power source, the source itself may be dead because of failure of a fuse. In modern home wiring, wall outlets are often connected to a separate circuit which has its own fuse. Therefore, these wall outlets may be dead while the ceiling lights in the house are operating properly. It is easy to check the wall outlet by plugging in a table or floor lamp that is known to be in good condition.

If the lamp does not light, the fuse box should be checked. This will be found near the electric meter. You can usually tell by inspection which fuse is burned out. It is well for you to carry a few spare fuses (15-ampere rating) in your toolbox just in case the customer does not happen to have a replacement.

Never put a penny or a piece of tinfoil behind a burned-out fuse. Fuses are placed in the circuits for protection against defective wiring and to eliminate fire hazards that develop when lines are overloaded. Fuses usually burn out when the line has too many appliances connected to it, but occasionally fuses will fail because of old age.

If you replace a fuse and the new one burns out immediately, there may be a short circuit in the receiver, in a lamp, or in some appliance. Unplug all devices in the house, then replace the fuse. If it blows again, the house wiring is defective. Recommend that it be checked for faults by a competent electrician. If the new fuse does not blow, plug the devices in again one by one, waiting a minute for each to warm up. When the defective device is plugged in, the fuse will blow again.

Defective Line Cords. If you are sure that there is voltage at the wall outlet or other source of power but if still there is apparently no power available to the set, you can suspect a poor connection in the line-cord plug or a break in the line-cord wire itself.

Some of the new types of line-cord plugs have no terminal screws; hence you cannot reach the bare line-cord wires at the plug for test purposes. In this case, check both wire and plug together with an ohmmeter. Connect the prongs of the plug together with bare wire or a large clip, make sure the receiver power switch is off, then measure the resistance between the ends of the line cord *inside the set*. If the resistance reading is infinity, there is a break somewhere in the line cord or in the plug.

Defects of this sort are sometimes quite difficult to locate since the wire may break inside the insulation, leaving no external evidence of the break. Do not attempt to repair the break in a line cord; replace the entire line cord.

The line cord of a television or radio set runs through a hole at the back of the chassis to terminals under the chassis. A rubber grommet like that in Fig. 2 is generally used inside the chassis hole to prevent the sharp metal edges from cutting into the line cord. If this grommet is worn or missing, it should be replaced before installing the new line cord.

Rubber grommets for replacement purposes are available in various sizes. To install one, squeeze the grommet into an oval shape, insert one end in the chassis hole, then work the rest of the grommet into position with your fingers. A screwdriver sometimes helps to position the grommet so the rubber groove in the grommet touches the sharp edges of the chassis around the entire hole.

Line cords with molded plugs attached are available at reasonable prices, but usually have inferior plugs without screw terminals. It is better to buy separate plugs with screw terminals and springy double-piece prongs that will make good contact in any wall outlet. The proper way of connecting the line cord to the plug is shown in Fig. 2. The separated wires of the cord should go around the prongs. The knot gives additional protection against loosening when someone jerks the cord to pull out the plug.

Some old plugs and occasionally a new one will not make a good connection in an outlet because the plug prongs have been bent in handling or the spring contacts in the wall outlet are worn. Bending the plug prongs slightly outward from the center with long-nose pliers will sometimes give a good connection in the outlet. This is all that you can do, because replacement of a defective wall outlet is a job for a licensed electrician.

When installing a new cord in a set, knot the cord inside the chassis so that any strain which is applied on the cord will not pull directly on solder joints you make. A simple knot like that shown in Fig. 2 is all that is necessary here.

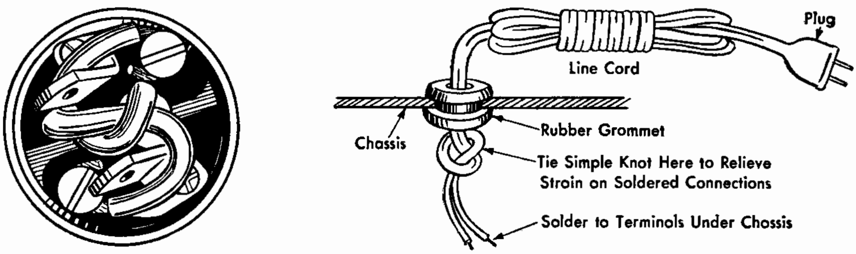


Fig. 2. How to tie a simple knot in a line cord inside the plug, to ease strain on terminal screw connections. Note also how the wires are run around the prongs to the screws. A knot is also used for the same reason at the other end of the cord, inside the chassis

When soldering a new cord into a set, be sure that all of the old wire has been removed from the solder lugs. See that the new wire is securely anchored with permanent hook joints or wrap-around joints before you do any soldering. Also, leave a little slack in the line between the knot and the solder lugs, so that no strain will be applied to the solder joints.

Low Power-line Voltage. If the power connection to the set is satisfactory but the set still does not operate properly, check the voltage of the power supply at the wall outlet with the a-c voltage range of your multimeter. If you find that the voltage is extremely low (below 100 volts), report it to the service department of the local power company. They will usually take steps to correct it immediately.

One effect of low line voltage on a television or radio set is to increase the warmup time to several minutes. It may take the set as long as ten minutes to operate properly after it is turned on if the voltage is extremely low. Even then the tubes will not be operating at their normal temperature, and the set will not perform well.

If the line voltage is too high, the set will probably operate very well, but the tubes will be heated much above their rated temperature and will be likely to burn out after a short period of time. High voltage may also cause howls and whistles that are difficult to eliminate.

D-C Power-line Troubles. In the older sections of some large cities 110-volt, direct-current power lines are still in use. Thus, in New York City there are still over 300,000 residences with d-c power meters; in Boston there are over 50,000 d-c power meters, and in Chicago about 25,000. In these homes and apartments you will encounter universal a-c/d-c sets, which can have the same line cord, plug, wall outlet, and fuse troubles as do a-c sets.

Sets designed especially for use with d-c power lines may occasionally have a polarized line-cord plug, which is like a standard plug except that one prong is set at right angles to the other. This type of plug can be inserted only one way in the corresponding d-c wall outlet and cannot be inserted in a standard a-c outlet.

More often in d-c power districts you will find conventional plugs on radio line cords. Here it is necessary that the plug be inserted in the right way to make the set operate. No harm is done if the plug is inserted wrong, but the set will not work. If the tubes light up but no sound is heard, the plug may be inserted in the wrong direction, giving the wrong polarity. It is then merely necessary to reverse the plug in the outlet.

Auto-radio Power Supply. When a radio is installed in a car, there is usually only one power lead. It runs from some point in the battery system (usually an ammeter terminal) to the radio set itself. This lead is usually a shielded cable which has somewhere in its length a small fuse holder. The two telescoping sections of the auto-radio fuse holder are locked together with a bayonet connection, as in Fig. 3. Inside the cylinders is a glass cartridge-type fuse.

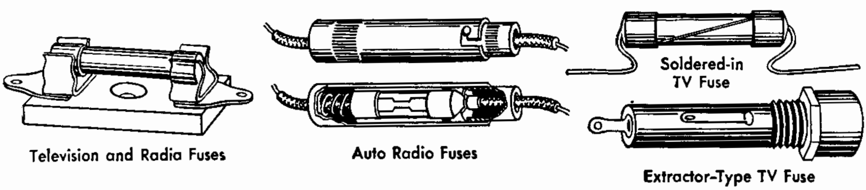


Fig. 3. Types of fuses often found in television and radio sets

In many auto-radio failures, the fuse has burned out. This may be due to the vibrator in the radio sticking and drawing a very heavy current, or it may be due to normal aging of the fuse. Ordinarily these fuses have a 10-ampere rating and are very easily replaced. Since this fuse is in a concealed place, your customer may not be aware of its existence.

If the replacement fuse burns out almost immediately when the auto radio is turned on, do not just put another fuse in. There is probably trouble inside the set. Remove the auto-radio cabinet and take off its top cover so you can remove the vibrator. Now install the new fuse and try the set If the second fuse *does not burn out,* you have evidence that *a new vibrator is needed* or there is other plate supply trouble.

Auto-radio Power Connections. A single-wire power connection is all that is needed for an automobile radio, since the metal radio cabinet is bolted to the bulkhead of the car and is therefore connected to the frame. The storage battery in the car has one terminal connected to the frame; hence the auto frame serves as the return path for battery current. If the mounting bolts get loose, the path may be broken.

If the power connections are secure and the radio set does not operate properly, measure the d-c voltage between the car frame and the terminal from which the radio gets its power. Do this first with the radio turned on and the motor running, then with the radio on but the engine stopped. The generator furnishes charging power to the battery when the engine is running fast, increasing the voltage of the entire system to as high as 8 volts in modern cars. This high voltage explains why a car radio often sounds louder when the motor is running. If the voltage is much below 6 volts with the engine stopped, the battery is defective or needs charging. It should be checked at a service station or a garage.

Types of Battery-operated Receivers. Practically all modern battery-operated radio receivers except auto radios use 1.4-volt tubes, which are designed especially to get filament current from a 1.5-volt dry battery. In addition, these sets require either a 67½- or 90-volt B battery to supply the plate voltage for the tubes. The two batteries may be separate or may be combined in a single AB battery pack, depending on the type of set and its design.

There are five distinct types of battery-operated receivers:

1. Portable receivers, which are the popular pickup type about the size of a small traveling bag, with a carrying handle at the top.
2. Personal receivers, about the size of a folding camera and often having a shoulder strap instead of a carrying handle.
3. Pocket receivers, small enough to fit into a coat or vest pocket and using subminiature tubes and parts along with extremely small batteries.
4. Home receivers, built to look like ordinary table-model or console radios but operating from batteries. Home receivers use the largest batteries

of all, since battery weight is unimportant here and larger batteries cost less per hour of operation.

5. Three-way portables, which are essentially like portable receivers but have a rectifier and switching arrangement that permits operation from a 115-volt a-c line or a 115-volt d-c line as well as from batteries.

Types of Batteries. The AB battery pack shown in Fig. 4 is the commonest today for portables, three-way portables, and home receivers. The pack generally has a single socket that fits a corresponding plug at the

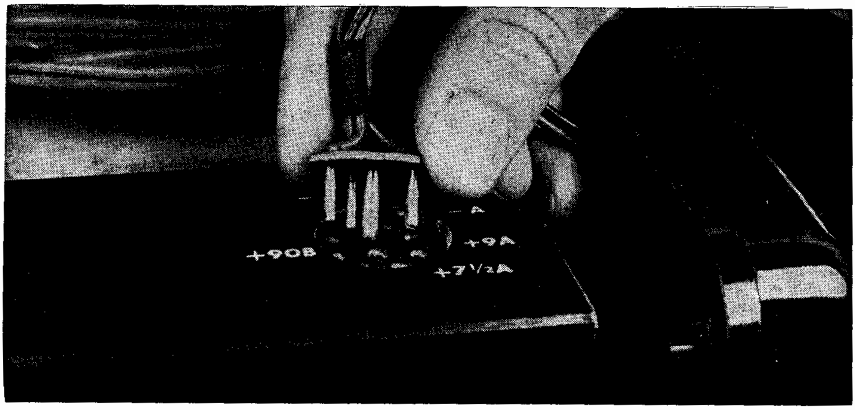


Fig. 4. Typical AB battery pack in three-way portable radio. To connect the battery, simply push the plug into the battery socket. Unequal spacing of pins makes it impossible to get the plug in wrong. (Ray-O-Vac photo)

end of the battery cable in the set, so there is no tedious connecting of individual wires when the battery pack is changed. Battery packs are balanced in design so that the B battery runs down a little before the A battery, as a rule. This ensures that all of the available energy in the more expensive B-battery section will be used.

Large AB battery packs for home radios will generally give between 650 and 1,000 hours of service. The exact life depends on such factors as the number of tubes in the set, the circuit design, and how far the volume is turned up. The louder the volume, the more power is taken from the B battery.

Portables and Home Sets. Some large portables and home receivers, particularly older models, use individual A and B batteries. The example in Fig. 5 uses four batteries. The battery compartments in these large sets are designed so that particular sizes of batteries must be used. These are selected by the manufacturer to give approximately equal life also but with the B battery running down first, just as for AB packs.

When separate batteries are used, the set will have a wiring harness, with individual plugs, snap connectors, or plain wires going to each battery. In modern sets, the battery plug and connector arrangements are usually such that it is practically impossible to make a mistake when

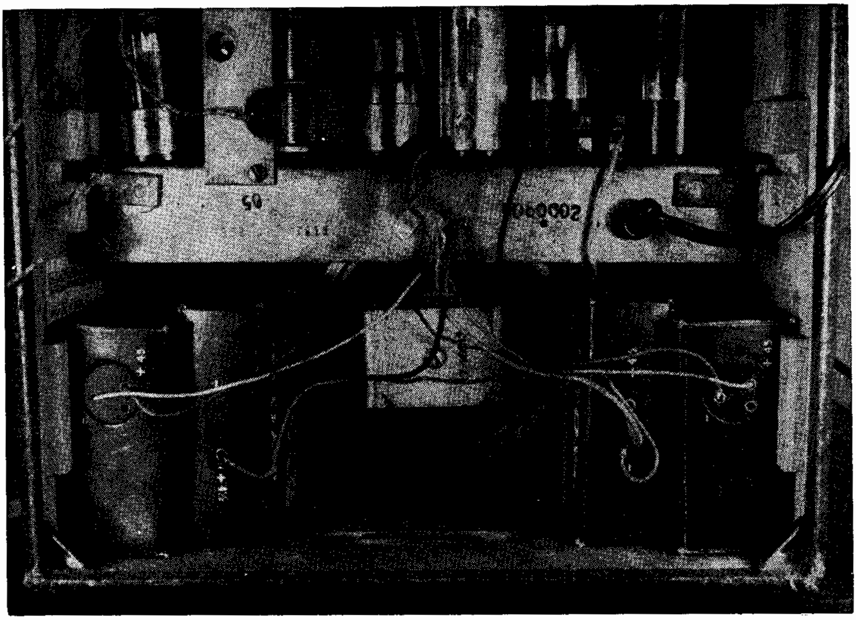


Fig. 5. Three-way portable radio using separate batteries rather than a battery pack. Two are 45-volt B batteries and the other two are 4½-volt A batteries. (Ray-O-Vac photo)

installing new batteries. With older sets, however, the wiring harness was often complicated and hard to hook up. Mistakes were easy to make unless diagrams and color-code markings were carefully followed; very often, an error in connecting the wires resulted in connecting the 90-volt B battery across the 1.4-volt filaments of the tubes, thereby burning out all the tubes in the set.

Personal and Pocket Sets. Personal and pocket receivers usually have separate A and B batteries. The A batteries in the larger personal sets are two or more standard flashlight cells in parallel, as in Fig. 6. Small pocket receivers use pencil-size flashlight cells, also connected in parallel. The 67½-volt B batteries are commonest, though a few sets use small-size 90-volt B batteries.

In these ultracompact sets, space and weight are both kept at a minimum; hence the A battery cannot be made big enough to last as long as the B battery. It is common practice to design the receiver so that anywhere from two to five sets of A batteries will have to be replaced before it is necessary to put in a new B battery. With these sets, then, the first thing to try is new A batteries. These make connections automatically

Fig. 6. Three-way personal portable radio, showing how flashlight-cell A batteries are installed. Connections are made automatically by spring clips when cells are pushed in and cover of set is replaced. The B battery, at right of cells, has snap connections. (Ray-O-Vac photo)

when pushed into position in the cabinet, hence are even easier to replace than tubes.

With personal and pocket receivers, take out the batteries whenever the set is stored unused for a month or more. The small batteries used in these sets will occasionally leak. The electrolyte in them is extremely damaging to metal parts inside the set. The resulting corrosion could easily damage the set beyond repair, as can be seen in Fig. 7.

In most modern three-way portables, the line-cord plug must be inserted in a special outlet on the chassis when battery operation is desired. Inserting the plug completes the connections to the batteries. Removing the plug disconnects the batteries to permit power-line operation.

Three-way Portables. A few models of three-way portables have the 1.4-volt tube filaments wired in series much as in universal a-c/d-c sets.

The series connection simplifies change-over from battery operation to power-line operation. The required A battery voltage is therefore 6, 7½, 9, or 10½ volts, depending on the number of tubes in the set. Since the

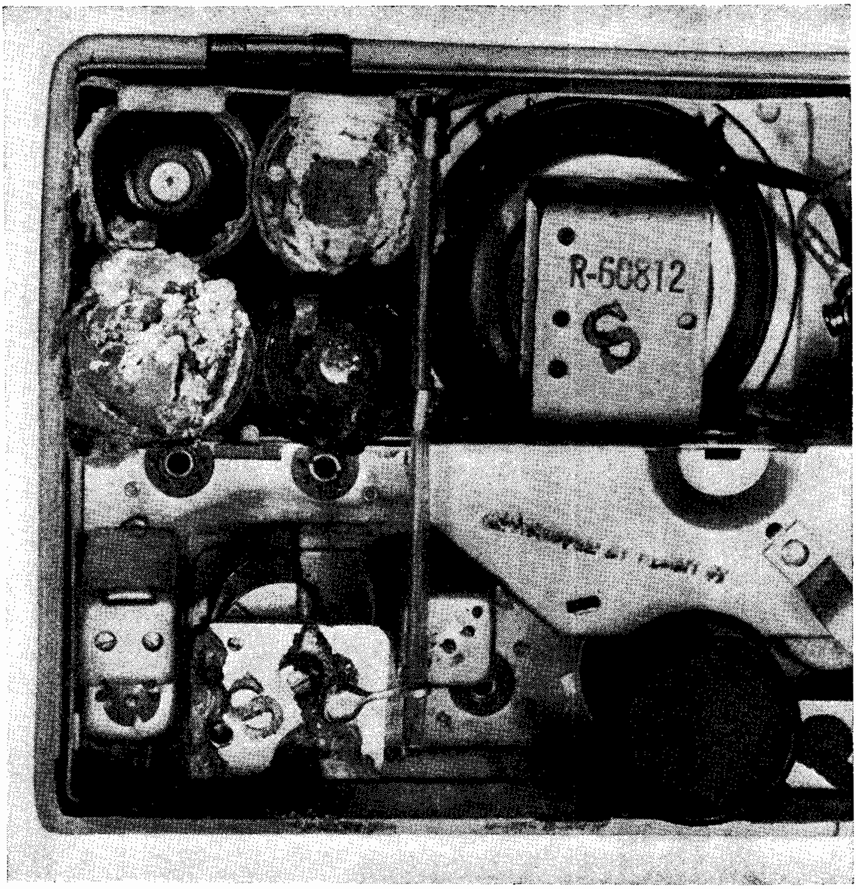


Fig. 7. Leaving batteries in a set for a long time after they are dead can result in a mess like this. Dead batteries in multimeters can make much the same mess. (Ray-O-Vac photo)

required A battery is built into the specified AB pack for the set, battery replacement presents no new problems.

In some three-way receivers the batteries are left in the circuit at all times. This tends to lengthen battery life, because on power-line operation the voltages are usually higher than battery voltages and send a reverse current through the batteries that has some charging effect.

Power-supply defects in a three-way portable receiver can be localized by determining whether defective operation exists at all times or only when the set is used on one of the power sources. If the set will not work on either type of power supply, a signal circuit, a bad tube, or a defective power-supply circuit should be suspected. If the trouble occurs only on battery operation, the batteries, the switching arrangement, or circuits used only on battery operation should be suspected. Trouble that occurs only on power-line operation is confined to the a-c/d-c power-supply system, its switching, or circuits that are only in use on power-line operation.

In some three-way portables, operation on a-c without a battery in the set changes the inductance of the loop antenna, reducing the sensitivity of the set. A sheet of aluminum foil or brass foil (not iron or steel) in the bottom of the battery compartment will restore normal sensitivity in sets where the loop goes around the entire cabinet and hence surrounds the battery. In other sets, the sheet of aluminum foil should be cemented to the side of the battery compartment that is closest to the loop antenna. This sheet of foil then has the same effect on the antenna as did the metal in the battery.

Battery Sets with Vibrators. Some farm radios and at least one model of portable radio are designed to operate from a single A battery, with no B batteries. The A battery furnishes filament current for the tubes and also drives a vibrator-rectifier-filter system like that used in auto radios to furnish the required higher B voltage. Some sets of this type use a large heavy-duty 1.5-volt A battery and have 1.4-volt tubes. One portable set uses a 2-volt spillproof storage battery for the same purpose and has a built-in arrangement for recharging this battery from an a-c power line. Still other sets, of older make, operate from a 6-volt storage battery as in auto radios, but are designed to have the lowest possible battery drain so that the battery will last a reasonably long time before it must be taken to a garage for recharging.

Effect of Weak Batteries. As a battery is used, its voltage gradually falls. The radio first loses its ability to receive distant stations, and the sound becomes distorted.

The drop in performance in a battery-radio set starts from the time a new battery is connected and gets progressively worse, until finally the set fails to operate at all. This reduction in performance due to dropping battery voltage is so gradual that it is not usually noticed by the customer as he uses the set. He probably would not consider replacing the battery as long as local-station reception was satisfactory.

There comes a time, however, when the set will play for only a short period when it is turned on. After the batteries have had a short rest the set may play again for an hour or so and then stop. At this point the customer will probably decide that he should replace the battery. This is usually done without bothering to check with the serviceman or measure the voltage of the battery.

All battery-operated sets made after World War II use standard battery sizes having terminals so designed that it is practically impossible to connect them improperly. This makes it convenient for the set owner to replace batteries himself if he wishes.

In many cases of set failure the customer will tend to blame the battery for failure of his set. Actually the life expectancy of some types of battery tubes is less than the life of an AB battery pack, so that the probability of tube failure is very great. Tubes in a radio should certainly be checked whenever a battery replacement is necessary. It may be found that the tube failure has caused the set to stop operating and that there is some battery life left in the old battery. *Caution:* Always turn off a battery set or three-way portable before removing or replacing tubes, to protect the other tubes from burning out.

In modern battery receivers you cannot see when the tubes are lighted unless the set is in a dark room and you carefully examine each tube. By looking at the bottom of the tube elements in a dark room you may be able to see a deep cherry-red color indicating that the filament is operating. When in doubt, check the tube in the tube tester.

Replacing A and B Batteries. With the larger portable sets having separate A and B batteries, it is best to replace both batteries when one goes bad. If you replace only one battery and allow the customer to use up the remaining life in the other, he will not get very good performance from his set and will have to replace the other battery in a short time. By then, the first new battery will be partly run down, and the customer will never get the best performance from his set.

Replacing C Batteries. A few sets use separate C batteries to obtain negative grid bias voltages for amplifier tubes. Since no current is drawn by grid bias circuits, the life of a C battery would seem to be its shelf life, which is usually several years.

Most radios will operate even after the C battery has dropped in voltage far below its nominal voltage, but they do so at the expense of increased current drain on the B battery. This shortens the life of the B battery. Therefore, to avoid frequent replacement of the more expensive B battery, it is advisable to replace the C battery each time you replace the B battery.

Battery-replacement Data. Most battery manufacturers have available to their dealers and jobbers a comprehensive replacement guide which tells you, by radio make and model number, the types of batteries required for almost every battery-radio set in existence today. With this information, it is easy to find the proper type of battery.

Inside the back of some portable radios you will find a label giving catalog numbers of batteries made by various manufacturers which will fit that particular radio.

Fig. 8. Inserting tray of new batteries in cabinet of three-way portable, after tying the 67½-volt B battery to the tray with a piece of wire. The five flashlight cells are installed with caps alternately up and down to provide the required series connection for 7½ volts. Always note battery positions carefully before removing them. (Ray-O-Vac photo)

When battery installation is somewhat complicated, as in Fig. 8, replacement and connection instructions will usually be found on a label pasted inside the cabinet. Look for it and read it carefully before putting in new batteries. Better yet, study the positions and connections of the old batteries before you take them out.

Checking Battery Voltages. When you are asked to repair a battery set, it is well to check the voltage of the battery. Measure the voltage of each battery with your multimeter when the set is turned on, so that the normal load is applied to the battery. If the A-battery voltage reads about half the rated value or less, it is probable that the set will not operate satisfactorily. Table 1 gives more exact voltages at which different sizes of batteries have reached the end of their useful life when measured under

Table 1. Throwaway Voltage for Radio Batteries

Voltage of New Battery, volts	*Normal Test Load, ohms*	*Throwaway Voltage for Normal Load, volts*	*Throwaway Voltage for No Load, volts*
1½	5	0.8	1.0
3	10	1.6	2.0
4½	45	2.4	3.0
6	120	3.2	4.0
7½	150	4.0	5.0
9	180	4.8	6.0
10½	210	5.6	7.0
22½	2,500	12.0	15.0
45	4,500	24.0	30.0
67½	6,700	36.0	45.0
90	9,000	48.0	60.0

normal receiver or test resistor load. If either section of an AB pack is exhausted, the set will not operate, and a new battery pack must be installed.

Battery-testing Precautions. Test radio batteries with a voltmeter, used while the set is turned on. If the set has been idle for several days, let it operate for at least 5 minutes before measuring battery voltages. A battery tested immediately after a long period of rest will read high, especially if no current is being drawn from the battery.

There may be times when you want to make a quick, rough check of the condition of a battery without bothering to put a normal load on it. In this case, measure the voltage with no load on the battery (nothing connected to it except the multimeter), and use the no-load values in the right-hand column of Table 1 to judge whether the battery should be thrown away.

Resistance-load Values for Testing Batteries. Sometimes a battery has to be tested accurately when its normal load is not available, as when the customer brings in only the batteries for testing. Here a resistance load should be connected across the battery to draw approximately the same current as is normally drawn by the radio set. Table 1 gives the correct resistance-load values for various battery voltages. Ordinary 1-watt resistors can be used in all cases. Connect the proper resistor directly across the battery terminals, then measure the voltage between the resistor leads. Where the battery has a socket for connections, insert the resistor leads in the correct socket holes and push a small nail in alongside each lead to get a firm connection for the test.

If you do a lot of work on battery sets and batteries, it may be desirable to have a battery-testing meter. This is just a voltmeter with built-in load resistors that allow you to select proper loads for various battery voltages. This tester can be purchased from regular instrument manufacturers.

Final Adjustment. After new batteries have been installed, the back of the set has been replaced, and the set is operating, look for an alignment hole in the cabinet. Tune in a weak station at about 1,400 kc on the dial and use a small screwdriver to adjust the screw for loudest signal. This is the final step and should be done on every portable set.

Selling New Batteries. If you find that your customer needs a new battery, you can sell it to him yourself. When you sell a battery to your customer, you should charge him the list price. The price at which the jobber will sell you batteries is about 30 per cent less than the list price, so that you can make a profit of about 30 cents on every dollar which the customer pays you for batteries.

It is common practice to make no service charge for replacing batteries in a customer's radio set if he brings it to your place of business. If there is some defect other than the dead batteries in the receiver, you will of course charge for the additional repairs.

Millions of battery-operated radios are still in use in small towns, rural communities, and farms that do not have electric power-line service. Servicing of these sets is more profitable than for a-c power-line sets, because batteries and tubes both need replacement as often as twice a year. The tubes used in battery radios have delicate filaments that may not even last as long as a good-sized battery in normal use.

The serviceman is the logical person to sell batteries to owners of battery-operated radios, because the set should be checked over and tubes tested each time batteries are replaced. A radio is so important to people in isolated locations that they want it kept in top-notch condition, and are willing to pay for replacement of weak tubes if you point out that they are likely to fail soon. If you can sell a battery pack and a few new tubes even once a year to a list of only a hundred steady customers, you have got a gross profit of at least $350 a year from sales alone, with very little work. Service charges for troubles in sets will boost this considerably, so do not overlook the rural business.

Dates on Batteries. Batteries on the shelf in dealer stocks run down gradually because of chemical action inside. This explains why batteries usually have a printed date on them. The date signifies the end of the period when the battery is like new. After that date the battery has lost a few hours of useful life.

The batteries that you sell should always be fresh and dated well ahead, to maintain your reputation for handling only high-quality products. Most people feel that a battery is completely worthless when outdated, and hence it is bad business practice to convince them otherwise. You can use outdated batteries in your own radios, since they will still give many hours of service, but do not try to sell them to your customers.

Keep only a small stock of batteries on hand, in the most needed types, to minimize the risk of having them get outdated before you can sell them. Better yet, order batteries only as needed, until you are sure there is enough battery business for you to risk keeping a stock on hand.

Battery-cable Troubles. If the battery tests good and all tubes are good but the set still does not operate, you can first suspect some defect in the battery cable. Look for a poorly soldered joint where the wires are connected to the plug. See if the battery wires are frayed, broken, or badly worn. Use your multimeter to check for continuity in each battery-cable wire. Fraying of the battery cable is quite common, since the cables are rather long and are usually made of materials which do not stand abrasion or wear. If the battery cable is in bad condition, it is a good policy to replace it.

You can buy standard battery cables with plugs attached. These cables are generally color-coded as follows:

Red: A+ and usually also B−
Black: A−
Blue: B+

When intermediate voltages are taken from a battery pack, other colors are used for the extra leads. Although standard colors are specified by RTMA for these, it is best to check the extra connections yourself against markings given on the set or in the service manual whenever there is any risk of getting battery wires connected wrong. Do not rely on color codes of wires too much, because manufacturers will sometimes use another color if they run out of the required color of wire.

When connecting a new battery cable, check each wire carefully to be sure you have the right connections. One incorrect connection may result in burning out four or five tubes which you will have to replace free. The safest way is to disconnect only one old wire at a time, and connect the new one in its place immediately.

Snap connectors do not ordinarily give trouble, but there is always a possibility of their making a loose fit. If this happens, spread out the connection cap on the battery a little with a small screwdriver.

Batteries with individual screw terminals are rare in radios today, but you may occasionally encounter them. Always bend the hook of the wire in a clockwise direction when putting a wire under a terminal nut. Tightening the nut then closes the hook instead of spreading it out.

QUESTIONS

1. Why is a grommet used at the hole through which a radio line cord enters the chassis?
2. When installing a new line cord, how is a strain-relief knot made?
3. Where is the fuse for an auto radio usually located?
4. On what three types of power will a three-way portable radio operate?
5. What are the symptoms of weak batteries in a radio?
6. Are tubes likely to fail oftener than batteries in some portable radios?
7. When should a C battery be replaced?
8. What meter is used for testing radio batteries?
9. Should the radio set be on or off when measuring battery voltages?
10. If a 67½-volt battery measures only 50 volts while connected to its normal load, is it ready for replacement?
11. What do dates on batteries mean?

12

TESTING AND REPLACING

Carbon Resistors

Why Resistors Are Important. In all receivers, from the simplest one-tube radio set to the biggest and finest television set, only a few different types of parts are used. These building blocks—coils, condensers, and resistors—work together with tubes to make possible the modern miracle of seeing and hearing actions that are occurring hundreds or even thousands of miles away.

If just one of these parts fails, the receiver may go completely dead, so not even a whisper comes from the loudspeaker and not even a flicker of light shows on the screen; it may look and sound like a thunder-and-lightning storm; it may hum; it may oscillate or squeal like a stuck pig.

No matter how the misbehaving set acts, only one thing is required to make it operate again. That one thing is to replace the part that has failed.

In about five out of every hundred sets coming to you for repair, the part that has failed will be a resistor. It is pretty important, therefore, to learn how to test resistors, find the bad one, order the correct size replacement, remove the bad one, and install the new one as in Fig. 1. It is important, yes, and it is also quite easy because resistors are the simplest electrical part used in receivers.

What Carbon Resistors Look Like. Most of the resistors used in television and radio sets are small carbon resistors, usually much thinner than a pencil and about half an inch long. They are molded to this cylindrical shape from a composition of clay and carbon, hence are also known as composition resistors. They have only two wire leads, one coming from each end of the resistor. The leads may come straight out of each end axially (in line with the body of the resistor), or may come off at right angles to the body of the resistor. The axial-lead resistors usually have a tan-colored plastic insulating covering around the body, whereas side-lead resistors have only paint on the body.

Most carbon resistors are circled with bands of different colors. Some condensers also have color bands or dots and look like carbon resistors, but when you study condensers, you will learn how to recognize them by their color markings.

Fig. 1. Installing new carbon resistor in television receiver in customer's home. Note use of blanket-type pad under receiver and toolbox. (Electrical Merchandising photo)

Review of Resistor Action. As you already learned, resistors provide an electrical path that has a definite amount of opposition to current flow. This opposition is called *resistance.* Increasing the resistance in a circuit increases the opposition to current flow, thereby reducing the current. On the other hand, decreasing the resistance in a circuit allows more current to flow.

In some circuits only a small amount of resistance is required for proper operation. In other circuits, however, a lot of resistance is needed. The unit used to specify the exact amount of resistance is called the *ohm* (pronounced like ome in the word home).

The resistance of any resistor is stated as being so many ohms, just as the voltage of any battery is stated as being so many volts. Large values are expressed in millions of ohms, called *megohms*. Thus, 5,000,000 ohms is 5 megohms, and 2,500,000 ohms is 2.5 megohms. A quarter-megohm, written 0.25 megohm, is therefore 250,000 ohms.

Abbreviating Resistance Values. The symbol used on diagrams to represent a resistor is a zigzag line. On most circuit diagrams there is not much space alongside a resistor symbol for printing the resistance value. Therefore, instead of writing out OHMS or MEGOHMS after the value, certain easily recognized abbreviations are used.

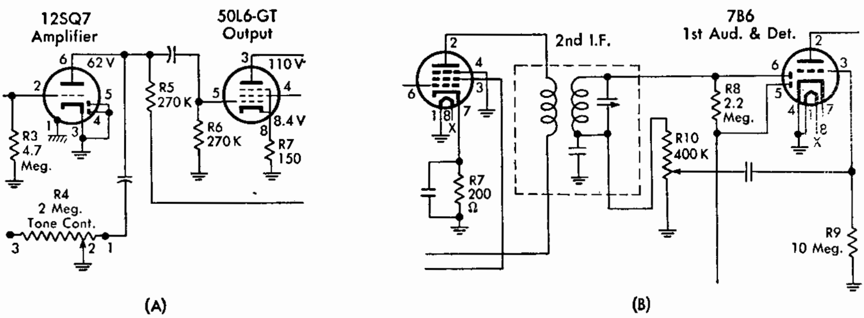


Fig. 2. Methods of specifying resistor values on circuit diagrams. Here the Greek letter omega represents ohms, K represents thousands of ohms, and Meg. represents millions of ohms

The simplest abbreviation is nothing at all, and that is exactly what is used to represent ohms on many circuit diagrams. Therefore, if you see a numeral alongside a resistor symbol with nothing after it, assume that the numeral is the resistance value in ohms. An example of this is indicated in Fig. 2A for 150-ohm resistor R7.

For megohms the abbreviation is logically MEG, written with or without periods. This is used also in Fig. 2A. This abbreviation is so logical that it has even become a part of the conversational language of a serviceman. Instead of saying two megohms, he will simply say two megs. Similarly, he will call out to his assistant, "Hey, Mac, hand me a two-meg resistor."

Sometimes it is even difficult to find space for lettering three zeros on a circuit diagram. For this reason, and also because it saves time, the letter K is used to represent a thousand ohms. Thus, 5K alongside a resistor symbol means 5,000 ohms; 250K means 250,000 ohms; 1.5K means 1,500 ohms. Note that K is used for this purpose in Fig. 2A.

Although the abbreviating system just described is widely used and entirely clear, some manufacturers use the capital Greek letter omega on diagrams to represent the word ohms, as shown in Fig. 2B. Read Ω as ohms whenever you see it, just as you would if Ω were not there. Sometimes Ω is used after MEG and after K also.

Other Abbreviations for Ohms. Occasionally you will find the letter M after a resistance value on diagrams. It may represent either a thousand ohms, like K, or a million ohms, like meg.

You may even find other abbreviating systems, but you will have no trouble figuring out their meaning if you first look at all the resistor values on the diagram. You will always find that thousands of ohms are represented by K, M, or the actual three zeros of the complete value. The remaining abbreviation will therefore be megohms. Another clue is the fact that values in megohms are never larger than 20 in receiver circuits, because 20 megohms is the largest resistor used.

Power Ratings of Resistors. The ability of a resistor to handle and get rid of heat is called its power rating. This power rating is expressed in *watts*, the same as the power ratings of electric toasters, electric-light bulbs, and all electrical appliances. The commonest wattage ratings for carbon resistors are ½, 1, and 2 watts.

As you will recall, the heat-producing power drawn by a resistor increases when the applied voltage is increased or when the current increases. If heat is generated by a resistor faster than it can be passed off to the surrounding air, the resistor gets hotter and hotter. The resistor may even smoke and eventually burn up.

The larger (longer and fatter) a resistor is, the higher is its power rating in watts and the more heat it can handle without getting too hot. Replacement resistors with various power ratings are shown actual size in Fig. 3.

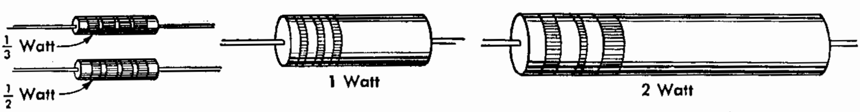


Fig. 3. Actual sizes of ½-watt, 1-watt, and 2-watt resistors of one make. Units made by other manufacturers may vary slightly from these sizes

You can use this illustration as a rough guide for finding the power rating of any carbon resistor.

Occasionally you will come across still-larger resistors, having power ratings up to 5 watts. Also, you will find much smaller carbon resistors in receivers, rated as low as $\frac{1}{10}$ watt because they are in circuits where there is practically no current to produce heat. Use ½-watt resistors for replacing these.

Finding Sizes of Burned-out Carbon Resistors. How do you find the correct size for the new resistor if the old one is burned out and there is no value printed on it or the value is charred beyond recognition? This problem has a simple answer—look up the circuit diagram of the receiver in your Photofact Folders, in Rider's Manuals, or in the manufacturer's service data, and locate the resistor on the diagram.

If the service manual that you are using contains a photograph or a pictorial wiring diagram showing the exact position of every resistor under

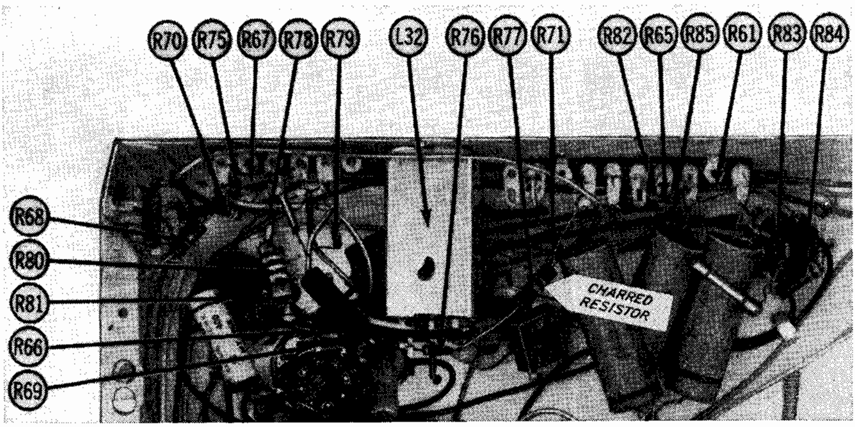


Fig. 4. Portion of parts-locating Photofact Folder illustration for Tele-Tone model TV-315 television receiver. If one resistor in the set were burned out, as indicated by arrow, this illustration would quickly identify it as R77. (Howard W. Sams photo)

the chassis, your job is easy. All Photofact Folders have labeled photographs for this purpose, as shown in Fig. 4. Just locate the bad resistor on the illustration with respect to easily recognized large parts. Note its identifying number, look up this number on the accompanying parts list (Fig. 5) or on the circuit diagram (Fig. 6), and read its resistance value in ohms. Usually the correct wattage rating is also specified.

As an example, assume the resistor at the right of the shield can in Fig. 4 is charred black. The arrow line and number identify it as R77, and Fig. 5 tells you that to replace it you need a 100,000-ohm 1-watt resistor. This table even gives the corresponding IRC (International Resistance Co.) part number for this resistor as BTA-100K, further to simplify ordering a replacement. The circuit shows the parts to which R77 is connected, but need not even be looked at for this job unless you forget how the old resistor was connected after you have removed it.

ITEM No.	RATING		REPLACEMENT DATA		IDENTIFICATION CODES
	RESISTANCE	WATTS	TELE-TONE PART No.	IRC PART No.	
R55	3.9Meg. 20%	½	TRC-395-1	BTS-3.9 Meg.	Sync Amp. Grid
R56	6800Ω 20%	½	TRC-682-1	BTS-6800	Sync Amp. Cathode
R57	22KΩ 20%	½	TRC-223-1	BTS-22K	Integrator
R58	8200Ω 20%	½	TRC-822-1	BTS-8200	Integrator
R59	1 Meg.	½	TRC-105-2	BTS-1 Meg.	Vert. Osc. Grid
R60	220KΩ 20%	½	TRC-224-1	BTS-220K	Vert. Osc. Plate
R61	56KΩ 20%	½	TRC-563-1	BTS-56K	Vert. Osc. Plate Decoupling
R62	6800Ω 20%	½	TRC-682-1	BTS-6800	Vert. Peaking
R63	2.2 Meg. 20%	½	TRC-225-1	BTS-2.2 Meg.	Vert. Output Grid
R64	1000Ω 20%	½	TRC-102-1	BTS-1000	Vert. Output Cathode - See note 7.
R65	1000Ω 20%	½	TRC-102-1	BTS-1000	Vert. Output Decoupling
R66	560KΩ 5%	½	TRC-564-3	BTS-560K 5%	Horiz. AFC Grid
R67	180KΩ	½	TRC-184-2	BTS-180K	Horiz. AFC Cathode
R68	100KΩ 5%	1	TRC-104-6	BTA-100K 5%	Horiz. AFC Cathode
R69	3.3 Meg. 5%	1	TRC-335-6	BTA-3.3Meg.5%	Voltage Divider
R70	150KΩ	½	TRC-154-2	BTS-150K	Horiz. AFC Filter Network
R71	8200Ω	½	TRC-822-2	BTS-8200	Horiz. AFC Filter Network
R72	30KΩ	½	TRC-303-12		Voltage Divider - Temp. Compensation
R73	120KΩ 20%	1	TRC-124-1	BTA-120K	Voltage Divider
R74	270KΩ	1	TRC-274-5	BTA-270K	Voltage Divider
R75	100KΩ 1%	½	TRC-104-SP		Horiz. Oscillator Grid - Temp. Compensation
[illegible]	[illegible]	½	TRC-103-2	BTS-10K	Horiz. Oscillator Transformer Shunt
R77	100KΩ	1	TRC-104-4	BTA-100K	Horiz. Oscillator Plate
[illegible]	[illegible]	½	TRC-470-1		Parasitic Suppressor
R79	180KΩ 20%	½	TRC-184-1	BTS-180K	Horiz. Output Grid
R80	82Ω 5%	1	TRC-820-4	BW-1-82 5%	Horiz. Output Cathode
R81	3300Ω 20%	½	TRC-332-1		

Fig. 5. Example of resistor replacement data given in a Photofact Folder, for same set shown in Fig. 4. Value for resistor R77 is encircled. (Howard W. Sams photo)

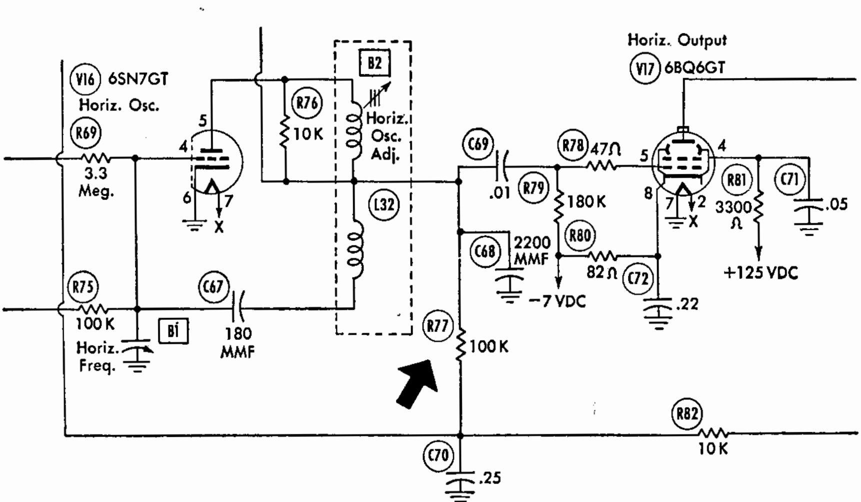


Fig. 6. Portion of circuit diagram for receiver of Fig. 4, with arrow pointing to R77

Use of Circuit Diagram. When no parts-locating photo or diagram is available, you can work from the circuit diagram itself. This has many landmarks that are easily identified both on the diagram and on the set. The best landmark is a tube-socket terminal.

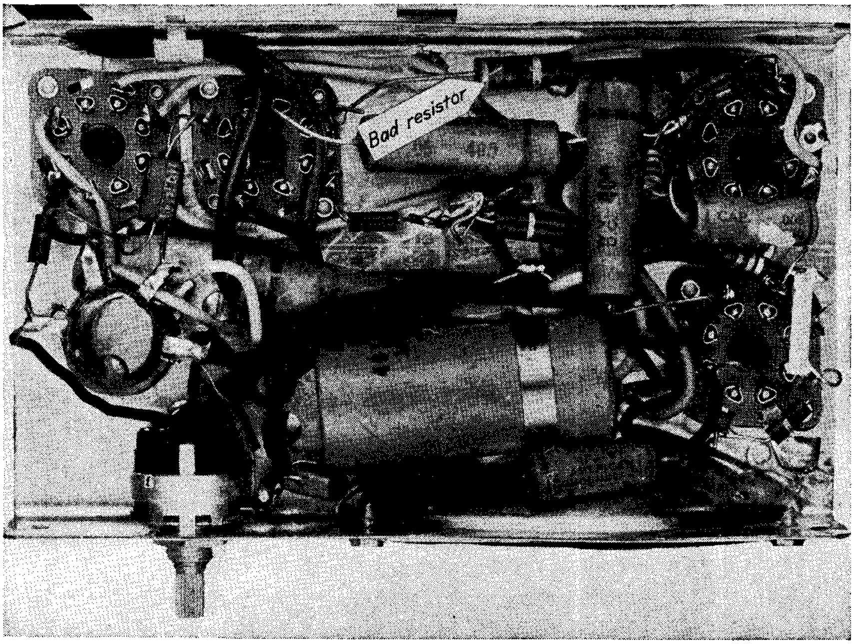


Fig. 7. Bottom of chassis of Aircastle model 5056-A a-c/d-c superheterodyne radio. Practically every resistor here goes to a tube terminal or other easily recognized landmark. Assume the problem is to find the value of the bad resistor at top center, the left lead of which goes to pin 7 of the 35Z5 socket. (Howard W. Sams photo)

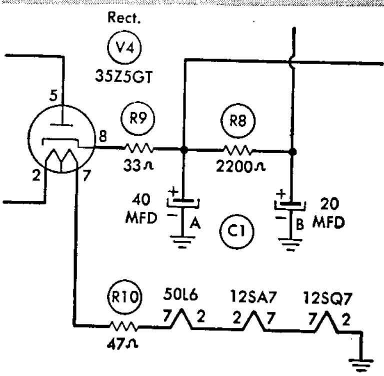


Fig. 8. This portion of the circuit diagram for the receiver of Fig. 7 shows at a glance that the only resistor connected to pin 7 of the 35Z5 tube is 47 ohms

If the bad resistor in your set is connected to a certain terminal on a particular tube, locate that tube on the diagram and look for a resistor connected to the same terminal. This is illustrated in Figs. 7 and 8.

If more than one resistor goes to the terminal in question, you will have to investigate where the other lead of the bad resistor goes. If the other lead goes, for instance, to a 100,000-ohm resistor in your set, you would then choose the resistor on the diagram that also went to a 100,000-ohm resistor. This is all advance information, and you will learn a lot more later about locating parts on diagrams.

Whenever tracing resistor connections in a set or on diagrams, consider wires as direct connections no matter how long they are. In a set, a resistor may be at one end of the chassis and connected by a long wire to a tube-socket terminal at the opposite end of the chassis. On a diagram the same resistor may be drawn right next to that tube terminal.

With this general information about locating resistors on a circuit diagram and in the receiver itself, you are ready for practical replacement information.

How Carbon Resistors Go Bad. Although carbon resistors by themselves ordinarily last a lifetime, occasionally one will fail because of mishandling, overheating, or failure of another part in the radio. No matter what the cause, however, they can fail in only three ways. They either break, burn out, or change their resistance value.

Broken Carbon Resistors. When a carbon resistor breaks, it no longer offers a path for current flow. A broken resistor is just like no resistor at all.

Any number of things can cause carbon resistors to break. The leads of the resistor may have been pulled too tight when the resistor was being connected into the circuit originally. The leads may have been bent too close to the body of the resistor. Too much force may have been put on the resistor when the set was being checked and repaired in a shop. Vibration or ordinary jarring may have caused the break at a weak point in the body of the resistor or in one of its wire leads.

Ordinarily you will not be able to find a broken carbon resistor just by looking at it. As long as the insulation does not break, there is no way to tell that the resistor is broken internally except by checking with an ohmmeter.

Sometimes a carbon resistor does not stay broken. Any little jarring of the resistor causes the two ends of the break to come together again. The next little jar may cause the two ends of the break to fall apart again, though. It may take days or weeks for the trouble to occur again, or the resistor may break and fix itself every few seconds. A resistor that will not stay broken is known as an intermittent defect.

Burned-out Carbon Resistors. If an excessively high current flows through a carbon resistor for any length of time or if the resistor develops a heat-producing internal flaw, the resistor begins to smoke. If this overheating is continued long enough, the resistor may actually burn in two. The resistor no longer provides a path for current flow, so the excessively high current stops.

Rarely will a carbon resistor overheat and burn up because of failure of the resistor itself. Ordinarily the overheating will occur either because one of the resistor leads touches another part in a crowded chassis or because of failure of some other part associated with the resistor in the circuit. If another part is at fault, merely replacing the resistor will not fix the set. If the defect that caused the resistor to overheat is not also fixed, the new resistor will overheat and burn out too. A shorted condenser is the commonest cause of resistor failure. That is why servicemen say that troubles most often come in pairs when one is a resistor.

Changes in Resistance Values. When carbon resistors overheat, their value of resistance changes. Sometimes the resistance may go back to its original value when the resistor cools off, but more often the resistance stays at its new and wrong value.

If the resistance of a resistor changes sufficiently, the receiver goes bad and a serviceman is called. The set may sound weak, distorted, or even dead, just as for failure of any other part.

Finding Bad Carbon Resistors. Often you do not even have to use a test instrument to find a bad carbon resistor. Your ears, eyes, and nose are enough to tell you which one it is, particularly if there has been overheating. Broken resistors and those with poor connections are found by the noise test, which involves tapping each resistor in the set with a wooden stick and noting which one makes the most noise when jarred. If these quick and easy methods do not work, you still have the always-reliable ohmmeter test to fall back on, for checking the resistance values of the suspected resistors. The three methods of finding a bad resistor will now be taken up in turn.

Ear-Eye-Nose Test. Most carbon-resistor failures are due to overheating. The overheating may cause the resistor to burn itself up or change its value of resistance. Most likely the resistor will be blackened, blistered, or entirely burned in two.

The first thing to do in checking for a bad resistor, therefore, is to inspect all the resistors under the chassis of the set. If you find one that is blackened, suspect it and check its value with an ohmmeter as described later. If you find one that is entirely burned in two, however, find what caused it to burn apart before replacing it.

If you do not find a bad resistor just by looking at the set, you may be able to find one when the set is turned on. If an excessively high current is passing through one of the resistors when the set is on, the resistor in trouble will give itself away. It may smoke like a house afire; it may crackle like butter frying in a hot frying pan; it may produce the strong pungent smell of an overheated resistor.

Checking for a defective part first with the ears, eyes, and nose is one of the most important procedures in servicing. Often the defect can be located by this means alone. If it is, a lot of time is saved, so always remember to look first. Use other means of finding the defective part only if you cannot do it this easy way.

Noise Test for Carbon Resistors. Sometimes a receiver becomes noisy when the resistance material in a carbon resistor cracks or one of the leads pulls loose from the resistance material. The noise occurs when the two ends of the break in the resistor temporarily come together and then fall apart again. Each time this make and break occurs, you will hear a crackling noise or a loud crash from the loudspeaker. If the action occurs often enough, it will sound like frying instead.

If you suspect that a resistor is causing the set to be noisy, check for the bad resistor with the set on and at normal sound volume. While listening to the sound coming from the loudspeaker, wiggle and tap each resistor and its leads with an insulating stick or piece of wood. If wiggling a particular resistor increases the noise, you have probably found the bad one.

To make sure that the resistor you suspect is actually the one causing the noise, keep all the other parts from moving while you wiggle the one resistor back and forth.

Measuring Resistance of Carbon Resistors. When you cannot find the bad resistor with your ears, eyes, and nose or with the noise test, then you will usually have to use an ohmmeter to measure the resistance of each resistor you suspect. For each resistor, compare the measured value with the specified correct value.

Before connecting the ohmmeter, always pull the receiver line-cord plug out of the wall outlet. If the receiver is a battery-operated set, always disconnect all the batteries. If the power source is not disconnected, you may burn out your meter or bend its pointer way out of line. This can happen in a fraction of a second. Meter repairs are expensive, so never use an ohmmeter where there is a possibility of getting it connected across a voltage.

If there are possible shunt paths across the resistor being measured, disconnect one end of a resistor that gives a suspicious low reading and measure it again. If you do not disconnect one end of the resistor, the resistance you measure may be the combined resistance of the resistor and some part connected directly across it. In this case the measured value will be too low and will be meaningless in so far as the resistance of the resistor is concerned.

When checking, connect the ohmmeter directly across the resistor. Choose a resistance range that puts the pointer near the center of the scale, where the ohms scale is easiest to read and has greatest accuracy.

Finding Open Resistors with an Ohmmeter. If there is no deflection of the pointer when you connect the ohmmeter across a resistor, even on the highest resistance range of the meter, you have probably found a bad resistor. It is broken or burned out internally, and is said to be open.

An exception occurs when the resistor has a higher resistance than can be measured with your ohmmeter. The ohmmeter then reads INFINITY, just as for an open resistor. You can determine this by looking up the value of the resistor on the circuit diagram or by determining its resistance value from the color code.

Most service-bench ohmmeters measure at least up to 20 megohms. No resistors are larger in value than this in receivers, so an infinity reading will mean an open resistor.

Finding Changed Values of Resistance with an Ohmmeter. When the resistance of the resistor being checked is more than 20 per cent larger or smaller than its rated value, the resistor may be the cause of the trouble and hence should be replaced. Thus, a 100-ohm resistor that measures less than 80 ohms or more than 120 ohms should be replaced. Replacement of an off-value resistor is the only way to find out if it is the troublemaker.

Finding Noisy Resistors with an Ohmmeter. If wiggling the leads of the resistor whose resistance is being measured causes the pointer on the ohmmeter to move back and forth, the resistor is bad. When the two broken parts in the resistor are touching, the meter will show the resistance of the resistor. When the two broken parts come apart, the meter will show an infinite or unmeasurably large amount of resistance.

Of course, the ohmmeter leads must be making good contact with the resistor leads during this wiggling; if they make poor contact, the meter pointer will flicker and a good resistor may be falsely accused. Always use alligator clips on the ohmmeter leads to get good tight connections.

Getting the Correct Replacement Carbon Resistor. Having found the bad resistor, the next step is getting a new resistor with the same or a higher power rating and the same value of resistance. The way these two ratings are found for the bad resistor will now be taken up.

Power Rating of Replacement. To find the power rating of a carbon resistor, compare its size with those shown actual size in Fig. 3. Resistors having the same physical size will have essentially the same power rating. When in doubt, choose a higher power rating for safety. Sometimes the power rating in watts is given after or under the resistance value on circuit diagrams, using the letter W to represent watts. Thus, ½W means a power rating of one-half watt.

In many receivers the smallest-size resistor that will not burn up is used by the manufacturer to save a few cents. Whenever a resistor burns out, it is a good policy to replace it with one having a larger power rating. The extra power-handling capacity of the bigger resistor may prevent its future failure.

Replacing tiny resistors with larger resistors not only ensures against callback due to failure of the new resistor but also gives you the added selling point of being able to say that the parts you put in are better than the original ones. Half-watt resistors are generally the smallest handled by jobbers for replacement use, anyway.

Resistance Rating of Replacement. The resistance value of a resistor can always be found on the circuit diagram or in the parts list of the receiver.

If the resistance value is printed on the bad resistor and can still be read, this is of course the easiest and fastest way to get the information. Printed values can be read directly, but more often the only markings are color bands and dots that represent the numerals of the resistance value. These color codes are easily read and are used often. It is well worth while for you to memorize the list of ten colors and their corresponding values after you have mastered the following explanation of the codes.

Color Coding of Carbon Resistors. The color code on a resistor specifies the resistance of the resistor in ohms just as well as if the value were printed. It is a standard RTMA (Radio-Television Manufacturers Association) code, now used by most manufacturers.

Color-coded resistors are painted with different colors in a definite manner to show resistance value. One method uses three equal-width bands of color around the body of the resistor. Another common method uses the body color of the resistor, an end color, and a central dot or band of color. In both methods, the three colors are read in a definite order, and numbers are substituted for colors according to the code in Fig. 9 to get the resistance of the resistor.

Occasionally a fourth color is used to show the tolerance or accuracy of the resistance marking. This color is easily identified because it is either

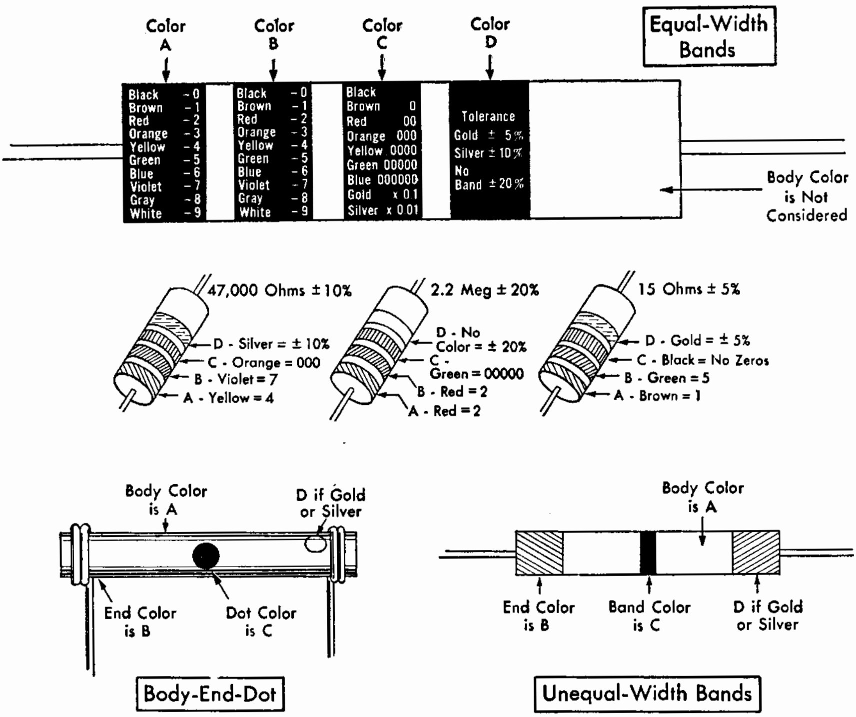


Fig. 9. Color code for carbon resistors, with three examples of reading equal-width bands

gold or silver. The tolerance color is ignored when reading the value of the resistor. The meaning of resistor tolerance is taken up later in this chapter.

Reading Resistors Having Bands of Color. When the resistor has three or more equal-width bands of color, the colors are read in order, starting with the one at the end. The first color is the first numeral in the resistor value. The second color is the second numeral in the resistor value. The third color tells the number of zeros that follow the first two numerals. This gives the resistor value in ohms. The fourth color band, if there is one, will be either gold or silver, and gives the tolerance of the resistor.

Reading Resistors Having Body-end-dot Color Code. When resistors have leads coming off at right angles to the body, a different method of painting the colors on the resistor is used. In this body-end-dot method, the body color of the resistor is the first figure in the resistance value. The end color is the second figure. The center dot is the number of zeros that follow the first two figures. The gold or silver tolerance color, if used, will be on the other end of the resistor.

The body-end-dot method of color coding is occasionally found on resistors having in-line leads, as at the lower right in Fig. 9. The method of reading these is the same as for side-lead resistors.

Just remember that, when color bands are of different widths, you read body color A first, then end color B, then center dot or band C. When color bands are all the same width, you read the colors in order from the end and ignore the body color.

Resistor Color-code Example 1. Suppose you have a resistor with bands of red, green, and yellow, reading from the end. Since the bands are equal in width, red represents the first numeral, which is 2. Next is green, which is 5. The third color is yellow, which stands for four zeros, so you simply put down four zeros after the 2 and the 5 to get the complete resistance value in ohms—250000 ohms. Adding a comma is the final touch to make it easier to read, giving 250,000 ohms.

Note that yellow represents the number 4 for colors A and B, and four zeros for color C. This holds true for all colors, so that black is 1 or one zero, red is 2 or two zeros, and so on. Thus you need only memorize the following list of ten items to memorize the color code:

Black is zero	Green is five
Brown is one	Blue is six
Red is two	Violet is seven
Orange is three	Gray is eight
Yellow is four	White is nine

Resistor Color-code Example 2. Suppose the background color of a resistor is brown, the end color is red, and the dot in the center is orange. This is read according to the body-end-dot method, so brown is 1, red is 2, and orange is 000. The resistance value thus is 12,000 ohms.

Resistor Color-code Example 3. Suppose color A is brown, color B is black, and color C is black. Here brown is 1, black is 0, and black for C means no zeros, so the value is 10 ohms.

Missing Colors. If one of the three color markings on a resistor appears to be missing, the missing color may be the same as the body color of the resistor. Therefore, try reading the body color when there is no other color in a location where one should be. The perfect example of this is an all-red resistor having leads coming out at right angles as in Fig. 9. Here body color A is red for 2, end color B is red for 2, and dot color C is red for 00, so the value is 2,200 ohms.

Tolerances of Carbon Resistors. The fourth color marking, either gold or silver, is used on some carbon resistors to specify the tolerance of the resistor. Tolerance means how much the actual value of resistance may deviate from the numerical value indicated by the color code.

In resistors, as in so many other things, accuracy costs money because it means more careful adjustment during manufacture. A 100-ohm resistor that is accurate to within 20 per cent (actual value somewhere between 80 and 120 ohms) may cost 10 cents, whereas a 100-ohm resistor that is accurate to within 1 per cent (actual value between 99 and 101 ohms) may cost seven times as much.

Most of the resistors used in radio receivers have a tolerance of 20 per cent. This means that their actual resistance may vary as much as 20 per cent above or below the value specified on the resistor. In circuits where a more accurate resistor is required, a resistor with 10 or 5 per cent tolerance is used.

Reading Tolerances. When no tolerance color is painted on a resistor, the tolerance of the resistor is 20 per cent. This means that, when you measure this resistor with an ohmmeter, you will get any value from 20 per cent below to 20 per cent above its rated value. Yes, strangely enough, a brand-new 100-ohm resistor may measure anywhere from 80 to 120 ohms and still be considered entirely good if it has 20 per cent tolerance. Here 20 per cent of 100 is 20, so the resistor can be as much as 20 ohms below or above 100 ohms.

If the tolerance band or color is silver, the resistor has a 10 per cent tolerance. This means that the resistance value can be anywhere between 10 per cent below and 10 per cent above its rated value. A 100-ohm resistor with 10 per cent tolerance could be anywhere between 90 and 110 ohms.

If the tolerance band or color is gold, then the tolerance of the resistor is 5 per cent. The resistance value now is somewhere between 5 per cent below and 5 per cent above its rated value, which for carbon resistors is pretty good accuracy. For a 100-ohm resistor, the tolerance range would be 95 to 105 ohms.

Locations of gold and silver tolerance markings on carbon resistors are shown in Fig. 9, but you will have no trouble spotting these because they are always gold or silver for resistors.

Figuring Tolerance Limits. It takes only a little simple multiplication to find what the actual limits of resistance are for a resistor having a particular tolerance. Knowing these limits, you can easily tell whether or not a resistor you are checking has changed its resistance too much. In addition, knowing the permissible limits of the original resistor allows you to use a replacement resistor anywhere within the limits, if you do not have a new resistor on hand with the same resistance as the old one.

To find the tolerance range of a resistor, multiply the resistance value in ohms by the per cent tolerance expressed as a decimal. Thus, for 20 per cent, multiply by 0.2 to get the tolerance value; for 10 per cent, multiply by 0.1; for 5 per cent, multiply by 0.05. Subtracting this tolerance value from the rated resistance value gives the lower limit, and adding gives the upper limit.

As an example, for a 50,000-ohm resistor with 20 per cent tolerance, the tolerance value is 0.2 times 50,000 ohms, or 10,000. Its lower limit of resistance would then be 50,000 minus 10,000, which is 40,000 ohms; its upper limit would be 50,000 plus 10,000, which is 60,000 ohms. Thus a 50,000-ohm resistor with 20 per cent tolerance may actually have any value between 40,000 and 60,000 ohms.

If the 50,000-ohm resistor had 10 per cent tolerance, it could vary only 5,000 ohms above and below its specified value—between 45,000 and 55,000 ohms.

In a similar manner, a 50,000-ohm resistor with 5 per cent tolerance could be between 47,500 and 52,500 ohms. Resistors with this small a tolerance are more expensive because they are more accurate (closer to specified value). For replacing bad carbon resistors in television and radio sets, a tolerance of 10 or even 20 per cent is satisfactory practically all of the time.

Tolerances of Replacement Resistors. In replacing a carbon resistor, the goal is to get a new one with the same resistance value in ohms, the same tolerance or a *lower* per cent tolerance, and the same or a *higher* power rating in watts.

When you do not have the right resistance value on hand, figure out the tolerance range and use any resistor that is within this range when measured with an ohmmeter. This check with an ohmmeter is highly desirable, because the new resistor will have its own tolerance range and its actual resistance value may be outside the acceptable limits. Of course, you can always connect a questionable resistor temporarily; if it cures the trouble, fine—leave it in.

Removing a Defective Carbon Resistor. Once you locate a defective carbon resistor and have obtained a suitable new resistor for replacement, the next step is to remove the bad resistor. Apply the hot soldering gun tip to the end of one of the resistor leads. As soon as the solder on the joint has melted, grasp the resistor lead with long-nose pliers near the joint, and gently pull and wiggle the lead until it comes out of the joint. Sometimes you may have to pry open the hook in the resistor lead first with pliers or a screwdriver so you can pull it out. If the lead is hopelessly jammed into a terminal lug with a lot of other wires, do not try to get it out; just cut it off as close as possible to the joint.

Repeat the unsoldering procedure for the other resistor lead, and your bad resistor is out. If you do a good neat job of unsoldering, you will not even be able to tell where the resistor was connected, and this brings a warning: Before removing a resistor, make a little diagram showing accurately the terminals to which it was connected, so that you cannot possibly make a mistake when putting the new part in. Make a mistake just once, and you will see why this warning is so important. Whereas it takes only a few minutes to locate a defective part, it can take hours to locate a good part that is connected wrong.

Making a diagram of connections is a good idea *before removing any part*. Suppose you were relying on your memory, and someone came into your shop just as you had pulled out the bad part. You might not get back to work on the set for several hours, and you would really have to be good to remember where that resistor came from after such a long interruption.

After removing the defective resistor, examine the terminals in the set carefully to make sure that you did not also loosen some other leads. Unsoldering often results in lumps of solder running down between terminals, so look for these also and remove all surplus solder. If the leads of the new resistor are to go through the holes in the soldering lugs, you may have to spend a little time cleaning the solder out of the holes with your freshly wiped hot soldering-gun tip.

Installing a New Carbon Resistor. The new resistor should always be installed just as soon as you have removed the defective one. This means that you should have the new resistor on hand before you remove the old one, to minimize chances for mistakes in installing the new one.

The leads of a new resistor will usually be longer than necessary. You can cut these leads down to the correct length either before or after installing the resistor. In both cases, leave the leads long enough so you

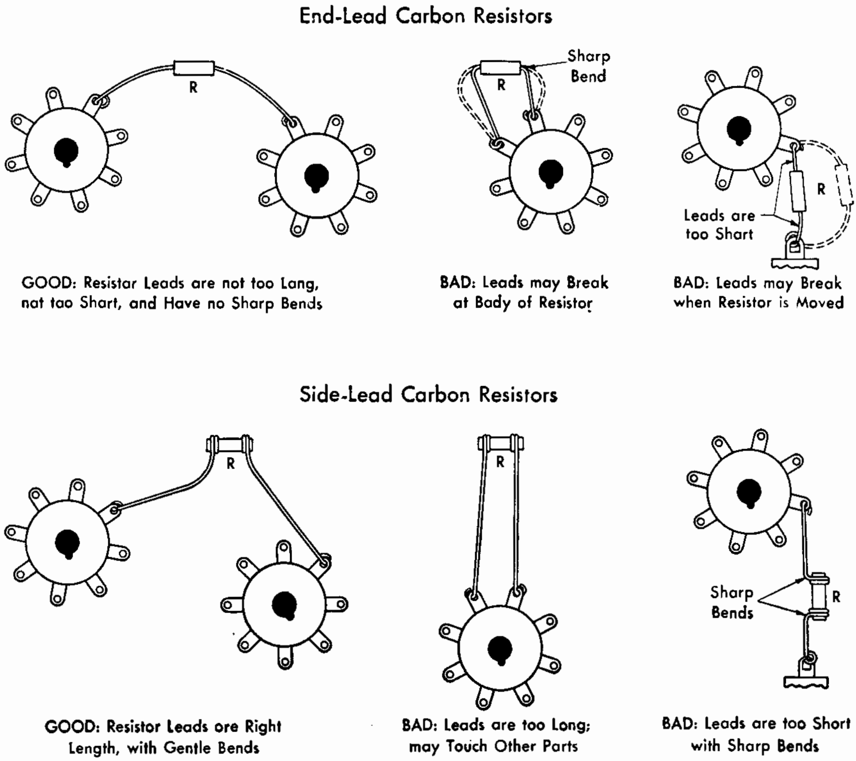


Fig. 10. Good and bad installations of replacement carbon resistors

can move the resistor around a bit after connecting it, but not so long that there will be danger of the bare leads touching other terminals. Examples of good and bad lengths of leads for carbon resistors are shown in Fig. 10.

Many servicemen prefer to insert the leads of the new resistor through the holes in the soldering lugs, pull the leads through far enough to get the resistor in the desired position, then bend back the leads to form hooks and cut off surplus wire.

Having installed the new resistor and adjusted the leads to the correct length, form permanent hook joints by crimping with pliers, then solder the joints. Remember—hold the hot soldering-gun tip on one side of the joint, and apply rosin-core solder to the new wire until the hook in the joint is filled with solder that flows smoothly over the soldering lug.

When there are a number of wires at the terminal to which a new resistor must be connected, it is sometimes difficult to get the resistor lead through the hole in the terminal. In this case it is perfectly all right to bend the resistor lead around one of the leads already connected to the terminal. Of course, make a permanent hook joint here also, and be just as careful to do a good soldering job.

Installing High-voltage Resistors. The carbon resistors used inside the shielded high-voltage compartment of a television receiver are often special types designed to withstand high voltages. When ordering a replacement from your jobber for one of these, be sure to specify that it is for the high-voltage power pack of the set. Better yet, get the correct replacement resistor from the manufacturer's distributor for that make of set.

Before removing a burned-out high-voltage carbon resistor, study its connections carefully. Notice how long each lead is. Notice how smoothly rounded are its soldered connections. Notice the exact position of the resistor. These things are important because a high-voltage discharge called corona can occur if the new resistor is put in carelessly. Corona occurs at sharp points in high-voltage circuits. The resulting colored glow in the surrounding air makes a buzzing sound and interferes with the television picture.

Check Your Work. After installing the new resistor, make one last careful check to be sure you have connected it to the correct terminals and to be sure you have put in the right value of resistor. Poke each soldered joint of the resistor with a screwdriver to be sure you have good tight joints. Adjust the position of the resistor so it does not touch other parts, and adjust its leads so they are well away from adjacent terminals and other leads.

Though practically all end-lead carbon resistors made today for replacement use have insulated bodies, it is still good practice to arrange resistors so they do not touch other parts. With noninsulated side-lead resistors, this spacing between parts is of course essential. Finally, inspect adjacent parts and joints carefully to make sure that no bare leads and terminals are touching.

Using Spaghetti on Resistor Leads. Very frequently, the underside of a chassis is so crowded that bare resistor leads are likely to touch adjacent parts and cause trouble. Here it is best to slip a short length of spaghetti insulation over each lead before installing the new resistor. Allow only enough wire to project from the spaghetti so you can form the hook joint. Avoid touching the spaghetti with your soldering-gun tip, because heat will make the spaghetti smoke and smell like any other burned insulating material.

Trying Out the Set. Having replaced the defective resistor, you are ready to test your work by trying out the set. You can do this without replacing the chassis in the cabinet. First turn on the set, with or without putting the knobs back on the shafts of the controls. Now plug the line cord into the power outlet on your bench.

If you are working on a universal a-c/d-c set, remember that the chassis can be electrically hot for one position of the line-cord plug. Use an isolation transformer between the set and the power line to protect yourself from a dangerous shock. If you do not have an isolation transformer, find the safe position of the plug and mark it.

To find the safe position of the plug, turn on the set first, insert the plug in the outlet, then check the voltage between the chassis and a grounded wire or pipe with a 150-volt a-c voltmeter range. If you get a full line-voltage reading, the chassis is hot. Reverse the plug and try again. This time, there should be a much lower voltage reading (perhaps 30 volts, because of condenser leakage currents). Now you can safely go to work on the set while it is operating. In this correct position of the plug, the grounded side of the power line is connected to the metal chassis of the radio set *when the set is turned on.*

Once you find the correct position of the plug in your particular outlet, mark this position with crayon or a piece of Scotch tape on the top side of the plug. During your work, turn the set on and off by pulling out the plug rather than by operating the on-off switch. This is necessary because, when the plug is positioned correctly, you can get a decidedly unpleasant shock from the metal chassis when the switch is off, unless you pull out the plug. This is why universal a-c/d-c sets always have a protective cardboard back to keep prying fingers away from the chassis.

With a-c receivers the position of the plug does not matter, as there is normally no danger of shock when you touch the chassis. Likewise, if you put a universal a-c/d-c set back in its cabinet and put the knobs and the back cover on, there will be no exposed metal to give a shock except possibly the exposed heads of the chassis mounting bolts.

Sometimes Resistors Are Not Guilty. With due respect for the possibilities of getting a shock, try out the receiver. If it works after the new resistor is installed, fine. Put the chassis back in the cabinet, replace all knobs, screws, and gadgets, wipe off the cabinet so it looks like new, then collect your money for the job.

Do not be discouraged if the set does not work after the new resistor is put in. Sometimes a resistor goes bad because of failure of one or more other parts, such as a condenser. If there are indications that your new resistor is running too hot and getting ready to smoke, look for a shorted tubular paper condenser somewhere near the resistor. You will learn how to test condensers like this in a following chapter. Look also for two leads that are touching together and causing a short circuit that overloads the resistor. Remember—troubles do not always come singly.

A lot of other parts can go bad along with resistors, making it necessary to use troubleshooting procedures. Just put the set aside until you are ready to tackle it again, or have another serviceman finish the job if the set has to be returned to its owner promptly. There is a lot more to fixing sets than can be learned all at once, so do not expect to be able to fix every set right from the start.

Recommended Stock of Resistors. Since it is both impractical and unprofitable to make a trip to a parts jobber every time you need a new carbon resistor, you will want to start with a good assortment of these resistors.

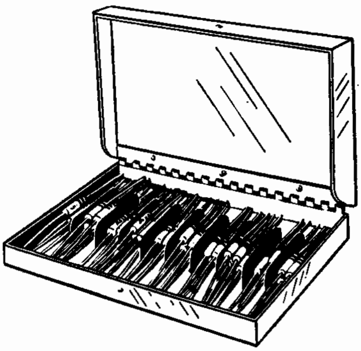
Some resistor manufacturers sell collections of the most used values in a handy cabinet, as shown in Fig. 11. Prices range from a few dollars to over $20, depending on the number of resistors and their power ratings.

The minimum assortment recommended is twenty-four different 1-watt resistors. Their values could be 220, 390, 470, 680, 1,000, 2,200, 3,300, 3,900, 5,600, 10,000, 12,000, 15,000, 22,000, 27,000, 33,000, 39,000, 47,000, 56,000, and 68,000 ohms, and 0.1, 0.27, 0.47, 1.0, and 2.5 megohms.

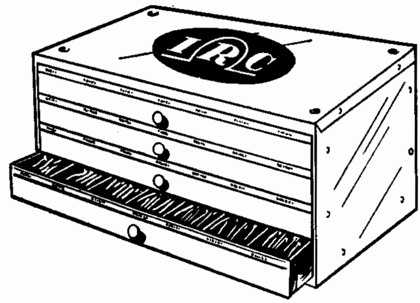
Of course, larger assortments are still more desirable, but the above will give you a good start at a big saving over the cost of individual resistors. Start with 1-watt assortments because these can be used to replace lower-wattage resistors just as well. Later you may also want to have an assortment of ½-watt resistors, as these are smaller and sometimes easier to install in a crowded television chassis.

As your business expands, you will find it profitable to buy the most used values of resistors in lots of ten of a kind, to eliminate the nuisance of frequent reordering. You can sometimes also save money by buying in lots of ten or more.

If you have a bit of spare room in your toolbox, put in the following ten resistors: 1,000, 5,600, 10,000, 23,000 and 47,000 ohms, and 0.1, 0.27, 0.47, 1.0, and 2.5 megohms. Hold them all together with a rubber band. Put in a few more sizes if you have room, because having the right resistor



4	1,000 Ohms	6	0.1 Meg	5	1.0 Meg
3	4,700 Ohms	3	0.22 Meg	4	2.2 Meg
4	10,000 Ohms	5	0.27 Meg		
5	47,000 Ohms	6	0.47 Meg		



2	47 Ohms	2	2,200 Ohms	3	33,000 Ohms	3	0.33 Meg
3	100 Ohms	2	2,700 Ohms	6	47,000 Ohms	6	0.47 Meg
2	220 Ohms	3	3,300 Ohms	2	56,000 Ohms	6	1.0 Meg
2	270 Ohms	5	4,700 Ohms	2	68,000 Ohms	5	2.2 Meg
3	470 Ohms	5	10,000 Ohms	6	0.1 Meg	2	3.3 Meg
6	1,000 Ohms	3	22,000 Ohms	5	0.22 Meg	3	4.7 Meg
2	1,500 Ohms	3	27,000 Ohms	6	0.27 Meg	2	10.0 Meg

Fig. 11. Examples of IRC carbon-resistor stock cabinets having sizes most needed for repairing television and radio sets. The larger the kit, the more likely it is to have the particular resistance value needed. Note that up to six resistors are furnished for the most needed sizes

on hand will save you a trip to the shop when you encounter a burned-out resistor on a house call.

Printed Resistors. Carbon or metalized resistance material can be printed, painted, or sprayed directly on a plastic chassis or on a block of insulating material to give what is known as a printed resistor. This technique has been used for some time in the manufacture of hearing aids and vest-pocket-size portable radio receivers, because resistors made in this way take practically no space.

Resistor-condenser combinations in television and radio sets also have printed resistors. Examples of printed resistors are shown in Figs. 12, 13, and 14. The resistors are printed directly over terminal rivets or over previously applied strips of silver ink that serve in place of wiring. The entire unit is then coated with an insulating material.

Testing Printed Resistors. Printed resistors can burn out or open just like ordinary carbon resistors, though failures are rare because they are used in circuits that carry little current. A printed resistor can be tested with an ohmmeter if its leads are accessible, just as you would test any other resistor. Their values are usually about a megohm in television and

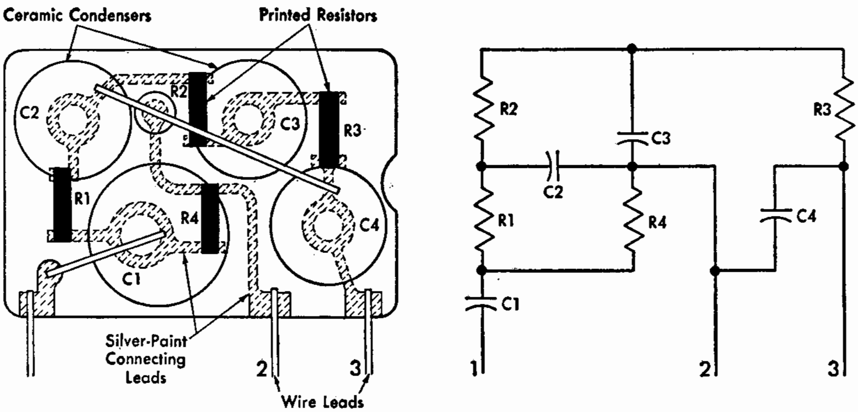


Fig. 12. Construction and circuit of a unit having four printed resistors and four ceramic condensers and yet only three wire leads. These resistors cannot be tested

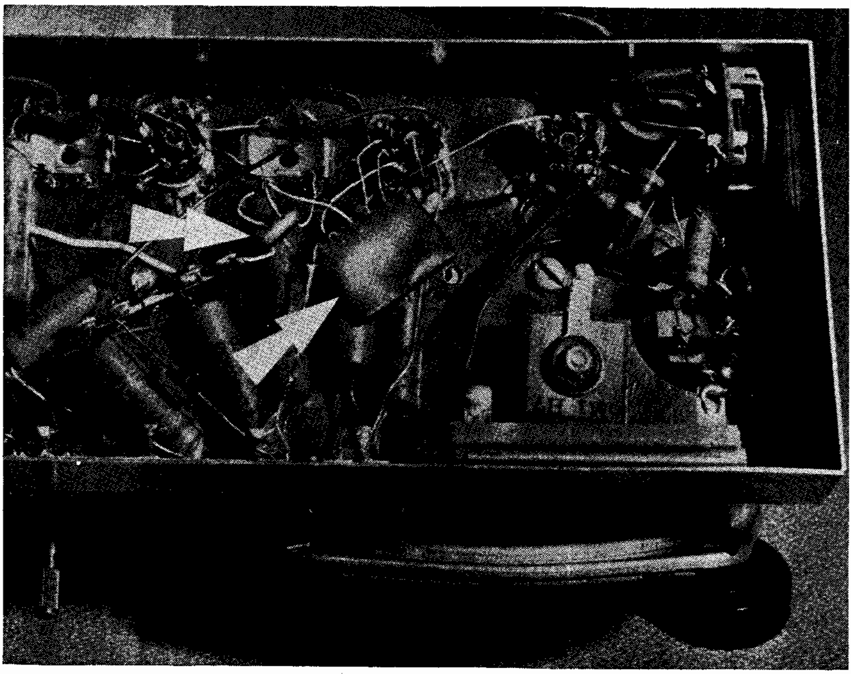


Fig. 13. Wells-Gardner radio set having two printed-circuit units, indicated by arrows. This set also uses a selenium rectifier (square metal unit just above loudspeaker) in place of a rectifier tube. (Centralab photo)

radio sets, so use the highest ohmmeter range. Just as with other carbon resistors, the correct value can generally be found on the circuit diagram or parts list for the set.

The printed resistors in Fig. 12 cannot be tested with an ohmmeter

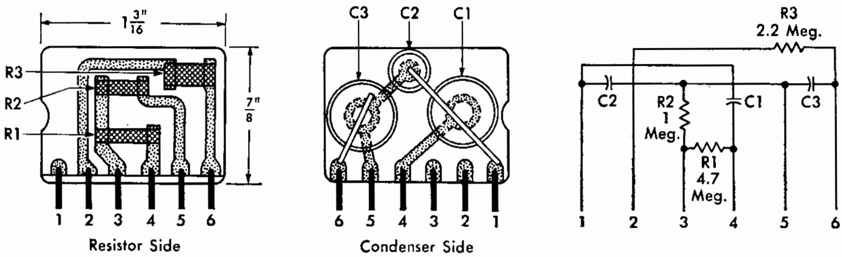


Fig. 14. Front and back views and circuit diagram of printed-circuit unit in which resistors can be tested individually with an ohmmeter because they go directly to external leads. Dots at line intersections on circuit diagram indicate connections; no dots then mean no connections

because their terminals are covered with insulating material and the resistors do not connect directly to the external leads of the printed-circuit unit. A condenser is in the path of every resistor between leads; hence ohmmeter measurements between leads of a new unit will give infinity readings. (A good condenser is the same as an open circuit to an ohmmeter.) Trying an entire new part is the only test you can make if an open printed resistor is suspected here.

The printed resistors in Fig. 14 can easily be checked with an ohmmeter because every one is connected directly to external leads. Thus, measuring between leads 3 and 4 checks R1, which should be 4.7 megohms within 20 per cent; measuring between 3 and 5 checks R2, which should be 4.7 megohms within 20 per cent; measuring between 2 and 6 checks R3, which should be 2.2 megohms within 20 per cent. Tolerance of printed resistors is generally 20 per cent. For a 4.7-megohm resistor, the tolerance range then is 3.8 to 5.6 megohms. For a 2.2-megohm resistor, the tolerance range is 1.8 to 2.6 megohms.

Replacing Printed Resistors. When a printed resistor fails, it is usually best to replace the entire printed unit with a new printed unit or with new individual parts.

If you can get at the terminals or if they go directly to external leads, it is sometimes possible to connect the correct resistance value of a ½-watt or smaller carbon resistor between the terminals of the bad resistor. First scrape away a path across the bad printed resistor to make sure it stays open. Hold the tip of the soldering gun on the joints only long enough to make the joint properly, to avoid unsoldering other connections. A low-melting-point solder is often used in assembling printed circuits, and excess heat would melt everything.

Reading Circuit Diagrams. Now that you are beginning to see the need for using circuit diagrams to get servicing information for fixing radios, a bit of extra information on reading these diagrams should prove useful at this time.

Several different ways are used on diagrams to show whether or not wires join when they cross each other. In that shown in Fig. 14, a dot is used to indicate that wires are connected together where they cross, and the dot is omitted when there is no connection.

In another widely used diagram-drawing method, a curved jumper or half-circle is used at a crossover to indicate that wires do not touch, and a dot is used to indicate a connection at a crossover.

In rare cases the dot is omitted when jumpers are used. If you see curved jumpers on the diagram, then you can assume that there is a connection wherever lines cross but do not have this curved jumper.

Combining Resistors in Series. Even though you try to keep a good stock of resistors on hand, there will be times when a needed value is

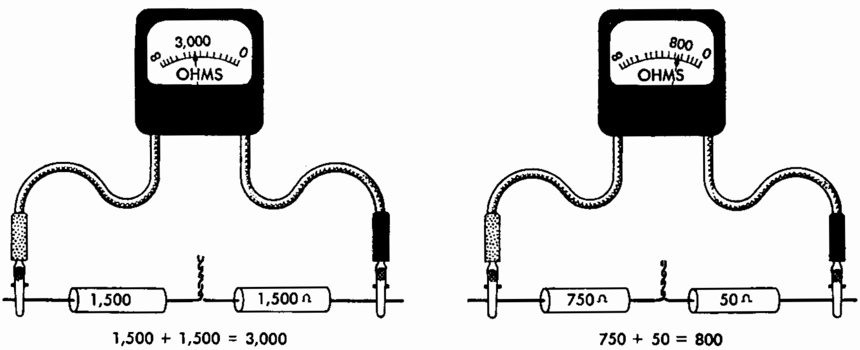
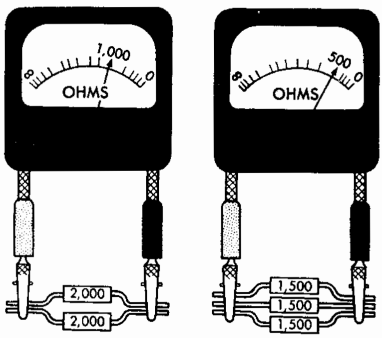


Fig. 15. When resistors are in series, add their values to get the total resistance

missing. Instead of holding up the repair job, you can combine two smaller-value resistors in series as in Fig. 15 to give the required value. Just remember that resistor values add when in series. Wrap a bit of insulating tape over the splice between the two resistors if there is a possibility that the splice will touch a bare terminal.

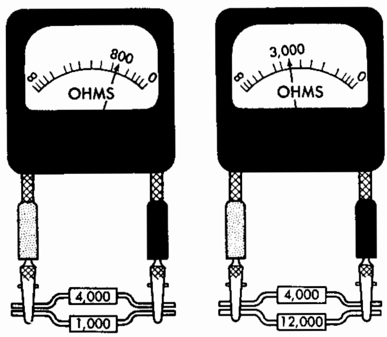
It is a good idea to check the combined resistance value with an ohmmeter, to make sure it is somewhere near the specified value. If it is too far off, try other combinations. Resistors can have up to 20 per cent tolerance. If the tolerances of individual resistors happen to be in opposite directions, the combined resistance will also be as much as 20 per cent off from what you expect.

Combining Resistors in Parallel. Resistors can also be combined in parallel to obtain a value that is not in your stock. The easiest way is to combine resistors that have the same value, as in Fig. 16. Just divide the resistor value by the number of resistors you put in parallel. Thus, if you need a 1,000-ohm resistor, connect two 2,000-ohm resistors in parallel. Similarly, three 1,500-ohm resistors in parallel give 500 ohms.



2,000 ÷ 2 = 1,000 1,500 ÷ 3 = 500

Fig. 16. When equal-value resistors are in parallel, divide the value of one of them by the number of resistors in parallel to get the combined resistance



Less than 1,000 Ohms Less than 4,000 Ohms

Fig. 17. When two resistors of unequal value are in parallel, the combined resistance is less than that of the smaller resistor, as shown by the ohmmeter readings here

When resistors of different values are connected in parallel, the combined resistance will always be lower than that of the smallest resistor in the group. Try connecting different combinations in parallel as in Fig. 17, and you will see that this always holds true. When a particular value is needed, start with the next higher resistor value that you do have, and try different resistor values in parallel with it until the ohmmeter shows that you have the right combination. With a little practice, you will be able to get close enough to the required value in two or three tries, without any complicated mathematical figuring at all. Remember that coming within 20 per cent is usually close enough.

QUESTIONS

1. How many ohms is 0.5 megohm?
2. How many ohms is 2.2K?
3. What are the commonest power ratings for carbon resistors?
4. Will a 2-watt resistor handle more current and power than a ½-watt resistor?
5. In what three ways do carbon resistors go bad?
6. What does an infinity reading mean when checking a resistor with an ohmmeter?
7. What is the value in ohms of a resistor having three equal-width bands, the first being *blue,* the second *gray,* and the third *orange?*
8. What is the value in megohms of a resistor that is color-coded *red, green,* and *green?*
9. If a color is missing on a color-coded resistor, what do you read?
10. If a 1,000-ohm resistor with 20 per cent tolerance measures 850 ohms, would you consider it good?
11. If a resistor that is color-coded *yellow, violet, orange,* and *silver* measures 33,000 ohms, would you consider it good?
12. Under what conditions is it desirable to shorten the leads of a new carbon resistor?
13. What is the combined resistance of two 1,000-ohm resistors in series?
14. What is the combined resistance of two 1,000-ohm resistors in parallel?

13

TESTING AND REPLACING

Wire-wound Resistors

Wire-wound Resistors. Though no two look alike, all of the resistors in Fig. 1 are made the same way, by winding a length of Nichrome resistance wire around a ceramic, glass, fiber, or asbestos form. For this reason, they are called wire-wound resistors. The wire used is just like that in the heating elements of electric stoves, but usually much thinner.

Some of the smaller wire-wound resistors, which have low wattage ratings, look exactly like end-lead carbon resistors. Other low-wattage types are wound on flat forms and encased in molded plastic so that they look like mica condensers. Larger fixed wire-wound units, with wattage ratings of 5 watts and up, have a variety of shapes and terminals, with the resistance wire wound on hollow tubular cores so heat can escape from the inside as well as the outside. The resistance wire is usually covered with enamel or other heat-resisting insulating material. Flexible resistors and line-cord resistors use the same kind of wire, wound around asbestos string and covered with braided insulation.

Some special types of wire-wound resistors have fixed taps for making extra connections, hence are called tapped resistors. Others have adjustable taps that can be slid to any desired position along the length of the resistor and tightened there with a screwdriver.

Ordinarily you will find wire-wound resistors only in power-supply circuits. In the power supply the current is usually considerably larger than anywhere else in the receiver, so the resistors often must have higher wattage ratings than the 5-watt limit of carbon resistors. Wire-wound resistors can be made large enough to have any required wattage rating.

How Wire-wound Resistors Go Bad. Only two things can ordinarily make wire-wound resistors go bad. They either burn out or one of their terminals gets loose.

If an excessively high current passes through a wire-wound resistor for any length of time, the wire may melt. When this happens, the resistor is said to be burned out or open, and it no longer offers a path for current flow.

Sometimes a bad contact develops between the resistance wire and a terminal of the resistor, as shown in Fig. 1. This may actually open up

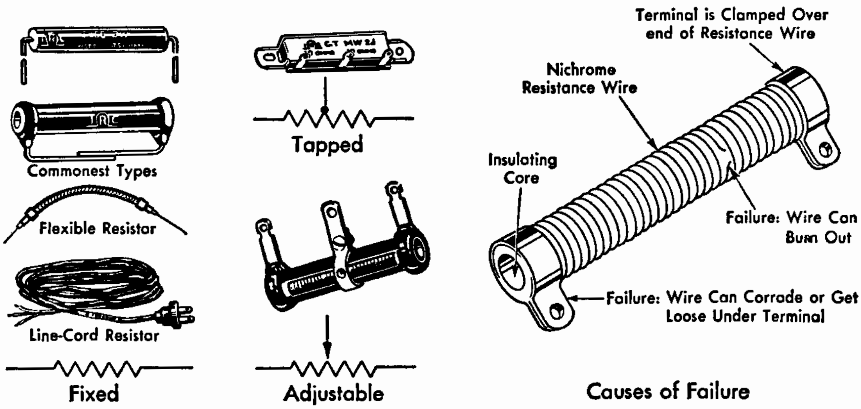


Fig. 1. Examples of three types of wire-wound resistors, along with their symbols and common causes of trouble in any wire-wound resistor

the resistor, just as does a burned-out wire. More often, though, a loose or corroded terminal connection makes the resistance value go way up, with the action often occurring intermittently. The resistor may be good when cool and go bad as soon as it warms up after the set is turned on, or may alternately be good and bad.

How Bad Wire-wound Resistors Are Found. Overheating and consequent melting of the resistance wire is the main trouble encountered in wire-wound resistors. You can usually spot an overheated resistor by its charred appearance or discoloration.

If you suspect a particular wire-wound resistor as being bad, measure its resistance with an ohmmeter. Remember that to measure the resistance the line-cord plug must be pulled out of the wall outlet. One end of the resistor must be disconnected from the circuit if there are other paths for direct current between the resistor terminals.

If the resistance measured is infinite, the resistor is open and should be replaced. If the measured resistance is more than one and a half times as high as it should be, or if it changes when one of the resistor terminals is wiggled, the resistor is likewise bad and should be replaced.

Resistance Values of Wire-wound Resistors. Once you have located a bad wire-wound resistor, the next job is to get the correct size of replacement. The resistance value of the new unit should be the same as for the old one if at all possible. Wire-wound resistors are generally used in parts of sets where the resistance value is somewhat critical. Standard tolerance for wire-wound resistors is 5 per cent for this reason.

Values of wire-wound resistors used in television and radio sets are generally well under 100,000 ohms. For higher values, carbon resistors are used. Always use the same type of resistor for a replacement—carbon for carbon and wire-wound for wire-wound.

When a wire-wound resistor is burned out, you will usually have to refer to the circuit diagram or parts list to find the resistance value, because printed markings and color codes generally disappear after a few years of use. Where printed markings are still clear, by all means use them. Likewise, if the resistor is color-coded and the colors are not faded, read the code to get the resistance value.

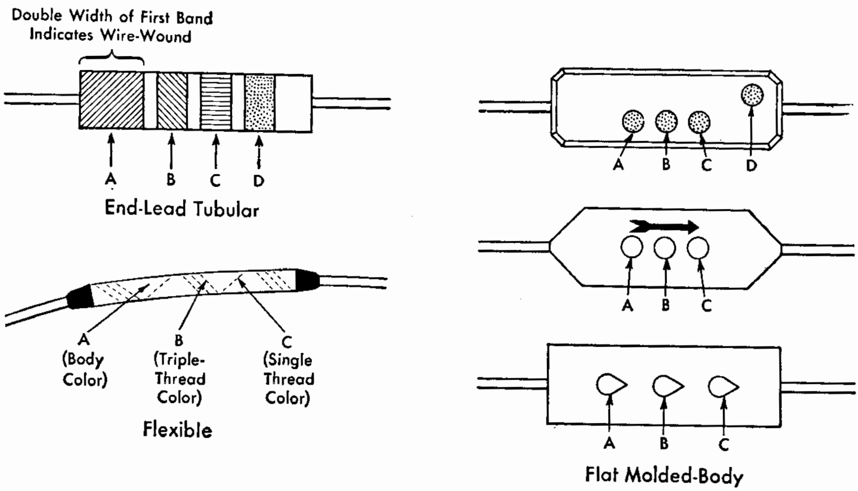
Color Codes for Wire-wound Resistors. When a wire-wound resistor is marked according to one of the RTMA systems shown in Fig. 2, you can read its resistance value directly just as for carbon resistors.

Small end-lead wire-wound resistors look exactly like carbon resistors and are color-coded the same way except that the first color band is twice as wide as the others to indicate wire-wound construction. With wire-wound resistors below 10 ohms, the regular RTMA color code does not work because the lowest it can specify is brown-black-black for 10 ohms. To take care of this, gold and silver colors are used for color C to indicate decimal multipliers.

How to Use Decimal Multipliers. For values from 1 to 10 ohms, gold is used for color C to represent the decimal multiplier 0.1. This means that the value represented by the first two colors must be multiplied by 0.1 to get the final value in ohms. Thus a 5-ohm resistor would be green-black-gold; here green is 5, black is 0, and gold means that 50 is multiplied by 0.1 to get 5 ohms. Similarly, red-green-gold is a 2.5-ohm resistor; here red is 2, green is 5, and gold means that 25 is multiplied by 0.1 to get 2.5 ohms.

For values from 0.1 to 1 ohm, silver is used for color C to represent the decimal multiplier 0.01. Thus, a 0.47-ohm resistor would be yellow-violet-silver (a pretty combination); yellow is 4, violet is 7, and silver means that 47 is multiplied by 0.01 to get 0.47 ohm.

Color Code for Flexible Resistors. Instead of using bands of color, flexible resistors are color-coded by means of different colored threads woven into the insulating covering.



Color A	1st Figure of Resistor Value	Color B	2nd Figure of Resistor Value	Color C	Number of Zeros After 2nd Figure	Color D	Percent Tolerance
Black	0	Black	0	Black	None	Gold	± 5%
Brown	1	Brown	1	Brown	0	Silver	± 10%
Red	2	Red	2	Red	00	None	± 20%
Orange	3	Orange	3	Orange	000		
Yellow	4	Yellow	4	Yellow	0,000		
Green	5	Green	5	Multiplier			
Blue	6	Blue	6	Gold	0.1		
Violet	7	Violet	7	Silver	0.01		
Gray	8	Gray	8				
White	9	White	9				

Fig. 2. Standard RTMA color code for wire-wound resistors, using same colors as for carbon resistors but different arrangements of the colors

The body color of the woven fabric covering is color A and gives the first number of the resistance value. The triple-thread color woven into the fabric is color B, for the second number in the resistance value. The color of the single thread woven into the covering is color C, for the number of zeros that follow or for the decimal multiplier.

As an example, suppose a flexible resistor has a yellow woven fabric covering, a green triple thread, and a single black thread woven into the covering. Color A is yellow for 4, color B is green for 5, and color C is black for no zeros, so the resistance is 45 ohms.

Dot Color Codes. Some wire-wound resistors are molded into plastic, much as mica condensers. These resistors are often marked with colored dots that give the resistance value. There will sometimes be an arrow or other marking to show the direction in which you read the colors of the dots. If there are four dots, the fourth will be gold, silver, or unpainted to indicate tolerance; you then know that you should start reading from the other end of the resistor even when there are no arrows to indicate this.

Power Ratings for Wire-wound Resistors. Ordinarily, you will have to look on the circuit diagram or in the parts list of the set to find the power rating of a bad wire-wound resistor. Even if these data were originally printed on the resistor, it will usually have faded out long ago because of heat.

Sometimes the power rating is placed under the resistance value on a circuit diagram. Here W represents watts, so 5W would mean 5 watts, and 10W would mean 10 watts.

The power rating of the new unit should be the same as for the old unit, or higher. This means that the new resistor should be the same physical size as the old, or even larger. Remember, however, that, if the new resistor is very much larger, you may have trouble fitting it into the available space in the chassis.

When in doubt about the power rating, you can safely order a 10-watt unit for the average television or radio set. Rarely are higher power ratings needed for single fixed resistors, even in power-supply circuits.

For convenience in installing, try to get a new resistor having essentially the same size and the same kind of leads or terminals as were on the old unit. Five-watt and ten-watt wire-wound resistors for replacement sometimes have both leads and terminals, but it is usually best to use the leads. Just ignore the terminals or cut them off.

Installing New Wire-wound Resistors. Follow the same procedure as for carbon resistors. Make a diagram of the connections, then unsolder the leads of the bad resistor and connect the new resistor in its place. Keep the leads short but not too short, just as for carbon resistors. With resistors, it does not matter which end goes to a particular terminal.

After installation of the new resistor, check for other defects in the circuit that might cause the new resistor to fail too. Look for wires that are touching each other or the chassis. Look for another bad part that could cause excessive current to flow through the new resistor. As with carbon resistors, shorted condensers are frequently the real cause of the trouble. Remember that wire-wound resistors rarely fail by themselves—they are usually overloaded by failure of another part in the circuit.

Finally, adjust the position of the new wire-wound resistor so it is well away from paper condensers or other parts that might be damaged by heat.

Tapped Resistors. Only two types of tapped wire-wound resistors are used to any extent in television and radio receivers. One is round like the

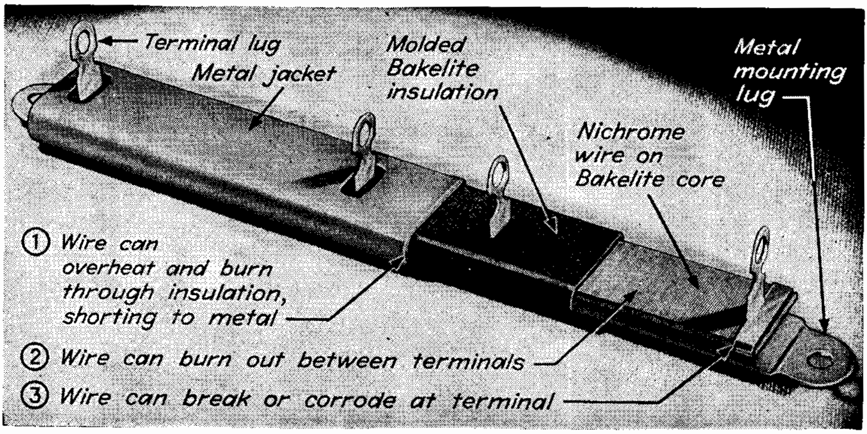


Fig. 3. Ways in which a metal-encased wire-wound resistor can go bad

ordinary wire-wound resistor but is usually thicker and longer, with extra terminals along its length. This type is held rigidly in position by brackets riveted or bolted to the chassis. The extra terminals or taps connect to the resistance wire along its length. The positions of the taps determine the amounts of resistance between the taps and the end terminals of the resistors.

The other type of tapped resistor, used much more often, is flat rather than round, and is generally enclosed in a metal housing or can, as shown in Fig. 3. The metal-encased types are sometimes called Candohms, this being the trade name of one manufacturer of these units. The metal can protects the resistance wire and its insulation against damage and helps to get rid of the heat generated by the resistor. Metal-encased tapped resistors are generally riveted directly to the side of the chassis, so that heat is transferred directly from the metal can to the heavy metal chassis.

Tapped resistors are used chiefly between B+ and B− of a power supply. The taps allow various fractions of the total voltage across the resistor to be taken off and used for tubes that require lower voltages.

Tapped resistors use the standard resistor symbol on circuit diagrams, with lines going to various points along the zigzag symbol to represent the taps, as in Fig. 1. Sometimes dots are used at the connecting points on the resistor symbol to indicate a connection, but more often no dots are shown.

How Tapped Resistors Go Bad. Since tapped resistors are exactly the same as ordinary wire-wound resistors except for the extra terminals, they have the same defects. They can burn between any pair of terminals, or one of the terminals can get loose. In addition, the metal-encased types can become grounded to their metal can and the chassis when the insulation burns up, as shown in Fig. 3.

Determining If a Tapped Resistor Is Bad. Whenever a tapped resistor is blackened or discolored, has a tarry mess around it, or smokes when the set is on, suspect it as being bad. It may be burned out or may be shorted internally to the metal shield.

To check a tapped resistor, first make a simple diagram of all the leads going to its terminals, somewhat as in Fig. 4. Now you

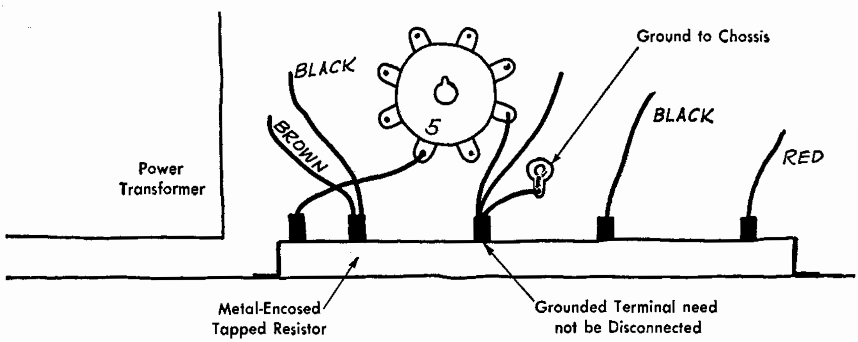


Fig. 4. Before unsoldering the leads of a defective tapped resistor, always make a rough sketch of the connections as a guide for connecting the new unit

can unsolder all the leads connected to the terminals of the resistor, to permit ohmmeter measurements. Leads connected to the grounded resistor terminal (the terminal connected to the chassis of the set) need not be removed for these measurements.

After removing the wires from the terminals, measure the resistance of each section (between two adjacent terminals) of the tapped resistor.

Compare each measured value of resistance with that specified for the corresponding section of the resistor on the circuit diagram of the set.

If the measured resistance is essentially the same as that specified on the diagram for a particular section, then that section of the resistor is good. If an infinite resistance (no needle deflection) is measured for one section of the resistor, that section is burned out. If the resistance measured is quite a bit less than the resistance specified for that section and the resistor is of the Candohm type, the resistor is shorted internally to the metal case.

If the resistance of every section of the resistor measures right, you have cleared the tapped resistor of suspicion, unless it is metal-encased and has no terminal connected directly to ground (the metal can or chassis). Here you will also have to measure the resistance between each terminal of the resistor and the metal can. A low or zero resistance reading between any terminal and the can means there is an internal short or ground between the resistance wire and the can.

Examples of ohmmeter readings pointing to an internal ground are given in Fig. 5. The ground fault in each case provides a zero-resistance

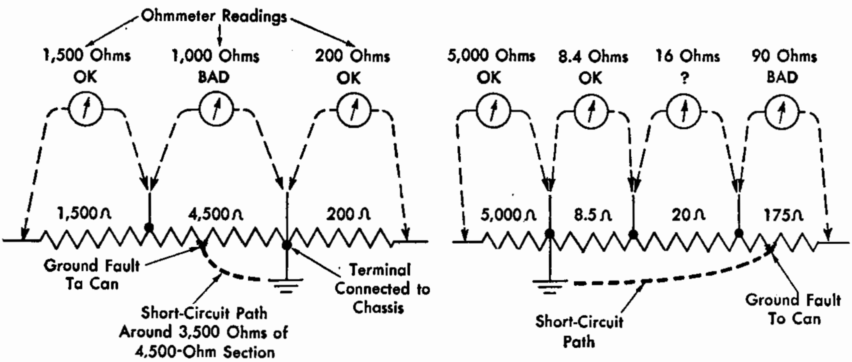


Fig. 5. Two examples of ohmmeter readings obtained when checking metal-encased tapped wire-wound resistors that have ground faults

parallel path across part of the resistance, causing the observed decrease in one resistance reading. When the fault is several sections away from the grounded terminal, the good intervening sections may show slightly lower resistance values because of the parallel path around them through other resistors and the short-circuit path, but the reduction is usually small. Thus, in the second example the 8.5-ohm section reads 8.4 ohms and the 20-ohm section reads 16 ohms, but by themselves these are not definite indications of trouble. The real clue here to a ground fault is the 90-ohm reading for the 175-ohm section.

When a metal-encased resistor is grounded through a fault, replace the entire unit. When there is a fault to ground, it is not practical to replace just the grounded section because you would first have to cut it out with a hacksaw to eliminate the unwanted ground.

Metal-encased resistors are noted for their bad behavior. It is wise, therefore, to suspect a unit, even a new one, whenever it looks like it might have been overheated by an excessive current.

Getting Replacement Tapped Resistors. Whenever you find a defective tapped resistor, always try to get the exact replacement for it. Exact replacements can usually be obtained from the set manufacturer's local distributor if the set is not more than five years old. Rarely if ever will you be able to get a correct replacement tapped resistor from a parts jobber or mail-order parts-supply firm.

To order the replacement, you need to know the manufacturer's stock number for the part, as given in the parts list for the set. When ordering, always give the model number of the set too.

Removing the Bad Tapped Resistor. With an exact-duplicate replacement tapped resistor on hand, the next step is removal of the defective unit.

If the tapped resistor is tubular, it will ordinarily be mounted on the chassis with mounting brackets that push against each end of the resistor to keep it in place. To remove the resistor, merely bend each spring bracket back slightly and allow the resistor to fall out. If any leads are still soldered to the unit, remove them first. These tubular tapped resistors are rarely used by set manufacturers but are occasionally used by servicemen for replacing other types.

Tapped resistors are usually of the metal-encased type, riveted to the chassis of the set. The easiest way to remove the rivets is to drill them out, using a drill slightly larger than the body of the rivet. Prop up the chassis rigidly for this. Make a starting hole for the drill with a center punch. Sometimes it is easier to drill out the rivet head, because it is on the outside of the chassis where there is more room to work. When the rivets have been removed, the unit will fall out.

Installing the New Tapped Resistor. If an exact-duplicate replacement is obtained, mounting will be simple. It is the same as for the old unit, except that machine screws and nuts are used instead of rivets. A popular size of machine screw for such replacements is a 6-32 screw ⅜ inch long, with corresponding nut. This will fit most of the holes originally made for rivets, making it unnecessary to enlarge the mounting holes.

Before reconnecting the wires to the terminals of the new resistor, check for another bad part that may have caused the original resistor to overheat and fail. The bad part may be just a lead that was touching the chassis or another lead, or it may be another defective part. A shorted paper condenser is often the guilty part. Unless this other defect is found, the new resistor may overheat and fail within a short time.

After reconnecting all the leads to the new resistor according to your diagram, check the connections carefully. One little mistake may ruin the new resistor. Checking your work against the circuit diagram of the receiver is the best way if the diagram is on hand.

As an added safety measure, measure the resistance between each terminal on the resistor and the chassis with an ohmmeter. Use the lowest resistance range and look only for zero readings. This quick check will reveal any accidental grounds to the chassis caused by a blob of solder or a wrongly positioned lead. If the meter goes higher than zero ohms, go on to the next terminal without even bothering to read the value. The readings are affected by the parts connected to the tapped resistor and hence will not agree with values on the diagram. Of course, if one terminal is connected intentionally to the chassis, a zero reading will be correct for it.

What to Do When New Tapped Resistor Is Unobtainable. In many cases the exact replacement tapped resistor may not be available. The manufacturer may have gone out of business, or he may not have a replacement on hand, especially if the set is more than five years old. In such cases it will be necessary to replace the defective resistor in some other manner or to replace only the defective portion of it.

Bridging the Defective Section of a Tapped Resistor. When the tapped resistor is merely burned out and is not internally grounded to the chassis, it is possible to bridge the burned-out section with an ordinary 10-watt wire-wound resistor, as in Fig. 6. The new resistor should have the same resistance value as the burned-out section. The leads of the new resistor are soldered to the terminals on each side of the burned-out section. The good portions of the tapped resistor are still used.

The wattage rating of any one section of a tapped resistor is usually only 4 or 5 watts. A 10-watt replacement resistor thus gives an ample margin of safety.

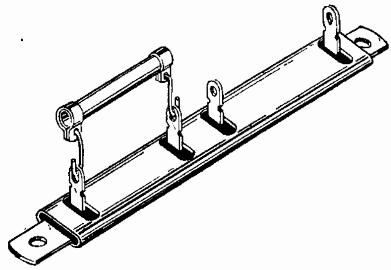


Fig. 6. Bridging a burned-out section of a tapped resistor with an ordinary 10-watt wire-wound resistor, after making sure there is no ground to the metal case at the fault

Since replacing only the burned-out section is simpler and much cheaper than replacing the whole tapped resistor, many servicemen do this even when an exact replacement can be obtained. There is one drawback to this type of repair, however. The two ends of the burned-out wire in the tapped resistor may touch together again and cause trouble, or the burned insulation around these ends may give way and cause a ground to the metal case. This is why it is best to put in an entire new tapped resistor whenever one is available.

After putting in the new resistor, check as usual for the part that caused the original resistor to burn out. Finally, adjust the positions of leads to the new resistor. Check also for accidental shorts to other terminals and to the chassis before turning on the set to see if the repair is successful.

Replacing a Tapped Resistor with Wire-wound Resistors. When a tapped resistor is internally grounded to the metal can and no exact replacement is available, a different method of repair must be used. One method is to use individual 10-watt wire-wound resistors to replace each

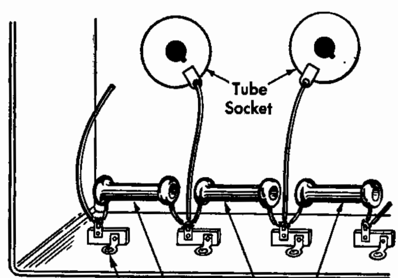


Fig. 7. Installation of three 10-watt wire-wound resistors on insulated terminals to replace a three-section tapped resistor

section of the tapped resistor, after removing the tapped resistor. These resistors are mounted on insulated terminals that you will have to install first. Connect the resistors in series in the proper order to give the equivalent of the defective tapped resistor. An example of a finished job of this type is shown in Fig. 7. The resistance of each separate resistor should

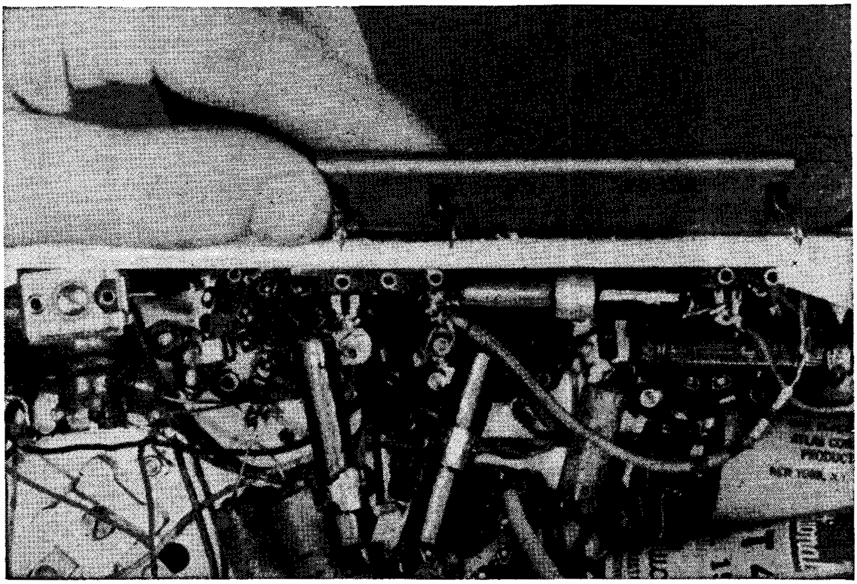


Fig. 8. Staggered arrangement of three 10-watt wire-wound resistors to replace the defective two-section metal-encased unit being held above the chassis. A resistor of the right value for one of the sections could not be obtained, so two smaller resistors were used in series to add up to the required value

be as close as possible to the resistance of the section it replaces. The correct values are obtained from the circuit diagram of the set.

To support the separate resistors off the chassis, fasten individual insulated terminals to the chassis with machine screws and bolts. Sometimes the original rivet holes can be used, but generally you will have to drill a new hole for mounting each terminal.

With the terminals in position, connect the new resistors to the lugs with permanent hook joints, in the same order as the sections of the tapped resistor, but do not solder them yet. First connect the circuit wires to the correct terminals of the new resistors, working carefully from the connection diagram you made previously.

It may be necessary to extend some leads by splicing on short lengths of insulated wire. When doing this, slip spaghetti insulation over the splice or tape the splice to prevent the bare wires from shorting against some other parts.

Since more room is required for mounting resistors in this manner, be sure that there is ample room on the chassis before starting. Staggered positioning of the resistors as in Fig. 8 often allows the replacement resistors to fit in about the same length of chassis as the old tapped resistor.

Soldering comes next. Be sure there is no solder dripping down from the insulated terminal lug to the metal mounting bracket of the terminal.

Flexible Resistors. In a flexible resistor, the Nichrome resistance wire is wound around braided glass or other heat-resisting material and covered with similar insulation.

Flexible resistors can be distinguished from ordinary wires because they are fatter and because they have metal terminal caps at each end. These caps fasten the resistance wire to the wire leads of the resistor.

Finding a Bad Flexible Resistor. To check the resistance of a suspected flexible resistor, unsolder one end of it from the set and measure with an ohmmeter. If a definite resistance reading is obtained and it does not change as the resistor is bent back and forth, the resistor is probably good. Values of flexible resistors are generally under 100 ohms.

Sometimes you will find the insulation on the flexible resistor broken so that the resistance wire is exposed. Although there is no actual break in the resistor, it should be replaced to prevent later troubles.

The resistance value of a flexible resistor can be found on the circuit diagram of the set. The colors of the resistor insulation may also tell you the value if they follow the standard color code and are not faded beyond recognition.

Replacing Flexible Resistors. Replacement flexible resistors cannot ordinarily be obtained from jobbers. However, they do sell kits of material from which you can easily make your own replacement. Another procedure, oftentimes easier and no more expensive, is to put in an ordinary 5- or 10-watt wire-wound resistor having the required resistance value.

In one form, kits for making flexible resistors are known as Yard-Ohm resistance kits because the resistance wire comes in spirally wound 1-yard lengths. The resistance wire can be obtained in resistance values ranging from 1 to about 500 ohms per inch. This enables a wide range of resistors to be made up. The kit also includes woven insulation, metal end caps, and leads.

To obtain the correct resistance kit for replacement of a flexible resistor, divide the resistance of the bad flexible resistor by its length in inches. This gives ohms per inch. Order a resistance kit that has about this same resistance per inch of length. For example, if the bad resistor is 15 ohms and is 3 inches long, divide 15 by 3 to get 5 ohms per inch as the required kit size.

After getting the resistance kit, cut off the same length of resistance wire, then assemble the new flexible resistor according to the instructions with the kit. This merely involves putting on the end caps and leads, squeezing the caps with pliers to make good contact with the resistance wire, and slipping a length of insulating braid over the assembled unit. Check the result with an ohmmeter if you like, to see how accurate you are at making resistors, but do not worry if you are a few ohms off. The receiver will not mind a bit.

Install the new flexible resistor in the same manner as the old unit. This is even easier than putting in a carbon resistor because you can bend the body of the resistor any way you like. As with all resistors, check for another defect that may have caused the flexible resistor to go bad, before turning the set on again.

Ballast Resistors. Iron, nickel, or Nichrome resistance wire is often mounted in a glass or metal radio tube housing to give what is known as a *ballast resistor* (also called a ballast tube or simply a ballast). The tube housing plugs into a tube socket the same as any other radio tube.

Mounting the resistance wire in a tube housing provides a simple means of getting the resistor in the open air above the chassis of the set, where heat can be dissipated much faster than for an equivalent resistor under the chassis. In addition, since the resistor is mounted above the chassis, the heat produced by the resistor cannot overheat parts beneath the chassis.

Identifying Ballast Resistors. Ballast resistors are found chiefly in television receivers and in older table-model a-c/d-c radio receivers.

If the ballast resistor has a glass housing or envelope, the resistance wire inside the tube will be plainly visible.

If the ballast resistor has a solid metal envelope, the simplest way of identifying it is to look up its number on a tube chart or tube manual. If not listed, you can be pretty sure it is a ballast tube. If the metal housing is punched with holes to permit air cooling, you know immediately that it is a ballast resistor. After you become more familiar with the tubes used in radios, you will be able to recognize ballast resistors without any trouble.

In some cases the marking or designation on the housing or base gives a clue. If the marking starts with a letter of the alphabet, either B, K, L, M, or W, it is usually a ballast resistor. Ordinary radio receiving tubes usually start with a number. Some of the older resistance tube designations also start with numbers, however, so do not jump to conclusions too quickly. Check catalogs and tube manuals when in doubt.

Where Ballast Resistors Are Used. A ballast resistor is connected in series with the filaments (or heaters) of the tubes in a set, to reduce the power-line voltage to the lower voltage required by the tube filaments. An example is shown in Fig. 9. Part of the line voltage is dropped or

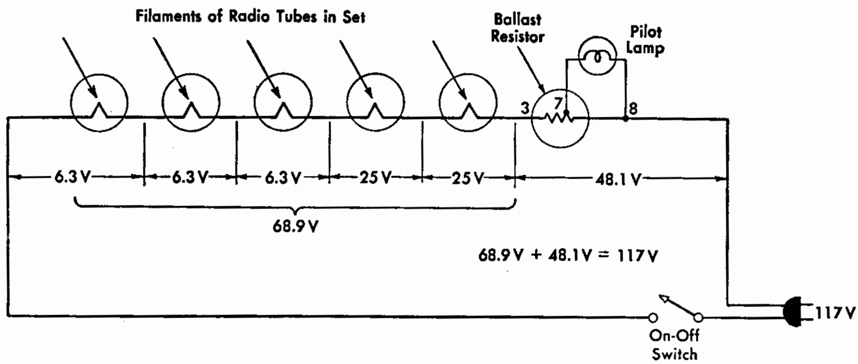


Fig. 9. How a ballast resistor is used to reduce the line voltage to the lower value required by the filaments (heaters) in a typical universal a-c/d-c radio set

wasted across the ballast resistor, so that only the correct amount is left to be applied to the filaments of the tubes.

In many ballast resistors a tap is provided on the resistance wire to furnish the correct voltage for a 6- to 8-volt (6–8v) pilot lamp. This tap is connected to one of the pins on the base, so that connection to it is made automatically when the ballast resistor is plugged into its socket. Thus, in Fig. 9 the pilot lamp in the set would be connected between terminals 1 and 4 of the ballast resistor.

Current-regulating Action. Some types of ballast resistors have an additional regulating feature. The resistance of the wire changes as the current through the resistor varies, in such a way as to counteract the change in current; this is true ballast action. When the current decreases because of a lower line voltage, the resistance wire cools off, and its resistance decreases just enough to bring current back up to the correct value. When the current increases because of a higher applied voltage, the resistance wire gets hotter and goes up in resistance, thereby reducing the current automatically to its correct value. Thus the ballast resistor maintains a fairly constant current through the filaments of the tubes, even though the line voltage applied to the set may vary over quite wide limits.

Checking Ballast Resistors. Since a ballast resistor is connected in series with the filaments of the tubes in the set, it breaks the entire filament circuit when it opens or burns out. When this happens, none of the tubes lights up. It is better to check the tubes first, however, since they fail much more often than do ballast resistors.

Many tube testers have provisions for testing ballast resistors, but this can be done just as easily with an ohmmeter. If the resistance is infinite as measured between the tube-base pins that connect to the ends of the resistance wire, the ballast resistor is burned out and must be replaced. Pin connections for ballast resistors can be determined by noting which terminals of the resistor socket are connected into the filament circuit.

Tracing Ballast-resistor Connections. Ordinarily one side of the line cord will go to one terminal of the ballast resistor, either directly or through the on-off switch. The other end of the resistance wire goes to the filament terminal of the first tube in the series filament string.

Having located the pins for the ends of the resistance, measure the resistance between them with an ohmmeter. This can be done directly between the pins while the ballast resistor is lying on the workbench, but it is usually much easier to measure between the corresponding socket terminals while the unit is plugged into the socket. (Pull the line-cord plug out of the wall outlet first.) If the resistance measured is infinite, then the ballast resistor is burned out and should be replaced. A good unit will measure under a thousand ohms. Most ballast resistors have somewhere between 135 and 400 ohms of resistance.

Replacing Ballast Resistors. The commonest types of ballast resistors can usually be obtained from a jobber as exact replacements. However, over 3,000 different types of ballast resistors were made. Occasionally you will not be able to get one of the older receiver types. Three types of universal adjustable ballasts are made for this purpose. You merely order the correct type and adjust it according to the instructions furnished. Your jobber will tell you which one to order.

Television receivers that have strings of tube filaments in series often use ballast resistors. Exact-duplicate replacements are usually available from jobbers for these.

Whenever replacing a ballast resistor, note which pins are missing on the old unit and cut off the corresponding pins on the new unit. This is important because the unused socket terminals of ballast resistors are often used as terminals for other circuits. If only three pins are needed, cut off all the others. Except for this, ballast-resistor replacement is just like tube replacement.

Line-cord Resistors. In many of the older universal a-c/d-c radios a line-cord resistor was used in series with the filaments. The line-cord resistor did exactly the same thing as a ballast resistor—it dropped part of the total line voltage so filaments of the tubes get the correct voltage value.

In a line-cord resistor the resistance wire is wound spirally on an asbestos cord located alongside the two insulated wires of the line cord. One end of the resistance wire connects to one of the prongs of the line-cord plug. The other end of the resistance wire comes out at the other end of the line cord inside the radio. This end is connected so the resistance wire is in series with the filaments of the radio tubes, as shown in Fig. 10.

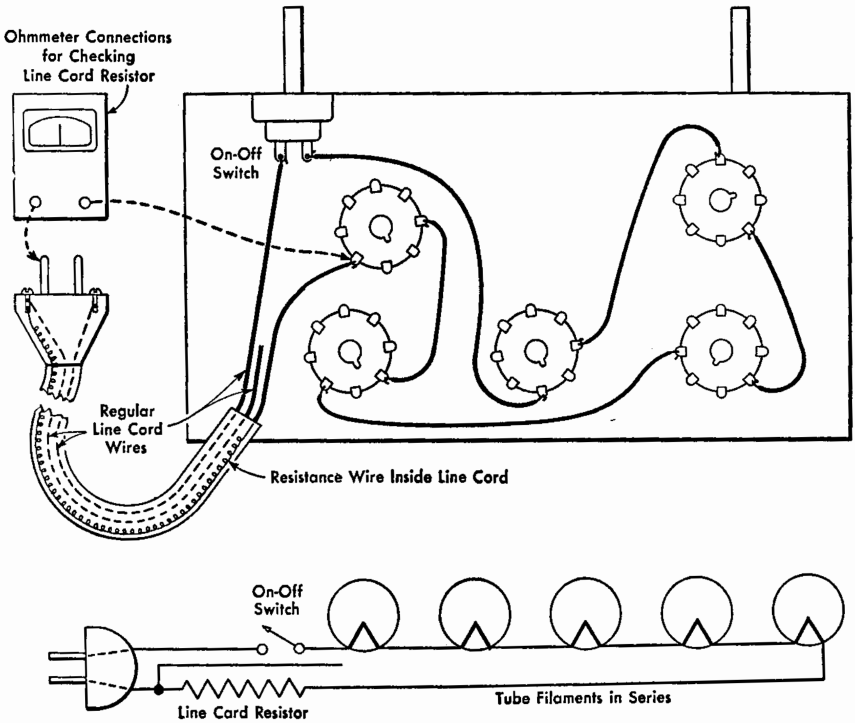


Fig. 10. Use of line-cord resistor to drop the line voltage to the correct value for five series-connected tube filaments

Thus, there is a complete path from one prong on the line plug through the line-cord resistor, through the filament of each tube in turn, and then through the on-off switch and back to the other prong of the line-cord plug.

Some line-cord resistors have a tap to provide the required 6 to 8 volts for a pilot lamp in the radio. In this case there will be four leads coming out of the line cord inside the radio: the two regular ones, one for the filament circuit, and one for the pilot lamp.

Recognizing Line-cord Resistors. Line-cord resistors can be distinguished from ordinary line cords by their appearance. First of all, they are usually fatter than an ordinary line cord. Second, they will be made with a woven fabric covering rather than a rubber covering. Third, they get quite warm when the set is turned on. This heating of the line cord is normal—it is the same amount of heat that would be given off by an equivalent ballast resistor in the set itself.

Finding a Bad Line-cord Resistor. Since a burned-out or broken line-cord resistor will also break the filament circuit of the radio, the line-cord resistor is one possible source of trouble when the tubes in the set fail to light up or become warm.

To check the line-cord resistor, first pull the line-cord plug out of the wall outlet. Now measure the resistance between the extra line-cord wire inside the radio and each of the prongs of the line-cord plug with an ohmmeter, as indicated in Fig. 10. The on-off switch of the radio should be in the off position for this. For one plug prong the reading should be infinite, and for the other prong it should be less than a thousand ohms, just as for ballast resistors. If the resistance measured is infinite for both prongs, the line-cord resistor is bad.

Repairing Line-cord Resistors. When you find a line-cord resistor that is bad, inspect the connections to each of the prongs on the line-cord plug. One of the prongs will have one end of the resistance wire connected also to its terminals. This connection may be broken.

If you find that the resistance wire is broken right next to the terminal of the line-cord plug, carefully pull out a small additional length of the resistance wire and refasten it to the plug terminal. If the plug does not have screw terminals, it will be best to take off the old plug and put on a new plug having screws. Be sure the resistance wire is connected to the same line-cord wire as before. Screw terminals on the plug allow you to make a good tight mechanical connection to the thin Nichrome resistance wire, as this wire is exceedingly difficult to solder.

If the line-cord resistor is broken or burned out internally, it will be necessary to get an entire new replacement cord of the right type.

Replacing a Line-cord Resistor. Replacement line-cord resistors, having the two regular line-cord wires and the plug as well as the resistance wire, are usually easily obtainable. For ordering, all you need to know is the resistance of the old line-cord resistor. One way of finding this resistance is by the color of the insulation on the resistance wire, since most line-cord resistors are coded according to an RTMA system. This will be covered first. You will also learn how to figure the resistance value. The colors will sometimes be faded beyond recognition because of the heat given off in use, preventing use of the color-coded value.

RTMA Color Code for Line-cord Resistors. With color-coded line-cord resistors, the insulation on the two regular line-cord wires is either red and blue or red and black. The insulation on the resistance wire is colored according to the resistance value in the line cord, as follows:

Yellow	135 ohms	Orange	260 ohms
Blue	160 ohms	Gray	290 ohms
White	180 ohms	Maroon	315–320 ohms
Green	200 ohms	Dark Brown	350–360 ohms
Light Brown	220 ohms		

The remaining wire, if there are four, will be for the pilot-light tap.

Figuring a Line-cord Resistor Value. The simplest way of finding the resistance value of an uncoded line-cord resistor is to look on the circuit diagram of the set. The resistor value in ohms will be found right next to the line-cord plug.

If the circuit diagram is not available, the resistance of the resistor can still be found. Add up the filament voltages of all the tubes in the set and subtract the total from 117 volts (the power-line voltage), to get the voltage that must be dropped by the line-cord resistor. Multiplying this voltage value by 3.3 gives the required resistance in ohms. (This assumes the set is of standard design, using tubes drawing 0.3 ampere heater current.)

As an example, take a radio using a 6A8, 6K7, 6Q7, 25A6, and 25Z6. Looking up the filament voltage of each tube in turn in a tube handbook shows that the individual filament voltages are 6.3, 6.3, 6.3, 25, and 25 volts, respectively. Adding these gives about 69 volts as the total required filament voltage for the set. Subtracting 69 from 117 gives 48 volts to be dropped by the line-cord resistor. Multiplying 48 by 3.3 gives 158.4 ohms as the resistance of the required line-cord resistor, and therefore a 160-ohm cord will work perfectly. Always choose the nearest available value.

Installing the New Line-cord Resistor. The new resistor is connected exactly like the old, using soldered connections in the set. Since the resistance-wire lead is the most fragile, allow plenty of slack for it inside the set so the strain goes on the other two leads if someone trips over the line cord.

Some line-cord resistors have the braided outer covering brought out as a tie cord at the receiver end. Fasten this cord to the chassis at some convenient point, pulling it tight enough so all the strain is on this tie cord when you pull on the entire line cord.

In no case should a line-cord resistor be shortened. To do so would also shorten the resistance wire and reduce the resistance, causing burned-out tubes or another burned-out line-cord resistor.

QUESTIONS

1. How do wire-wound resistors go bad?
2. Are resistance values of wire-wound resistors likely to be higher than 100,000 ohms?
3. What is the value of a wire-wound resistor that is coded *green, black,* and *silver?*
4. How are Candohms mounted on a chassis during manufacture of a set?
5. What can be done when an exact replacement for a tapped wire-wound resistor is not available?
6. How does a flexible resistor differ in appearance from an insulated wire?
7. What does a ballast resistor do in the filament circuit of a set?
8. When a line cord for a radio feels quite hot, what does this mean?

14

TESTING AND REPLACING

Controls and Switches

Why Variable-resistance Controls Are Needed. All of the resistors considered up to now have had essentially fixed resistance values. True, the position of the tap in an adjustable tapped resistor could be changed, but this required a screwdriver and could be done only with power off.

All television and radio receivers require in addition a type of resistor in which the position of the tap or the resistance value can be conveniently controlled by turning a knob. These control units are called *potentiometers*, often abbreviated as *pots* when talking about them.

Figure 1 shows the front-panel controls on a modern television receiver. It is common practice in television to use concentric controls in place

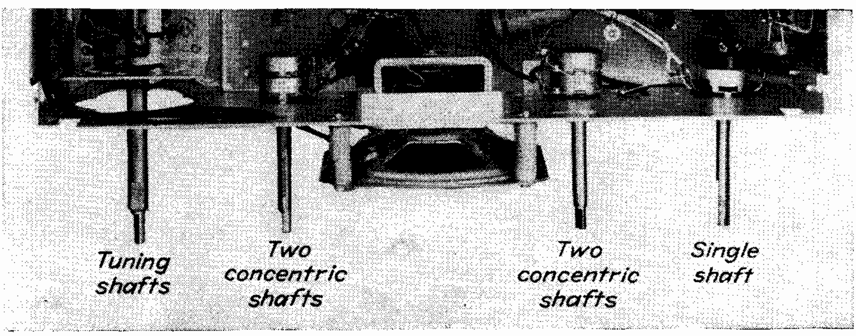


Fig. 1. Bottom of Westinghouse television-receiver chassis, showing front-panel controls. Left to right: station-selector and fine-tuning controls; contrast and brightness controls; vertical and horizontal hold controls; combination volume control and on-off switch on single shaft. Loudspeaker is mounted directly on center of chassis. (Howard W. Sams photo)

of two individual knobs and controls. Concentric controls make the set appear less complicated to operate.

There are still more controls at the rear of a television set. Instead of knobs, these usually have slotted shafts that can easily be turned with a screwdriver or knurled shafts that can be turned with fingers, as shown in Fig. 2.

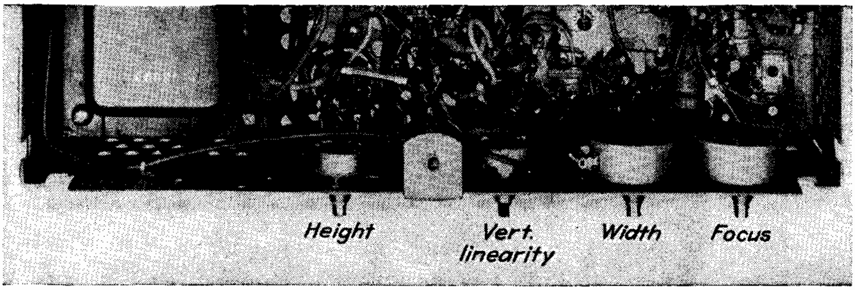


Fig. 2. Bottom rear of Westinghouse television chassis, showing screwdriver controls. Bottom of power transformer can be seen at left. (Howard W. Sams photo)

Tuning and band-changing controls will be covered in a later chapter since they do not involve resistance. In this chapter, only the controls that involve potentiometers will be taken up.

Potentiometer and Rheostat Symbols. The standard symbol used on circuit diagrams to represent a potentiometer is shown in Fig. 3. The arrow represents the movable contact.

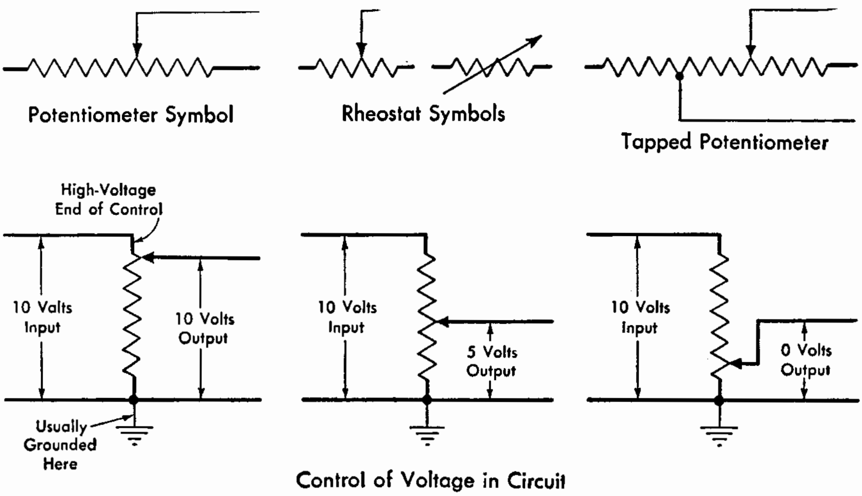


Fig. 3. Potentiometer and rheostat symbols, and manner in which a potentiometer controls the amount of voltage passed on to the next stage or circuit

You will also see on circuits the symbols for a rheostat. This is a potentiometer with one end terminal not used. The resistance between the other two terminals changes when the shaft of the control is rotated; hence a rheostat is a variable resistance. One rheostat symbol is the same as that of a potentiometer except for an end terminal being unconnected. The other rheostat symbol uses a slant arrow through the resistance symbol to indicate that it is variable.

Rheostats are used chiefly for hold controls, sync controls, and focus controls in television receivers, and occasionally for tone controls.

How a Potentiometer Controls Voltage. In a potentiometer, moving the contact arm varies the fraction of voltage passed on to the next circuit, as also indicated in Fig. 3. When the contact arm is at the high-voltage end of the resistance element, all of the input voltage is passed on to the next stage. As the contact arm is moved toward the low-voltage or grounded end of the resistance element, the output voltage is lowered.

Construction of Potentiometers. Figure 4 gives a quick look inside some typical potentiometers. Two types of carbon resistance elements are used.

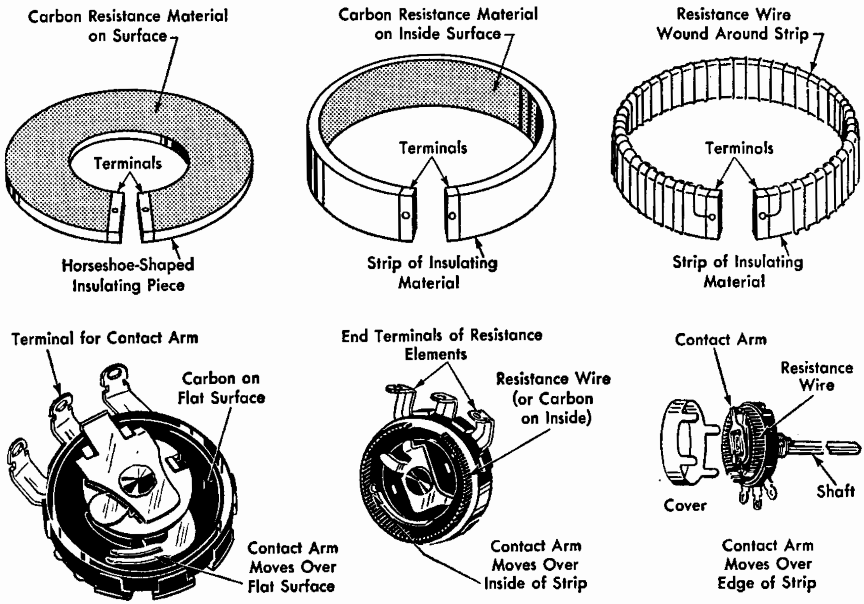


Fig. 4. Construction details of resistance controls that can occasionally be repaired when they go bad. The center terminal always goes to the movable contact arm, and the outer terminals go to the ends of the resistance element

One type has a horseshoe-shaped flat piece of insulating material coated on one side with carbon resistance material. The other type has a strip of insulating material bent to form an almost complete circle and coated on the inside with a carbon resistance material. Wire-wound potentiometers have a similar bent strip of insulating material with the resistance wire wound around it.

All types of potentiometers have a movable contact that is mounted on, but insulated from, the shaft that goes through the center of the potentiometer. This movable contact provides the desired movable connection with the resistance material. The position of the contact varies as the shaft is rotated.

Concentric Potentiometers for Television Sets. A single potentiometer has a solid brass or aluminum shaft going through the entire unit. Attached to the inner end of the shaft is an insulating piece that supports the movable contact arm. To illustrate how concentric controls work, suppose a hole is drilled lengthwise through the center of the shaft. This could be done without affecting operation of the control. Next, take another potentiometer with a long, thin shaft and push its shaft through the hole in the first, from the rear. Mount both controls so their housings cannot turn, place a wheel-shaped knob on the shaft of the first, and place a small-hole knob on the small inner shaft of the second. This is the basic construction of the concentric potentiometer used so extensively in television receivers. The front knob turns the rear unit, and the rear knob turns the front unit.

Concentric potentiometers differ somewhat in detail from the construction just described. Both shafts are larger, so that the inner shaft is standard thickness and the outer shaft is more like a sleeve around the other. Also, there are metal tabs in the housing for locking the two controls together rigidly. The mounting for the first then serves for the second as well.

Except for the concentric mounting and operating arrangement, concentric potentiometers are just like two individual units. When testing or troubleshooting, you consider them individually. Only when ordering replacements or assembling replacements from special kits do you need to consider the concentric arrangement.

Combining Switches with Controls. The on-off switch for a television set is usually mounted on the back of the volume-control potentiometer, just as in radio sets. This allows one front-panel knob to do two jobs. When the volume control is turned to its counterclockwise limit (turned all the way to the left), the volume will decrease to a minimum and the switch will click OFF. When the control is rotated clockwise from this position, then, the switch will click ON first. Further rotation clockwise will increase the volume.

In television sets, on-off switches are often mounted at the rear of a concentric control and are then actuated by the knob for the rear control.

How Potentiometers Go Bad. In any moving mechanical part there are friction and resultant wearing away of material. In potentiometers this action can produce poor contact between the resistance element and the moving arm. Friction and motion can also impair the connection between the moving arm and its fixed terminal lug (the center lug).

With volume-control potentiometers, both types of wear cause noise to be heard from the loudspeaker when the control is rotated. In television sets, these poor contacts can cause flickering of part or of all of the picture when the control is rotated, but the control is still said to be noisy.

In general, if noise is heard or its effects seen on the picture when a control knob is touched, turned, pulled, or pushed, the control is certainly defective and requires either repair or replacement.

A potentiometer opens when one of the terminals breaks away from the resistance material or when the resistance material burns out or breaks. This type of trouble is rather rare in radio sets, but burnout occurs quite often in television receivers when failure of some other part results in excessive current through the control.

If a volume control has no effect on volume, there is most likely a break in its resistance element. With tone controls and other television controls, however, the trouble is more likely to be in some associated part when a control has no effect.

Repair of Noisy Potentiometers. An open or burned-out potentiometer must always be replaced, as repairs are practically impossible. Noisy potentiometers should really be replaced also, but customers are often unwilling to pay the cost of this unless the control is so bad that the set can no longer be used. This is particularly true in television sets, where concentric controls double the replacement cost. (When one unit of a pair goes bad, both must usually be replaced.)

If a set has been standing unused for several months or more, the potentiometers in it may become noisy merely because of dirty contacts. Here, turning the control rapidly from one extreme of rotation to the other a number of times will often clean the contacts and eliminate the noise.

A noisy potentiometer can often be repaired by applying a cleaning fluid to the contact arm and resistance element. Carbon tetrachloride or Carbona will often work, but best results are obtained with one of the special fluids made for the purpose, such as No Noise Volume Control and Contact Restorer. First, try applying the fluid alongside each terminal of the contact with a medicine dropper. The terminals should be pointing upward, so the fluid drips down them to the resistance element. Rotate the control back and forth through its entire range a few dozen times while the fluid is running down.

Sometimes it is necessary to take the back cover off the potentiometer and apply the fluid directly to the resistance element, the contact arm, and the shaft.

Do not try bending the contact arm unless it is obviously loose at all positions. Bending to get more contact pressure may cure the trouble for a while, but eventually the excessive pressure may wear away the entire resistance element.

If the volume changes suddenly when a volume control is rotated, the resistance material is badly worn out somewhere along its length. The control will also be noisy, but here replacement is required because no liquid cleaner can bridge a gap over missing resistance material.

Repair of On-Off Switches. If the switch on a potentiometer is not operating, the control should be taken out of the chassis and the switch cover or entire switch unit removed. To determine whether the trouble is electrical or mechanical, connect an ohmmeter to the switch terminals and operate the switch lever with a finger or screwdriver. For one switch position the ohmmeter should read zero. It should read infinity for the other position. If these readings are not obtained, the switch is electrically defective. A new switch is needed. This will usually mean buying a new potentiometer to fit the new switch, as a new switch will rarely fit on an old potentiometer.

If the ohmmeter shows that the switch is in good condition electrically, it is possible that the switch-operating arm at the rear end of the potentiometer shaft is bent out of position. A bent arm will not operate the switch toggle properly; hence the switch stays either open or closed all the time. In this case, try to bend the arm back into proper position with long-nose pliers.

Testing Potentiometers with an Ohmmeter. You can usually tell when a volume control needs replacement by listening for noise and for sudden changes in volume while turning the control. Similarly, you can in some cases detect a noisy picture-control potentiometer by rotating it back and forth while watching the picture. The picture will jump unsteadily and have streaks or flashes of light.

At times you may want to measure the resistance of a potentiometer with an ohmmeter. Make a diagram of the leads going to the terminals of the control, then unsolder and remove the leads from the terminals. If the control has an on-off switch, leave the switch terminals connected since they are in a separate circuit. Place the ohmmeter test leads on the two outside terminals of the potentiometer. This measures the whole resistance element, because each end of it is attached to one of the outside terminals. For a carbon potentiometer, use the highest ohmmeter range, as values of carbon units are often as high as 2 megohms.

If the ohmmeter shows a definite value of resistance, the potentiometer is not open. If there is no deflection of the ohmmeter (infinity reading) even on the highest range, chances are that the potentiometer is bad.

Where to Get Replacement Potentiometers. When a potentiometer goes bad, there are three different ways of getting the correct replacement unit:

1. First and best of all, a needed control may be in your own stock of spare parts, if this includes individual potentiometers of the most used

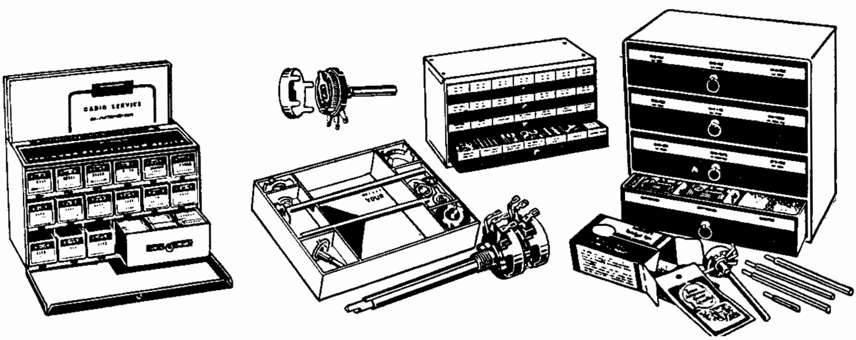


Fig. 5. Examples of potentiometer kits available as a basic stock for a service shop

sizes and one or more collections or kits of potentiometers like those shown in Fig. 5. With the needed part on hand, you can complete the repair job and get the set back to the customer in the fastest possible time.

2. If the needed potentiometer is not on hand, the next best source for it is your parts jobber. This involves a delay, depending on how soon you make a trip to the jobber or how soon he makes the next delivery to you.

3. Most time-consuming of all is getting the exact-duplicate replacement from the distributor handling parts for the make of set involved. Even if the distributor is in your home town, this involves making a special trip that generally takes at least an hour of working time. If there is no local distributor for that set, you will have to mail in the order and get the part back by mail. This takes around a week at the very least. Use mail orders only as a last resort, when you cannot obtain a satisfactory equivalent replacement from a jobber.

Potentiometer-ordering Data. Rarely will you find complete data stamped on a potentiometer for use in reordering. The resistance value alone is not usually enough for ordering. You need to know whether it is carbon or wire-wound, whether it has an unusually high wattage rating, whether it has a fixed tap, whether it has a taper in the resistance element, and whether it has any unusual mechanical features, such as a combined on-off switch, a combined concentric control, a special shaft shape, size and length, and similar data.

Giving all these data is the hard way of ordering a control. It is much easier to give the set manufacturer's number for the original part or the number of the correct replacement made by a potentiometer manufacturer. Fortunately, these parts numbers can be obtained from a number of sources.

One of the most complete sources of potentiometer data is the "Photofact Folder" for the receiver. This folder will have a parts list giving the manufacturer's original part number for the potentiometer and the correct replacement part number for several different manufacturers of potentiometers. For some controls a shaft type number and a switch type number must be given along with the potentiometer number. An example of "Photofact Folder" data for a television receiver is shown in Fig. 6.

As a rule, the manufacturer's service manual gives only the manufacturer's part number and the resistance value for potentiometers. Older "Rider's Manuals" are usually condensations of manufacturer's manuals, hence give this same information. Newer "Rider's Manuals" give additional parts-ordering information.

Several manufacturers of potentiometers put out reference manuals listing sets by make and model number. Each manual gives the correct replacement parts number for that manufacturer's make of control. One good example of this is the Mallory "Radio Service Encyclopedia," which gives Mallory replacement parts numbers for many other parts in addition to potentiometers. Centralab, Clarostat, and IRC have also had their own potentiometer replacement manuals.

CONTROLS

ITEM No.	RATING		REPLACEMENT DATA				INSTALLATION NOTES
	RESISTANCE	WATTS	Packard Bell PART No.	IRC PART No.	CLAROSTAT PART No.	CENTRALAB PART No.	
R1A	500KΩ	½	25022	Q13-133	AG-60-Z	B-60-S	Volume control
B	Shaft		Not req.	Not req.	FS-3	Not req.	Attach to R1A per instructions
C	Switch		Not req.	76-1	SWB	Not req.	Attach to R1A per instructions
				Concentrikit			
R2A	1Meg	½	25820	B11-137 *	RTV-21	SBB-619	Vert. hold control - panel
B	50KΩ	½		B11-123 *			Horizontal hold control - rear
C	Shaft End			E-202 *			Attach per instructions in "Concentrikit"
				Concentrikit			
R3A	500KΩ	½	25821	B11-133 *	RTV-169	SBB-620	Brightness control - panel
B	5000Ω	½		B11-114 *			Contrast control - rear
C	Shaft End			E-202 *			Attach per instructions in "Concentrikit"
R4A	3Meg	½	25805D	Q11-140	AM-67-Z	AN-84	Height control
B	Shaft		Not req.	Not req.	FKS-1/4	AK-1	Attach to R4A per instructions
R5A	5000Ω	½	25807B	Q11-114	AM-19-S	AN-10	Vert. linearity control
B	Shaft		Not req.	Not req.	FKS-1/4	AK-1	Attach to R5A per instructions
R6	1500Ω	4	25812		RTV-6	VK-130	Focus control - wire wound
R7	20Ω	2	25808A	W-20X10	RTV-3	SVT-901	Vert. centering control - wire wound tapped @ 10Ω
R8	30Ω	2	25828	W-30	43-30	VK-112	Horiz. centering control- wire wound

* Additional parts to be used in concentrikit..

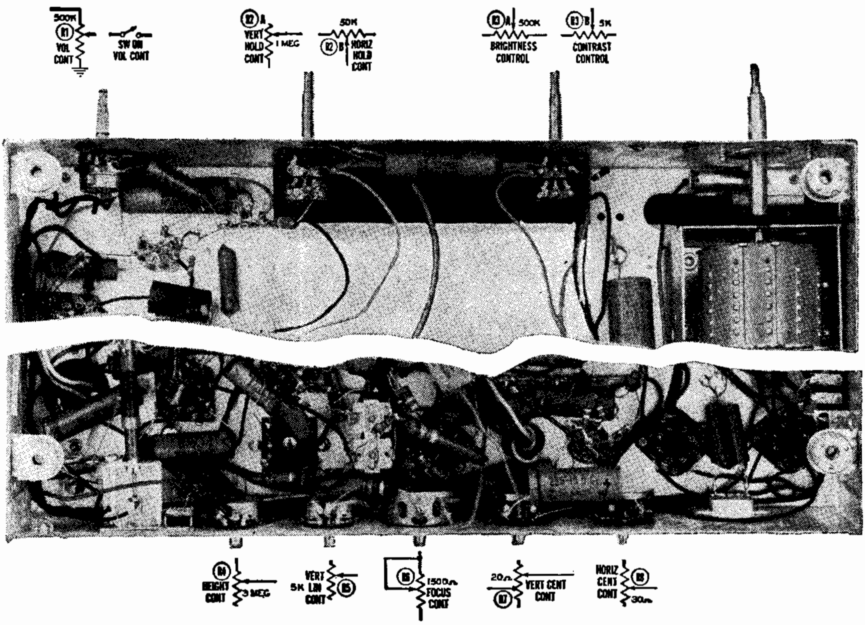


Fig. 6. Potentiometers in a Packard-Bell television receiver. The corresponding circuit-diagram symbols and data are shown alongside each control. The table shows how the replacement data for these controls are presented in Set 122, Folder 6 of Photofact Folders. (Howard W. Sams photo)

Better yet for all-round use is the latest edition of Howard W. Sams "Red Book." This lists sets by make and model number and gives just about as much replacement data on potentiometers as do the individual "Photofact Folders."

At some parts jobbers, it is only necessary to give the make and model number of the set and the function of the control (whether volume, brightness, contrast, etc.). The salesman will look up the set in one of his own manuals to get the number of the correct replacement part. This takes time, however, so do not expect such service all the time or from every jobber.

Ordering Shafts. Most controls come with a universal shaft that fits the majority of control knobs. When a set has special knobs, however, it is necessary to specify the correct special shaft also when ordering. This is why shaft numbers are given for some replacement controls.

Some of the most used types of shafts are shown in Fig. 7. If the new potentiometer does not have the correct shaft, the knob may not fit.

The shaft and potentiometer are often sold disassembled, and must be put together according to instructions furnished with the parts. Another type has a fixed shaft but uses adapter clips to make this shaft fit various knobs.

Ordering Switches. If the on-off switch is mounted on the defective potentiometer, order a replacement switch at the same time as you order the control. The switch on the defective unit will not ordinarily fit on the new control. The stock number of the correct switch is also listed in most manuals after the number of the replacement potentiometer.

Determining Type of Potentiometer. If the resistance of a potentiometer is above 10,000 ohms, you can be reasonably sure that it is carbon, even though a few wire-wound controls are made in resistances up to 50,000 ohms. If the resistance is more than 50,000 ohms, you are quite safe in assuming that it is a carbon control. Controls under 10,000 ohms may also be carbon, so here you cannot judge from the value alone.

A sure way to determine the construction of a potentiometer is to remove its back cover. This can usually be done by prying out three or four metal tabs that are bent around the front of the unit. With the resistance element exposed, you can tell at a glance whether it is carbon or wire-wound. If it is wire-wound, the coils of wire on which the movable contact rides will be plainly visible. Carbon controls will have a smooth black resistance element.

Wire-wound potentiometers ordinarily have a power rating of 3 to 5 watts. They are used, therefore, in circuits where appreciable current and power must be handled. Carbon controls have much lower power ratings, and for this reason are used chiefly in circuits where little or no current flows through the potentiometer.

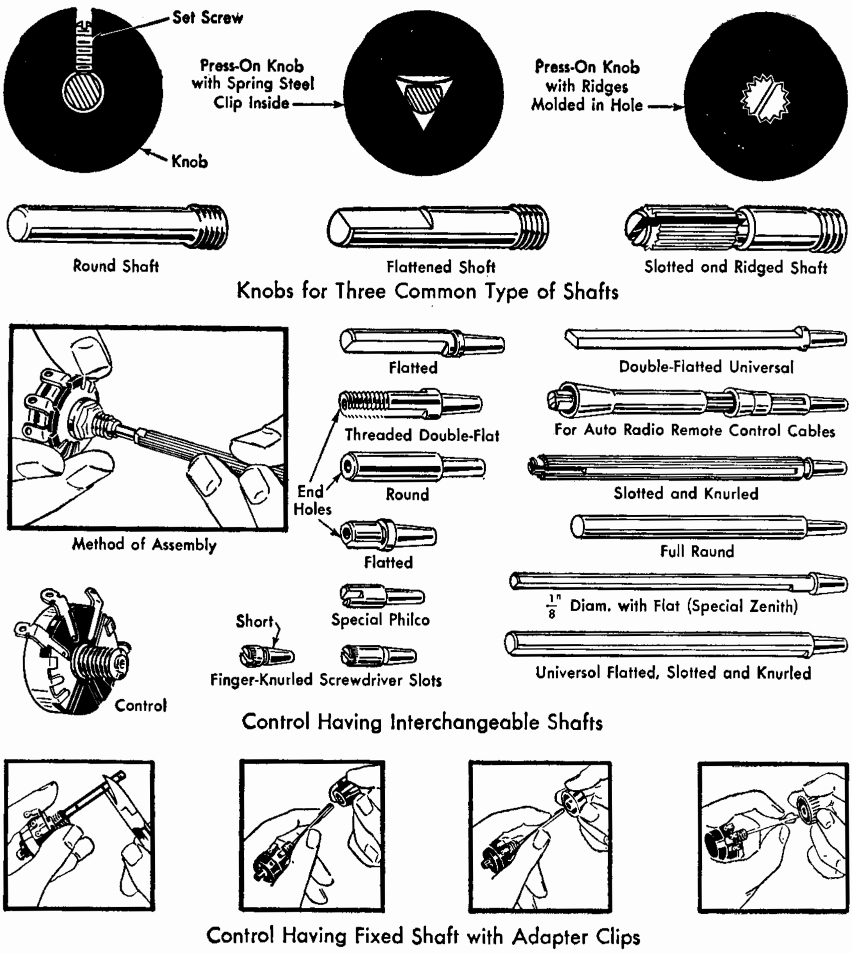


Fig. 7. Examples of the different types of shafts used on potentiometers

If a carbon control is replaced with a wire-wound control, the wire-wound control may cause excessive noise as the shaft is rotated. The noise results from the fact that the resistance in wire-wound controls does not vary smoothly; it varies in steps as the contact moves from one turn of wire to the next.

Always replace wire-wound controls with wire-wound, and replace carbon controls with carbons.

Dimensions of Potentiometers. In many small radios, especially personal portables, a midget-size volume control is used. Ordinarily these controls are about a half inch less in diameter than standard controls, and fit into a much smaller space. In ordering a replacement, therefore, give some attention to the space available. If the diameter of the old unit is less than about 1¼ inches, a midget or universal replacement control should be ordered. This is the size you usually get for replacements, anyway.

Taper of Potentiometers. In some potentiometers, the resistance is not evenly distributed along the resistance element. Instead, it has a low value per unit of length at one end and much higher values per unit of length as you move toward the other end. This variation in resistance per unit length inside the control is called *taper.*

Linear taper is widely used in television receivers and is found in practically all wire-wound controls. With linear taper the resistance per unit length is the same along the entire resistance element.

With left-hand taper, rotating the shaft in a clockwise direction causes the resistance between the center terminal and the left-hand terminal to increase slowly at first and then more and more rapidly as rotation continues. Volume controls in practically all television and radio receivers have left-hand taper.

With right-hand taper, rotating the shaft in a clockwise direction causes the resistance between the center terminal and the left-hand terminal to increase rapidly at first and then slower and slower. Controls that vary the grid-bias voltage of a tube generally use right-hand taper; such controls are rare in modern sets.

Why Taper Is Needed. The reason for having a tapered resistance element in some carbon potentiometers is most easily understood by considering volume controls.

When listening to a program, you expect the set to be twice as loud at the full-on position of the volume control as at its middle position. Similarly, you expect to get twice as much volume at the middle position as at the quarter-on position. In other words, you expect the loudness to vary linearly with the position of the volume-control knob.

In order to double the apparent loudness, the strength of the audio signal must be more than doubled. It must, in fact, be increased almost ten times. This is based on a known characteristic of the human ear. The resistance of the volume control must therefore vary by factors of ten between the positions where the volume is to be doubled or halved. This is done by tapering the resistance of the volume control.

Several other kinds of taper are in use, because different tapers are needed when a control is used in different circuits. All, however, accomplish the same result—they make the action of the control change the way you expect it to.

There is no need to worry about taper when you can find the parts number for the correct replacement control. This number is always given in Photofact Folders.

Extra Taps on Volume Controls. You may find an extra terminal on some volume-control potentiometers. This terminal will usually be placed away from the regular three terminals of the control. The extra terminal connects to the resistance element somewhere along its length. This tap is usually used as part of an automatic-tone-control circuit that increases the loudness of the low notes at low volume. This compensates for a characteristic of the human ear that makes weak low notes sound weaker than they actually are.

Replacement volume controls are available with taps in various positions. The position or resistance value of the tap need be matched only roughly because it has no effect at ordinary volume and can be changed considerably in value before a difference in tone at low volume is even noticed. When ordering by parts number, you do not need to worry about taps.

Removing Defective Controls. When you find an open or noisy potentiometer, leave it in the set until you have the correct replacement unit on hand. If wires were unsoldered for testing, put them back on their correct terminals while waiting for a new unit. This minimizes chances of making a mistake when changing potentiometers.

To remove a potentiometer, first unsolder all leads. If there is any danger of getting the leads mixed up, make a simple connection diagram first.

Next, loosen the nut that holds the potentiometer in place on the chassis. This nut can be loosened with a wrench or with ordinary pliers. Standard thread is always used, so turn the nut counterclockwise to loosen it.

Assembling and Cutting the Shaft. Assembling a separate shaft on a potentiometer is simple and easily done by following the instructions that come with the shaft. Sometimes the shaft locks itself when pushed in. Sometimes a locking washer must be put on after the shaft is inserted. Sometimes the shaft comes with the attached movable contact and is installed from the rear after removing the back cover of the potentiometer.

The shaft on a replacement control will usually be much longer than is needed. Before installing the control, cut off the excess length. Use the length of the old shaft as a guide for marking the shaft of the new control with a pencil, crayon, or file. Next, clamp the end of the shaft in a bench vise and cut off the excess length with a hacksaw. Filing the rough end of the shaft will give the job a professional look.

Another way of cutting the shaft is to file a small nick in the shaft over the cutoff mark. Now hold the control side of the shaft with a pair of pliers, and break the shaft at the nick by bending it away from the nick. This method is faster, but can be used only with the aluminum-alloy type of shaft that breaks easily.

Assembling a New Switch. Assembly instructions always come with replacement on-off switches. It may take you 10 minutes to read and follow the directions the first time you put one on. Once you have done it, however, you will be able to put additional controls together in a few minutes.

Assembly methods vary considerably among the different manufacturers; hence only a general procedure can be given here. Assume that the problem is to put together a volume-control and an on-off switch.

First, remove the back plate or cover of the volume control by bending up the clamping lugs.

Second, rotate the shaft of the volume control until the movable contact arm is in the middle position.

Third, snap the actuating arm of the switch to the ON position. This will be the clockwise position as you look at the inside of the control. Remember that you turn a set off by turning the shaft knob counterclockwise. The set is on when the contact arm is in mid-position, so turn the switch on before assembling it.

Fourth, place the on-off switch on the back of the volume control. Hold it in place with your hands and turn the shaft of the volume control counterclockwise as far as it will go. The switch should click off. If the switch does not click off, try the other position of the switch and put the parts together again. If the switch still does not work, study the assembly instructions again.

Fifth, fasten the switch to the volume control permanently by bending the clamping lugs.

Assembling Concentric Potentiometers. Exact-duplicate replacements for concentric potentiometers come factory-assembled as a single unit, with the shaft already cut to the correct length. Universal replacements are purchased as separate parts, but assembly instructions are always included. These instructions may seem complicated the first time you read them, but once you have assembled a concentric control you will agree that the job is not at all hard.

One important part of the assembly is getting the potentiometers in their correct positions. Remember that the hollow outer shaft always gets the knob and potentiometer that are next to the front panel of the set. The solid inner shaft takes the smaller front knob and the farthest-back potentiometer.

Whenever a switch is used on a concentric control, it will of necessity be mounted on the farthest-back potentiometer and controlled by the

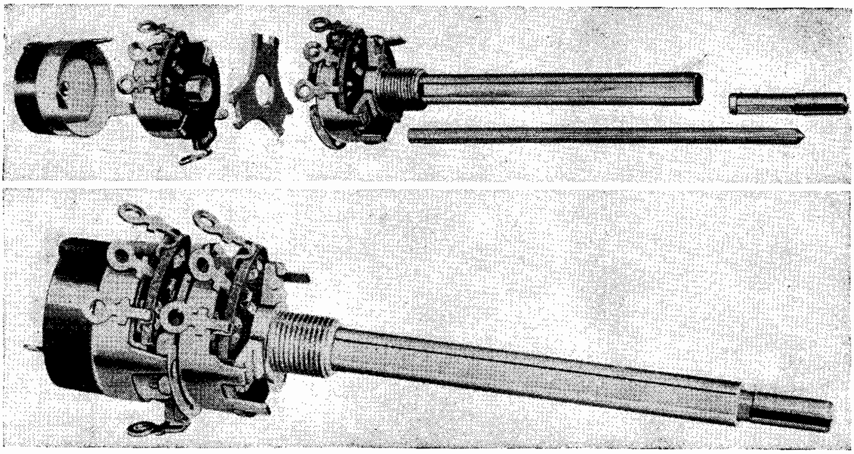


Fig. 8. Universal concentric control with switch, before and after assembly. (Mallory photos)

front knob. An example showing assembly of a universal concentric control with switch is given in Fig. 8.

Mounting a New Potentiometer. Insert the shaft of the new assembled control through the hole in the chassis or the mounting bracket, working from the inside of the chassis so the new control is in the same position as was the old one. Place a lock washer and nut on the shaft, and tighten the nut with your fingers. Do not tighten the nut with a wrench until after all the wires have been connected to the control. This will allow you to turn the control slightly so as to be able to connect all the wires to the terminals without working in a crowded space.

In some sets an aligning hole is provided on the chassis for a control. New controls generally have a corresponding pin or projection on the shaft side of the control. When the control is rotated so that the pin fits into the hole on the chassis, the pin prevents the control from rotating when the shaft is turned. Ordinarily, this method of keeping the control from rotating is not needed because the nut on the shaft, when tightened properly, provides sufficient holding force.

If the new control has an aligning pin but there is no hole for it in the chassis, simply bend the pin out of the way or cut or break it off.

Connecting a New Potentiometer. After the new unit is in place on the chassis, attach all the wires to the terminals with permanent hook joints, by following the connection diagram that you previously made. Next, adjust the control to its final position, and tighten the nut with a wrench or pliers. It is important that this nut be tight. If it is not, the entire control will rotate when the shaft is rotated.

Finally, solder all the connections on the new control. Soldering is done last because movement of the control after soldering may break wires or loosen joints.

Grounding of Potentiometer Terminals. In some circuits, particularly in older radios, the center terminal of a control potentiometer (going to the moving contact) is grounded. In other sets one of the end terminals is grounded. These grounds may be made internally in the old control and hence may be overlooked, but the circuit diagram for the set will show them.

If the diagram is not conveniently available, check for intentional grounds in the old control by measuring between its housing and each terminal in turn with an ohmmeter.

Many replacement potentiometers come with a grounding lug that looks like an oversize soldering lug. When a ground is needed, the hole in this lug is placed on the potentiometer bushing before the shaft is inserted in the chassis hole. The other end of the lug is bent so it makes contact with the correct terminal. This lug is soldered later along with the wire joints, according to instructions that come with the control.

Checking Performance. With the new control installed and all connections soldered, turn the set on and try out the control. It should vary the volume of the sound (or whatever else it is controlling) smoothly and without noise or irregularity.

If the volume decreases instead of increases as a volume control is rotated clockwise, the wires to the two outside terminals of the volume control are crossed. Unsoldering these two end terminals and reversing the wires will usually clear up the trouble.

If the new control has little or no effect on the volume of the radio, check the old control again for an internal ground connection between one of the terminals and the metal shaft of the control. If the ohmmeter test or the circuit diagram shows that a ground is required, connect a short piece of wire from the correct terminal to a nearby grounded terminal on the chassis.

Stocking Replacement Potentiometers. The best way to start your stock of universal replacement potentiometers is with a collection or kit of single units, shafts, and switches assembled by manufacturers especially for servicing requirements. In addition, when you start working on television sets, you will need a kit made up by manufacturers for replacing concentric controls.

The control that you will replace most often in television and radio sets is the volume control. If you prefer not to get a kit of controls, the following sizes will make a good starting stock of individual controls. Each should of course have the correct taper for audio volume control (taper 1 for Mallory units and taper E for IRC units). All are carbon controls.

One....	10,000 ohms
One....	50,000 ohms
One....	0.1 megohm
Two.....	0.25 megohm
Four....	0.5 megohm
Three...	1.0 megohm
One....	2.0 megohms
Eight....	SPST (single-pole single-throw) attachable on-off switches

Your own parts jobber can give you good advice on controls to carry in stock to meet the needs of your particular locality at the start. Once you have been servicing sets for a half year or so, you will have acquired experience to guide you in reordering.

Summary. The steps in replacing a defective potentiometer are

1. Obtain the correct replacement.
2. Make a sketch of the original connections.
3. Unsolder all leads and remove the defective control.
4. Assemble the new control, cut its shaft to the correct length, and put on the switch if one is needed.
5. Install the new control, leaving the mounting nut loose.
6. Connect all the leads to the correct terminals on the new control, using permanent hook joints.
7. Add a ground to the correct terminal of the new control if the old unit had an internal ground.
8. Adjust the control to its final position and tighten the nut.
9. Solder all connections.

QUESTIONS

1. What is a symptom of a worn volume control in a radio set?
2. Name one place where you can find potentiometer-ordering data when no information is on the defective unit.
3. Should a new on-off switch be ordered for use with a new volume control?
4. How does the resistance element in a carbon-type control differ in appearance from that in a wire-wound control?
5. Why isn't it necessary to understand more about taper than is given in this chapter?
6. If the shaft of a new control is too long, so that the knob sticks way out from the cabinet, what should be done?
7. Why should a defective control be left in the set until the new control is obtained?
8. If the volume goes down when it should go up while you are trying out a newly installed volume control, what should be done?

15

TESTING AND REPLACING

Condensers

Condenser Troubles. Next to tubes, fixed condensers cause more trouble than any other part in television and radio receivers. This means that it is highly essential to learn how to test the many different kinds of condensers, so that you can quickly locate the one that has gone bad. Some condensers are frequent troublemakers, while others rarely go bad. Once you are acquainted with the peculiarities of each type, you will know which to suspect first when working on a receiver.

Equally as important as testing condensers is knowing how to order the correct replacement condenser and install it properly. You will learn all these things in this chapter.

Simple Condensers. A very simple condenser can be made from two metal plates separated by air or other insulating material, as shown in Fig. 1. The condenser connecting leads are soldered or riveted to the metal plates.

The electrical size of a condenser is called its *capacity*. The larger the plates, the higher is the electrical size or capacity of the condenser.

Any two metal objects that are separated by insulation have capacity between, and hence form a condenser. Even two insulated wires have capacity when side by side or when twisted together. In some television and radio sets, short lengths of hookup wire twisted together are actually used to give extra capacity between two points, such as shown in Fig. 1.

With condenser plates of a given size, moving the plates closer together increases the capacity.

The better the insulation is between the plates of a condenser, the higher is the voltage that can be applied before a spark jumps through the insulation between the plates.

The capacity of a condenser can be increased by using a better insulation than air between the plates. This insulation is technically called the dielectric material. Examples of insulating materials used in condensers are air, mica, paper, special chemicals, mineral oil, ceramics, thin sheet plastic material, and even glass.

The different types of condensers are named according to the kind of dielectric between their plates. The commonest types of fixed condensers

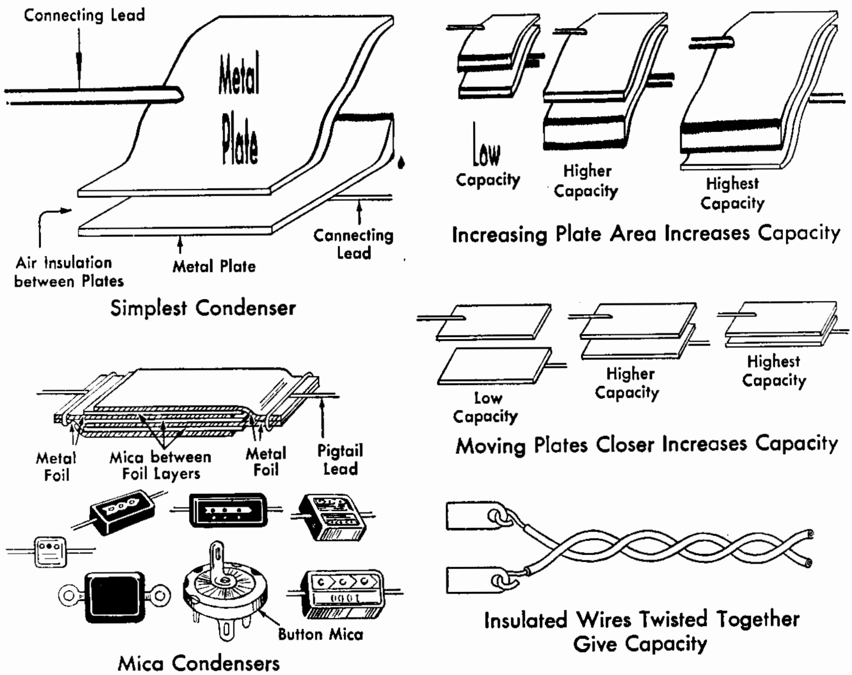


Fig. 1. Getting-acquainted facts about condensers, and examples of mica condensers

used in television and radio sets are mica condensers, paper condensers, electrolytic condensers, and ceramic condensers.

Mica Fixed Condensers. One simple construction found in actual condensers is that used in mica condensers, also shown in Fig. 1. These have metal-foil plates separated by thin sheets of mica insulation. For higher capacities, additional plates and mica sheets are used in an interlocking comb arrangement. Practically all mica fixed condensers are encased in molded Bakelite to protect the thin foil plates and the mica from dirt and moisture.

In silvered mica condensers, the foil layers are omitted and a silver coating is deposited directly on each mica sheet to serve as a plate. Button-type silvered mica condensers have round rather than rectangular mica sheets.

Paper Condensers. In this commonest of all condensers, thin strips of metal foil are used as plates, with one or more thicknesses of insulating paper between the plates. The foil and paper strips are wound into a tight roll to occupy minimum space. This roll is then inserted in a tubular cardboard or metal container, as in Fig. 2. Sometimes a plastic housing

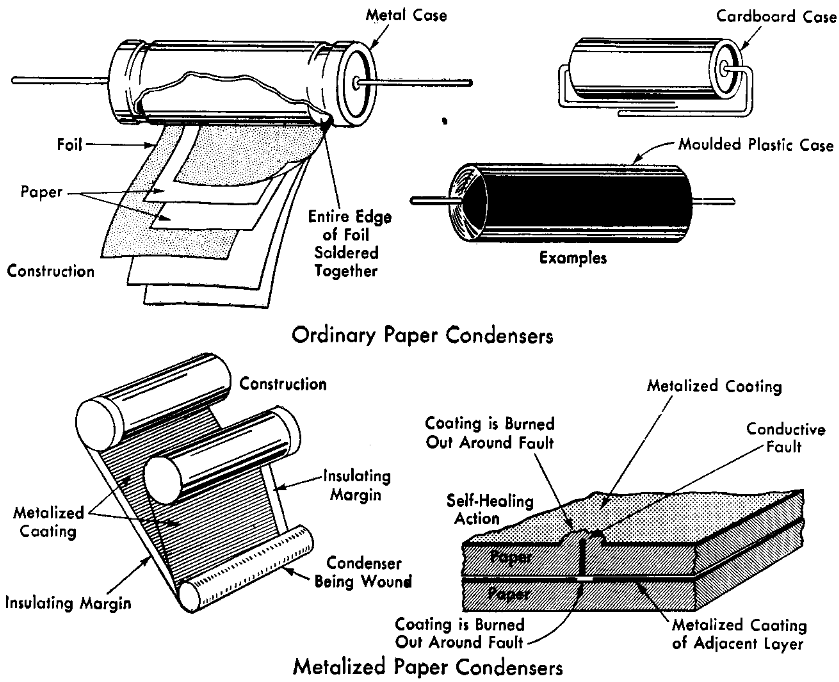


Fig. 2. Construction details of the two important types of paper condensers

is molded around the roll. Because of this tubular shape, paper condensers are often called tubular condensers.

The capacity of a tubular paper condenser is made larger in any or all of three ways: (1) by using wider foil and paper strips, which makes the condenser longer; (2) by using longer paper and metal strips, which makes the condenser thicker; (3) by using thinner paper insulation between the layers of the foil.

Thinner insulation breaks down more easily when voltage is applied, however. A spark jumps through a flaw in thin insulation and burns out the paper, allowing the opposite metal-foil layers to touch and short out the condenser. Thick paper insulation is therefore needed when condensers must withstand high voltage.

Sometimes no metal foil is used in paper condensers. Instead, a thin metallic coating is deposited on one side of each paper strip. These tubular condensers are called metalized paper condensers. Whereas ordinary paper condensers stay shorted when a conductive flaw develops between the foil plates, metalized paper condensers are self-healing. The metallic coating burns out around the flaw and isolates it, as shown in Fig. 2. This leaves the condenser practically as good as new.

Electrolytic Condensers. As Fig. 3 shows, an electrolytic condenser has metal-foil plates rolled together much like paper condensers, but uses a

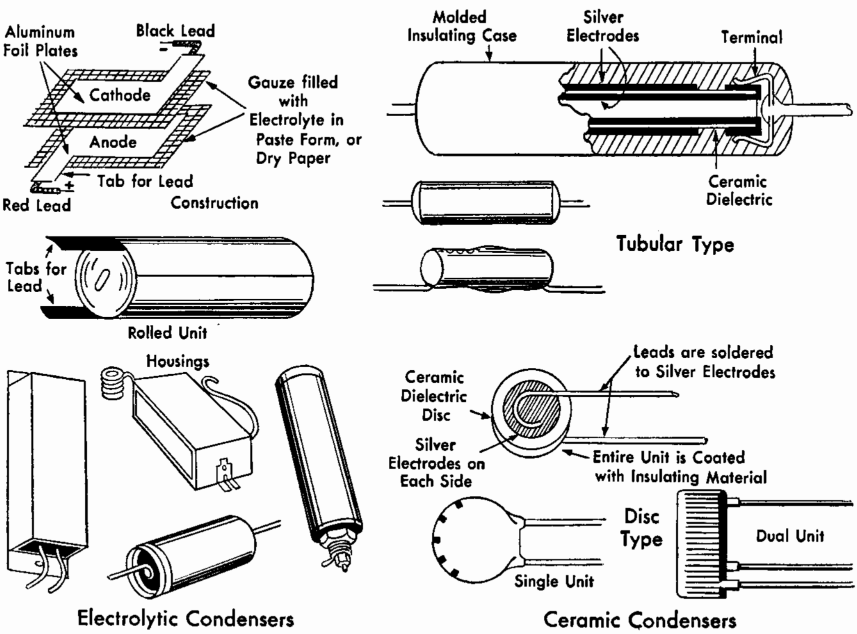


Fig. 3. Useful facts about electrolytic and ceramic condensers

chemical paste between the plates. This paste or electrolyte is held in position by gauze or blotter paper. It produces on the positive plate an extremely thin chemical oxide film that acts as the insulating material or dielectric. This film gives a much higher capacity than can be obtained with ordinary insulation.

Ceramic Condensers. A special ceramic material serves as the insulation between the plates in ceramic condensers, also shown in Fig. 3. The ceramic material is molded into a thin rectangular wafer, a cylinder, or a disk and baked until it is hard as rock. Thin coatings of silver are then placed on each face of the ceramic to serve as plates. Connecting leads are soldered directly to the silver or are soldered to crimped-on end terminals that make contact with the silver. The entire unit is then covered with insulating material or molded in Bakelite to keep out moisture.

Studying Condenser Troubles. Paper condensers are the most common troublemakers among all these types of condensers, hence will be taken up first in this chapter. Electrolytics come next, because they can go bad from natural aging alone. Mica and ceramic condensers rarely give trouble, hence are taken up last.

Before starting on condenser test and replacement procedures, however, you need to know just a little about what condensers do, along with practical information on condenser ratings and condenser symbols.

What Condensers Do. If a condenser and lamp are connected in series across a d-c voltage as in Fig. 4A, the lamp will not light. When the same

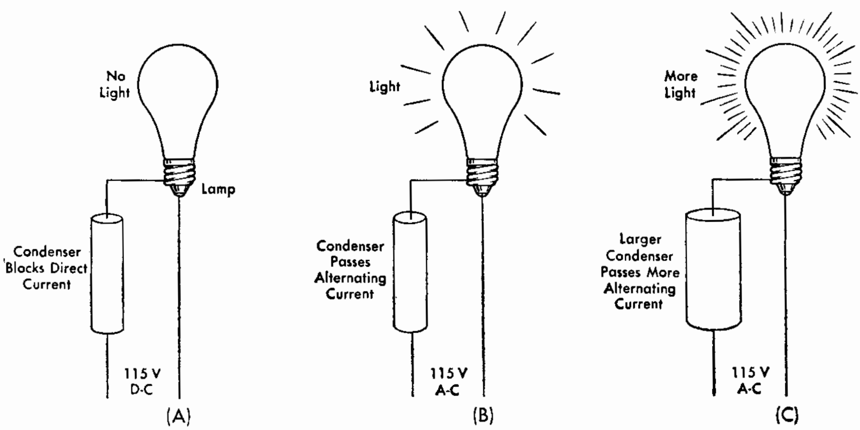


Fig. 4. The larger the condenser in an a-c circuit, the more alternating current it passes

condenser and lamp are connected across an a-c power line as in Fig. 4B, however, the lamp lights up. This simple experiment shows that a condenser passes alternating current but blocks the flow of direct current.

If the electrical size of the condenser is increased, as in Fig. 4C, the condenser passes more alternating current and the lamp glows brighter. The larger the electrical size or capacity of a condenser, the lower is its opposition to alternating current. This opposition is measured in ohms just as for resistors but is called *impedance* rather than resistance.

Condenser Impedance. The opposition or impedance of a condenser is not a fixed value like the opposition of a resistor, because the impedance depends on frequency as well as on the electrical size of a condenser. Instead, the *impedance* of a condenser *increases* when the *frequency* of the a-c voltage is *decreased.*

At zero frequency, which is d-c, the impedance of a condenser is a maximum, and current flow is blocked. At extremely high frequencies, on the other hand, the impedance is practically zero ohms and the condenser passes alternating current readily.

For a given frequency, a higher capacity gives a lower impedance. Low impedance is needed in power-supply filter circuits to cut down hum; hence large capacity values are needed in power-supply filter circuits.

In radio-frequency and video-frequency signal circuits, the frequencies are so high that only very small capacity values are needed to get low impedance. This is why you see such small condensers in the tuners and other signal circuits of television receivers.

How a Condenser Passes A-C. Actually, no current flows through the insulation of a condenser from one set of plates to the other. Instead, electrons pile up on one set of plates, leaving a shortage of electrons on the other set of plates. When the polarity of the battery or the polarity of the a-c power line reverses, the electrons pile up on the other set of plates.

The larger the capacity value of the condenser and the higher the battery voltage, the more electrons will be transferred from one condenser plate to the other. When the available voltage can push no more electrons onto the negative plate, the electron-transferring action stops, and the condenser is fully charged. There is then no further movement of electrons in a d-c circuit.

If the battery is disconnected from a charged condenser, the condenser stays charged. A high-quality condenser can hold its charge for several hours. If initially charged to a dangerously high voltage (even 115 volts can be dangerous sometimes), a condenser can give a deadly shock if accidentally touched by someone. This is why television servicing instructions so often call for discharging a high-voltage condenser by connecting its terminals together with a short-circuiting wire.

When a charged condenser is discharged by short-circuiting it, there is a popping sound and a spark as electrons rush through the shorting wire to equalize the number of electrons on the plates.

When a condenser is connected in an a-c circuit, the condenser discharges and then charges up with opposite polarity each time the polarity of the a-c voltage source reverses. It is this back-and-forth movement of electrons during charge and discharge that produces the effect of alternating current passing through a condenser. This is why we say that a condenser blocks d-c but passes a-c.

Ratings of Condensers. The amount of alternating current that a condenser will pass depends on the ability of the condenser to store electrons on its plates. This ability depends in turn on the total area of the condenser plates, their spacing, and the insulation used between the plates.

The electron-storing ability or *capacity* is one of the ratings of a condenser. The greater the capacity of a condenser, the more electrons it can store on its plates and the better it conducts alternating current.

A condenser is often called a *capacitor*. These two terms have exactly the same meaning. Servicemen seem to prefer the term *condenser*, but you will see both terms in magazines and catalogs.

Capacity is also known as *capacitance*. Here the simpler term is preferred by servicemen.

Another important rating of a condenser is its *voltage rating*. This is the maximum voltage that can safely be applied to the condenser. A greater voltage may cause the condenser to break down and conduct a current directly from one plate to the other. The breakdown occurs when a spark jumps between the plates through a tiny flaw in the insulation. The heat of the spark burns out the insulation and makes it conductive. Sometimes the heat even melts the metal foil of the plates, so the metal flows between the plates and causes a direct short circuit.

The two important ratings of a condenser are thus the capacity rating and the voltage rating.

Capacity Rating. Just as the resistance of a resistor is given as so many ohms, the capacity of a condenser is given as so many *microfarads*. The greater the capacity of a condenser, the more microfarads it has.

With many condensers, the microfarad is much too large a *unit of capacity*. Capacity is therefore also expressed in millionths of a microfarad, called *micromicrofarads*. One microfarad is equal to one million micromicrofarads.

Condensers used in television and radio sets range in capacity from about 10 micromicrofarads for the smallest ceramic or mica unit to about 100 microfarads for the largest electrolytic.

Abbreviations for Microfarad. On circuit diagrams, in catalogs, and in books and magazines, the word microfarad is usually abbreviated as mfd, mf, or μf, used either with or without periods. The last version uses the Greek letter μ (pronounced mu). Thus, an 8-microfarad condenser might be listed as 8 mfd, 8 mfd., 8 MFD, 8 MFD., 8 mf, 8 MF, 8 μf, 8 μF, or

8 μFD. The meaning of the abbreviations will always be clear, since there are no other similar abbreviations.

In asking for an 8-mfd condenser at a jobbers, a serviceman would probably say, "Gimme an 8-mike condenser," because *mike* is the slang abbreviation for microfarad.

The abbreviation for micromicrofarad is mmfd or $\mu\mu$f. Thus a 500-micromicrofarad condenser would be designated as 500 mmfd, 500 $\mu\mu$f, or 500 $\mu\mu$F.

Micromicrofarad is sometimes pronounced micromike by servicemen. You would therefore ask the jobber for a 500-micromike condenser.

Changing Microfarads to Micromicrofarads. Sometimes you may want to know the capacity of a condenser in micromicrofarads when its value is given in microfarads. To change from microfarads to micromicrofarads, multiply the microfarad value by one million. This can be done by moving the decimal point six places to the right, as follows:

0.0002 mfd = 000200. mmfd = 200 mmfd
0.001 mfd = 001000. mmfd = 1,000 mmfd

Changing Micromicrofarads to Microfarads. The value of a condenser in micromicrofarads can be changed to its value in microfarads by dividing the micromicrofarad value by one million. This can be done by moving the decimal point six places to the left, as follows:

500 mmfd = .000500 mfd = 0.0005 mfd
10,000 mmfd = .010000 mfd = 0.01 mfd

The zero at the left of the decimal point in the final values 0.0005 mfd and 0.01 mfd has no particular meaning. It is the standard way of writing decimal numbers.

Voltage Rating of Condensers. The voltage rating is printed on many condensers along with the capacity rating, somewhat as shown in Fig. 5.

Fig. 5. Typical methods of labeling paper condensers with capacity and voltage ratings

This voltage is often labeled DCWV, which means direct-current working voltage. Sometimes V.D.C., D.C.V, D.C.W., D.C.V.W. or other combinations of the letters D, C, W, and V are used, but all have the same meaning as DCWV.

Some condensers, particularly electrolytics, also have a peak voltage rating. This is the highest voltage the condenser is rated to withstand momentarily. The rating is important in power-pack filter circuits and other circuits that may have voltage pulses along with a steady d-c voltage.

Common voltage ratings found on condensers in television sets are 200, 400, and 600 volts for paper condensers and 150, 350, and 450 volts for electrolytic condensers.

Symbols for Condensers. On circuit diagrams, fixed condensers are represented by the standard symbol shown in Fig. 6, which has one straight

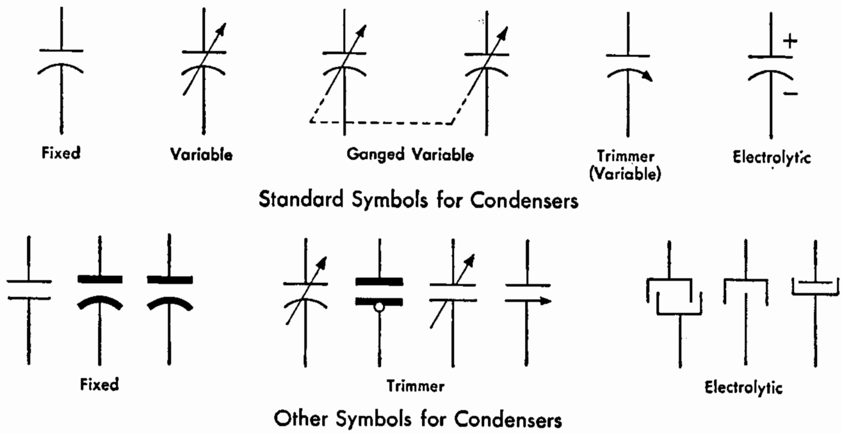


Fig. 6. Symbols used on circuit diagrams to represent different types of condensers

line and one curved line. An older symbol using two straight lines is still widely used and means the same thing.

If the condenser is variable, as for tuning condensers, an arrow is drawn diagonally through the symbol just as for variable resistors, or an arrowhead is placed on the curved line.

Many variations of the condenser symbol may be found, but all have two plates facing each other, just as in an actual condenser. Examples of these are also shown in Fig. 6, since you will find them in older diagrams. Some are still in use.

The capacity value of the condenser will usually be found alongside the symbol on a diagram. Only rarely, however, will the voltage rating of the condenser be shown on a circuit diagram. Look in the parts list in a service manual to find the voltage rating of a condenser.

Connecting Condensers in Parallel. When condensers are connected in parallel, their combined capacity is the *sum* of their individual capacity values. Thus, 0.02 mfd and 0.03 mfd in parallel give 0.05 mfd. Parallel connections are seldom used, however, because single condensers are generally available in the required size or close enough to it.

Do not connect condensers in series. With a series connection, one condenser will usually get more voltage than the other because the leakage resistances of two condensers are seldom the same. The condenser with the highest resistance will get the greater share of the voltage and may break down.

Testing and Replacing Condensers. With this general description of what condensers look like, what they do, and how they are rated, you are ready to learn how to check and replace each type of condenser in turn, starting with the most common type—the paper condenser.

How Paper Condensers Go Bad. Unlike most other parts, paper condensers need not be abused to go bad. They can fail at any time, especially if they are of cheap make or if they have too low a voltage rating for a particular circuit.

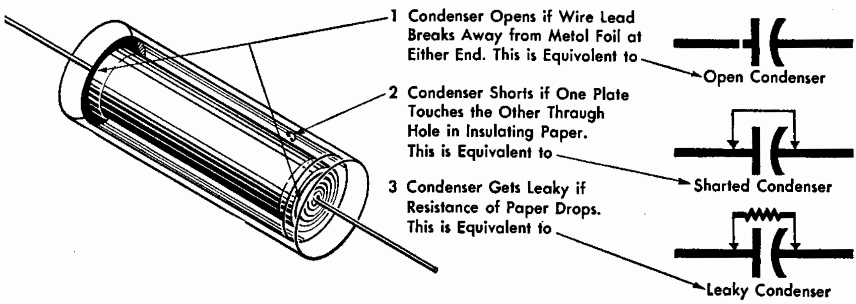


Fig. 7. Three common ways in which paper condensers go bad

Condenser failure can occur in three ways. It can be an *open* or actual break in the leads inside the condenser. It can be a direct *short* between the plates due to failure of insulation. Third, the condenser can become *leaky*. This means that the insulation between plates deteriorates and drops in resistance, allowing electrons to leak through from one plate to the other.

These three types of faults in paper condensers, shown in Fig. 7, will now be considered separately.

How Paper Condensers Open. Paper condensers are said to be open when they break somewhere internally. Usually one of the leads breaks away from the metal foil inside. Open up an old paper condenser and you will see exactly how this can happen.

When a paper condenser becomes open, the effect is pretty much the same as if a lead to the condenser itself were cut. In addition to blocking d-c, the condenser now also blocks the a-c television or radio signal.

The best way to find an open paper condenser in a receiver is to shunt each suspected condenser in turn with a good condenser, as described later under condenser-substitution tests. An ohmmeter is not reliable for finding an open, because open condensers give the same near-infinity resistance reading as good paper condensers.

Sometimes the open in a condenser is not permanent, but intermittent. When this happens the condenser works properly part of the time and does not work at all the rest of the time. An intermittent open can also cause noisy operation.

An intermittently open condenser often occurs because one of the leads of the condenser pulls away from the metal foil when the condenser is heated, cooled, or jarred. Thus a paper condenser may work all right before the receiver has had a chance to warm up. Once the set has warmed up, the heat may move the wire lead of the condenser just enough to make the set stop playing. Similarly, a paper condenser may work for a while, then quit, but start operating properly again as soon as the set is jarred.

How Paper Condensers Short. A paper condenser is said to be shorted when a direct connection or a low-resistance connection develops from one plate of the condenser to the other. This happens when the insulation between the condenser plates breaks down.

The insulation may break down because the voltage across the condenser is too high for its rating. The high voltage causes a spark to jump from one plate to the other, carbonizing the insulation and producing a low-resistance connection between the plates.

More often, a paper condenser breaks down because its insulation deteriorates. Paper insulation tends to weaken after many years of use, especially if the condenser becomes warm in the set or if the receiver is operated in a humid location and moisture gets inside the condenser. Eventually the insulation may weaken sufficiently to allow a spark to jump between the plates and produce a low-resistance carbon path from one plate to the other.

A properly designed condenser should not wear out during the lifetime of the set. Unfortunately, however, some receiver manufacturers choose to save a few cents by using cheap condensers. As a result, much of your work will involve replacing shorted or otherwise defective condensers.

How Paper Condensers Become Leaky. Paper condensers are said to be *leaky* when they pass an appreciable amount of current directly from one plate to the other. The term *leakage* does not mean dripping of wax or liquid. Rather, it refers to lowered electrical resistance that allows electrons to leak or flow through the condenser.

Leakage of paper condensers is usually specified as the leakage resistance measured by an ohmmeter connected to the leads of the condenser. The leakage resistance of a good paper condenser is very high, from 50 megohms

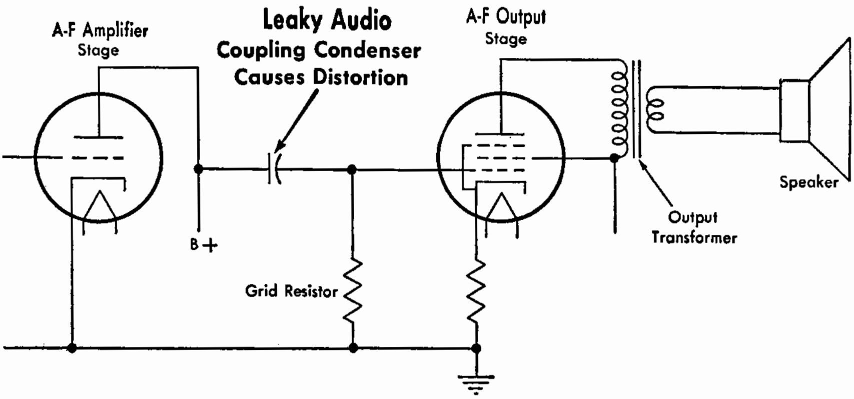


Fig. 8. If a receiver sounds badly distorted, the cause may be a leaky coupling condenser. This will be a paper condenser somewhere between 0.002 mfd and 0.05 mfd, connected between the control grid of the a-f output tube and the plate of the a-f amplifier tube

up to 5,000 megohms. With continued use, however, the leakage resistance may become low enough to upset normal operation of the set.

Leakage is not ordinarily an important defect of paper condensers. In most circuits using these condensers, the leakage has no effect on performance until it gets bad enough to approach the low resistance of a short circuit.

One place where a leaky condenser can really make trouble is in audio coupling circuits. When the coupling condenser in the circuit of Fig. 8 becomes leaky, the effect is that of a resistor connected across the condenser. This resistor allows current to flow from B+ through the grid resistor to ground. The resulting voltage drop across the grid resistor acts as a positive grid bias that causes the tube to distort the audio signal badly. This is why servicemen suspect a leaky audio coupling condenser whenever the sound is badly distorted in a television or radio receiver.

If you measure less than 20 megohms leakage resistance for any suspected paper condenser, disconnect it and try a new condenser of the same size temporarily. In most cases, there will be no change in performance, but there are enough times when low leakage resistance is the trouble to justify trying a new one. Better yet, replace any condenser that measures below 20 megohms, because it is likely to get much worse soon and cause trouble.

When to Suspect a Paper Condenser. The majority of bad paper condensers can be found by noting certain visible clues in the receiver.

Any condenser that appears to have become hot during operation of the set should be suspected. Heat often causes condensers to become open, shorted, or leaky. Heating is indicated when the wax at the ends of the condenser bulges out. Sometimes the wax runs out of the ends of the condenser. Sometimes all the wax inside the condenser may disappear, so that the cardboard housing fits loosely over the rolled foil. The condenser then feels hollow when pinched with the fingers.

To check a condenser you suspect of being bad because of overheating, substitute a known good condenser and see if this clears up the trouble.

Whenever you find a burned-out resistor or a smoking resistor in the radio, suspect a paper condenser connected in the resistor circuit as being shorted. A shorted condenser is by far the most common cause for a resistor's overheating and burning out.

To find the condensers that are in the same circuit as the resistor, follow the leads going off from each end of the resistor. All of the condensers found connected to either one of these leads should be suspected as being bad. Check the resistance of each suspected condenser with an ohmmeter.

If wiggling any condenser or twisting the outer case slightly produces a noise in the loudspeaker while the set is on, suspect that condenser as being bad. If noise or hum is produced continuously, wiggling the bad condenser may cause additional noise or may cause the noise and hum to stop altogether.

Checking Paper Condensers with an Ohmmeter. When you suspect that a certain paper condenser is shorted, connect an ohmmeter across the terminals of the condenser, and measure its resistance. The condenser does not ordinarily have to be disconnected to make this test, as a dead short will show up as zero ohms even if the condenser is in parallel with other parts.

If the resistance as measured is zero or almost zero, chances are that the condenser is shorted. To make sure of this, unsolder one lead of the condenser and again measure the resistance of the condenser. If the resistance measured is still zero, the condenser is definitely shorted and should be replaced.

If the resistance of the condenser measures infinite when disconnected, the condenser is not shorted. A coil or resistor was in parallel with the condenser in the circuit and was giving the low-resistance reading. Replace the condenser connection and continue your hunt for the shorted condenser.

Ohmmeter Kick Test for Condensers. The actual capacity of a condenser can be measured only with special test equipment. The approximate capacity, however, may be determined by connecting the highest range of an ohmmeter to the condenser terminals. The battery in the ohmmeter charges the condenser, and the sudden but momentary charging current makes the meter pointer kick momentarily. The larger the capacity of the condenser, the greater is the kick. A good 1-mfd or larger paper condenser will give a large kick of the meter pointer, while that of a 0.01-mfd condenser will be barely visible. By comparing the kick with that of a good paper condenser of known capacity, you can roughly estimate the value of an unknown capacity.

Measuring Leakage Resistance with an Ohmmeter. When connecting an ohmmeter to measure the leakage resistance of a paper condenser, the meter pointer will first kick to the right. After the condenser has charged, the pointer will come to rest. The amount of resistance indicated by the ohmmeter will then be the leakage resistance of the condenser.

With a 20-megohm ohmmeter range and with a good condenser, this leakage resistance reading will be infinity on the meter scale. Only with a very leaky condenser will the reading be enough below 20 megohms so it can be read on the meter scale.

Checking Paper Condensers by Substitution. When you suspect a paper condenser of being open, intermittent, or leaky, the best way to check the condenser is to substitute a known good condenser of about the same size in its place. If the new condenser clears up the trouble, then the suspected condenser is bad and should be replaced. For testing, the value of the new condenser is not important, but for the permanent replacement you will want to get the correct value.

To check paper condensers by the substitution method, keep 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, and 0.25 mfd paper condensers with 600-volt ratings on hand. It is a good idea to get three or four of each to provide a stock of spares, since these are the sizes of paper condensers you will need most often.

For a temporary check, unsolder one lead of the suspected condenser and then hold the leads of the new condenser on the terminals to which the old condenser was connected. Be sure the leads of the new condenser make good contact. If in doubt, solder them to the terminals with temporary lap joints for the check. With the new condenser connected, turn on the set and check its performance. If the new condenser has no effect on the set, remove it and connect the old condenser back again.

When testing by substitution, do not shorten the leads of the good condenser. Just be careful that these long bare leads do not touch any other bare leads or terminals.

In connecting the test condenser, be sure that the lead marked OUTSIDE FOIL or having a black band nearby goes to the same terminal as did the corresponding lead of the original condenser.

Hold the new condenser by its insulated housing, not by a bare lead, when making a substitution test with the set turned on, to avoid getting a shock. Only when condenser leads are insulated, as they often are in electrolytics, can you safely hold them while power is on.

Sometimes the presence of your hand on the substitute condenser may cause hum or prevent normal operation. Whenever you suspect this condition, solder the substitute condenser in position temporarily for the test.

Remember that one lead of the old condenser must be disconnected before substituting a new condenser to check for a leaky or short-circuited paper condenser. Only when the faulty condenser is open can you connect a good condenser directly across a suspected condenser, without bothering to disconnect one lead of the suspected condenser.

Always leave the bad condenser in the set until the new one is on hand. Since one of its leads is disconnected for the final ohmmeter test or for temporary substitution of a good condenser, you can easily read printed values even on the underside of the bad condenser.

It is a good idea to hook the disconnected lead of the bad condenser back on its terminal when going for a replacement, so you will not connect it wrong later.

When printed values are on the underside of a connected paper condenser in a set, there is some risk of breaking the leads by turning the body of the condenser so the values can be read. You may prefer instead to keep a small mirror in your toolbox, to use with your flashlight for reading values underneath such parts.

Ordering Replacement Paper Condensers. Only two things need be known to order a replacement paper condenser: the capacity and the voltage rating of the defective condenser. If these ratings are not printed on the condenser or if the printing is faded, the capacity rating must be obtained from the parts list or the circuit diagram just as for resistors.

If the voltage rating of a paper condenser is unknown or if it was below 600 volts, always get a 600-volt unit. It costs only a few pennies more than the 200- or 400-volt unit that may have been in the set, and will give much longer service. It is foolish to try to save a few pennies on a repair job that will bring you a good many dollars.

When the cheapest possible parts are used, the law of averages works against you because the part is more likely to fail during your guarantee period on the repair job. This means a repeat call, taking many dollars worth of your time to fix the set over again. Widely advertised makes of condensers are generally high in quality, so stick to these for replacements. Stay away from the bargain counters.

To find the value of the condenser when a pictorial diagram or photograph of the chassis is part of the servicing data, locate the defective condenser on the photograph and note its identifying number. Look up this number in the parts list to find the capacity value.

Condenser values are generally assumed to be in *microfarads* when no unit is given after the value. Microfarad values will generally be decimal values or whole numbers up to 100, while micromicrofarad values will be whole numbers ranging from around 10 up to several thousand.

If only the circuit diagram of the set is available, locate some signpost, such as a tube terminal, to which one end of the condenser is connected in the set. Locate this same signpost on the circuit diagram and note the value of the condenser connected to it. If more than one condenser is connected to this point, note which parts are connected to the other end of the bad condenser in the set, and look for these on the circuit diagram.

To reduce the number of different capacity values that have to be ordered by manufacturers and kept in stock by servicemen for replacement, RTMA has established preferred capacity values having the significant figures 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, and 100. Order the value nearest to that of the old condenser, as capacity values rarely need to be exact. Thus, you can use 0.01 for 0.012, 0.05 for 0.047, 0.047 or 0.056 for 0.05, 0.22 for 0.2 or 0.25, etc.

Obtaining Replacements for Condensers of Unknown Capacity. Occasionally you will run into a set in which the condensers are unmarked and there is no servicing information available. In such a case, you will have to make a guess at the size of replacement. It is helpful here to look at a few circuits of somewhat similar receivers of other makes, and note the value of the condenser used in that same position in these sets.

The physical size of a bad condenser is also an aid to guessing its capacity value. Actual sizes of condensers vary considerably depending on their make and voltage rating, but comparison with your stock of new condensers will give you a rough guide to the capacity value of the unmarked paper condenser.

When guessing at a condenser value, connect your first guess in temporarily and try the set. If the set works again, connect the condenser in permanently. If the set does not operate quite right with the new condenser, take out this condenser and try one of different capacity. Continue this testing and trying until a condenser is found that restores the set to normal. In most cases, this will require only one or two quick substitutions.

If the original condenser has a voltage rating above 600 volts, replace it with the same higher value. Buffer condensers in auto-radio vibrators usually have a voltage rating somewhere between 1,200 and 2,000 volts. Use a replacement condenser with the same voltage rating as the original when above 600 volts.

Outside Foil. The designation OUTSIDE FOIL, OUTER FOIL, GROUND, or similar wording, usually with a heavy black ring or line, will usually be seen at one end of a tubular paper condenser. The lead at that end is connected to the outer metal foil inside the condenser. This outside-foil lead is connected to the circuit terminal which is at or near ground potential. The outer foil then serves as a shield for the condenser. Use the same outside-foil connections as for the old condenser and you will be correct.

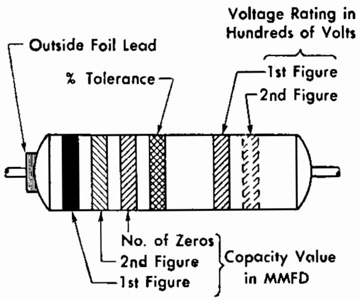
On molded paper condensers, a plastic or solder bead may be used around the lead at one end to indicate the outside-foil connection.

Color Code for Paper Condensers. Newest use for color codes is in specifying the capacity value, voltage, and tolerance of tubular paper condensers. This system was first used on paper condensers having molded plastic housings, but applies to other types of housings as well. With color rings on molded plastic paper condensers, the units look very much like carbon resistors. The color-code system differs sufficiently from that of resistors, however, so you will know whether a unit is a resistor or a condenser as soon as you start reading its color code.

The color code for paper condensers is given in Fig. 9. The colors have the same values as for the standard RTMA resistor color code; hence there is nothing new to memorize. Only the method of reading the colors is different.

First of all, the capacity rating will always be in *micromicrofarads* when expressed by color-code markings. Remember that you multiply mfd values by 1,000,000 to change them to mmfd, so that 0.002 mfd becomes 2,000 mmfd and 0.27 mfd becomes 270,000 mmfd.

Color-code markings will always be crowded toward one end of a paper condenser. This is the end you start reading from.



Example. 0.0047 MFD, 1,600 V D-C, ±20%

Band	Color Code
1st	Yellow . . . 4
2nd	Violet 7
3rd	Red 00
4th	Black . . . ±20%
5th	Brown . . } 1,600 V
6th	Blue . . . } 1,600 V

Color	Significant Figure	No. of Zeros	Capacity Tolerance
Black	0		±20%
Brown	1	0	
Red	2	00	
Orange	3	000	±30%
Yellow	4	0000	±40%
Green	5	00000	±5%
Blue	6	000000	
Violet	7		
Gray	8		
White	9		±10%

Fig. 9. Color code used by one manufacturer for tubular paper condensers having molded plastic housings. Other manufacturers may use different tolerance colors; thus, Du Mont at one time used a black band or none for 20 per cent, white or silver for 10 per cent, and yellow or gold for 5 per cent

As Fig. 9 shows, the first color ring stands for the first figure in the capacity value. The second color ring stands for the second figure in the capacity value. The third color ring stands for the number of zeros following the first two figures. So far, this is exactly the same as for resistors.

The fourth color ring gives the capacity tolerance in per cent, and here is where the system differs from resistors. For condensers, black is 20 per cent, white is 10 per cent, and green is 5 per cent. There are also two new tolerance colors: orange for 30 per cent and yellow for 40 per cent.

Usually you will not have to bother to figure out the meaning of the tolerance color, because values of paper condensers are rarely critical in radio or television circuits. Servicemen do not bother to specify tolerance when ordering replacement paper condensers, because the units given them by jobbers have close enough tolerance for all practical replacement purposes.

After the fourth ring there will be a larger space, with room for a special color ring to indicate some special characteristic of condensers made for use in military radio and electronic equipment. Then will come either one or two color rings to specify the significant figures of the voltage rating. Two zeros are always added to the significant figures given by the rings. Thus, red is 200 volts, yellow is 400 volts, blue is 600 volts. Two rings are used only for ratings above 900 volts. Thus, brown and black means 1,000 volts, brown and yellow means 1,400 volts, and brown and blue means 1,600 volts.

With color-coded tubular paper condensers it would be confusing to use a black ring at one end to indicate outside foil. Instead, a plastic button or solder bead is used on the lead that goes to the outside foil of the condenser.

When you encounter a color-coded part that cannot be read with standard color codes because the resulting value does not make sense, always refer to the circuit diagram or service manual to get the correct value. Some manufacturers used private codes of their own for marking paper condensers, prior to adoption of the standard code just described. These differ in the method of expressing tolerance and working voltage but give the capacity value in mmfd the same as for the standard code.

Colored-dot Code for Paper Condensers. Some paper condensers were made with molded plastic rectangular housings like those commonly used

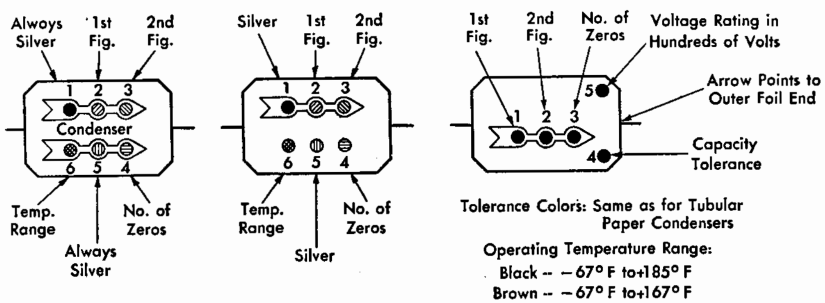


Fig. 10. Color codes used on paper condensers that look like mica condensers. For service work, the tolerance and temperature-range data on these condensers can usually be ignored. The first arrow or only arrow points to the outside-foil end

for mica condensers. These paper condensers will usually be bigger than most mica condensers, and will have a special six-dot color code in which the first and fifth dots are always silver. Except for being able to read the color code, it makes little difference what these contain inside. When they go bad, you can replace them with either a mica or a paper condenser having the same capacity and voltage rating.

The six-dot code used on some flat molded paper condensers is given in Fig. 10. If there are two arrows, the condenser is held so that the printing on the condenser can be read, and colors are read in the direction indicated by the arrows. If there is only one arrow, the condenser is held so this arrow points from left to right. The first dot will then be silver. The second dot gives the first figure in the capacity value. The third dot gives the second figure. The fourth dot gives the number of zeros that follow the first two figures to give the capacity of the condenser in mmfd.

The fifth dot is always silver. The sixth dot indicates the safe operating temperature range of the condenser. Black means that the temperature range of the condenser is from −67 to +185°F; brown means the temperature range is from −67 to +167°F.

Composition Condensers. A new composition condenser looks like a resistor and has between its plates a clay-like composition material. Composition condensers generally have extremely small capacitance values, under 5 mmfd. They are identified in Du Mont sets by the special color code using one, two, or three bands as follows: 0.68 mmfd—blue, gray, silver; 1.0 mmfd—brown; 1.5 mmfd—brown, green; 2.2 mmfd—red; 3.3 mmfd—orange; 4.7 mmfd—green.

If a tiny resistor-like unit tests open and has an odd color marking, it may be one of these new condensers. They can be replaced with the same or other type of condenser having the same ratings.

Removing the Defective Condenser. Once a replacement paper condenser of the same capacity and an equal or greater voltage rating than the original has been obtained, make a simple sketch of the terminals to which the defective condenser is connected. This sketch should identify the outside-foil terminal. Usually it does not matter which way a paper condenser is connected, but there are enough times when it does to justify putting the new condenser in the same way as the old one.

Installing the New Condenser. To install the new condenser, first place it in the set so the lead marked OUTSIDE FOIL goes to the terminal to which the outside foil of the defective condenser was connected. Now make permanent hook or wrap-around joints to the correct terminals, squeeze the joints with pliers, and solder them to complete the job.

Leave the condenser leads long enough so they do not pull on the condenser after installation. In auto radios or in other radios subject to a lot of vibration, this means placing the condenser against the chassis or some other fairly solid part to prevent it from vibrating excessively.

When soldering, apply heat on each terminal only as long as necessary. Excess heat may melt the wax inside the condenser or even loosen its soldered connection to the rolled foil inside.

If these precautions are not followed, the condenser may open or become intermittent as a result of one of the leads inside the condenser pulling away from the metal foil. Avoid introducing a new trouble in this manner, because you rarely suspect a new part.

Resonant Condensers. A special type of paper condenser found in the i-f sections of many of the newer television and radio receivers is the resonant paper condenser. These condensers look like ordinary paper condensers, but they work differently. They have a built-in coil characteristic that makes them extremely effective in passing a signal current of one particular frequency, usually the intermediate-frequency value, while offering high opposition to undesired signals above or below the desired i-f signal frequency.

You will have no trouble in identifying resonant condensers, because they are marked RESONANT. Special notes are usually printed on circuit diagrams to call attention to these condensers. Common values are 0.05 mfd, 0.1 mfd, and 0.2 mfd, with 400-volt ratings. At one time these were the only values made in resonant condensers.

How Resonant Condensers Go Bad. Since resonant condensers are basically paper condensers, they go bad the same way. They can short, open, or become leaky. Ohmmeter tests for these defects are made the same way as for paper condensers.

When a resonant condenser goes bad, it will usually cause squealing or whistling to be heard from the loudspeaker as the receiver is tuned in to a radio station. The pitch of the squeal may change as the receiver is tuned.

Replacing Resonant Condensers. To make a thorough test of a suspected resonant condenser when the ohmmeter reading does not definitely indicate a defective unit, substitute a known good one that has the same capacity and is resonant at the same frequency (455 kc in most cases). If this new condenser clears up the trouble, connect it in permanently. In replacing resonant condensers, never use anything but another resonant condenser of the same capacity and resonant frequency. An ordinary paper condenser should not be used as a permanent replacement.

Electrolytic Condensers. Equally as important as paper condensers in servicing are electrolytic condensers. These units are generally called *electrolytics*. They come in a wide variety of sizes and shapes, as shown in Fig. 11. The can types are made especially for mounting above the chassis, while the tubular and rectangular cardboard types are made for mounting under the chassis. Some are single units having only two leads or terminals. Others have two or more condensers in the same housing and hence have three or more leads or terminals.

The commonest type of electrolytic condenser is the dry electrolytic. This has two foil plates rolled loosely together, with the plates separated from each other by paper soaked with a moist chemical called the electrolyte. Older types used a liquid electrolyte instead of a paste between the plates, and for this reason were called wet electrolytics.

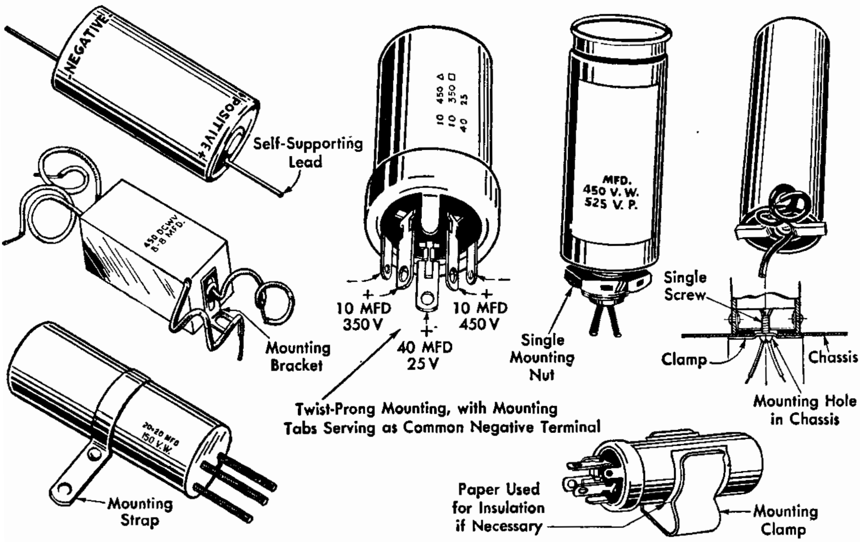


Fig. 11. Typical housings and mountings for electrolytic condensers. On twist-prong types, outer prongs are twisted after they are inserted in the slots in the mounting wafers

Where Electrolytic Condensers Are Found. Electrolytic condensers are used in every television and radio receiver, because this type of condenser provides greater capacity in a given space than does any other type of condenser.

Most electrolytics are used in power-supply circuits, where large values of capacity are needed. Here the electrolytics help filter or smooth out the d-c voltage supplied by the power supply to the set, hence are often called filter condensers. A power-supply filter has two or more electrolytics, usually combined in a single housing.

Another place where you will usually find an electrolytic condenser is in the audio output stage. Here the electrolytic is connected across the cathode resistor which is between the cathode terminal of the output tube and ground (the chassis). The electrolytic provides a low-opposition path for audio signals around the cathode resistor.

You will have no trouble spotting an electrolytic on a chassis and on the circuit diagram of a set. You will be able to distinguish it from other condensers by its large physical size as compared to the other condensers in the set and by its high value of capacity (above 4 mfd). Terminal polarity markings are another clue to electrolytics.

Polarity of Electrolytic Condensers. Unlike other condensers, electrolytics have a definite polarity. The positive lead of the condenser must always be connected to the positive side of the voltage source.

With single-unit tubular electrolytics, which look somewhat like large paper condensers, the lead marked + should go to the positive terminal in the circuit. The other lead, either unmarked or marked −, is the negative lead of the condenser and should go to the negative terminal in the circuit.

Colored-lead Codes for Cardboard Electrolytics. Tubular electrolytics often have different colors of insulation on the leads to indicate polarity. For a single unit (having two leads), the red lead is positive, and the black lead is negative.

With tubular electrolytics having two or more sections in one housing, each lead will usually be a different color, and the color identification code will be printed on the housing. Usually there will be only one negative lead, serving in common for all sections. Occasionally you will find units with separate negative leads for each section. These are for receivers where the negative terminals of the electrolytics do not all go to the same point.

No standard color code has been adopted for electrolytic condenser leads; hence each manufacturer uses his own combination of colors. As a rule, *black* will be the *common negative lead.* When more than one negative lead is provided in multiple units, brown is generally used for the other negative lead. Red, blue, green, and orange are generally used for positive leads. Do not rely on this information about colors, however; verify the meaning of a color by noting the identifying data printed on the condenser or given in the service manual for the receiver.

Terminal Identification on Can-type Electrolytics. With can-type electrolytics, the metal can itself is usually the negative terminal of the condenser, and should go to the negative terminal in the circuit (most often the chassis). Convenient soldering tabs project from the bottom of the can for making the negative connection.

Sometimes there may be a separate lead or terminal coming out the bottom of the condenser for the negative terminal. In this case, the metal can is nothing more than the housing for the condenser.

The positive terminal of a can-type electrolytic is always a terminal or lead coming out of the bottom of the can. Polarities of terminals or leads are usually marked on the housing of the condenser.

With can-type electrolytics having two or more condenser units, the terminal lugs are identified by stamped or punched-out squares, triangles, half-circles, and other geometric shapes, and the meanings of these code markings are given on the side of the condenser. There is no standard code for these, so always read the data on the side of the condenser. An example is shown in Fig. 11.

If by mistake, or otherwise, the polarity of an electrolytic is reversed when connected into a receiver, gas forms inside the condenser when voltage is applied. The pressure of this gas can get high enough to explode the housing of the condenser and cause considerable damage to the receiver. For this reason, be sure to get the correct polarity of the leads when connecting a new electrolytic.

How Electrolytics Go Bad. Electrolytics do not have an indefinitely long life. Some may need replacement before the set is a year old, while others may last 5 or 10 years. Hardly ever does an electrolytic last as long as the set itself. The life depends on the quality of the original condenser used and on the design of the set.

An electrolytic condenser opens when one of the leads inside corrodes because of the presence of the chemical. Such a defect is rare, however, because most condensers are designed to prevent it from happening.

An electrolytic also effectively becomes open when it loses its original capacity or develops a high series resistance. Both of these troubles are caused by drying out of the chemical paste in the condenser. Heat hastens the process of drying out, so it is not uncommon to find electrolytics failing in crowded under-chassis locations or in small radios where the heat is excessive because of insufficient ventilation.

Electrolytic condensers are said to be shorted when a low-resistance path develops between the plates of the condenser. A shorted condenser can be found by measuring its resistance with an ohmmeter. The resistance of a shorted electrolytic is very low, usually close to zero.

When the resistance is lower than normal (way below 50,000 ohms) but still nowhere near zero, the condenser is said to be leaky. A leaky condenser will usually have lost part of its capacity also. For this reason, leakage and loss of capacity will be considered together as the last major trouble encountered in electrolytics.

Leakage Current in Electrolytics. Unlike other types of condensers, electrolytics always have quite an appreciable leakage current. If this leakage current were measured for a good electrolytic, the current indicated might be as high as 8 milliamperes under normal operating conditions. Servicemen rarely measure this, however, because of the difficulty of making current measurements.

Instead of measuring leakage current, the leakage resistance of an electrolytic can be measured with an ohmmeter. The resistance indicated will generally be above 300,000 ohms for a good electrolytic used as a power-supply filter condenser, and can be as high as 10 megohms. Low-voltage electrolytics (50 or 25 volts) used as bypass condensers in cathode circuits can have a resistance as low as 100,000 ohms.

An electrolytic condenser has two different resistance values, depending on the polarity of the ohmmeter connections. If the ohmmeter is connected wrong, no harm is done, but the measured resistance is much lower. Instead of bothering to figure out polarities, most servicemen measure the resistance both ways and use the *higher* of the two readings. The lower reading has no meaning. Wait a few seconds for the ohmmeter pointer to stop moving before reading the resistance value of an electrolytic.

Do not rely on ohmmeter tests for anything more than finding open or shorted electrolytics. Leakage-resistance readings mean so little toward deciding whether an electrolytic is good that many servicemen do not even bother to make them. Performance of the electrolytic in the set is what really counts.

With age, the leakage of an electrolytic condenser usually increases. This means that its leakage resistance decreases. Eventually the leakage resistance may become so low and the leakage so great that the condenser no longer works right in the set. An annoying hum is then usually heard along with the program. Such a hum is an indication that the condenser is leaky and needs replacing.

Danger of Relying on Ohmmeter Tests. Although a low ohmmeter reading (below 50,000 ohms for the highest of the two readings) is proof that an electrolytic is bad, a high reading does not clear the condenser of suspicion. An electrolytic may show extremely high leakage resistance when subjected to the low test voltage of an ohmmeter but still leak badly when the normal operating voltage of the receiver is applied. Therefore, whenever a leaky electrolytic is suspected, replace it temporarily with a good electrolytic and note whether the trouble is cleared up.

Shelf Life of Electrolytics. When electrolytic condensers are not used for a long period of time, they tend to deteriorate. This occurs even when they sit on the shelf, so beware of bargain sales on electrolytics. Old electrolytics can have high leakage current and often also very much less capacity than their rated value.

If an electrolytic has stood on the shelf for several years, it probably should not be used at all. Whenever you install an electrolytic that may be a few years old, allow the set to operate for 15 to 30 minutes after completing the repair job. If the set still works O.K. and hum is not objectionably loud, you can assume that the condenser has re-formed itself and is as good as new.

Watch the rectifier tube for the first few minutes when trying a questionable new electrolytic. Turn off the set instantly if the tube gets red-hot inside. A long-idle electrolytic can have such high leakage current that it acts almost as a dead short on the power supply, overloading the rectifier tube. Such an electrolytic should be thrown out.

When to Suspect an Electrolytic Condenser. If a receiver has a loud hum that can be heard when a regular program is on, suspect an electrolytic condenser in the power supply as being bad. This hum will be just about the same loudness when the set is tuned to a station as when tuned between stations.

If a radio receiver squeals or whistles as you tune in the stations, suspect an electrolytic condenser. This squeal will change its pitch as you tune in and out of the station, coming to zero frequency (no squeal) when you are right on the station. Oftentimes hum will also be noticeable in such a set, giving a double clue to a bad electrolytic in the power supply.

If a radio receiver motorboats (makes a put-put sound like an outboard motor), suspect one of the electrolytic condensers in the set. Sometimes the motorboating will speed up and slow down as you tune the radio in and out of a station. The same trouble can occur in the audio system of a television receiver.

If a can-type electrolytic mounted above the chassis has a deposit of white on the top, or one of the electrolytics under the chassis looks discolored and bulged out, suspect that electrolytic as being bad. The white foam alone on top of the can does not mean the condenser is bad, though; suspect the condenser only if the set also hums, squeals, motorboats, or has something else wrong. Foaming is normal for some electrolytics in metal cans, because they have gas escape vents around the top.

If the plates of the rectifier tube become red or the tube shows other signs of overheating while the set is in use, suspect one of the electrolytic condensers in the power supply as being shorted. More often than not, however, some other part is at fault when you observe this condition.

How to Check Electrolytic Condensers. There is only one sure way of telling whether a given electrolytic in a receiver is good or bad. Substitute a known good electrolytic of the same capacity and voltage rating in place

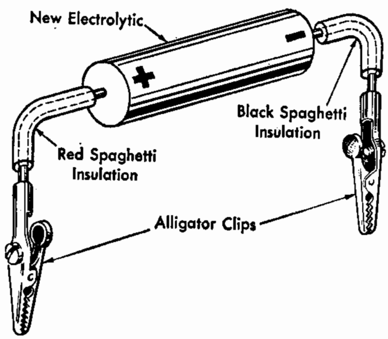


Fig. 12. Method of placing alligator clips on the leads of an electrolytic so it can more easily be connected into a circuit temporarily to check a suspected unit

of the one you suspect. If this condenser clears up the trouble, you know that the old electrolytic is defective.

Since you will want to use this substitution method for checking electrolytics, it is a good idea to make up a few electrolytics with small alligator clips on their leads, as shown in Fig. 12, to speed up testing by substitution. Some types of alligator clips will have to be soldered to the condenser leads, while others will have screw terminals for the leads. Either type will do. Slip spaghetti insulation over each condenser lead before putting on the clips. Do not shorten the condenser leads.

The sizes of electrolytics to make up in this manner should include 80-mfd 150-volt, 50-mfd 150-volt, 20-mfd 450-volt, and 10-mfd 450-volt units. These will take care of practically all the substitutions you will have to make in checking for a bad electrolytic.

When you are testing by substitution to determine whether an electrolytic in the set is good or bad, the test capacity value need be only approximately the same as that in the set. If none of the test condensers agrees in value with that of the original condenser, use the next higher capacity. Thus, to check a 16-mfd electrolytic, use the 20-mfd test electrolytic.

Use the test units for replacements about once a year and buy new ones for test purposes, so as to have only fresh electrolytics on hand.

Checking Single-section Electrolytics. To check an electrolytic condenser when it is the only one in the condenser housing, first try clipping a test condenser of about the same size across the suspected unit. Be sure the clips grip the terminals or leads tightly so they cannot move out of place and short to other terminals when the set is turned on. If the condenser in the set is open, has lost capacity, or has developed high series resistance, the good condenser will improve the performance of the set. This proves that the condenser in the set is bad. Always *pull out the line-cord plug* before changing an electrolytic, as electrolytics have *dangerously high voltages* when the set is on.

Some servicemen connect their multimeter to measure the B+ voltage (across the output filter condenser) while shunting each filter condenser in turn with a good unit. If the voltage goes up more than about 3 volts when the new unit is shunted across, or if hum is noticeably reduced, the old filter condenser in the set should be replaced.

Shunting a good condenser in this way does no good if the suspected condenser is shorted or leaky. The condenser in the set can therefore still be shorted or leaky if the shunt test gives no change in performance. You then have to disconnect one lead of the suspected condenser so you can connect the test condenser in its place. Repeated burning out of rectifier tubes and blowing of receiver fuses are signs of a shorted electrolytic condenser.

If the condenser in the set has leads, unsolder one of them to check for shorts or leakage. If it has terminals, unsolder all the leads from one of the terminals. Keep these leads connected together but away from the terminal.

Many of the older can-type electrolytics have only a single terminal. The other connection is made to the chassis automatically by the condenser mounting. Here the metal can is the negative terminal and is directly connected to the mounting arrangement.

After disconnecting the suspected electrolytic, clip the test condenser in its place. The positive lead of the test condenser should be clipped to the terminal or bunch of wires to which the positive of the original condenser was connected. The negative lead should be clipped to the negative side of the old condenser, which will often go to the chassis.

If the test condenser restores normal operation, you have found the trouble. Remove the test condenser and proceed to replace the original bad condenser.

Checking Multiple-section Electrolytics. To check a multiple-unit electrolytic, made up of two, three, or four electrolytic condensers in a single housing, check each section separately, starting with the highest-capacity section.

To determine the highest-capacity section of the condenser, note which lead of the condenser is marked or coded as having the highest capacity. Ordinarily only the positive lead or terminal for each section of the condenser is marked, because the negative leads or terminals of all the condenser sections are connected internally to the single common negative terminal. This common lead will be marked COMMON NEGATIVE on tubular and rectangular cardboard-housing electrolytics and will be the metal can or a lead coded as COMMON NEGATIVE for can-type condensers.

After determining which positive lead or terminal goes to the highest-capacity section of the condenser, first try shunting the test condenser across this section, just as when testing a single-unit electrolytic. If this gives no change in performance, disconnect the suspected section and clip a test condenser of the same capacity in its place just as for testing a single condenser. The positive lead of the test condenser should go to the terminal or wires to which the positive side of the original condenser was connected, and the negative lead to the negative side. In doing this, be sure the alligator clips of the test condenser do not short against any other part or terminal.

If substitution of the test condenser clears up the trouble, that section of the electrolytic in the set is bad. Usually the highest-capacity section is first to go bad; if it tests good, however, repeat the substitution test for each other section in turn.

If only one section of a multiple-section electrolytic condenser is bad, you can connect a single-section replacement in place of the defective section after cutting off the positive lead of the bad section. However, it is best to replace the entire multiple-section condenser. Chances are that if you replace only the defective section of the original electrolytic, some other section will fail soon. This will mean repair work that you will usually have to do free, because the customer expects his set to work for a reasonably long time after you have repaired it.

Checking Electrolytics of Unknown Capacity. If the capacity of a suspected electrolytic condenser is not known, a rough check of its condition can still be made. To do this, disconnect the suspected condenser, and use your judgment as to which of the test condensers to clip in first. For an a-c receiver use 450-volt test condensers, and for an ordinary universal a-c/d-c set, use 150-volt test condensers. Some a-c/d-c sets use a voltage-doubling rectifier circuit that gives more than 150 volts, so measure the d-c voltage across the old electrolytic first if there is a chance that it is higher. Use the 450-volt test condensers for anything above 150 volts.

Ordinarily if the condenser is of the single-unit type, start off by using a 10-mfd test condenser and progress to larger condensers. If one of these clears up the trouble, chances are that the original electrolytic is bad.

If, on the other hand, the condenser is one section of a multiple-unit electrolytic in a universal a-c/d-c set, start with a 30-mfd test condenser, then try a 50-mfd test condenser. These two should give you a satisfactory test of the electrolytic in question.

Ordering Replacement Electrolytics. Practically all electrolytics have capacity values and voltage ratings marked directly on the units; hence ordering a replacement is simple. If the defective electrolytic is one of the rare units that are not marked, look up the condenser in the servicing data for the receiver just as you would for any other unknown part.

Capacity values for electrolytics are not critical, but it is good practice to get values that are within a few mfd of those originally in the set. Using too small an electrolytic may cause the set to sound distorted, to hum, to squeal, or to motorboat. Too big an electrolytic, on the other hand, costs you more money unnecessarily. A condenser many times larger than the one originally in the set may also have some undesirable effect on receiver performance.

When the voltage rating of an electrolytic condenser is unknown, use a 450-volt replacement electrolytic if it is for an a-c set. Use a 150-volt unit if it is for an ordinary universal a-c/d-c set. Use a 350-volt unit for universal sets having a voltage-doubler rectifier circuit.

Another way of finding the required voltage rating is to measure the highest voltage that will be across the replacement condenser. Connect the positive lead of the voltmeter to the positive lead of the test electrolytic that you have clipped into the set. Connect the negative lead of the voltmeter to the negative lead of the test electrolytic. Use a high d-c voltage range (around 500 volts) initially. Turn the set on and note the highest voltage reading on the voltmeter as the set warms up. The replacement condenser must have a working voltage at least 25 volts greater than this voltage. Thus, if the voltage measured is 125 volts, a 150-volt replacement is satisfactory. If the voltage measured is 270 volts, a 350-volt replacement should be used.

A replacement electrolytic can have the same working voltage rating as the original unit or a slightly higher voltage rating, but never more than about twice the voltage rating of the original. This is the opposite of what is recommended for paper condensers, where a higher voltage rating means longer life. With electrolytics, rated capacity is obtained only at rated working voltage.

Surge Voltage Rating. The maximum voltage that an electrolytic condenser can withstand for short periods of time without breaking down (without shorting internally) is called the *surge* or *peak voltage rating*. This rating is important because, just after a receiver is turned on, the voltage applied to the electrolytics is greater than the voltage after the set has warmed up. You can neglect the surge voltage rating when ordering a replacement electrolytic, however, because this rating is of interest chiefly to the designer of the set. Get a new unit having the same or higher d-c working voltage and you will be all right.

Type of Replacement to Get. In general, get a tubular electrolytic to replace a tubular or rectangular paper-housing electrolytic. Get a can-type electrolytic to replace a can-type electrolytic. Do not worry if the new unit is much smaller in physical size than the old; modern condensers are all smaller than those made 5 or 10 years ago.

If an exact replacement is not available for a multiple-unit tubular electrolytic, get one with the closest higher set of capacities, provided that no one capacity is more than one and a half times the value it should be. Otherwise, use separate tubulars, or use one dual electrolytic and one or more single electrolytics to replace the sections of the defective condenser.

In obtaining replacements for can-type electrolytics, always try to get a replacement using the same type of mounting as the defective condenser. If this is impossible, be sure to order the hardware you will need to mount the new condenser.

One other thing to note when ordering can-type electrolytics is whether or not the metal can of the condenser serves as the negative terminal. If a separate negative lead or terminal is used, you will save yourself work by getting a replacement with a similar separate negative lead or terminal.

Examples of replacements for multiple-section electrolytics are shown in Fig. 13. The original condenser blocks in the left-hand column contain the same condensers, and each has three leads, yet the blocks could not be interchanged. The block in Fig. 13A has a common negative lead for both condensers, while the block in Fig. 13*B* has a common positive lead for both condensers. A two-condenser block with separate positive and negative leads can be used to replace the condensers, as shown, or separate

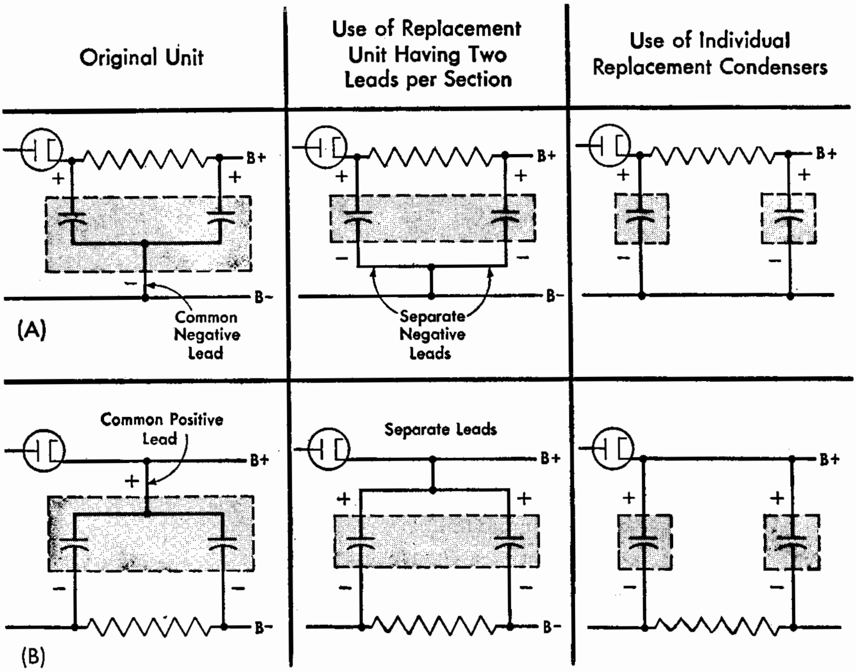


Fig. 13. Methods of replacing multiple-section electrolytics having common leads

condensers can be used if an exact-duplicate replacement is not conveniently available.

Removing the Defective Condenser. Once you have the correct replacement electrolytic, make a rough sketch that identifies the leads on the old unit. Mark the polarity of each lead on your sketch. If the condenser is of the can type, mounted above the chassis, make a note as to whether the can is insulated from the chassis with a fiber washer or not. Only after doing all this should you unsolder all the leads of the condenser from the set.

With all the leads disconnected, the defective electrolytic can be removed from the set. With tubular or square types, this involves merely lifting out the condenser or first removing a single screw or rivet on a clamp or bracket and then lifting out the condenser.

When the mounting strap of an electrolytic is riveted to the chassis, it can often be twisted off with pliers as in Fig. 14. The rivet can then be cut or sawed off so it will not rattle. The strap of the new unit can be bolted to the chassis by using the same hole or soldered to the chassis.

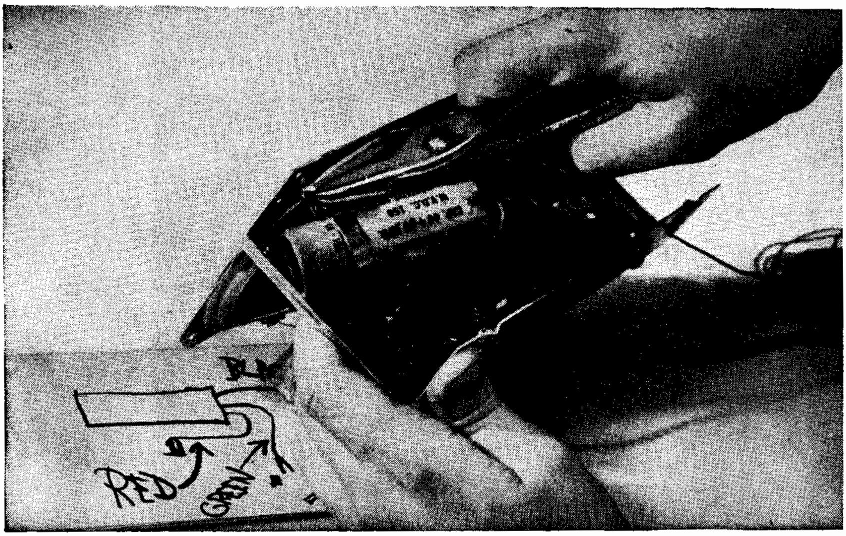


Fig. 14. Using pliers to break off the mounting strap of an old tubular electrolytic. The rivet remaining in the chassis can then be cut off with diagonal cutters

With can-type electrolytics, first unfasten the condenser from the chassis or from its socket by removing the mounting nut or by removing the rivets of the mounting wafer.

Mounting the Replacement Electrolytic. Ordinarily you will be able to get the required replacement for any electrolytic to fit into the space made available by removing the defective condenser.

To mount a tubular electrolytic, merely connect the wires themselves to the proper terminals in the set. The larger units often have a metal mounting strap that can be bolted or soldered to the chassis. Smaller units are light enough to be supported by their own leads, hence require no mounting hardware.

A common mounting arrangement found on replacement can-type electrolytics is that shown in Fig. 15. This fits into the hole left by removal of the old can-type electrolytic. The metal or Bakelite mounting plate, shaped much like a wafer-type tube socket, is bolted to the chassis first.

This may fit the holes left by the old mounting plate; if not, set the plate in position on top of the chassis, mark the chassis with a pencil or a sharp tool where holes are needed, and drill holes of the correct size for the mounting bolts you will use. Always place lock washers under the nuts when mounting parts.

After bolting the plate in position either above or under the chassis, insert the electrolytic from the top so the mounting tabs project down-

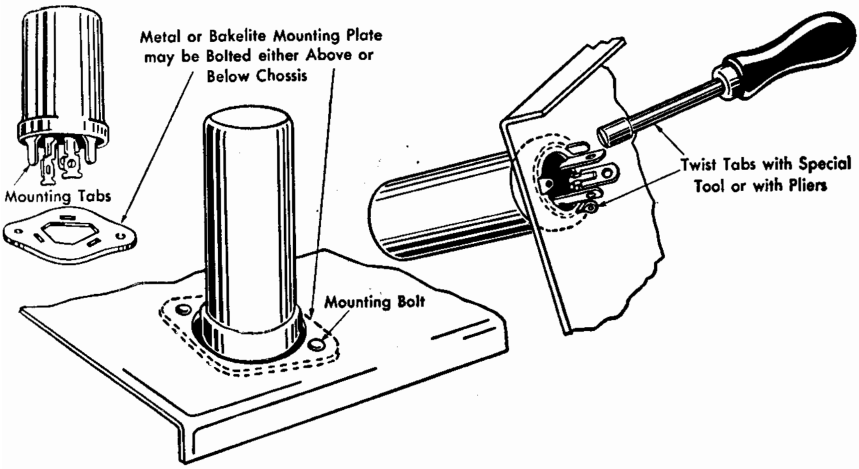


Fig. 15. Common method of mounting replacement can-type electrolytic condenser

ward through the slots in the plate. With the chassis on its side, hold the electrolytic in position with one hand on top of the chassis, and twist each mounting prong underneath with pliers. One of these prongs is used also as a terminal when the can is the common negative; hence one or more of the prongs may have soldering holes.

An under-chassis spring clamp mounting is used for can-type electrolytics in some television receivers. The old unit is pulled out of the clamp and the new unit pushed in position, so that the whole mounting job takes only a few seconds.

Connecting the Replacement Condenser. Using the sketch you drew of the connections to the original condenser, connect the leads and terminals of the new condenser as illustrated in Fig. 16. In doing this, pay particular attention to polarity. With multiple-section electrolytics, be especially careful to get each section of the new condenser connected correctly according to your diagram.

With can-type electrolytics, if the metal can of the original unit was insulated from the chassis by a fiber washer or some other insulating means, mount and connect the new unit the same way.

As with all other repairs, double-check the new installation against your diagram before trying out the set. Even experienced servicemen occasionally make a mistake.

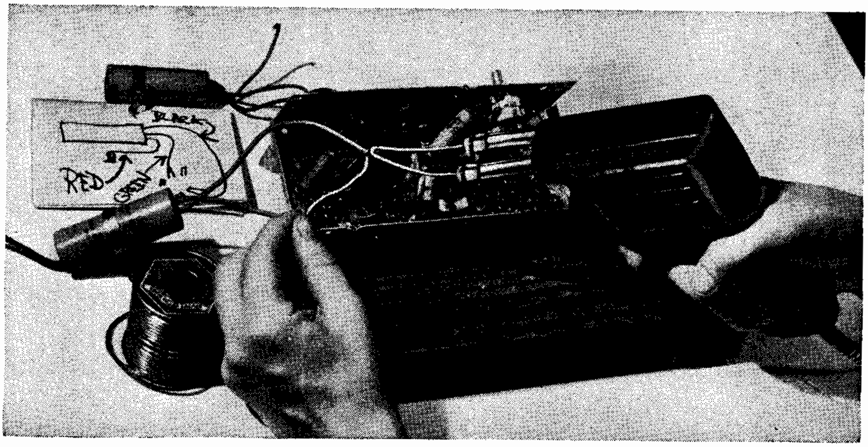


Fig. 16. Connecting leads of replacement tubular electrolytic. Sketch at upper left was made before removing the old unit. New unit is bolted to chassis after being connected

Replacing Can-type Electrolytics with Tubular Electrolytics. There will be jobs where you want to replace a can-type electrolytic with a tubular paper-housing electrolytic. One reason is that tubulars are usually on hand, whereas can-type units must be ordered specially from your jobber. Such replacements can be done if a few precautions are observed.

Electrolytic condensers are seriously affected by heat. Replacement tubular units should therefore be kept well away from voltage-divider resistors, filament voltage-dropping resistors, and other parts which give off considerable heat.

In general, it is not safe to use a tubular electrolytic condenser under the chassis as a replacement for a can-type unit mounted vertically above the chassis. The can-type units have metal housings that can dissipate substantially more heat. A tubular unit placed in a much warmer location under the chassis may fail prematurely even though it has the same capacity and voltage rating as the original can-type unit.

There will be many receivers where the only practical replacement you can get for a can is a tubular unit that has to be mounted under the chassis. As long as you recognize the heat problem, you can as a rule do this safely. Just keep the tubular electrolytic as far away as possible from any part that produces considerable heat, such as wire-wound resistors that normally are too hot to touch.

Leave the defective can-type condenser in the set so as not to have an empty hole in the chassis. Do not use any terminals of the bad electrolytic for connecting the new condenser into the circuit. Instead, install a mounting lug near the defective electrolytic, move the wires from the terminal on the bad electrolytic to this lug, and connect one lead of the new tubular condenser to this lug. Connect the other lead of the tubular electrolytic to the chassis if the can-type electrolytic was connected to the chassis, or to the lead going to the can if the can was insulated from the chassis.

Replacing Wet Electrolytics. When a liquid chemical is used instead of wet paper between plates of an electrolytic condenser, the unit is called a WET ELECTROLYTIC. It will always be a vertically mounted metal-can unit, and is found only in old sets. You can actually hear the liquid sloshing around when you shake one of these. The can is always negative.

Two types of wet electrolytic condensers have been used in radio receivers. The standard wet electrolytic is the commonest. The regulating wet condenser is a special condenser designed to regulate the voltage output from the rectifier system while the tubes in the set warm up.

Any wet condenser that makes a hissing or sparking sound when in a receiver is defective and should be replaced.

Wet electrolytics can usually be replaced with special high-voltage dry electrolytics rated at 500 volts d-c working voltage. Ordinary 450-volt dry electrolytics will usually break down when used to replace wet units, however.

Testing the Set. With the new electrolytic condenser connected, turn the set on. If everything has been done properly, the set should work like new again.

Sometimes, however, the receiver will not work right. Look at all the connections—are they good? Look for pieces of solder that may have dropped into the set and are shorting some terminal to the chassis. Check connections again to make sure the replacement electrolytic is connected properly. If the leads happen to be reversed, the condenser will not work. It will become very warm in just a short time, and will have to be replaced again even if it does not explode. If the receiver worked all right with the test electrolytic, something must be wrong with your permanent installation of the new electrolytic.

Recommended Stock of Electrolytics. In addition to a supply of test condensers with attached clips, as previously described, you will want to keep on hand a good supply of new electrolytics for replacement use. Your requirements will depend on the type and number of receivers you service per week; hence only a minimum starting stock can be given. Experience will tell which sizes and types require a larger stock.

Practically all 150-volt and lower-voltage units are tubular or rectangular cardboard-housing types for mounting under the chassis; hence low-voltage can-type units need not ordinarily be carried in stock. Both can and tubular units will be needed in the higher voltage ratings, however. A few multiple-section units of the types most used should also be kept on hand, because they are much quicker to install than separate condensers. Table 1 gives the recommended minimum stock.

Table 1. Recommended Starting Stock of Replacement Tubular Electrolytic Condensers

Voltage, volts	*Capacity, mfd*	*No. in Stock*	*Voltage volts*	*Capacity, mfd*	*No. in Stock*
50	25	1	250	8	1
150	8	1	250	20	1
150	20	2	450	8	1
150	30	2	450	16	2
150	40	2	450	20	1
150	40–40	1	450	30	1
150	50–50	1	450	16–16	1

Mica Condensers. One type of condenser that rarely goes bad is the mica condenser. These units, made of alternating thin sheets of metal foil and mica, are small in size as well as capacity. Usually they are no bigger than a postage stamp and less than a quarter of an inch thick. Capacity values range from about 5 to about 10,000 mmfd.

Most mica condensers have brown or black molded plastic housings on which capacity values are stamped directly or indicated by a color code of from three to six colored dots.

How Mica Condensers Go Bad. Although finding a bad mica condenser is a rare event, sometimes you may run across one that has become shorted, open, or leaky. In leaky mica condensers, a leakage path for current forms between the two leads of the condenser. This can be caused by dirt and moisture that collects in the tiny cracks and irregularities of the plastic housing of the condenser or caused by moisture that gets inside the condenser.

Shorted mica condensers are generally due to faulty construction or to application of a voltage greater than the voltage rating of the condenser.

Open mica condensers are rare because of the rugged construction of the condensers. Sometimes, however, you may find a mica condenser with a cracked housing that has allowed the plates to pull apart. Opens can also occur in the leads just inside the plastic housing, if the condenser has been roughly handled during its installation or during troubleshooting by a serviceman.

How to Check Mica Condensers. If you should suspect a mica condenser for some reason, the best test is substitution of a known good mica condenser. To do this, unsolder one lead of the condenser in the set and temporarily solder the known good mica condenser in its place. If it restores proper operation of the receiver, you have found the trouble. Ordinarily a 250- or 500-mmfd test condenser can be used to tell if a particular mica condenser in the set is bad, regardless of the size in the set. Whenever convenient, however, use a test condenser that is the same capacity value as the original or close to it, because mica condensers are often in tuned circuits where capacity values are critical.

Obtaining Replacement Mica Condensers. To determine the capacity value of a defective mica condenser, first look on both sides to see if the value is printed or stamped directly on the unit. The printing usually is not too good, so look carefully.

If the value is not printed on the condenser but you have the service data on hand, look up the value there just as you would for a resistor.

Mica-condenser ratings are often given by color codes. Although a number of different codes are in use, reading any of them is easy once the type of code is identified so you can locate the dot representing the first figure of the capacity value. The remaining dots are then read in sequence.

The mica-condenser color codes in common use are given in Fig. 17. Each gives the capacity value in micromicrofarads, and some give additional ratings also. Each code system will now be taken up.

Reading the Three-dot RTMA Color Code. The old three-dot RTMA color code for mica condensers, adopted in 1938 and now seen only on old condensers, is shown at the top in Fig. 17. The colors represent the same figures as in the RTMA resistor color code. The capacity of the condenser in mmfd is found by reading the dots in the direction of the arrow. When there are no arrows but there is printing on the condenser, read the colors from left to right when the condenser is held so the printing on it can be read.

The color of the first dot gives the first figure in the capacity value. The color of the second or middle dot gives the second figure in the capacity value. The color of the third dot gives the number of zeros that must follow these first two figures to give the capacity of the condenser in micromicrofarads.

As an example, a condenser whose three dots from left to right are brown, black, and red is 1,000 mmfd.

Reading the Four-dot Mica-condenser Color Code. As can be seen in Fig. 17, the four-dot system has one additional dot to indicate the capacity tolerance (how much the actual capacity can deviate from the marked value). The meanings of the tolerance colors are here exactly the same as for carbon resistors.

Whenever a mica condenser has two rows of dots, the dots are read in clockwise sequence when the condenser is held so printing on it can be read. Some condensers also have arrows to indicate the direction in which the dots are read. Reading clockwise means reading the top row from left to right, then going down and reading the bottom row backward, from right to left. When there is only one dot (for tolerance) in one row, hold the condenser so this dot is at the lower right.

As an example, a condenser with green, black, brown, and silver dots would be 500 mmfd $\pm$ 10 per cent.

Reading the Six-dot RTMA 1947 Code. The six-dot code used most often today is that adopted by RTMA in 1947. This same code, except for a different identifying first dot, is also used on mica condensers made for military equipment, hence is also known as the American War Standard (AWS) code and the Joint Army-Navy (JAN) code. With a still-different identifying first dot, the code is used on paper condensers that have flat molded plastic housings like mica condensers.

Hold the condenser so the identifying arrow points to the right and the printing on the condenser can be read. The first dot, at the upper left, will then be either white, black, or silver. White and black both mean it is a mica condenser; hence you should replace it with a mica condenser. Silver means it is a paper condenser and should be replaced with a paper condenser. The first dot has no other significance from a replacement standpoint.

The second, third, and fourth dots give the capacity value in micromicrofarads just as for the other systems. The fifth dot (the middle dot in the bottom row) gives the capacity tolerance of the condenser, with the colors having the meanings shown alongside the diagram for this code in Fig. 17.

The sixth dot (lower left corner on the condenser) is a quality-indicating dot.

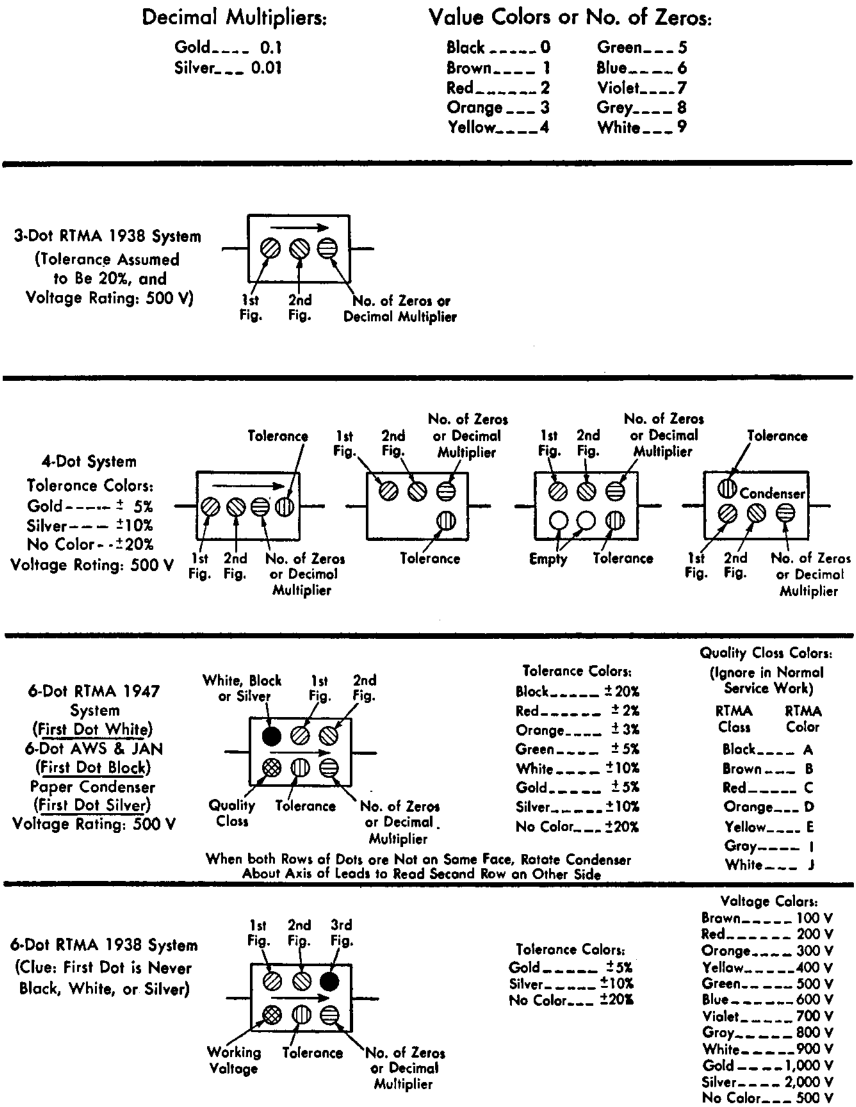


Fig. 17. Color codes used for mica condensers. All give the capacity value in mmfd

The quality rating is extremely important for mica condensers used in oscillator circuits of television receivers. A replacement mica condenser with the wrong quality rating may cause the television receiver to drift out of tune when room temperature changes. The quality colors may have slightly different meanings in the AWS and JAN codes (black first dot), but the difference can generally be ignored in service work.

Sometimes one row of dots is on each side of the condenser. Start with the side having the code-identifying white or black first dot. Holding the condenser by its leads as if the leads were the shaft of a wheel, rotate the condenser as if turning the wheel, to see the other side. Read this row of dots from right to left just as if both rows of dots were on the same side.

As an example of how to read a condenser having the six-dot RTMA 1947 code, suppose that dot colors when read in correct order are white, brown, red, brown, red, and yellow. The first dot is ignored, as it merely identifies the code. The next three dots, brown, red, and brown, give the capacity as 120 mmfd. The fifth colored dot, red, gives the tolerance as 2 per cent, which means the actual capacity of the condenser is within 2 per cent of 120 mmfd. The sixth colored dot, yellow, indicates the quality of the condenser as being type E. There being no special printed designation, its voltage rating is 500 volts.

Reading the Six-dot RTMA 1938 Code. This now-obsolete code will be found on mica condensers in old sets. When the condenser is held so printing can be read and the arrow points to the right, the first dot gives the first figure in the capacity value. You can distinguish this code from the other six-dot code because the first dot will never be black or silver, and very rarely white. Black cannot appear because the first significant figure of the value is never zero. Silver has no meaning as a value color. White does stand for 9, but mica-condenser values starting with 9 are rarely if ever used in television and radio receivers.

This old mica-condenser code is the only one that gives the working voltage. With all the other mica codes it is assumed that the working voltage rating is 500 volts unless otherwise marked on the condenser. There is one other unusual feature in this old code; it specifies three figures of the capacity value instead of two figures given by all the other codes. This permits specifying values like 125 mmfd accurately, whereas the other codes have to mark them either 120 or 130 mmfd. Experience showed that it was not necessary to specify capacity values to such accuracy with color codes, since they can always be printed or stamped on the condenser when necessary.

All information for reading the old six-dot RTMA code is given in Fig. 17. As an example, a condenser marked brown, red, green, brown, gold, and green would be 1,250 mmfd with 5 per cent capacity tolerance and a voltage rating of 500 volts. A condenser marked brown, black, black, gold, gold, and green would be 10 mmfd; here the first three dots mean 100 mmfd, and the gold fourth dot means that 100 is multiplied by 0.1 to get 10 mmfd.

Mica-condenser values for receivers are rarely over 10,000 mmfd. If the capacity indicated by a color code is over this value, the code is not being read correctly.

In rare cases you may have a condenser that is marked with some private code. When in doubt about code markings, the safe procedure is to refer to service data on the set.

Replacing Mica Condensers. Once you have obtained a replacement mica condenser having the same capacity and the same other ratings as the defective condenser, replacement is the same as for a resistor.

Keep lead lengths the same as for the old unit, and adjust the new condenser to the same position as the old. Mica condensers are often in critical signal circuits where even the movement of a lead out of position can cause trouble. Never move leads around unnecessarily. Positioning of leads is called lead dress, and is often highly important.

Silvered Mica Condensers. When looking through catalogs and when buying replacement condensers, you will encounter silvered mica condensers. These use silver-coated mica sheets instead of alternate layers of mica and foil. This construction gives more precise capacity values that are less likely to be affected by time, temperature, and humidity.

Silvered mica condensers are most often used in pushbutton tuning circuits, oscillator circuits, and fixed tuning circuits, such as in the i-f amplifiers of television and radio receivers.

Button-type silvered mica condensers are used chiefly in television receiver circuits where compactness, short leads, and high leakage resistance are essential. Capacity values ordinarily range from 15 to 1,000 mmfd. These units contain a stack of silvered mica disks encased in a metal housing. The metal housing connects to alternate silver-coating electrodes all around the edges of the disks; hence the housing is one terminal. The other terminal goes through the center of the stack and makes contact with the silver layers that are not connected to this housing. This design permits the charging current to fan out in all directions from the center terminal through the silver layers, which is highly desirable in high-frequency circuits.

Button-type silvered mica condensers are color-coded with six dots that are read in a clockwise direction when held so the center terminal is facing you. The first three dots give the significant figures in the capacity value. The fourth dot gives the number of zeros. The fifth dot gives the per cent tolerance according to the 1947 RTMA code for mica condensers, and the sixth dot gives the characteristic. The code is summarized in Fig. 18.

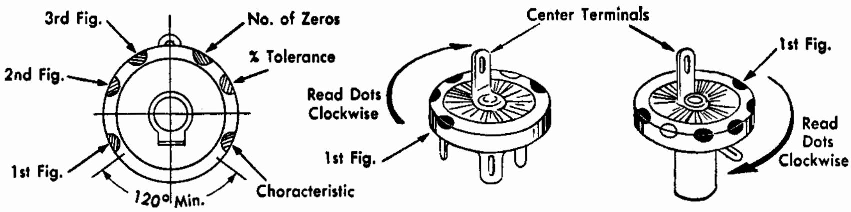


Fig. 18. Color code for button-type silvered mica condensers

Testing, reordering, and replacement of silvered mica condensers are done in essentially the same way as for ordinary mica condensers. Since the silvered types are more expensive and hence used only in critical circuits where their special characteristics are essential, it is important to get an exact duplicate for the replacement.

Stock of Mica Condensers. You do not need much of a starting stock of mica condensers, since they go bad so seldom. One of each of the most used sizes in 500-volt ratings with self-supporting leads will do nicely for the start. Use these as test substitutes for units of the same values having special characteristics, to verify the cause of trouble. Where the code on a bad unit indicates a particular temperature coefficient, however, you will have to order a new unit of that same type. There are too many possible combinations of characteristics for mica condensers to keep all of them in stock, so start with one each of the following 500-volt units:

0.00001 mfd (10 mmfd)	0.0005 mfd (500 mmfd)
0.00003 mfd (30 mmfd)	0.0007 mfd (700 mmfd)
0.00005 mfd (50 mmfd)	0.001 mfd (1,000 mmfd)
0.00007 mfd (70 mmfd)	0.003 mfd (3,000 mmfd)
0.0001 mfd (100 mmfd)	0.005 mfd (5,000 mmfd)
0.0003 mfd (300 mmfd)	

Ceramic Condensers. A relatively new type of condenser that is used in place of mica condensers in many television and radio receivers is the ceramic condenser.

All ceramic condensers have a hard ceramic insulating material, with a silver coating fired onto the opposite faces to serve as the plates or electrodes. Connecting leads are soldered to the silver coatings.

The three types of ceramic condensers in common use are tubular ceramics, disk ceramics, and plate ceramics. Each has its own particular uses.

Tubular Ceramics. In a tubular ceramic, the insulating material is a ceramic tube. A silver coating on the outside of the tube serves as one plate of the condenser, and a silver coating on the inside of the tube serves as the other plate. Wire connecting leads are soldered to the coatings and brought out either axially or from the sides as in Fig. 19, just as for resistors. These units therefore look much like resistors, but are recognized easily because of their special color-code markings. Another recognition clue is the white, light-brown, or dark-purple body color commonly used.

In receivers the frequency of each resonant circuit will change slightly with changes in temperature. This is due to a great many small changes in resistance, capacity, or inductance in coils, tube bases, tube sockets, resistors, variable condensers, and wiring. It is impractical to correct each of these characteristics by itself at a reasonable cost. Instead, a single temperature-compensating tubular ceramic condenser is used in the oscillator circuit to correct automatically for the over-all frequency change of the rest of the receiver with temperature. Usually this compensating condenser will have a negative temperature coefficient of capacity. This means that an increase in temperature reduces the capacity of the condenser. A negative coefficient of 1,400 parts per million per degree centigrade, for example, means the capacity will drop 8.4 per cent when the temperature is raised from 25 to 85°C.

Since tubular ceramics are generally used only in critical circuits, replacements for them should have exactly the same capacity, temperature, and tolerance ratings as the original.

Condenser-Resistor Combinations. A few receivers are using tubular ceramic condensers having a carbon resistor inside. Sometimes the ceramic condenser is in two sections, to give two condensers and a resistor. These combinations are called C and R units. They may have either two or three leads. An example is shown in Fig. 19.

If one element in a C and R unit goes bad, try to get a replacement for the entire unit. If this is not available, replace with standard individual parts having the values specified in the service manual for the set.

Disk Ceramics. These coin-size units have a thin disk of ceramic material, with the silver coating fired onto opposite faces. Wire leads are

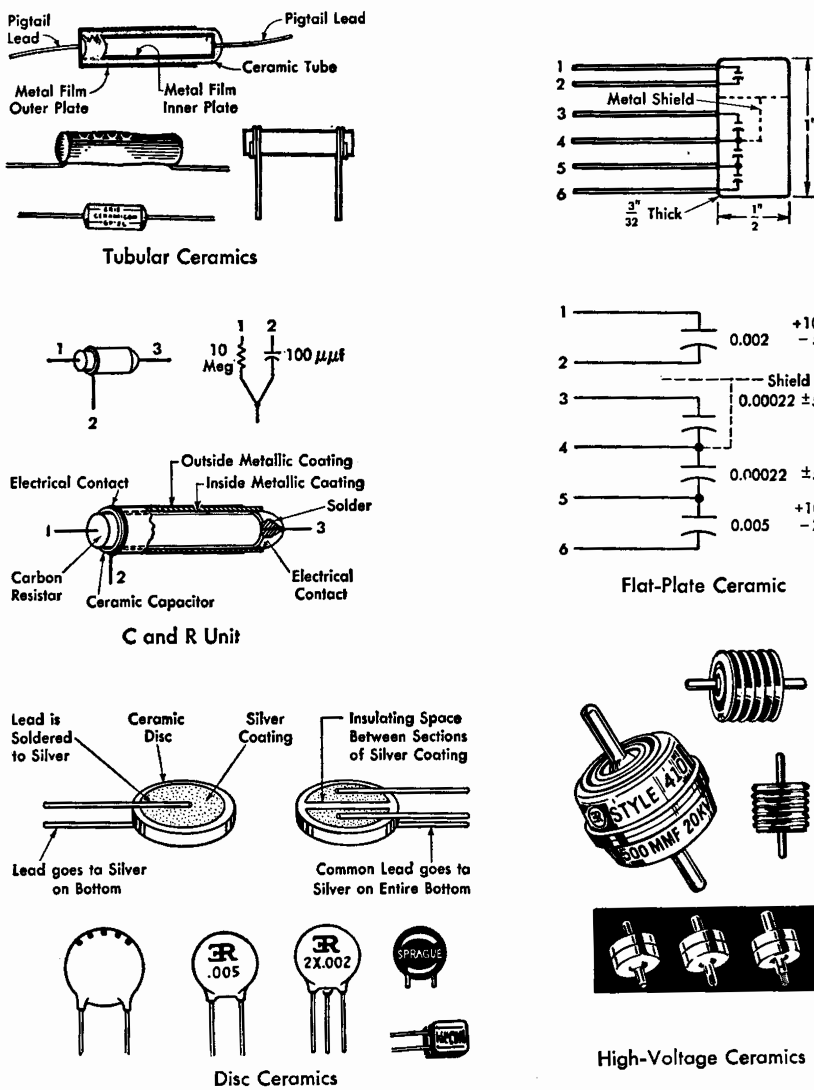


Fig. 19. Examples of different types of ceramic condensers

soldered to the coating and brought out as in Fig. 19. By dividing the conductive coating on one face and running separate leads, two condensers can easily be obtained from a single disk. Disk ceramics are coated with a light-brown plastic material that serves to insulate the condenser from other parts and protect it from effects of high humidity.

The characteristics of the insulating material and the methods of manufacture are such that production of disk ceramic units with close capacity tolerance is not practicable. Disk units will therefore have high tolerances, sometimes 100 per cent.

For coupling and bypassing applications, close capacity tolerance is usually not important. For these applications the disk ceramic condenser is widely used because it is cheaper than a comparable mica condenser.

The voltage rating of a disk- or plate-type ceramic condenser is usually 500 volts.

Plate Ceramic Condensers. To save space and simplify wiring, the condensers associated with one part of a circuit are often all placed on one rectangular ceramic plate. An example of this is shown in Fig. 19. This multiple-unit condenser was designed for use in the second detector circuit of a universal a-c/d-c radio receiver. The metal shield that separates the first condenser unit from the others helps to keep signals in their proper paths, so that i-f signals cannot get into the audio stages and so the audio output signal cannot get back to the first audio stage. Other combinations of capacity values will be found on ceramic plate units used in television receivers.

Ceramic plates are tested just as if they were individual units mounted side by side. When a defective section is found, replace the entire plate if an exact-duplicate replacement can be obtained. These units do not often go bad, but when they do, other sections of the same unit are likely to fail also in the near future.

If the correct replacement plate is not obtained, get individual disk ceramic condensers of the correct sizes and use the circuit diagram of the receiver as your guide for connecting these properly in place of the flat-plate unit.

High-voltage Ceramic Condensers. By stacking silver-coated ceramic disks so the disks are in series, extremely high voltage ratings can be obtained. For high-voltage power-supply filters in television receivers, 20,000-volt ceramic condensers like that in Fig. 19 are widely used. Instead of being soldered, these fit into special clips or connectors that have smoothly rounded surfaces. Any sharp metal corners in a high-voltage circuit can be the starting point for a high-voltage discharge; hence even the ends of the terminal rods of these condensers are rounded.

Testing Ceramic Condensers. All types of ceramic condensers will have extremely high leakage resistance when good, comparable to that of mica condensers. An ohmmeter test will therefore read infinity for a good ceramic. Any reading below 50 megohms is therefore an indication of trouble, particularly in high-voltage ceramics. If substitution of a new unit having somewhere near the same ratings restores performance of the set, you have confirmation of the ohmmeter indication.

When a ceramic condenser is suspected of being open or leaky, check it by substituting a known good ceramic condenser of about the same rating in its place. Since ceramic condensers hardly ever go bad, though, do not suspect one as being defective unless you have good reason to.

Ceramic-condenser Color Code. To replace a ceramic condenser, you need to know the ratings of the defective condenser. Sometimes the capacity value will be printed right on the condenser itself. You can always look up the capacity value of the condenser in the parts list or on the circuit diagram for the receiver. Most often, however, you will read the color code on the condenser to get its value and other ratings.

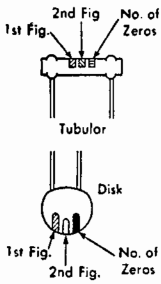
The standard RTMA color code used on ceramic condensers of all types is shown in Fig. 20. Always start reading from the end having the band on tubular ceramics and from the farthest counterclockwise dot on disk ceramics.

The color of the first band or dot indicates the temperature coefficient of the condenser. This tells how much the capacity changes for every degree change in temperature. A negative sign means that the capacity decreases when the temperature goes up. A positive sign means that the capacity goes up with the temperature.

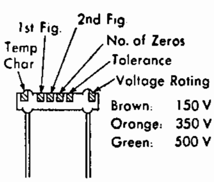
The next two dots or bands of color give the first and second figures of the capacity value. The fourth dot or band of color gives the number of zeros that follow the first two figures to give the capacity value in micromicrofarads.

The fifth dot or band of color indicates the capacity tolerance of the condenser. This tells how much the actual capacity value can differ from the value specified by the color-code markings.

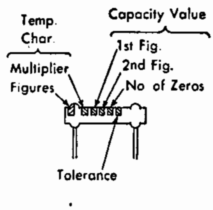
As an example, suppose that the colors as read in order on a ceramic condenser are green for the wide-band end, then gray, red, brown, and black. This condenser would have a temperature coefficient of minus 330 parts in a million for each degree centigrade rise in temperature, a capacity of 820 mmfd, and a capacity tolerance of ± 20 per cent.



3-Dot Code



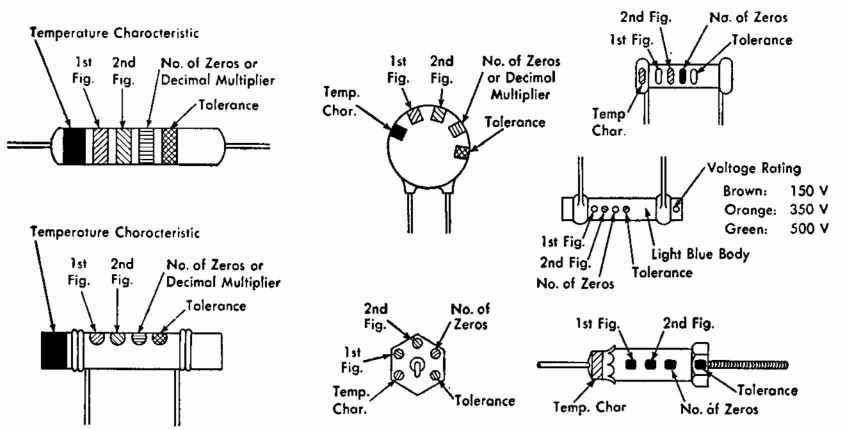
6-Dot Code with Voltage



Temperature Characteristic

Color	Figures	Multiplier
Black	0	− 1
Brown	—	− 10
Red	1	− 100
Orange	1.5	− 1,000
Yellow	2.2	− 10,000
Green	3.3	+ 1
Blue	4.7	+ 10
Violet	7.5	+ 100
Gray	—	+ 1,000
White	—	+ 10,000

6-Dot Code with Two Temperature Colors



5-Dot Color Codes

Color	Temperature Characteristic in Parts per Million per Degree C	Printed Temp. Char.	1st Figure	2nd Figure	No. of Zeros or Decimal Multiplier	Capacity Tolerance: 10 mmfd or Less	Capacity Tolerance: Above 10 mmfd
Black	0	NPO	0	0	—	2.0 mmfd	20%
Brown	− 30	N030	1	1	0	0.1 mmfd	1%
Red	− 80	N080	2	2	00	—	2%
Orange	− 150	N150	3	3	000	—	3% or 2.5%
Yellow	− 220	N220	4	4	0000	—	—
Green	− 330	N330	5	5	—	± 0.5 mmfd	5%
Blue	− 470	N470	6	6	—	—	—
Violet	− 750	N750	7	7	—	—	—
Gray	+ 30	P030	8	8	0.01	± 0.25 mmfd	—
White	Any	—	9	9	0.1	± 1 mmfd	10%
Gold	+ 100	P100	—	—	0.1	—	—
Silver	Any	—	—	—	0.01	—	—

Fig. 20. Color codes for ceramic condensers. On 5-dot codes, fifth dot is sometimes omitted

An older ceramic-condenser color code uses one band with three dots. Here the band is the first figure of the capacity value. The first dot is the second figure. The second dot is the number of zeros or the decimal multiplier. The third dot is the voltage rating, wherein brown through white represent 100 through 900 volts just as for the obsolete 1938 RTMA color code for mica condensers; gold is then 1,000 volts, silver is 2,000 volts, and no color means 500 volts. The capacity tolerance in this band-and-three-dot code is assumed to be 20 per cent.

Replacing Ceramic Condensers. Disk ceramic condensers used as plate or screen bypass condensers are not critical. The size of the replacement may vary somewhat from the size of the original. For example, in a set that uses 1,000-mmfd ceramic condensers as screen bypass condensers on the video i-f stages, the replacement can be a 1,500-mmfd unit. You might even be able to use 1,000-mmfd replacements in a set that originally had 1,500-mmfd bypass condensers.

Since ceramic plates are simply combinations of disk ceramics, capacity values are likewise not critical when replacing a plate with individual disk units.

Values of tubular ceramics are usually critical, but in television receivers particularly the trend is toward using general-purpose tubulars in place of mica condensers in noncritical circuits. When the color-code marking indicates that the unit may have any temperature characteristic, the replacement unit can have any other temperature color and can generally be somewhat different in capacity without affecting set performance.

Combining Condensers in Parallel. Sometimes you may be faced with the problem of obtaining a paper, electrolytic, mica, or ceramic condenser whose electrical size may be quite critical. When you do not have the time to obtain the correct replacement, or the correct replacement is not available, you can use two condensers in parallel to give the desired electrical capacity. For example, suppose you need a 0.15-mfd condenser. Here you could connect a 0.1-mfd condenser in parallel with a 0.05-mfd condenser to obtain a total capacity of 0.15 mfd, since *capacity values add when condensers are in parallel.*

Condensers in Printed Circuits. Miniature pocket-size radios, hearing aids, and television tuners sometimes use printed or stamped circuits in place of wiring. The condensers used here can be ordinary disk ceramics that are soldered directly to a silvered area on the flat ceramic chassis. Sometimes the condenser is obtained by placing the silver coating on opposite sides of certain portions of the ceramic chassis.

It is unlikely that you will find a condenser that has gone bad on a printed circuit. About the only thing that usually happens is that dirt and moisture may collect on the outside of the condenser, forming a leakage path from one condenser plate to the other or from one lead to the other. This can occur only when the condensers are not sprayed with an insulating lacquer. Cleaning with a soft brush is the best way of removing the dust.

QUESTIONS

1. What two types of condensers give the most trouble in receivers?
2. What happens to a condenser when too high a voltage is applied?
3. What is the equivalent in mfd of 2,000 mmfd?
4. What things that you can see, feel, or hear would make you suspect a paper condenser?
5. If a paper condenser gives a 10-megohm reading when disconnected and checked with an ohmmeter, is it shorted, leaky, or open?
6. Is it normal for a large good paper condenser to make an ohmmeter pointer kick upward momentarily?
7. What is the best voltage rating to order for a paper condenser if the old unit was rated 200 volts?
8. What is the purpose of the OUTSIDE FOIL marking at one end of a paper condenser?
9. Do color codes for paper condensers give the value in mmfd or in mfd?
10. What can happen if an electrolytic condenser is accidentally connected with reversed polarity?
11. What is the only sure way of telling whether an electrolytic condenser is bad?
12. Why is it bad business to touch the bare terminals of an electrolytic condenser while a set is turned on?
13. Why is it usually undesirable to mount a new electrolytic under the chassis when the old unit was mounted above the chassis?

16

TESTING, REPAIRING, AND REPLACING

Coils and Transformers

What Coils and Transformers Mean to Servicemen. Television and radio receivers have quite a number of different coils. Some of these, called *choke coils,* work individually to keep signals in their proper paths. Some coils act with a condenser for tuning a circuit to a desired signal frequency or for blocking an undesired signal frequency, as in wave traps.

Two or more coils working together form a transformer that transfers signals from one circuit to another without wire connections. Transformers also serve to change a-c voltages to higher or lower values as required by receiver circuits.

In television receivers, four coils work together in the deflection yoke on the picture tube to make the electron beam move back and forth and paint the picture on the screen.

Most of the coils in a receiver are not visible because they are mounted in metal housings or shields. Once you have worked on a few sets, you will have no trouble recognizing the shields that contain coils. A quick way to get acquainted with coils and transformers is by looking at those in a typical radio set, as shown in Fig. 1.

If the antenna transformer in a radio fails (opens), no radio signal gets from the antenna to the tuned circuit feeding the mixer–first detector, and the set goes dead.

If the oscillator transformer fails, there is no oscillator signal for changing the incoming radio signal to the fixed 455-kc value which alone can get through the i-f amplifier. Again the set goes dead.

If either i-f transformer fails, the i-f signal path is blocked, and the set goes dead.

If the output transformer fails, the path for audio signals from the output tube to the loudspeaker is broken, and no sound is heard.

If the filter choke coil goes bad, the receiving tubes get no plate voltages; hence no signals get through, and the set is dead.

If the power transformer goes bad, tubes get neither filament nor plate voltages, and the set is again silent.

Still other troubles develop if any of these coils or transformers become shorted instead of open.

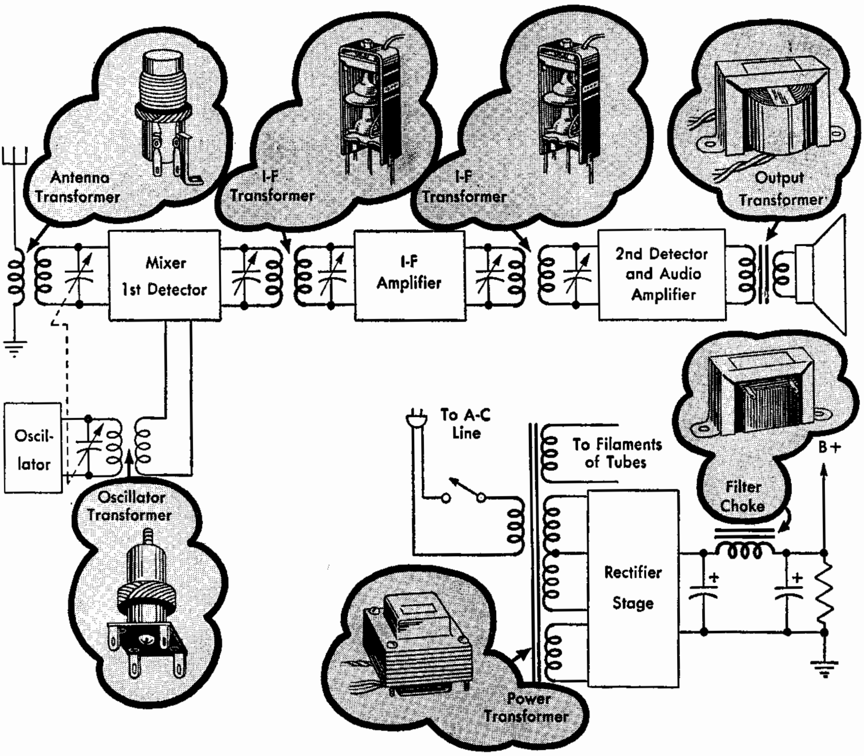


Fig. 1. Transformers in a typical a-c superheterodyne radio receiver, and their symbols

Coil Repairs and Replacement. Even though coils and transformers are important to the operation of a set, they are fortunately not too much of a servicing problem. Coils do not go bad as often as tubes, condensers, and resistors. When they do go bad, you either have a simple repair job of resoldering a joint or splicing a broken wire or you have to install an exact-duplicate replacement of the entire unit. If factory parts are no longer available, you will be able to order and install universal replacement parts for the majority of sets without difficulty, by following the simple instructions given in this chapter.

To fix the majority of receivers, you need to have only a general idea of how coils and transformers work. This will be given first, before you get definite instructions for testing, repairing, and replacing coils that are used individually or are combined in transformers.

How Coils Work. A coil is nothing more than a length of insulated copper wire wound around some sort of wood, paper, or plastic form. It may have a single layer of turns or many layers. It will have one lead for the start of the winding and one lead for the finish. The insulation of the wire may be enamel, cotton, silk, or a combination of silk or cotton over enamel. Coils for some r-f circuits have crisscross or basket-weave windings, but most coils are wound in layers with the turns of wire side by side.

The resistance of a coil as measured with an ohmmeter will always be the resistance of the length of copper wire used in winding the coil. Since copper wire has very low resistance, a coil offers very little opposition to direct current.

A break anywhere in the wire used for making a coil creates an open circuit, which has very high resistance. An ohmmeter is therefore the instrument you use for testing coils. A low reading means the coil is probably good, while an infinite reading means the coil is open.

Coil Impedance and Inductance. Although coils have very little effect on the flow of direct current, they provide an excellent control over alternating current. This is because coils oppose *any change* in the current flowing through them. The more often the current is changing, the greater is the opposition. This opposition of a coil is called *impedance*, and is expressed in ohms the same as for condensers and resistors. At higher frequencies, current is changing faster; hence the coil offers more opposition or impedance to the change in current.

A coil opposes a change in current by producing in itself an a-c voltage that opposes the applied a-c voltage. This opposing voltage is called a *self-induced voltage.*

The coil rating that determines how much self-induced voltage there will be for a given change in current is called *inductance*. The inductance rating is the *electrical size* of the coil, just as capacity is the electrical size of a condenser and resistance is the electrical size of a resistor. The higher the inductance rating, the greater will be the impedance of a coil for alternating current. The impedance of a coil thus increases when the inductance is increased and when the frequency is increased.

The unit of inductance is the *henry*, abbreviated h or H. A smaller unit is the millihenry, abbreviated mh or MH. One millihenry is equal to a thousandth of a henry. A still-smaller unit is the *microhenry*, which is a millionth of a henry.

Inductance values of coils in the power supplies of television and radio sets can be as high as 1,000 henrys. Inductance values of coils in tuning circuits of radio sets are much smaller, ranging from a fraction of a millihenry to several hundred millihenrys. In television-receiver tuning circuits, still-smaller coils are used, rated in microhenrys.

How Inductance Is Changed. The inductance value of a coil depends on three things: the number of turns of wire in the coil, the shape or dimensions of the coil, and the material used in the center or core of the coil. Winding more turns on a coil makes its inductance go up. Removing turns makes its inductance go down. Spreading out a coil, so that the same turns take more space, also reduces the inductance.

Changing the core material is the easiest way of changing the inductance of a coil. The three common types of core materials—air, powdered iron, and solid iron—will now be taken up one by one.

Air-core Coils. When alternating current is sent through a coil, a magnetic field is produced around the coil. This can be represented on diagrams as loops threading through the center of the coil, as shown in Fig. 2A for a coil that has only air and insulating material inside.

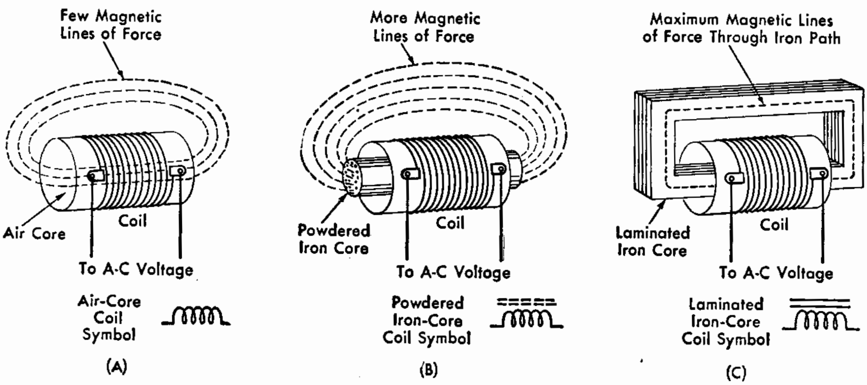


Fig. 2. Three types of coils, all wound on much the same cardboard form but having different cores. Corresponding circuit symbols are shown below

The inside of a coil is called the *core*. A coil with only air inside is called an *air-core coil*. Since insulating material is nonmagnetic, it is considered to be the same as air. Coils wound on fiber, paper, solid wood, or plastic are therefore also called air-core coils. A coil has its lowest possible inductance when the core is air.

Powdered-iron-core Coils. A given alternating current through a given air-core coil produces a definite number of magnetic lines of force. If a powdered-iron core is placed in the coil under the same conditions, many more lines of force are obtained, as shown in Fig. 2*B*. The tiny iron particles in this core provide much better paths than air for the magnetic field inside the coil, so a given current through the coil makes more lines of force. This means that the inductance of the coil increases when a better core than air is put in.

Powdered-iron cores are widely used because they need less copper wire to get the same amount of opposition to a-c. In addition, it is easy to adjust the inductance of the coil by moving the powdered-iron core in or out. The inductance is highest with the core all the way in the coil, and the coil is then tuned to the lowest frequency at which it can be used. The inductance is lowest with the core all the way out, and the coil is then tuned to its highest frequency.

Iron-core Coils. When a complete path through iron is provided for magnetic lines of force, as in Fig. 2*C*, the maximum possible number of magnetic lines of force is obtained. The coil then has maximum inductance, and is known as an *iron-core coil*. The opposition that an iron-core coil offers to alternating current is extremely high.

Coils in Series and Parallel. In television receivers and in all-wave radio receivers, two or more coils are sometimes combined to get extra tuning bands. In a television set, the station-selector switch connects coils together automatically as required. In all-wave radio sets the band-changing switch does the job.

When coils are connected together in series, their inductances add just as for resistors. The combined inductance is therefore greater than that of any of the individual coils. Coils in series therefore tune to a lower frequency than any of the coils alone.

When coils are connected together in parallel, the combined inductance is less than that of the smallest inductance in the group. Resistors in parallel act the same way. Coils in parallel tune to a higher frequency than does the smallest coil by itself.

How Transformers Work. Whenever the alternating current reverses in a coil, the magnetic lines of force reverse their direction also. These continually changing or reversing lines of force can transfer electricity from one coil through space to a second coil. The first coil is called the *primary coil*, and the second coil is called the *secondary coil*. This action is indicated in Fig. 3A for a simple air-core transformer. The alternating voltage that is produced in the secondary coil has the same frequency as that of the current flowing through the primary coil.

Increasing the number of lines of force that are changing in the secondary coil increases the induced voltage. Maximum lines of force are obtained when a complete iron core passes through both coils as in Fig. 3B. An iron-core transformer thus gives the highest possible secondary voltage for a given pair of coils.

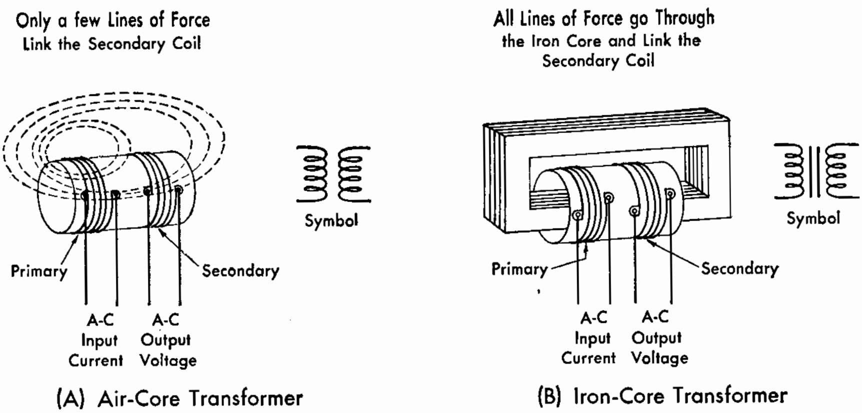


Fig. 3. Two types of transformers and their circuit symbols

The secondary voltage of a transformer depends also on the ratio of secondary turns to primary turns. If the primary and secondary have the same number of turns, the ratio is 1 to 1, and the secondary voltage is the same as the primary voltage.

When the secondary has more turns of wire than the primary, the secondary voltage is higher than the primary voltage. An example of this is the high-voltage secondary winding of a power transformer.

When the secondary has fewer turns than the primary, the secondary voltage is less than the primary voltage. An example of this is a filament winding on a power transformer, which gives 6 volts for tube filaments when the primary voltage is 115 volts a-c.

How Coils Go Bad. The commonest trouble you will encounter in an individual coil or in one of the windings of a transformer is a break in the wire, called an open circuit. Less common is a short circuit between adjacent turns due to failure of the insulation on the wire. Still rarer yet is a change in the electrical value of the coil when in a tuned circuit.

The first two troubles apply to all types of coils and transformers, and for this reason will be taken up in detail now, before considering testing and replacement of individual parts. The third type of trouble, involving a change in value, is fixed by realigning the receiver.

Open Circuits in Coils. A break in the wire of a coil is generally caused by a chemical action known as electrolysis, which is similar to corrosion and eats right through the copper wire. This action generally occurs near or at one of the terminals to which the ends of the coil are connected. Ordinary vibration can also break the fine wire of a coil right at the terminal. Slipping of a sharp tool or careless handling of an exposed coil can nick the wire anywhere so that it eventually breaks. Sometimes the coil form expands enough with temperature on a hot day to stretch and break the coil wire at a weak point.

Testing Coils with an Ohmmeter. When a coil of any type is suspected of being open, the quickest way to check it is by measuring its resistance

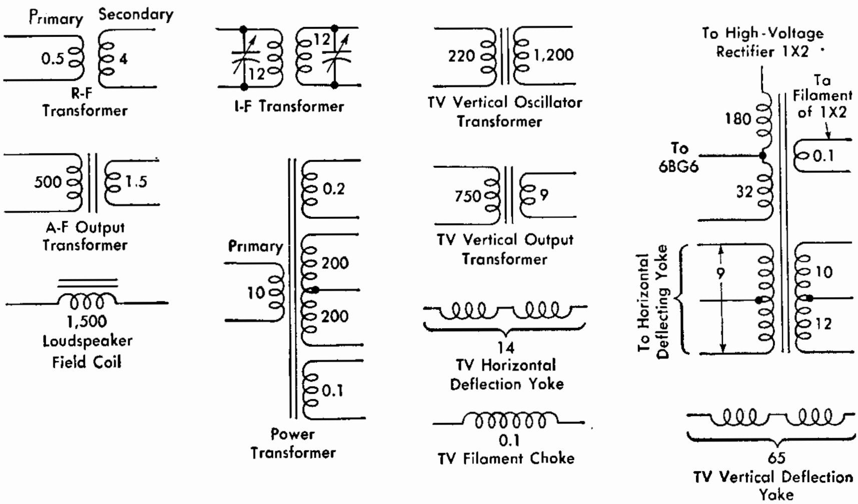


Fig. 4. Examples of coil resistance values in ohms. These values differ greatly in almost every set, so always refer to the service manual when the exact value is needed

with the lowest ohmmeter range. Try this first without unsoldering any coil connections. The correct resistance of each coil is generally given on circuit diagrams in service manuals. Examples of resistance values for radio and television coils are given in Fig. 4.

If an ohmmeter test between the two leads of a coil gives an infinity reading, inspect the terminals carefully. If no damage is visible, wiggle each soldered connection on the coil while watching the ohmmeter to see if you can find an easily repaired external break.

If the measured resistance of a coil is much lower than the specified value, unsolder one lead of the coil and measure again. The low reading may be due to some other part in parallel with the coil. If the reading is still way low, some of the turns in the coil may be shorted together.

Repairing Breaks in Coils. With patience and the right technique you can repair a break in even the finest wire used in coils, provided it is at the end of a winding so you can get at it. Clean the insulation off the broken end of the coil wire with a strip of fine sandpaper, as shown in Fig. 5. Use very gentle pressure because sandpaper can cut right through fine wire.

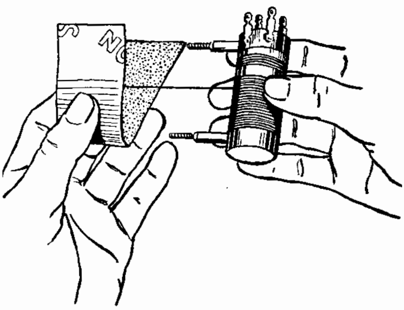


Fig. 5. Using small piece of sandpaper to remove enamel insulation from coil wire

Assuming the break is near a terminal or external lead, solder a short length of extra wire to this terminal or lead, and splice its other end to the cleaned end of the coil wire. A simple hook joint is adequate. Leave a little slack in the repaired connection, and anchor the repaired joint in position with electrical Scotch tape or with a few drops of speaker cement. Soldering the new piece of wire to the terminal first minimizes chances for breaking the delicate wire of the coil while working.

The windings of iron-core transformers are usually covered with insulating paper. Insulated leads will come out from between the outer layers of paper. If the ohmmeter indicates an open, carefully cut the outer layer of paper to expose the coil joints for examination. Once the paper is cut, avoid moving the leads because some of the wires that they connect to may be extremely fine. If the break is found to be here, it can be repaired and the insulating paper fastened back in position with electrical Scotch tape.

Short Circuits in Coils. Shorts between adjacent turns or adjacent layers of a coil are almost impossible to detect by measurements with an ohmmeter because they have so little effect on the resistance of the coil. Performance of the receiver is just about the only clue to this trouble. Short circuits in air-core transformers of tuned circuits upset the tuning action, generally to such an extent that realignment does not cure the trouble. In iron-core transformers a short circuit makes the coil get hot and may eventually burn it out. This heat is accompanied by a pungent smell of burning insulation, which is easily recognized.

Coils with short circuits cannot ordinarily be repaired. Complete replacement of the defective unit is therefore required. Short circuits in condensers and other parts of a set can also make power transformers and filter chokes get hot, so check this possibility first before replacing a hot transformer or choke.

Servicing Procedures for Each Type of Coil and Transformer. In the remainder of this chapter, each type of coil and transformer will be taken up in turn from a servicing standpoint. Detailed instructions will be given for testing suspected units, for repairing them where possible, and for ordering and installing replacement units. The order in which these parts will be taken up is (1) r-f chokes; (2) television peaking coils; (3) r-f transformers; (4) i-f transformers; (5) output transformers; (6) power transformers; (7) filter chokes; (8) special television coils.

Replacing R-F Chokes. Single air-core coils, called r-f chokes, are used in television receivers but are rarely found in radio sets. They have two

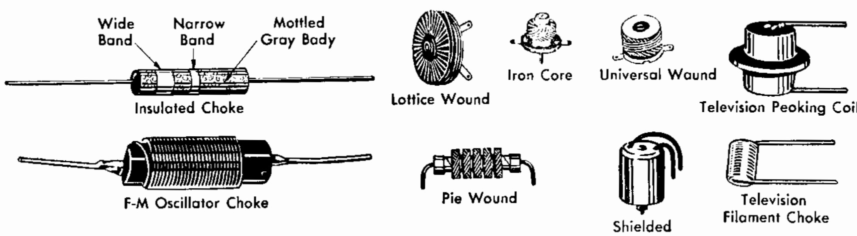


Fig. 6. Examples of r-f choke coils. Each has two terminals

leads or terminals and either an air core or a powdered-iron core. The resistance of a good r-f choke coil will usually be less than 10 ohms.

R-f choke coils will usually be found in the stages ahead of the i-f amplifier in a radio receiver, but can be almost anywhere in a television-receiver circuit. A defective unit can be replaced with a new coil having about the same size and shape so as to give approximately the same inductance. If the coil is in a tuned circuit, however, a more exact replacement will be required. This may mean trying a few different sizes of new coils if the inductance value of the original coil cannot be determined. Fortunately, r-f chokes rarely go bad.

Examples of chokes are shown in Fig. 6. The insulated choke can be distinguished from a resistor by its mottled gray body and by its two color bands that give the inductance value in microhenrys. The colors represent the same figures as in all other RTMA color codes. The wide band gives the figure to the left of the decimal point, and the narrow band gives the figure to the right of the decimal point. Thus, a wide black band and a narrow yellow band mean 0.4 microhenry; a wide red band and a narrow violet band mean 2.7 microhenrys.

Replacing Television Peaking Coils. In television receivers you will find single coils called peaking coils. When it is necessary to replace a peaking coil, get an exact-duplicate replacement if possible. If you cannot, get one that looks as much like the original as possible, in the hope that its characteristics will be close enough to give acceptable performance.

Many peaking coils are wound on resistors. The value of the resistor will not affect the performance of the circuit too much. However, if the inductance of the replacement varies, the high-frequency response of the video amplifier may fall off and cause loss of picture detail.

Other special single coils encountered in a television receiver, such as pulse-shaping coils, should be replaced by exact duplicates.

Use of Chokes in Wave Traps. An r-f choke coil and an adjustable condenser are often used together to block out a strong local station that is interfering with reception of other stations. A coil-and-condenser combination used for this purpose is known as a wave trap.

Wave traps are occasionally used with television receivers to suppress the signal of an interfering station. In homes near a powerful station, wave traps are often needed on radio sets as well as on television sets to suppress the extremely strong signal of the nearby station so programs of other stations can be seen or heard.

If the r-f choke in a wave trap goes bad, it is best to replace the entire wave trap.

You can install wave traps yourself to take care of interference complaints, if you know the approximate frequency of the interfering signal. Wave traps come with various tuning ranges, and you need one whose range includes the interfering frequency. Full instructions come with the unit for making the necessary tuning adjustment and making correct connections to the antenna and ground terminals of the receiver.

Identifying R-F Transformers. The language of television and radio is sometimes confusing. Two or more coils working together for transferring i-f signals are correctly called an *i-f transformer*. On the other hand, two or more coils used for much the same purpose in antenna, r-f amplifier, or oscillator tuned circuits are often called *antenna coils* and *oscillator coils*. The correct name for these is transformer, but even in catalogs you will sometimes find them listed as coils. All this does not matter a bit, as long as you know what to ask for or to order from catalogs.

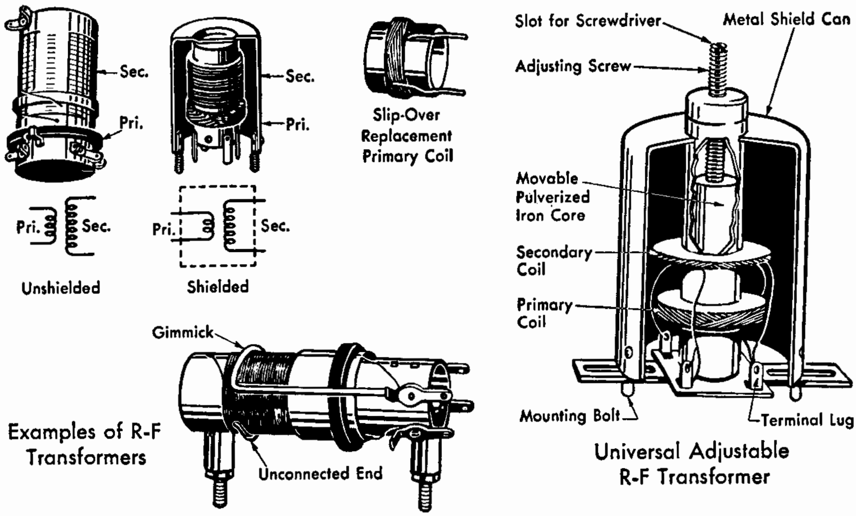


Fig. 7. Practical information on r-f transformers for a-m radio sets

Examples of shielded and unshielded r-f transformers for radio sets are shown in Fig. 7. The primary winding burns out most often. When this occurs, a slipover primary winding can be slipped over the burned-out winding and connected in its place, to make replacement of the entire transformer unnecessary. The slip-on coils are available in different diameters. Order the size next larger than the outside diameter over which the replacement coil must fit after the defective coil is cut away. Cut through the entire old primary with side-cutting pliers to speed removal.

To order the correct replacement r-f transformer, you must first identify the job which that transformer does in the receiver. Here are a few clues that will serve for most jobs until you become more familiar with circuits.

In a radio receiver, always locate the antenna transformer first because it is the easiest to identify positively. It will almost always be above the chassis. One of its terminals will be connected to the antenna of the set, either directly or through a small fixed condenser. Another terminal will be connected to one stator section of the gang tuning condenser.

The oscillator transformer is usually under the chassis, unshielded. One of its leads also goes to a stator section of the gang tuning condenser, but none of its leads goes to the antenna.

If the sections of the gang tuning condenser have different sizes of rotor plates, the oscillator lead will go to the section having the smaller rotor.

In larger radio sets that have three-gang tuning condensers there will be an r-f transformer also. This will be a little more difficult to identify until you have studied circuits, but if you can locate the plate terminal of the r-f amplifier tube, you can identify that transformer also. One of the r-f transformer terminals will go to the plate of the r-f amplifier tube. Another terminal will go to the additional stator section on the gang tuning condenser.

Technically, antenna and oscillator transformers are r-f transformers since they are used in r-f circuits. When the term r-f transformer is used in a general way, it therefore applies to antenna and oscillator transformers too.

Quality of R-F Coils. The effectiveness of a coil in an r-f transformer is greatly reduced if it develops a higher resistance than normal. A poor connection at a terminal or a corroded wire that is almost entirely eaten away will increase this series resistance. This in turn reduces the quality of the coil, commonly called the *Q* of the coil. The lower the *Q*, the poorer is the performance of the coil in a tuned circuit.

Coil *Q* is also reduced by electrical leakage through the coil insulation and the coil form. When coils lose their *Q*, the sensitivity and selectivity of the receiver both drop. Stations on adjacent frequencies then interfere with each other, the volume is less than normal, and distant stations cannot be received.

One rather common cause of low *Q* is a high-resistance soldered connection on a coil. For this reason, it pays to apply a hot soldering iron to each coil terminal in turn. Hold the iron in place long enough to make the solder melt and flow. Apply a little fresh rosin-core solder to each joint also, so the rosin flux can clean up any corrosion at the joint.

The insulation on the wire used in winding coils can deteriorate through natural aging, insufficient moistureproofing during manufacture, or just through being in a damp or salty atmosphere. Coil insulation can also be spoiled by flood damage or other sudden but temporary immersion in water. Here, baking of coils by placing the set in direct sunlight or in a moderately hot oven may restore the coils, but at some risk of melting out the wax from condensers and other parts in the receiver.

Replacement of coils having poor insulation is the best procedure. Fortunately, coils are just about the last thing to suspect when you encounter a complaint of poor selectivity and poor sensitivity, because so many other defects can do the same thing. In general, it is best to leave all coils alone until you have eliminated tubes and all other parts as possibilities.

Gimmicks on R-F Transformers. Occasionally you will find on a radio-receiver antenna transformer a short length of bare or insulated wire that is connected to a terminal at one end only, much as shown on one of the transformers in Fig. 7. This wire is called a *gimmick*. It provides a small value of capacitance between the primary and secondary windings, to make the performance of the radio set more nearly uniform for all stations in the broadcast band. As a rule, you will find gimmicks only in older and cheaper table-model sets. Do not worry about the ends being unconnected; just leave them alone.

Ordering New R-F Transformers. When a new r-f transformer is required for a high-quality radio receiver, try first to obtain an exact-duplicate unit from the local distributor of that set or directly from the factory. For ordering, give the make and model number of the receiver and the part number of the transformer. This part number can be found in the service manual of the set or in collected volumes of service data, once you have identified the function of the transformer (whether it is the antenna, oscillator, or r-f transformer).

Exact-duplicate r-f transformers can also be obtained from certain coil manufacturers. These firms issue catalogs listing sets by make and model number and specifying the correct replacement for each transformer. Some firms will even wind special transformers to duplicate a defective r-f transformer that is sent to them. Your jobber may take your order for special units, or he can give you the names of coil manufacturers who are providing such replacement service.

When the receiver has several wave bands and uses an r-f transformer with a tapped coil or multiple windings on the same form, an exact duplicate or a rewinding job is necessary. Matched sets of coils with taps for the police band may be available for a-c/d-c receivers, however.

Ordering Universal Replacement R-F Transformers. Since r-f transformers are used in tuned circuits that have a great effect on receiver performance, an exact-duplicate replacement ensures that the set will work right. Ordering from the factory or from a coil manufacturer takes a lot of your own time and delays the repair job at least a week, and this may not be justified for cheap sets. For these you can obtain universal antenna, oscillator, and r-f transformers from jobbers. These will replace broadcast-band transformers in most receivers. They sometimes have a screwdriver adjustment like that shown in Fig. 7, and come with installing and adjusting instructions.

If the original transformer was unshielded, be sure to order an unshielded new transformer. Likewise, use a shielded new transformer if the old one was shielded. This holds for all replacements of antenna, oscillator, and r-f transformers.

Tracking of r-f transformers means much the same as follow the leader in games. Tracking is good if all stations come in at their correct tuning-dial settings. Tracking is bad if stations come in at dial settings that are different from actual station frequencies.

In small table-model radio sets, where tuning-dial settings cannot be read closer than 50 or 100 kc, you can forget about tracking problems. The customer will never notice that stations are coming in at different points on the dial than before. When you take up receiver alignment procedures, you will learn how to make coils track the tuning dial in larger and more expensive radio sets.

Replacing R-F Transformers. When you have an exact-duplicate replacement, the terminals, leads, and mounting facilities of the new transformer will be exactly like those of the old, and your job will be simple. Even so, it is easy to get careless and make mistakes in connections. To play safe, always make a rough sketch that shows all connections accurately, before removing the old transformer.

When replacing any parts in r-f and i-f circuits, get the habit of making lengths and positions of leads essentially the same as for the old part. This arrangement or dress of wiring is critical in a few broadcast sets, and becomes extremely important in f-m and television sets. Training yourself now to observe and to record on sketches the positions of wires is excellent preparation for television work, yet takes no more time than doing a careless and sloppy wiring job.

Soldering lugs rather than leads are generally used on r-f transformers. If some of these lugs are hard to reach for unsoldering the old part, snip off part of the lug with side-cutting pliers rather than risk breaking and shortening the lead by unsoldering in cramped quarters. You can then bend the lead out into the open for unsoldering the cutoff portion of the lug from the wire.

Mounting Universal Replacement R-F Transformers. When a universal replacement transformer is used, the terminals and mounting facilities will undoubtedly be different from those of the old unit. You may therefore have to drill new holes in the chassis for mounting. Use nuts and bolts for mounting the new unit. Always put a lock washer under each nut.

Replacement of any r-f transformer will generally involve drilling or otherwise removing one or more rivets, since these parts are usually riveted to the chassis.

Universal replacements can be used only for conventional r-f transformers having two windings and no taps. Whenever a transformer has extra windings or has taps for short-wave bands, you will have to get an exact-duplicate replacement from a coil manufacturer or from the factory.

Connecting Universal R-F Transformers. Getting the proper connections for a universal replacement coil is generally no problem if you trace the leads from the coil windings to the coil terminals for both new and old coils. No matter whether you have an antenna, oscillator, or r-f coil, one winding will be smaller than the other. Locate the terminals of this smaller winding on the old coil, number these terminals A and B on your sketch, then locate the terminals for the smaller winding on the new coil. Measure between these terminals with an ohmmeter to check yourself; the reading should be only a few ohms, close to zero. Assign the letter A to one terminal and B to the other. The remaining two terminals on the new coil should likewise give nearly zero ohmmeter reading; assign these the letters C and D, and do the same for your sketch. It is now a simple matter to make connections to the new coil, even though its arrangement of terminal lugs is entirely different from that of the old coil.

For the antenna and r-f coils, it does not matter which of the two terminals for the smaller coil gets marked A. For the oscillator coil, you have a 50–50 chance of getting connections right the first time. If the set does not work after the new oscillator coil is installed, reverse the leads to terminals A and B. If more convenient, you can reverse the leads to terminals C and D and get the same result.

The above procedure allows you to replace coils without bothering with their circuit connections. Even after you have learned more about circuits, you may still prefer this simple procedure for replacing standard coils.

In some two-winding circuits, one lead of each coil may go to the same point in the circuit or to ground. Transformer manufacturers save the price of one terminal lug by connecting both coil leads to one terminal lug on the transformer. The r-f transformer then will have three terminals rather than four. On the universal replacement transformer there is a separate terminal for each lead of each winding. Locate the correct separate terminals and connect them together with a short length of bare or insulated wire to duplicate the connections of the original coil.

Television Tuner Coil Troubles. Television receivers have antenna, r-f, and oscillator transformers just as do radio sets. The individual windings

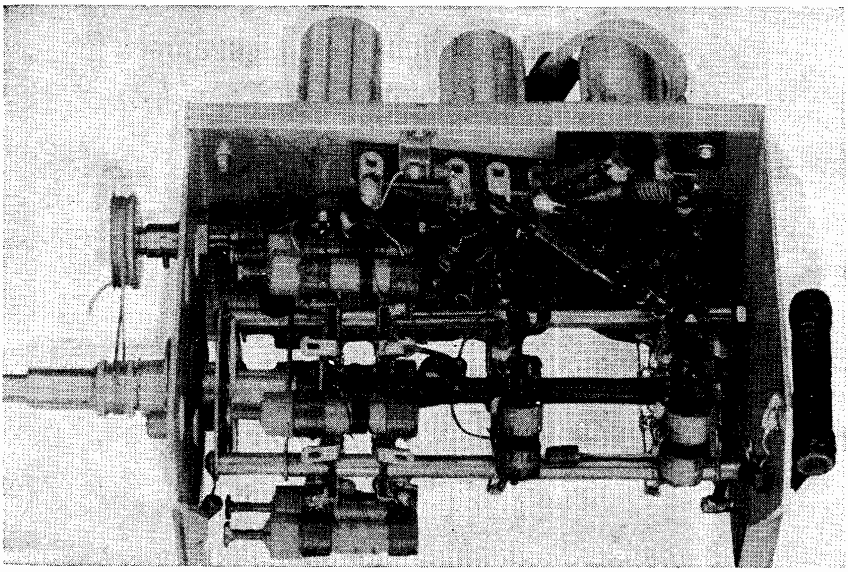


Fig. 8. Tuner used in vhf television receiver, showing coils having only a few turns of heavy wire for the antenna, r-f, and oscillator transformers. (Howard W. Sams photo)

or coils for television station frequencies are small and have few turns. They come on a separate small tuner chassis having the tuning mechanism and the tubes associated with station tuning (the r-f amplifier tube, mixer tube, and oscillator tube), as illustrated in Fig. 8.

If one of the coils in the tuner of a television receiver is damaged, it is usually impossible to obtain an individual replacement. Even if the replacement were available, the average serviceman may not have the equipment available to realign the tuner.

Many distributors will exchange a defective tuner for one in good operating condition. The cost of the exchange is far less than the cost of a new tuner. If you run into tuner trouble, call the distributor for that make of receiver to see if he has this exchange service, before buying an entire new tuner.

Some television receivers use what is known as a turret tuner. Replacement of coils is simple in these. The coils are arranged in strips that are held in position by a spring. The spring is simply moved back, and the entire strip is removed. Replacement strips are available from the receiver distributor. If a replacement is not available, one of the unused adjacent-channel strips can sometimes be adjusted to work satisfactorily for the channel having the defective coil strip.

Identifying I-F Transformers. One of the easiest parts to identify in a radio set is the i-f transformer, because it is always in a square or cylin-

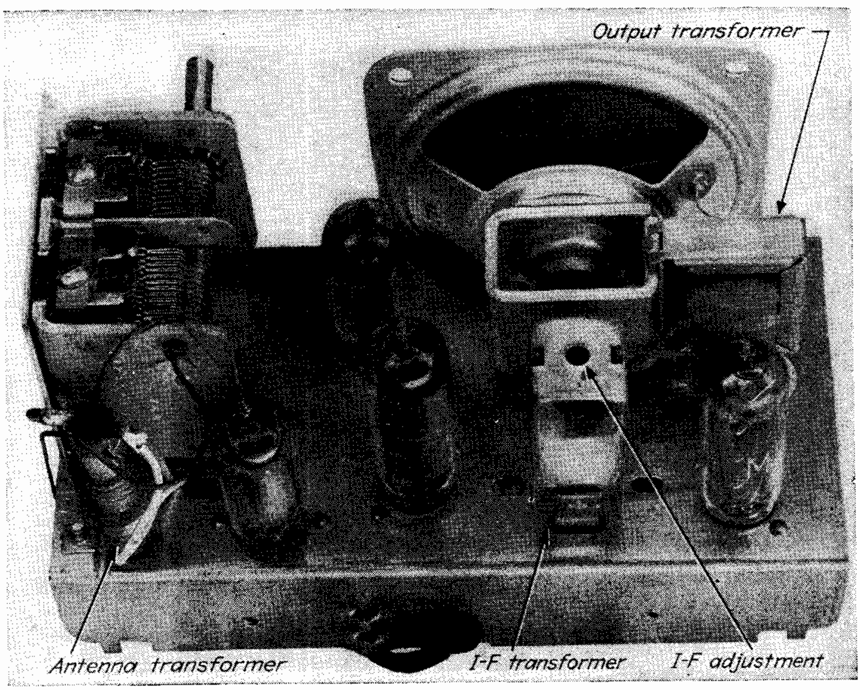


Fig. 9. Location of i-f transformer on a universal a-c/d-c radio set (Aircastle model 90121). Antenna transformer is unshielded. Output transformer is mounted on loudspeaker, which in turn is bolted to chassis. This set has only four tubes, all miniatures. (Howard W. Sams photo)

drical shield can on top of the chassis and always has two adjustments somewhere. Sometimes these adjustments are trimmer-condenser screws that are accessible through holes in the top of the unit. In newer sets you will usually find threaded-shaft adjustments for powdered-iron slugs, now widely used in place of trimmer condensers. One adjustment for these will be through a hole in the top of the can, and the other will be under the chassis, as shown in Figs. 9 and 10.

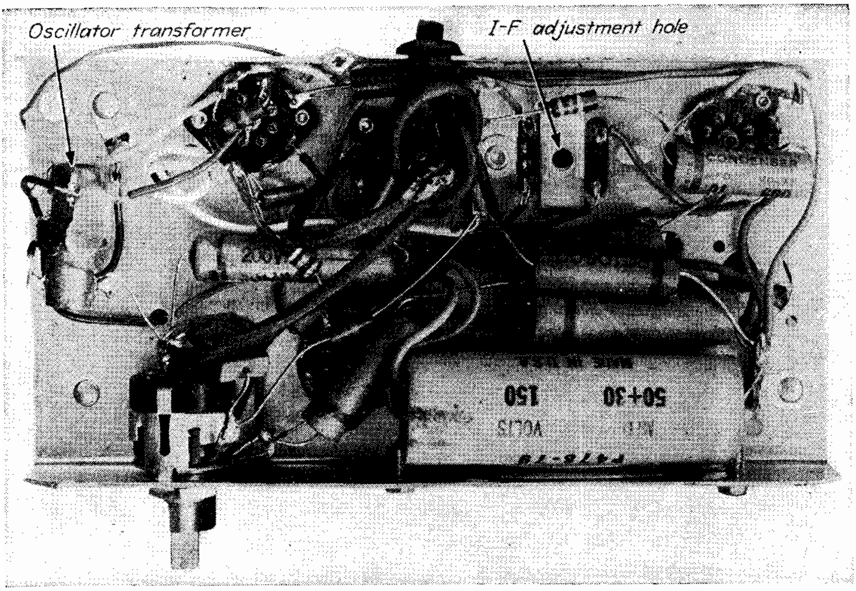


Fig. 10. Bottom of chassis of Aircastle model 90121 receiver, showing lower adjustment for i-f transformer and the four terminals of this transformer. (Howard W. Sams photo)

The leads or terminals of i-f transformers always come out under the chassis through a large hole. The shield can will be riveted, bolted, snap-fastened, or otherwise mounted on the chassis. The parts inside will in turn be fastened to the shield with a screw or other means. Sometimes it is possible to remove the shield without disturbing the coils and their connections, for checking parts inside and repairing broken coil leads.

What I-F Transformers Do. You will recall that in a superheterodyne receiver the oscillator and the mixer–first detector act together to change the frequency of the incoming station signal to a new value called the intermediate frequency, which for modern broadcast sets has been standardized at 455 kc. This 455-kc signal is fed into the i-f amplifier where it gets tremendous amplification. The i-f transformers serve as the tuned circuits for doing this. Their tuning adjustments are all set to 455 kc at the factory, and need to be readjusted only occasionally by servicemen.

One i-f transformer is used ahead of and after each i-f amplifier tube. Small table-model sets generally have only one i-f amplifier tube, so look for only two i-f transformers on these. On larger sets having two i-f amplifier tubes, look for three i-f transformers. In f-m and television receivers, where still more i-f amplifier tubes are used, you can generally expect to find one more i-f transformer than there are i-f amplifier stages.

Many different symbols are used on circuit diagrams to represent an i-f transformer, as shown in Fig. 11. Solid or dashed lines drawn through the coil symbols or between them indicate use of a pulverized-iron slug. Arrows may or may not be placed on these lines to indicate that the slug is adjustable.

I-F Transformer-lead Color Code. Most i-f transformers have terminals or leads that are identified according to the standard RTMA color code, as indicated in Fig. 11. This is a help in making connections to a new i-f transformer. Many older sets do not follow this color code, however, so it is still a good idea to make a rough sketch before disconnecting leads from the old part.

You cannot rely completely on any system of coding leads of parts because manufacturers of these parts are only human. If they run out of a certain color of wire, many will switch to some other color rather than lay off workers or delay shipment of an important order. If you suspect that colors of leads are wrong, by all means ignore them and rely on your sketch.

Removing Coil Shields. All i-f transformers and most r-f units have metal shield cans. These prevent stray electromagnetic fields from interfering with the action of the coils.

A shield can must usually be removed before the coils inside can be inspected for poor joints or breaks in the wires. When spade bolts are used for mounting the shield on the chassis, just remove the two nuts under the chassis and lift out the shield. The coil assembly will usually come off with the shield, but the leads under the chassis will limit the distance the unit can be lifted up. Look for one or more other bolts on the shield and remove these to separate the shield from the coil.

Sometimes the shield is fastened with a single mounting bolt. In rare cases it is riveted to the chassis, so that drilling is required to get it off. Another type of coil mount uses spring clips that snap into chassis holes.

To loosen these, squeeze the two prongs of the clip together with pliers while pulling up on the shield.

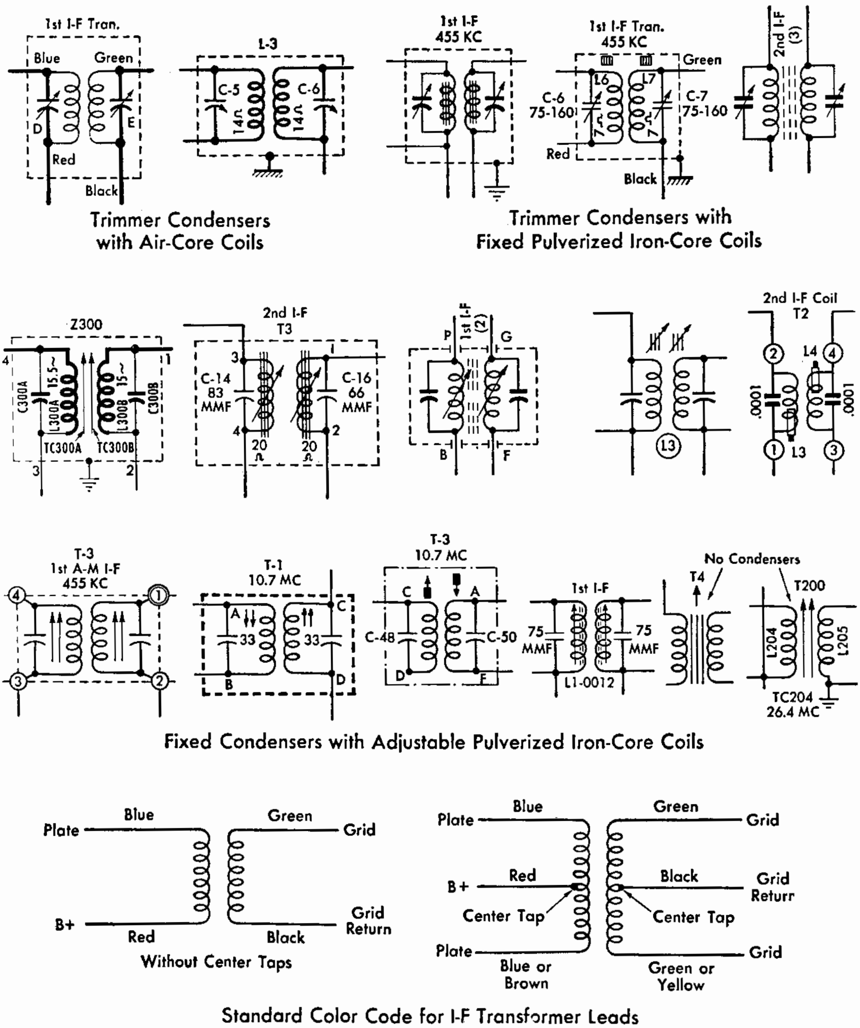


Fig. 11. Symbols used to represent i-f transformers on circuit diagrams. The dashed-line boxes that represent the metal shield can are not always shown, even though practically all i-f transformers are shielded. Color code helps identify leads

In some i-f transformers, a grid lead comes out of the top of the shield and has on its end a top-cap clip that fits over the top cap of a tube. If this lead is long enough, the shield can be slipped up on it far enough to expose the coil terminals. If the lead is too short, unsolder the clip temporarily to get the shield out of the way.

Common Troubles in I-F Transformers. Broken leads are perhaps the commonest defect you will encounter in i-f transformers, yet even these are rare. You may not have to replace a transformer for months at a time even when operating a full-time servicing business.

A simple break in a lead can generally be repaired by soldering in a short section of extra wire, just as for any other coil. If the receiver has been operated for a long time in a salt atmosphere near the seashore or in a damp basement location, so that there are corrosion spots on all exposed leads of the windings and mold on the insulation of the windings, replace rather than repair.

Look for green corroded spots on the exposed coil windings. These are where electrolysis is at work. If there is only one, scrape it clean and solder in a short piece of fine wire carefully to bridge across the gap. A small piece of ordinary Scotch tape or No. 33 electrical Scotch tape can be used to insulate the joints. If there is more than one corroded spot, replace the entire coil.

Mechanical failures in the adjustments of an i-f transformer are likewise a reason for replacement.

Ordering and Replacing I-F Transformers. Exact-duplicate replacements are rarely needed for i-f transformers. The important thing is to get a new unit having the same i-f value as the old. This is a problem only on very old sets, made long before 1940. On all more recent a-m broadcast-band sets the i-f value is 455 kc.

You will also have to specify whether the transformer is input, interstage, or output. The input i-f transformer is the first one coming right after the mixer–first detector. The output i-f transformer is the last one, coming just ahead of the second detector. Any i-f transformers in between these two, if present, are called interstage i-f transformers.

The advantage of getting an exact-duplicate replacement is that it will fit in the same mounting holes. With a different unit, you may have to drill new holes and possibly even enlarge the hole through which the leads or terminals come out. Before drilling, always examine the other side of the chassis to be sure no parts are damaged when the drill breaks through.

New i-f transformers are connected by following much the same procedure as for r-f coils. The color code will be an additional help here. Most new i-f transformers come with leads rather than lugs. If the colors of the leads are the same for the old and new units, do not cut the leads of the old unit entirely off. Leave about an inch of wire on each at the chassis terminal, so you can match colors and thereby minimize mistakes when connecting the new unit. The short stubs of wires can be removed one by one as you connect the corresponding new leads.

Some manufacturers have universal replacement i-f transformers that can be used anywhere in a set. If you can get this type of transformer, you do not need to specify where it is to be used.

Replacement i-f transformers are generally adjusted only approximately to the correct frequency at the factory. The set may work quite well sometimes when the new part is connected, but usually realignment is necessary. This job should be turned over to another service shop until such time as you have learned alignment techniques and obtained the necessary signal generator.

F-M Receiver I-F Transformers. The i-f transformers in f-m receivers generally use the i-f value of 10.75 mc that has become standard for these receivers. Replacement transformers are readily available at most jobbers and wholesalers. Some manufacturers use a slightly different i-f value in their f-m receivers, and a transformer designed for this frequency should be used if available. In most cases, however, a 10.75-mc i-f transformer can be installed and adjusted to the new frequency if the required signal generator is available.

Television I-F Transformers. The i-f transformers and i-f coils used in television receivers require exact-duplicate replacements. These can be obtained from the distributors for various makes of sets. For many of the more common makes of sets, your jobber will have equivalent replacement units made by transformer manufacturers. These are quite satisfactory as a rule and can save you a trip to the distributor, so try your own jobber first.

Practically all replacement i-f transformers for television receivers require critical adjustments after installation. This adjustment calls for special test equipment, and should not be attempted until you are familiar with television-receiver alignment procedures.

What Output Transformers Do. The iron-core unit that gives the most trouble in receivers is the audio output transformer. This transformer transfers the audio signal from the output stage of the receiver to the voice coil of the loudspeaker.

The primary winding of an output transformer is always the one that has the most turns and the finest wire. The primary winding always has one direct connection to the output tube and one direct connection to a B+ terminal in the set. The secondary winding has just a few turns of heavier wire and connects directly to the two terminals of the voice coil on the loudspeaker, as in Fig. 12.

In large sets having two output tubes (said to be connected in push-pull), the primary winding will have a center tap that connects to B+, and

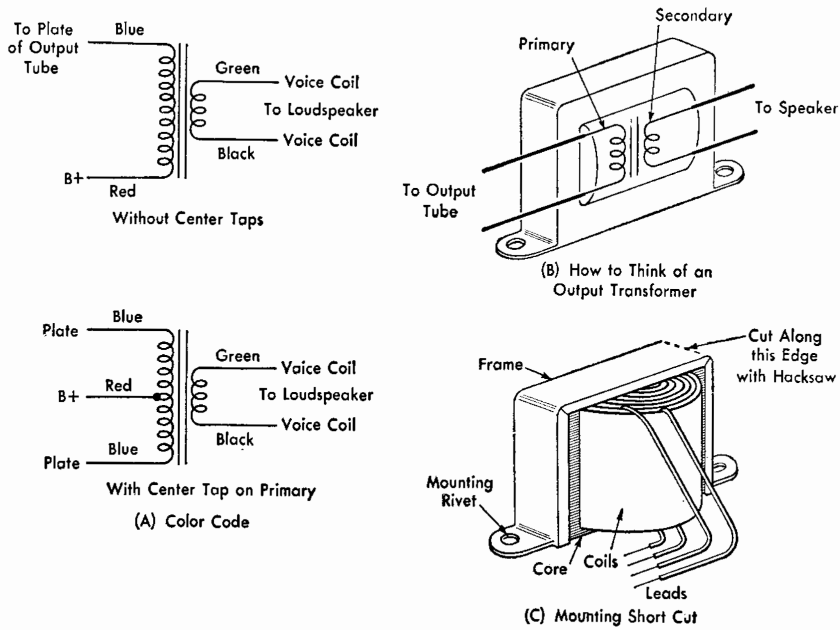


Fig. 12. Practical information on audio output transformers

each end of this primary winding will go to the plate of one output tube, as also shown in Fig. 12. Standard RTMA color codes for output-transformer leads are indicated on this diagram.

The chief job of the output transformer is matching the characteristics of the output stage to those of the loudspeaker. The output stage works best when feeding into a high-impedance load. Each type of tube requires a particular size of load for best operation. These load-impedance (a-c opposition) values range from 1,500 to 25,000 ohms. The voice coil of the average loudspeaker, on the other hand, has an a-c impedance that is generally somewhere between 4 and 16 ohms. The output transformer provides the match required between these two widely different impedance values.

Ratings of Output Transformers. Catalogs of output transformers generally specify the power output in watts, along with the primary and secondary impedance values. The larger the set and the larger its loudspeaker, the higher will be the output-transformer power rating. For ordinary table-model sets this transformer rating will invariably be 3 watts or less. The average console will have an 8-watt output transformer, and only a few of the more expensive sets will go as high as 30 watts.

Common Troubles in Output Transformers. Just as with other coil devices, a broken lead or wire is the commonest trouble in output transformers. This break is generally due to corrosion. Excessive current can, of course, overheat and burn out the winding, but this is a rare possibility in output transformers.

Short circuits may occur between adjacent turns or between layers of turns if insulation is damaged by overheating. Shorted turns cause weak volume and distortion, but these symptoms cannot be blamed on the output transformer immediately because several other receiver defects give the same symptoms. Substitution of a good universal output transformer is the only practical test for shorted turns.

About the only time you can repair an output transformer is when there is a break in a lead that is right under the outer layer of insulating paper. Instructions for making this type of repair were given earlier in this chapter.

Testing Output Transformers. An open circuit in an output transformer can be detected with an ohmmeter. It is always best to disconnect one lead of the winding before making the test. There is often a condenser across the primary winding. If leaky or shorted, this condenser can make the ohmmeter indicate continuity even when there is a break in the primary winding.

The voice coil is always directly across the secondary winding, and would definitely hide an open in the secondary if you failed to disconnect one secondary lead.

Do not expect to obtain ohmmeter readings corresponding to rated impedance values. The d-c resistance of a winding, as measured with an ohmmeter, is always much less than the a-c impedance value. A reading of infinity for any winding indicates an open circuit.

The windings of an output transformer are insulated from the iron core, since this core is usually mounted directly on the chassis. The secondary winding is normally also insulated from the core. In most sets, however, nothing happens if one secondary lead is touching the core. Oftentimes a secondary lead is grounded to the chassis and is thus directly connected to the core.

The ohmmeter reading between the primary winding and the core of an output transformer should be higher than about 1 megohm. If appreciably lower and if the tone quality of the set is unsatisfactory, you are justified in replacing the transformer.

Shorted turns cannot ordinarily be detected with an ohmmeter, since they have so little effect on the total resistance. Poor tone quality and signs of overheating are symptoms pointing to shorted turns. There will also be a disagreeable odor of burned insulation coming from the output transformer. Replacement is the only remedy.

Ordering New Output Transformers. It is rarely necessary to order an exact-duplicate replacement output transformer from the manufacturer or distributor of the receiver. Replacement units that will work satisfactorily can generally be obtained from your jobber, oftentimes with special universal mounting brackets that eliminate drilling new mounting holes.

The power rating required for the new transformer is the same as the audio output rating in watts for the entire set. This value is usually given in the service manual for the set. When in doubt, use a higher power rating. Transformer size goes up with power rating, so be sure there is space for the larger unit in the set. Another advantage you get from a higher power rating is improved tone. The higher the power rating, the greater the cost of the new unit.

You can usually go to a jobber and get a satisfactory replacement simply by naming the output-tube type number with which the output transformer is to be used. The great majority of sets have more or less standard voice-coil impedances of 3.2 to 4 ohms, and salesmen know pretty well by memory the impedance required by different output tubes. If you wish, you can look up the impedance of the tube yourself in a tube manual. Be sure to specify whether you have a single output tube or a push-pull stage using two tubes. Catalogs often abbreviate push-pull as PP and abbreviate voice coil as VC.

Universal Replacement Output Transformers. A replacement unit designed for the particular tubes in your set is cheaper and somewhat easier to install than a universal replacement unit. It is generally impractical, however, to keep on hand in a small shop all the different sizes of output transformers you are likely to need.

Keep on hand at least a few universal output transformers. These have extra windings and leads so that they can be used in a great variety of sets merely by choosing the proper leads and snipping off the others. Instruction sheets showing how to do this are generally furnished with the transformers.

You may have to charge the customer a dollar or two more to cover the extra cost of the universal unit. This extra charge is justified because you will be able to finish the repair immediately, without making a special trip to the jobber or waiting for his next delivery.

Complete connecting instructions are packed with each universal output transformer. The general procedure is to connect the primary first. The correct secondary leads are then soldered to the points from which the original secondary leads were removed.

If the voice-coil impedance is given in the service data for the set, the output-transformer instructions will tell you which two of the secondary leads to use. If the voice-coil impedance value cannot be found, try the 4-ohm lead and then the 8-ohm lead, and use the one that sounds best when the speaker is in the receiver cabinet. Modern loudspeakers usually have voice-coil impedances of 4 or 8 ohms.

A slight mismatch of impedances is unimportant. However, a large mismatch will decrease the volume to some extent and make the high notes too weak or too strong. If the receiver does not sound normal when back in its cabinet, try another secondary tap.

Do not disconnect the secondary leads of the output transformer while the set is turned on. Removing the load can damage the output tube.

Installing New Output Transformers. The leads of new output transformers are generally color-coded. It is still a good idea to make a rough sketch of connections before disconnecting the old unit.

Connecting of the new unit is merely routine soldering procedure. Leads will generally be longer than necessary, so do not be afraid to shorten them first.

Output transformers are generally riveted to the chassis or loudspeaker during manufacture. Removal of the old unit therefore involves drilling out rivets first. Use nuts and bolts for mounting the new unit. When drilling out rivets on the loudspeaker, be extremely careful to keep drilled-out particles away from the voice coil and air gap. Pack cloth or tissue paper back of the cone to catch the drillings.

A short cut for replacing small output transformers without drilling rivets is also shown in Fig. 12. Cut the frame of the old unit along a top corner with a hacksaw as shown, and bend the top part of the frame up so the core and coil assembly can be taken out. The replacement transformer, with its frame removed, is inserted, the frame is bent back in place, and the hacksaw cut is soldered. Use a heavy-duty soldering iron or the second heat position on a soldering gun and you will have no trouble soldering the cut edges together.

What Power Transformers Do. The job of the power transformer in an a-c receiver is to change the 117-volt a-c line voltage to lower and higher values. The commonest type of power transformer is that shown in Fig. 13

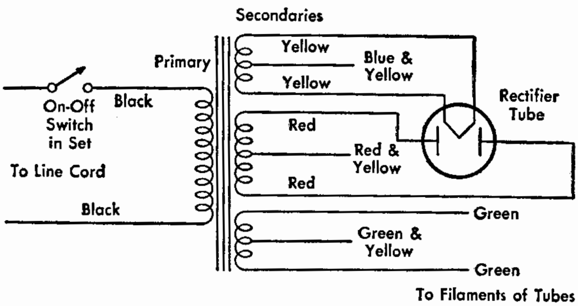


Fig. 13. RTMA color code for power-transformer leads. If there is one more filament winding, it has brown outer leads and a brown-and-yellow center tap. A fourth filament winding would hove slate outer leads and a slate-and-yellow center tap

in symbol form. This has a primary winding that connects to the line cord of the set through the on-off switch. It has one center-tapped high-voltage secondary winding that provides about 350 volts a-c between the center lead and each outer lead, or 700 volts between the two outer leads. It has one separate filament winding for the rectifier tube, usually providing 5 volts a-c. Finally, it has a filament winding serving all the other tubes in the set, usually providing 6.3 volts a-c. These are the approximate voltages that you should measure with an a-c voltmeter when an a-c receiver is turned on, if everything is operating normally.

The voltages in a power transformer can be dangerous to your meter as well as to you. Most dangerous is the voltage across the entire high-voltage secondary winding. To protect yourself and your meter, make a-c voltage measurements across only half the high-voltage winding at a time.

In very large radio sets and in television sets there may be more than two filament windings on the power transformer. Also, some sets may have one or more taps on the primary winding to take care of different line voltages in different communities.

The chief differences in power transformers are in size, shape, and method of providing for connections. The larger the set, the greater is the power that must be drawn from the power transformer and the thicker is the wire used for the windings. The iron core must also be correspondingly larger, to transfer the required power from the primary to the various secondaries.

Common Troubles in Power Transformers. Only two defects can ordinarily occur that make replacement of a power transformer necessary. One is an open winding, and the other is a partially or completely shorted winding.

The commonest of these troubles is the shorted winding. This is extremely easy to recognize by its characteristic pungent and disagreeable odor of burned insulation. Do not blame the power transformer immediately when you smell this, however. A short circuit in the set may overload the transformer and make it heat up enough so the insulation begins smoking. To check for this, remove all tubes from the set and then turn it on. If the transformer still smokes, it is defective and should be replaced. Make a final ohmmeter check, however, for short circuits between transformer leads themselves, since two leads touching each other could create the overload.

Finding Short Circuit in Set. If the transformer smokes when tubes are in but not when tubes are removed, there is a short circuit somewhere in the set. The transformer may still be good, but should not be used until the trouble in the set is found. If the transformer does not overheat and does not give off a smell after the defective part or connection is repaired or replaced, you can assume the transformer is good and leave it in.

Here are some hints for finding a short in a receiver. Remove the chassis from the cabinet, take out all the tubes, then turn on the set and watch the bottom of the chassis for signs of arcing between transformer secondary leads or terminals. If you see or hear an arc when you push wires with a stick of wood, the insulation on the wires may be defective. Tape or replace a defective lead.

Look for signs of arcing on the insulating wafer of the rectifier tube socket. It will show as a charred path between terminals. If the rectifier has a wafer socket, the arcing may be occurring between the two wafers, where it cannot be seen. If the transformer overheats when all tubes are out, disconnect one by one the transformer leads going to the rectifier socket and see if this removes the overload.

Any socket that shows evidence of arcing should be replaced, as the carbonized path is sure to give further trouble even if scraped clean. The only emergency repair you can make is a saw cut through the burned region. This provides an air path to stop the arc, though at a great sacrifice in socket strength.

A good power transformer will normally operate at a temperature of about 70°F above room temperature. It will therefore feel hot when touched, but should not burn your fingers. Suspect the transformer only if it burns your fingers, gives off a smell of burning insulation, or makes a sizzling sound due to boiling of the sealing compound inside.

Never allow a transformer to smoke any longer than is necessary. Continued heating will eventually ruin any transformer. Also, the more smoke you make, the longer the disagreeable odor will linger in the room.

When a power transformer develops a short circuit, it must be replaced. Repair would mean complete rebuilding, which is not economical even if you had coil-winding machinery.

How to Recognize Open Windings. An open power-transformer primary winding will make the receiver completely dead, with no tubes or pilot lamps lighted. To verify this, connect the ohmmeter to the prongs of the line-cord plug and turn the set on; the reading should be around 100 ohms or less for a good primary, and infinity if the primary is open. Verify that the open is in the transformer by repeating the measurement directly across the primary winding. This must be done because the break can just as well be in the line cord, the on-off switch, or elsewhere in the primary circuit.

Replacement of a power transformer is a time-consuming job because of the many leads involved, and is expensive for the customer as well, so always double-check your verdict.

Testing Power Transformers with an Ohmmeter. If one of the filament windings opens, the tube or tubes connected to that winding will be cold. If the rectifier filament is cold and the tube itself is good, check the rectifier filament winding by measuring between the filament terminals on the rectifier socket with an ohmmeter. The reading should be essentially zero ohms for a good reading. Always pull out the line-cord plug before making any ohmmeter measurements.

If the rectifier is lit but all other tubes are cold, remove all these tubes and make a similar ohmmeter check between filament terminals on any one of the amplifier sockets. Again, a low reading means good, and infinity means a break in the filament winding or in the connections to it. Measure directly across any suspected filament winding with the ohmmeter to verify the break.

To check for an open in the high-voltage secondary, measure with an ohmmeter between the two plate terminals of the rectifier tube socket. The reading should be somewhere under 1,000 ohms for a good winding. This gives a check on both paths of the secondary.

Testing Power Transformers with an A-C Voltmeter. Resistance measurements in a power transformer are made with the set turned off and disconnected from the power line. If you prefer, you can get essentially the same information by making a-c measurements on secondary windings while the set is on.

Measure each half of the high-voltage secondary separately, by measuring between the chassis and each rectifier-tube plate terminal in turn. This is possible because the center tap of the high-voltage secondary is always grounded to the chassis either directly or through a very small resistance.

Ordering New Power Transformers. To order a replacement power transformer, you need only specify the voltage and current ratings of each secondary winding. These values automatically ensure getting the correct primary winding and the correct size of core. Try to get a unit that has the same general shape and mounting arrangement as the old unit, to simplify fastening it to the chassis. An example of a good replacement power-transformer installation is shown in Fig. 14.

Certain known facts help you to identify the windings on the old transformer. First of all, there will be a primary winding with two leads, one going to the on-off switch and the other directly to the line cord. There will be a high-voltage center-tapped secondary with three leads. There will be a filament winding for the rectifier with two leads. The remaining leads will go to the filament windings for the other tubes. If the other tubes all require the same filament voltage, they are probably supplied from a single winding that may or may not have a center tap. If there is a center tap, there will be three leads.

An examination will show if there are other transformer leads going to tube filaments. By noting the tube numbers and looking in a tube chart, you can determine the voltage which each filament winding must deliver.

The rectifier filament winding will usually be 5 volts. The current rating of this winding will be the same as the rated filament-current value for the rectifier tube, as given in tube charts or tube manuals.

Except for the rectifier, the tubes in modern a-c sets usually have 6.3-volt filaments that are connected in parallel to a 6.3-volt filament winding on the power transformer. To get the current rating for this winding, use a tube manual to find the filament current drawn by each tube, and add up these filament-current values. The replacement transformer should have a 6.3-volt filament winding that can deliver this total current or more.

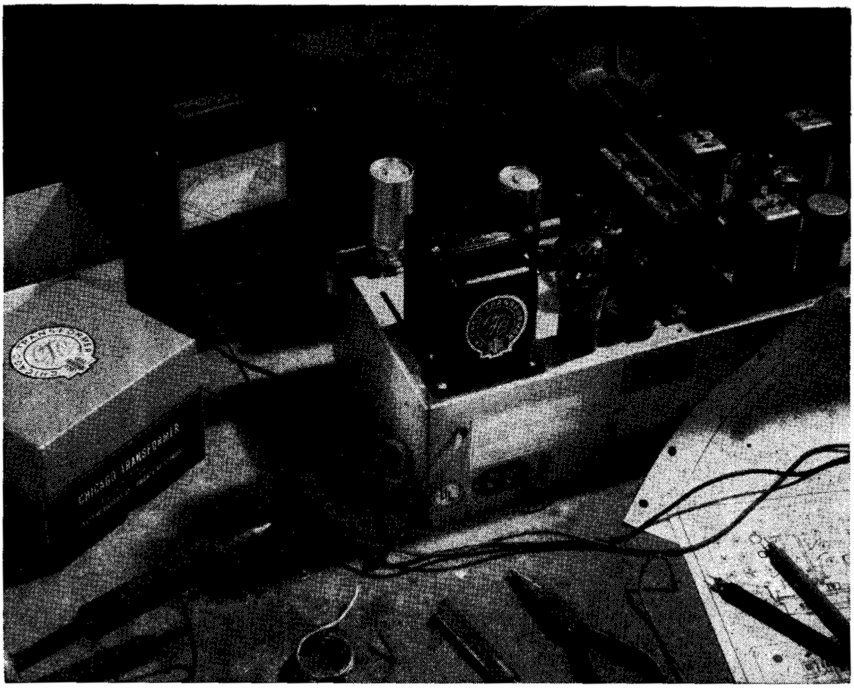


Fig. 14. Good installation of replacement power transformer in hole for old unit at left rear corner of chassis. This a-c radio set has three i-f transformers, in rectangular shield cans at the right of the three-gang tuning condenser. (Chicago Transformer Division photo)

As an example, if a set has six amplifier tubes each drawing 0.3-ampere filament current, the total filament current would be 1.8 amperes, and you would order a winding rated at 2 amperes. This is the minimum value, and any rating higher than this is all right too. This winding will almost always have a center tap, designated as CT in catalogs. The tap will usually be grounded to the chassis of the receiver.

Exact-duplicate Replacement Power Transformers. The biggest problem in ordering a replacement power transformer is determining the rating for the high-voltage secondary winding. You may sometimes find these data in service manuals, but only rarely. For this reason, it is desirable to obtain an exact-duplicate replacement power transformer whenever possible. These are available from jobbers as well as from the manufacturer or distributor of the set, for most sets. All connecting leads and lugs will then be in the same places as the old unit, simplifying change-over of the many wires involved. More important yet, the new transformer will fit in the available space and holes, as does the replacement shown in Fig. 14. This is particularly important if the original transformer fits down into a hole or window in the chassis.

With auto-radio transformers an exact duplicate is best because the transformer usually is a tight fit in a shielded compartment. The transformer in an auto radio has only one secondary winding, for the high voltage, as all the tube filaments connect to the 6-volt auto storage battery.

Even with an exact duplicate, it is still highly desirable to make a rough sketch of connections before removing the defective power transformer. Some servicemen fasten marked slips of paper to each lead, because it is hard to avoid mistakes when there are so many leads to be changed.

Several manufacturers of replacement power transformers have catalogs specifying the correct transformer for each make and model of receiver. This information is also given in the "Radio Industry Red Book."

Universal Replacement Power Transformers. There will be many sets for which exact-duplicate power transformers cannot be obtained. For these, you will have to choose a universal replacement unit that has the required windings and can be mounted without too much chassis cutting or drilling. Some of these universal units are designed for average receiver conditions, so that you need to know only the number and types of tubes in the set. Thus, in a transformer designed for a six-tube receiver, the rating of the high-voltage secondary will usually be close enough to that required by the set.

The safest way is to figure out the requirements for each secondary winding and order a universal transformer that gives exactly the voltages needed. Some of these transformers have adjustable mounting brackets that save a lot of work because they fit many different mounting hole spacings.

The leads or terminals of new universal power transformers are generally identified on instruction sheets that come with the unit. When leads are used, they will generally also be colored according to the standard RTMA color code for power transformers (given in Fig. 13). Do not rely too much on colors of leads, however, as some transformers have different color arrangements.

With power transformers, it does not matter whether connections to the ends of a winding are reversed or not.

If the replacement transformer has leads for an extra secondary winding that is not needed or a filament center tap that is not needed, cut the unused leads short and tape the ends to prevent the wires from touching anything.

Identifying Unmarked Power-transformer Leads. On rare occasions you may want to use a power transformer that has no printed or color-code identification of its leads or terminals. Use the ohmmeter first to locate pairs of terminals that show continuity. When three show continuity, one is a center tap.

Next, measure the resistance of each winding. The high-voltage secondary winding will be above 50 ohms per section (on each side of the center tap) or above 100 ohms for the total winding. The primary winding will be around 10 to 15 ohms. The filament windings will be around 1 ohm each or less.

Having located the primary winding, connect it temporarily to the 115-volt a-c power line and use an a-c voltmeter to measure the voltages across the secondary windings. This identifies each winding positively and tells its voltage. Remember that voltages are somewhat higher than rated values when a transformer is operating without its loads. A 6.3-volt winding may read as much as 7.5 volts on no load, and a 5-volt winding may read 6 volts.

If the receiver circuit diagram gives resistance values for the power-transformer windings, you may be able to do the entire lead-identifying job with your ohmmeter. Filament windings have such low resistance, however, that ohmmeter tests are not reliable for distinguishing between the filament windings. Voltage measurements should be made to complete or verify the identification of the 5-volt winding.

Silencing Vibrating Laminations. If an annoying hum is heard from a receiver even when the loudspeaker is disconnected, the iron laminations in the power transformer may be loose and vibrating. Sometimes this trouble can be cleared up by tightening the bolts that hold the transformer together. More often you will have to drive thin pieces of metal between the laminations to stop the noise. Triangular glazier's brads, used for anchoring window glass, are handy for this purpose. In an emergency, even a small nail will do.

Isolation Transformers. It is often necessary to make voltage measurements on a chassis that is connected directly to its power-line plug. The safe procedure here is to use an isolation transformer between the power line and the receiver, as in Fig. 15. These are made especially for servicing, and well worth their cost. The transformer gives out the same a-c voltage (about 115 volts) that is applied to it, but is safe because there is no direct connection between its output terminals and the power line.

Cost of an isolation transformer ranges from $4 to $10 depending on power-handling capacity. Most universal a-c/d-c sets draw under 40 watts, so a 50- or 100-watt unit is large enough for small radios. Some television sets also have a hot chassis; since these draw considerably more power, an isolation transformer rated at 250 watts or even higher is preferable

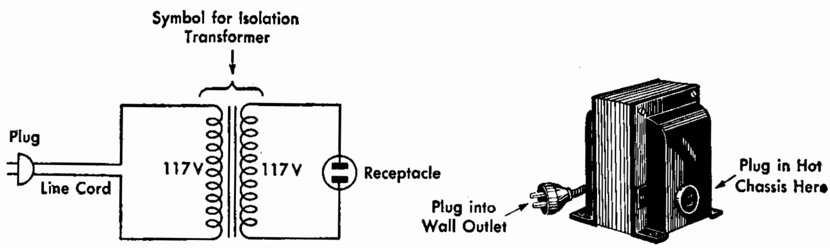


Fig. 15. Method of using an isolation transformer between the power line and a universal a-c/d-c radio set to prevent hot-chassis shocks while working on set at workbench

if you plan to do a lot of television servicing. Ratings in va (volt-amperes) can be considered roughly equal to ratings in watts.

Testing and Replacing Filter Chokes. Some sets use a single iron-core coil called a filter choke to work with the electrolytic condensers in suppressing a-c hum in the power supply. This choke generally has only two leads. In older and larger sets you may occasionally encounter a filter choke having a third lead going to a tap.

You can suspect the filter choke if the set is dead and there is no d-c voltage between one of the choke terminals and the chassis. An open circuit in the choke is the commonest trouble here since it has fine wire in its winding. Check with an ohmmeter directly across the terminals, with the set disconnected from the power line. The reading should be somewhere between 50 and 2,000 ohms if the choke is good.

Try first to get an exact-duplicate replacement choke from the manufacturer or the replacement specified in the "Radio Industry Red Book" or in transformer catalogs.

Only a few a-c/d-c receivers use filter chokes. When replacing one of these, it is generally sufficient to ask for an a-c/d-c filter choke, since these sets are all so much alike. Best results are obtained, however, by using a choke having the same inductance value and the same current rating as was originally in the set. The inductance is figured for a particular direct-current value, and will be lower if the choke has to carry more than its rated current.

In radio receivers using a power transformer, the filter choke will usually be rated at 8 or 10 henrys, with a current rating somewhere between 60 and 100 ma. If no service data are at hand, you are pretty safe if you order a 60- or 80-ma unit for sets having fewer than seven tubes and an 80- or 100-ma unit for sets having seven or more tubes.

Replacement of filter chokes is essentially the same as for output transformers. You will have to remove the rivets used for mounting the original unit, and mount the new unit with nuts and bolts. Connections are simple, and no special precautions are necessary.

Loudspeaker field coils are often connected to serve also as filter chokes, but their replacement involves special problems that are taken up in the loudspeaker chapter.

Special Coils Used in Television Sets. A few of the special coils and transformers associated with the picture tube in a typical television receiver are shown in Fig. 16. An open circuit is the commonest defect you will encounter in these. An ohmmeter reading under about a thousand ohms generally indicates a good coil, and an infinity reading means the coil is open.

It is practically essential to have the circuit diagram of a television receiver at hand when testing coils with an ohmmeter. A great many of the coils have resistors and other coils connected across, and these affect ohmmeter readings in many cases. A glance at the circuit diagram will show whether or not it is necessary to disconnect a coil lead before making an ohmmeter test.

The positions of coil leads in television sets are often highly critical, so do not unsolder these leads at random. Be sure you have a good reason for suspecting a particular coil before unsoldering to make a conclusive test with an ohmmeter. If the coil proves to be good, resolder the lead in exactly the same position it had before.

When a television set gets out of order, the nature of the pattern on the screen becomes a definite clue to the location of the trouble. This is why a knowledge of troubleshooting techniques is so important when working on television sets. Until you have learned these, it will be safest to confine your replacing of coils to those that are burned out or show other visible signs of a defect and to those having open circuits that you can locate with an ohmmeter and circuit diagram without disconnecting a lot of leads.

Ordering Replacement Television Coils. Exact-duplicate television coils are essential practically every time. Most of these will have to be ordered from the manufacturer of the set or from the local distributor of that set. In a few cases, you will be able to obtain the correct replacement coils from jobbers, chiefly for sets that were made in large quantities. The RCA

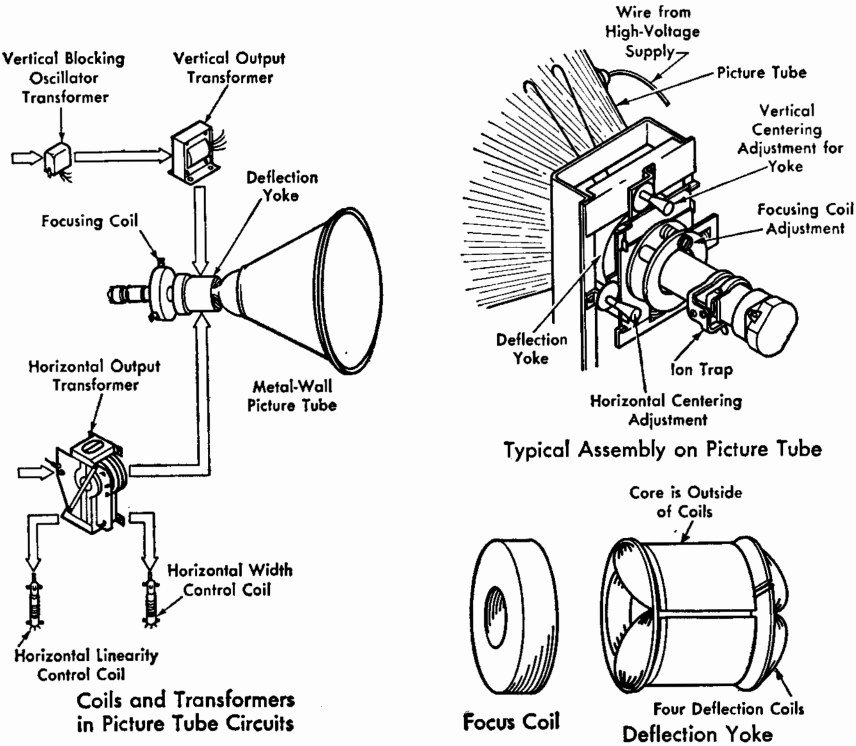


Fig. 16. Coils and transformers used in the picture-tube circuit of a television set. In some sets, focusing is built into the electron gun and no focus coil is needed

model 630TS circuit is an example; this was in mass production for a long time, and the same circuit was also used by many other manufacturers, so correct replacement coils should be available for a long time.

When ordering a new coil from a manufacturer, be sure to give the serial number of the set as well as the make and model number and the identifying name of the coil. Better yet, give the manufacturer's own part number as listed in the service manual.

Electromagnetic deflection yokes and focusing coils, such as those shown in Fig. 16, require positioning adjustments after being replaced. These you can make without test equipment, by following instructions given in the service manual for the set.

QUESTIONS

1. When a coil opens in a radio set, what happens to the sound?
2. Where do breaks in coils usually occur?
3. When a power transformer gets hot and smells, what is likely to be wrong in it?
4. Where are i-f transformers located in a radio set?
5. When ordering a replacement i-f transformer for a radio set that is less than five years old, what should be its i-f value?
6. What is the usual power rating of the output transformer in an ordinary table-model radio set?
7. Can a break in the primary winding of an output transformer be detected with an ohmmeter?
8. What should be done with extra leads on a universal replacement power transformer?
9. If a radio set hums even when the loudspeaker is disconnected, what is a possible cause?

17

ADJUSTING AND REPAIRING

Tuning Devices

Why Tuning Is Needed. A good modern radio set with an outdoor antenna can in some locations pick up over a hundred different stations in the broadcast band, one for each 10-kc division on the dial. A television receiver in a good location can also pick up a number of different stations. Tuning is the process of selecting the signals of the one desired station while rejecting all the other signals.

The actual job of tuning is done with coils and condensers working together in pairs. In some television receivers, only coils are needed for tuning, as the circuit wiring provides the very small capacity values needed for tuning.

A coil and condenser connected together in parallel form a tuned circuit that responds best to some particular frequency which is called the *resonant frequency*. The tuned circuit accepts and passes a signal at this resonant frequency but presents opposition to signals that are above or below this frequency.

When there is only one tuned circuit, the receiver will accept a desired signal but may let a couple of undesired signals on nearby frequencies get through also. This is why receivers have at least two tuned circuits in the station-selecting section and four or more additional fixed-frequency tuned circuits in the i-f amplifier. The more tuned circuits there are, the more selective is the receiver.

A fixed coil and a fixed condenser in parallel can tune to only one frequency. To get other stations, either the condenser or the coil in the tuning section must be changed in value. A tuning condenser can be used with a fixed coil, or a fixed condenser can be used with an adjustable coil. Both methods are used in modern receivers.

How Tuning Is Obtained. Another way of tuning in different stations is to use a fixed coil with a switch that gives a choice of a number of different fixed condensers. Each condenser is then the correct value for one of the stations it is desired to pick up. The same effect is obtained by using one fixed condenser with a switch that puts in different values of coils. Both of these methods are used in modern television receivers as well as in radio sets having pushbutton tuning. Some television-receiver tuners go even farther and change both coils and condensers for each channel.

In modern television and radio sets, tuning adjustments are ganged together to give single-knob tuning. With pushbutton or switch-type tuning, the tuning circuits are also changed simultaneously.

The various ways of obtaining gang-tuning action are taken up in this chapter, along with troubleshooting, repair, and replacement of the tuning devices used in television receivers, f-m radio receivers, and a-m radio receivers.

Gang Tuning Condensers. The two-gang tuning condenser shown in Fig. 1 is the commonest type you will find in radio sets. When the shaft is rotated, metal plates mounted on the shaft move between fixed metal

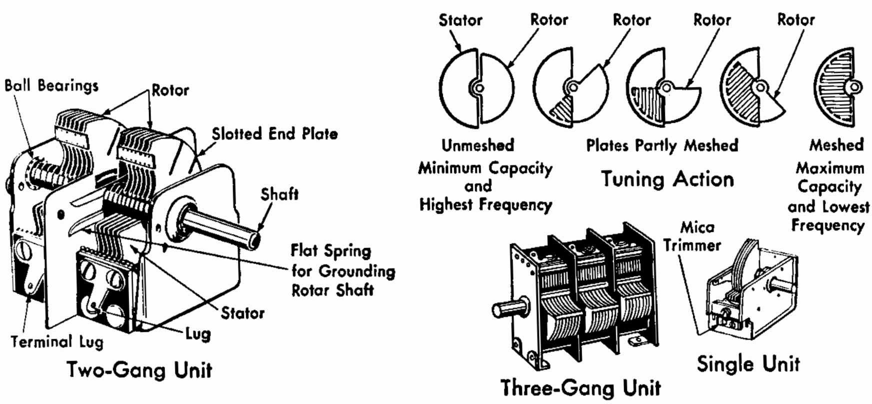


Fig. 1. Tuning-condenser information. Two-gang and three-gang units are the commonest

plates. This varies the capacity between the two sets of plates. The movable plates are called the *rotor*. The stationary plates are called the *stator*.

A two-gang unit has two rotors mounted on the same shaft, so that they turn together and provide tuning of two circuits simultaneously. Both rotors are grounded to the frame of the condenser through a flat spring that is mounted on the condenser frame and presses against the middle of the rotor shaft.

The two stator sections are mounted on insulating strips so that they are not connected to each other or to the frame. Terminal lugs are provided for each stator.

A receiver is tuned to the highest frequency in a band when the tuning-condenser plates are entirely apart or unmeshed, because this gives minimum capacity. Similarly, fully meshed plates tune to the lowest frequency and have maximum capacity, as indicated in Fig. 1. This fact is worth remembering when you are tuning in stations to try out a set on your workbench and have no tuning dial for guidance. In many sets the dial is attached to or printed on the cabinet, and does not come out when you remove the chassis.

Each section of a gang tuning condenser usually has a trimmer condenser connected between the stator and the frame. The trimmer is thus in parallel with the tuning-condenser section. This trimmer condenser usually consists of two metal plates with a sheet of mica in between for insulation. An adjusting screw permits moving these two plates together or apart to make the very small change in capacity needed for matching the tuning-condenser sections during alignment. Never touch trimmer screws except when actually aligning a receiver.

How Tuning Condensers Are Mounted. In most sets the tuning-condenser mounting bolts provide the connection between the rotors and the chassis of the set. The nuts that are on these bolts under the chassis should be tight and should have lock washers that bite into the chassis to ensure good contact.

In larger and more expensive sets the gang tuning condenser is usually insulated from the chassis by vibration-absorbing rubber washers. One or more of the condenser mounting bolts are in this case connected to the chassis with flexible wire that does not transmit vibration. Ordinary stranded wire is usually adequate, but sometimes you will see braided wire soldered between the chassis and lugs under the heads of the condenser mounting bolts. Look for these grounding wires under the chassis, directly below the gang tuning condenser.

A floating rubber mounting is used for tuning condensers so the rotor plates will not vibrate and cause howling in the loudspeaker each time the set is bumped or jarred. This same vibration can also occur when volume is turned up so that the loudspeaker is vibrating the whole cabinet and chassis.

Slotted Plates. On some gang tuning condensers the two outer plates of one or more rotor sections will have deep slots. This can be seen in Fig. 1. The slots permit bending sections of the outer plate in or out individually during alignment, to make minor adjustments in capacity so that stations will come in at their correct dial settings. Do not try to straighten out slotted plates, because they are intentionally bent. Their settings can be just as critical as those of trimmer condensers.

Tuning-condenser Troubles. A symptom pointing to tuning-condenser trouble is noise heard whenever the tuning knob is touched or when the set is tuned. The noise may occur at only one point on the tuning dial or at several or all points. The cause can be plates rubbing together or a poor connection between the rotor and the tuning-condenser frame. Intermittent troubles, particularly those that can be reduced or cleared up by slapping the cabinet, are often due to poor rotor connections.

The flat spring that serves to make contact with the rotor shaft is usually easy to remove for cleaning. When you get the spring out, clean it on both sides with fine sandpaper, and scrape out the groove in the rotor shaft.

If the rotor spring is not readily removable, run a small strip of fine sandpaper between the spring contacts and the rotor shaft to improve the wiping contact. Any gummy dirt here should be removed with cleaning fluid and a small brush. Do everything else you can to improve the quality of the connection between the rotor and the frame if trouble is traced to this point.

Dirt in the rotor shaft bearings can make a tuning condenser turn hard. Apply a few drops of cigarette-lighter fluid, carbon tetrachloride, or any other cleaning fluid to each bearing, then turn the tuning condenser back and forth about a dozen times to work out the dirt. Wipe off surplus fluid and all dirt, then apply fresh oil or petroleum jelly to the bearings to complete the job.

Shorted Tuning Condenser. Warping of the frame of the gang tuning condenser can throw the rotor out of line enough so rotor plates touch the stator plates and short-circuit the condenser for part or all of its range of rotation. Loose condenser mounting screws, bumping the condenser frame with a heavy object, or warping or bending of the plates are other causes of a shorted tuning condenser. The condition can be recognized by a scraping sound heard when tuning the set.

Shorts in a tuning-condenser section can be verified with an ohmmeter connected between the rotor and stator of the section, provided the coil for that section is temporarily disconnected. Flaky conductive particles, such as peeled metal plating, can get between the plates and cause momentary or partial shorts. Look for these first after stopping the rotor at a position where the ohmmeter indicates a short. Next, with the ohmmeter indicating a short, try tightening or loosening the condenser mounting bolts while watching the ohmmeter, to see if this clears up the short. Examine the rotor and stator plates carefully to see if any of the inside plates are bent. Straighten such bent plates with a thin knife. If the trouble still persists, check end play next.

End Play in Rotor Shaft. Each rotor plate should be midway between adjacent stator plates when meshed. When only a few plates are off center, they have probably been bent accidentally, and should be straightened by carefully inserting a thin knife between the plates. When all rotor plates are off center, look for an end-play adjustment, as the entire rotor shaft has shifted out of position. Perfect centering is not essential, provided the rotor plates move clear of the stator plates at all times.

Gang tuning condensers sometimes have an end-play adjusting screw that presses against the end of the shaft and is held in position by a locknut. To remove end play, loosen the locknut, then tighten the screw with a small screwdriver until there is no end play in the rotor shaft. Now carefully tighten the locknut without disturbing the setting of the screw.

Tuning-condenser Grounding Troubles. With rubber-mounted tuning condensers, poor soldered connections on the flexible grounding leads going from the condenser frame or mounting bolts to the chassis are a common cause of trouble. The connection to the chassis should be suspected even though it looks all right, because rosin under the lump of solder may provide the insulating film that is causing trouble. Whenever in doubt, resolder these connections with a large iron, applying rosin-core solder to get fresh flux.

If the grounding leads go to soldering lugs that are riveted to the chassis, the rivet itself may be the cause of a poor connection. Solder the lug to the chassis with a large hot iron to eliminate this possibility, because rivets can make bad contact even though they feel tight. The oxide films that form on metal provide the troublemaking insulation here.

Troubles with Tuning-condenser Plates. Dirt between the tuning-condenser plates and on the stator insulation is another cause of trouble. Wipe off the insulation with a scrap of cloth dipped in cleaning fluid. Clean out dust and metallic particles from between the plates with a pipe cleaner, a feather, or a piece of paper. The plates should be unmeshed during cleaning.

Tuning Knobs. The simplest way of tuning a receiver to different stations is by rotating the shaft of a gang tuning condenser. In most small sets this is done by putting a knob on the end of the shaft. Sometimes the circular tuning dial will be printed directly on the cabinet, and the knob will have a pointer or other indicating mark. In other sets the mark will be on the cabinet, and the knob itself will have the dial scale. In television sets likewise, the channel numbers may either be on the front of the set or on the knob for the station-selector switch.

Replacements for loose or broken knobs are obtained from jobbers when needed. The knobs are held in place on the shaft with a screw, a spring, or simply by friction of corrugations inside the knob and on the shaft, just as for volume controls.

To remove the chassis from the cabinet of most sets, you must first remove the tuning knob. If this knob has markings, it must be put back in exactly its original position to make the tuning dial read correctly. For an a-m broadcast set, turn the tuning-condenser plates until they are completely unmeshed or apart, then put the knob back on so that it reads at the farthest mark on the low-frequency end of the dial, usually just beyond the 540-kc mark. This will usually be accurate enough for these sets, but check your work now by tuning to a station whose frequency you know. A strong station well away from all others on the dial is best for checking the setting. Readjust the knob if necessary so that the station comes in at its correct point on the dial.

Friction Disk Drives for Tuning. Smoother and more accurate tuning action is possible when some form of vernier tuning is used. With this, the tuning knob has to be turned several revolutions rather than just half a revolution to go from one end of the dial to the other. Friction drives were widely used for this purpose a few years ago. In some of these, a small metal wheel on the tuning-knob shaft gripped and turned a large disk or the circular dial itself on the rotor shaft.

Friction-drive mechanisms using rubber wheels will often slip when the rubber hardens with age. This calls for replacement of the rubber wheel. An assortment of different types of friction-drive rubbers can be obtained for less than a dollar, and will take care of most jobs.

Planetary Drive. Another older type of friction drive for dials uses a planetary system of steel balls located between the tuning-knob shaft and a hollow outer shaft that is geared or directly connected to the tuning-condenser shaft. When the set is tuned, the balls revolve around the tuning-knob shaft and make the outer hollow shaft turn at slower speed. This gives the desired vernier or speed-reducing action.

Planetary drives are practically sealed mechanisms, so there is nothing much you can repair when they slip as a result of wear of the shafts. Try first to get a replacement drive, though chances of finding one are pretty slim. An emergency repair can be made by soldering the moving parts of the drive together or drilling and bolting them together, to provide an ordinary direct drive for tuning. Be sure to explain to your customer that this was done only because the correct replacement was not available.

Other Manual-tuning Mechanisms. Many other variations of friction- and gear-drive mechanisms will be found in the older sets. The servicing problems they present are entirely mechanical and are usually easy to figure out when you encounter them. Slippage of friction drives calls for tightening of something. Hard turning calls for oiling or for straightening of some bent part.

Broken dial pointers and dial windows are one common trouble that you can fix, however. Replacement pointers for the commonest types of dials are available at jobbers. You can even get a plastic replacement dial window that comes with a template to aid in cutting with scissors to any desired smaller size.

In all friction- and gear-drive systems the pointer will be on the tuning-condenser shaft, so that slippage at the tuning knob does not affect the accuracy of its reading. A pointer is replaced the same way that you replace a knob directly on the tuning-condenser shaft, by setting the pointer to the last line beyond 540 with plates fully meshed. The new pointer is simply pushed over the exposed end of the shaft, and friction holds it in place.

The development of dial-cord drives permitted locating the tuning dial, tuning shaft, and tuning condenser practically anywhere on the chassis, so that almost any shape and type of cabinet design could be used. As a result, other types of drives are seldom used in modern sets, except for the simple direct drive where the tuning knob goes directly on the tuning-condenser shaft. Each type of dial-cord drive will now be taken up in detail.

Types of Dial-cord Drive Systems. There are two main types of tuning drives that use dial cord. The simplest of these has a pointer that rotates on a round tuning dial. The other has a pointer that slides along a straight dial that looks like a ruler; this is often called a slide-rule dial.

Except for having more idler pulleys, the slide-rule dial presents much the same servicing problems as the rotating-pointer dial. Therefore, once you master the simple rotating-pointer dial-cord systems, you will only have to get acquainted with techniques for stringing cords around idler pulleys to become an expert on the slide-rule dials also.

Simple Dial-cord System. A high percentage of modern receivers use a strong braided dial cord for driving the tuning condenser. The simplest arrangement is that shown in Fig. 2, which is widely used in table-model

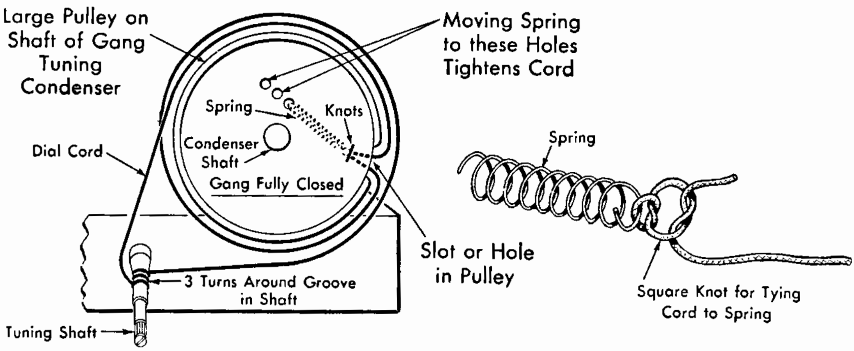


Fig. 2. Simplest dial-cord drive for a gang tuning condenser, and method of tying square knot

sets. The cord is looped several times around the tuning-knob shaft to provide necessary friction, and both ends are anchored to a spring inside a large pressed metal pulley fitted on the tuning-condenser shaft. The pointer is directly on the tuning-condenser shaft. These cords take a lot of punishment and break quite often. Installation of a new cord is then required.

A surprisingly large number of service calls to a customer's home result from failure of the dial-drive system. The tuning knob then spins freely but nothing happens, and the customer has no way of tuning the set. Knowing how to restring dial cords is therefore just as important as being able to replace a burned-out resistor.

When a dial cord breaks, it generally comes off all the pulleys and produces a tangled mess that at first glance seems hopeless to restring without detailed manufacturer's instructions on that particular set. Actually, however, familiarity with a few of the commonest arrangements and with the jobs that dial cords do in sets, plus a few hours of practice on a few sets, is all you need to tackle most of these jobs.

Slipping Dial Cord. Perhaps the greatest source of trouble in dial-cord drive systems is slipping rather than breakage. Slipping can be due to too smooth a surface on the cord, to insufficient tension, or to some part not turning or moving freely.

Cords become smooth and slippery after a period of use, because of slippage on the tuning-drive shaft. Roughening of the shaft itself is definitely not a recommended repair, because a rough shaft will quickly cut into and break the cord. If the set has been in use for several years, replacement with a new cord is the best solution even if the cord is tight and shows no wear. The reason for doing this is that the surface of the cord has become too smooth, and will slip again in a short time no matter how much you tighten it or rub it with rosin.

A loose cord can be tightened in several ways. Tuning-condenser drums often have several tabs or holes over which the free end of the spring can be hooked. If the spring is in the closest hole, moving it to stretch the spring will tighten the cord, as indicated in Fig. 2.

If it is possible to untie one of the dial-cord knots, pull up the string and tie a tighter knot. This may call for resetting the dial pointer, as covered later under restringing of cords. If the knot cannot be untied but there is sufficient slack, cut the cord close to the knot and retie it with more tension.

When a dial cord slips but has no slack, its friction can often be restored temporarily by applying a friction-producing compound to the cord. This is available at jobbers in powder, stick, or liquid form. The liquid form is preferable because it penetrates the entire cord and then shrinks the fibers, giving a tightening action at the same time. The liquid is easily applied with a dropper or small brush to the entire cord. In an emergency you can make up cord-tightening liquid by dissolving rosin in ordinary gasoline. The gasoline dries out after being applied to the cord, leaving the rosin to provide the friction. Treated cords rarely work well for long. Some may work only in warm weather and others only in cold weather. Furthermore, the rosin on the cord tends to gum up the pulleys and drive mechanisms, causing new troubles. Therefore, replace rather than repair troublemaking cords whenever possible.

Loosening one end of a slipping cord, twisting it a number of times, then replacing the cord will often stop slipping. Twisting shortens the cord a small amount and roughens its surface slightly.

When the spring cannot be moved to increase tension, some servicemen take a few turns off the spring to achieve the same result or put in a shorter spring. This gives a satisfactory repair, but is not generally recommended because the shorter spring is stiffer and has less ability to take up further stretch. Once a dial cord starts stretching, it is generally best to put in a new cord.

When slipping is due to binding of one of the pulleys or shafts in the tuning system, straightening or bending a pulley bracket may fix this. If oil appears to be needed, use only a few drops and apply it carefully so that none gets on the dial cord.

A worn pulley may turn freely when loose but bind when pressure is applied to it by the cord, so inspect all pulleys carefully. If pulleys are gummed from old oil or grease, wash this away with carbon tetrachloride before applying new oil.

Never use oil on wood pulleys. Oil makes wood swell and thus increases friction. Blow powdered graphite into wood pulley bearings instead.

Slipping may occasionally be due to too much end pressure on the tuning-condenser shaft. For this, remove the end-pressure screw at the rear of the gang tuning condenser, apply a drop of oil to the ball bearing inside, and replace the screw. Adjust it so there is no end play in the rotor shaft, then tighten the locknut.

Variations in Dial-cord Drives. The commonest way of using a dial cord to make a tuning knob turn a tuning-condenser shaft has just been studied. Some of the common variations of this same system for rotating-pointer drives are shown in Fig. 3. All permit locating the tuning knob away from the tuning condenser and provide speed reduction to make tuning easier.

Crossing the cord reverses the direction of rotation. On most sets, the dial pointer is supposed to turn clockwise when the tuning knob is turned clockwise, but there are a few exceptions. When the cord is broken, there is no easy way of telling whether or not it was crossed. Restring such a cord so the pointer and knob turn in the same direction.

A cord is generally run around the tuning-knob shaft anywhere from 1½ to 3½ times. Extra turns around this shaft give additional friction to prevent slippage. If the shaft is grooved for the cord, the size of the groove will determine how many turns you can get on without having them pile up on each other and jam. If the shaft is smooth, additional turns give no trouble, so put on three or more.

Choosing a Replacement Dial Cord. A broken or worn dial cord should be replaced with special dial cord made for this purpose. Never use fish-line, string, or thread because these materials stretch and soon slip. The cost of correct nonstretching cord is only a few cents for the average job.

The special cord made for dials has minimum stretch, high surface friction, ability to withstand bending over small shafts, and a breaking strength of at least 20 pounds. The cord is generally treated chemically during manufacture to make it more flexible and keep it soft. The outer braid material is usually nylon or silk to get good friction, and the inner

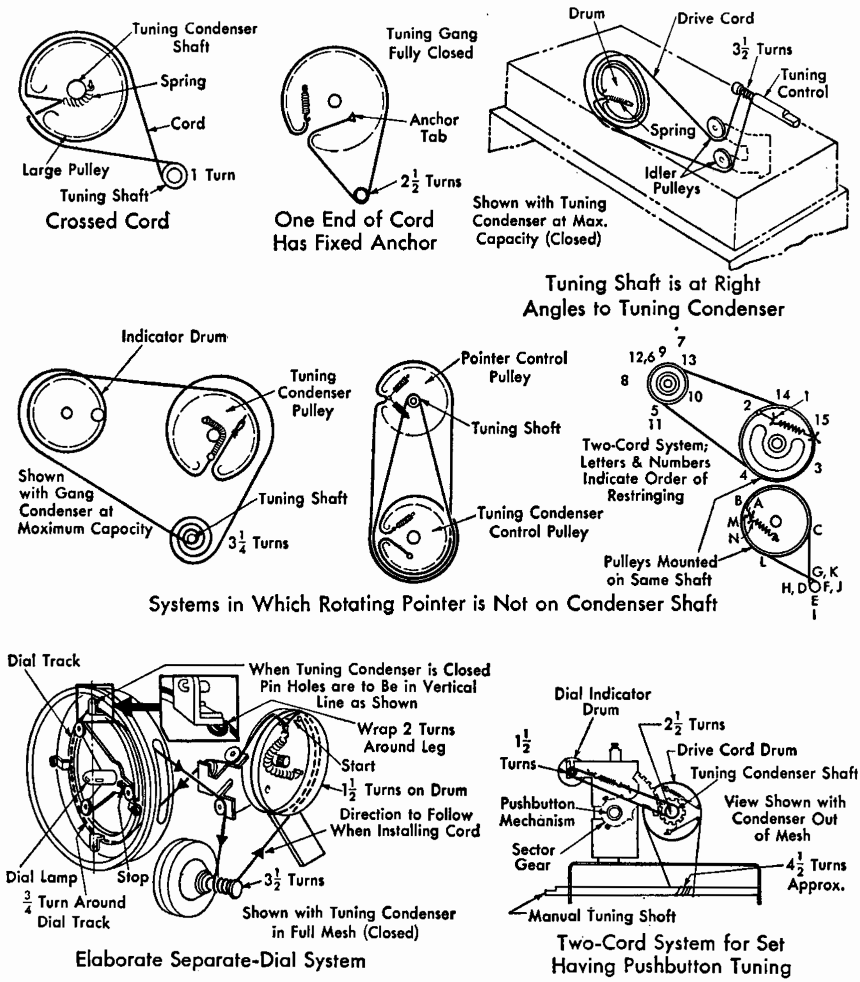


Fig. 3. Examples of dial-cord drives for rototing-dial or rotating-pointer systems

core is braided from linen, glass fibers, or special low-stretch nylon threads.

Three sizes of dial cords are available for general replacement purposes, and take care of almost 90 per cent of the requirements. These sizes are (1) extra-thin; (2) standard; (3) medium-thick. When you get into actual service work, keep a spool of each size on hand.

The correct size of replacement cord is easily determined by comparing the broken cord with samples of new cord. When in doubt, try the standard size (0.03–0.034-inch) first. Too thick a cord will slip around small drive shafts and will not fit properly into grooves on pulleys and shafts.

Be sure the cord does not bind against any panel or support bracket during its entire travel. Be sure the cord is not too large to fit properly in the worm-type drive pulley sometimes used. If the standard cord gives trouble at any of these locations, use the extra-thin cord.

When you get into actual servicing work, it will pay you to keep small quantities of special cords on hand also. A few receivers require heavier nylon cords, special steel, phosphor bronze or monel metal cables, or metal belts. All are available on small spools, and cost very little in comparison to your charge for labor on a tuning-drive repair job.

Restringing Simple Dial-cord Systems. Before removing the old cord on a simple rotating-pointer dial-cord system, make a rough sketch showing how the cord runs around pulleys if it is still on any of them. Do not rely on your memory; this sketch will save a bit of figuring when putting on the new cord. Next, remove the old cord. Do not bother untying knots; cut them with side-cutting pliers.

Before putting on new cord, check the tuning-knob shaft and the tuning condenser to be sure they rotate freely. Oil with special light dial oil if necessary, wiping off surplus oil carefully.

Examine the cord tension spring inside the large pulley next. If it is permanently stretched or if there are signs that turns have been removed, put in a new spring. You can buy an assortment of dial springs for this purpose.

On most jobs you can restring the system without first cutting the cord from the spool. Start by tying the end of the cord to the spring with a square knot. For a typical simple system, such as that in Fig. 2, bring the cord out of the hole in the pulley and around the top of the pulley, then down to the tuning-knob shaft. Go around this shaft the required number of times (use 2½ or 3 turns as a trial number when in doubt), back around the other side of the large pulley and once around it, then down into the pulley slot. Loop the cord through the end of the spring to which the other end is already tied, and pull tight enough so the spring is exerting tension. The amount of tension is easily determined by experience with a few jobs; it should be enough to provide tuning without slipping, and yet the cord must not be so tight that it twangs like a violin string when tapped. Now cut the cord, leaving ample surplus to tie the final square knot.

After tying the last knot, check operation over the entire tuning range. Watch for binding and excessive strain on any part. If everything checks all right, snip off any surplus cord from the knots. Finally, apply a dab of speaker cement to each knot to ensure against loosening.

If the new cord must be cut to length before stringing, allow a few inches extra so you can tie the knots easily. It is far better to waste a few inches of cord than to do the job over because you did not leave enough to tie a secure knot easily.

Place the anchoring end of the spring in the hole closest to the opening in the pulley if there are several anchor points. This permits later shifting of the spring to tighten the cord if necessary.

With rotating-pointer dials the position of the tuning condenser during restringing does not ordinarily matter. The pointer is attached to the tuning-condenser shaft and will therefore read correctly after the job is done. Only with slide-rule dials is it necessary to give attention to the position of this condenser during or after stringing.

Simple Slide-rule Dial. The simplest way of obtaining sliding action of a pointer on a straight dial is with the arrangement shown in Fig. 4.

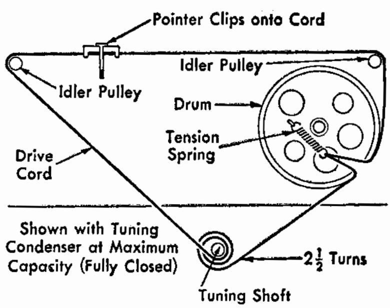


Fig. 4. Simplest slide-rule system for making a pointer move over a straight tuning-dial scale

This has the same large tuning-condenser drum and tuning-knob shaft as for rotating-pointer dials, and two idler pulleys. The sliding pointer has spring tabs that grip the cord tightly yet permit sliding the pointer along the cord for adjustment after restringing. The pointer is easily pulled off the cord and replaced on it.

Sometimes the end of the cord that goes directly to the sliding pointer (not first around the tuning shaft) is tied to a rigid tab inside the drum, rather than to the spring. This ensures that stretching and contraction of the spring during use does not affect the position of the pointer on the tuning dial.

Restringing a Simple Slide-rule Dial. Make a rough sketch before removing the old cord on a slide-rule dial system, particularly when replacing a stretched cord that is still on some or all the pulleys. Pull the pointer off the cord, then cut away the knots on the large pulley or drum.

Using the same size of new cord, tie one end securely to the fixed metal tab on the drum, or to the spring if there is no tab. Run the cord out of the slot or hole in the drum, around the top of the drum, around the two idler pulleys as shown, around the underside of the tuning shaft and three times around it, then back into the drum for tying to the spring. Do this exactly the same way as for rotating-pointer dials, but make a temporary loop knot that you can easily untie. The amount of tension is important. By checking tension on a few new sets having slide-rule dials, you will quickly learn what it should be.

Next, turn the tuning condenser so its plates are completely meshed together, then push the pointer onto the dial cord at about 54 on the dial scale. Check tuning action over the entire dial now, to make sure the pointer moves to 1,600 when the plates are fully unmeshed. Check for binding and rubbing of any moving parts. If everything works all right, tie a permanent knot at the spring to complete the restringing job.

As a final check, turn on the set and tune in a station that you can recognize positively. Slide the pointer along the cord carefully to the frequency reading of this station, and fasten the pointer there. Sometimes this is done by crimping the pointer support over the cord gently with pliers. Sometimes a drop of speaker cement between the pointer frame and the dial cord will serve. Most pointers have spring clips that grip the cord sufficiently so nothing else is needed, however.

Variations in Slide-rule Dial Systems. Representative examples of other ways of making a pointer move over a straight tuning dial are shown in Fig. 5. The chief differences are in the locations and numbers of idler pulleys that serve to change the direction of travel of the cord. When cord ends are anchored to the gang-tuning-condenser pulley, the restringing procedure is exactly the same as for the simple slide-rule dial once you determine the correct order of stringing around the pulleys.

Several trials may sometimes be necessary, but fortunately you will know positively when the job is right by checking its performance. With the tuning-condenser plates fully meshed, the pointer should be at 55 on the dial, and should move smoothly to 1,600 as you turn the tuning knob to unmesh the plates. Clockwise rotation of the knob should on most sets increase the frequency, but this does not always hold true. To change

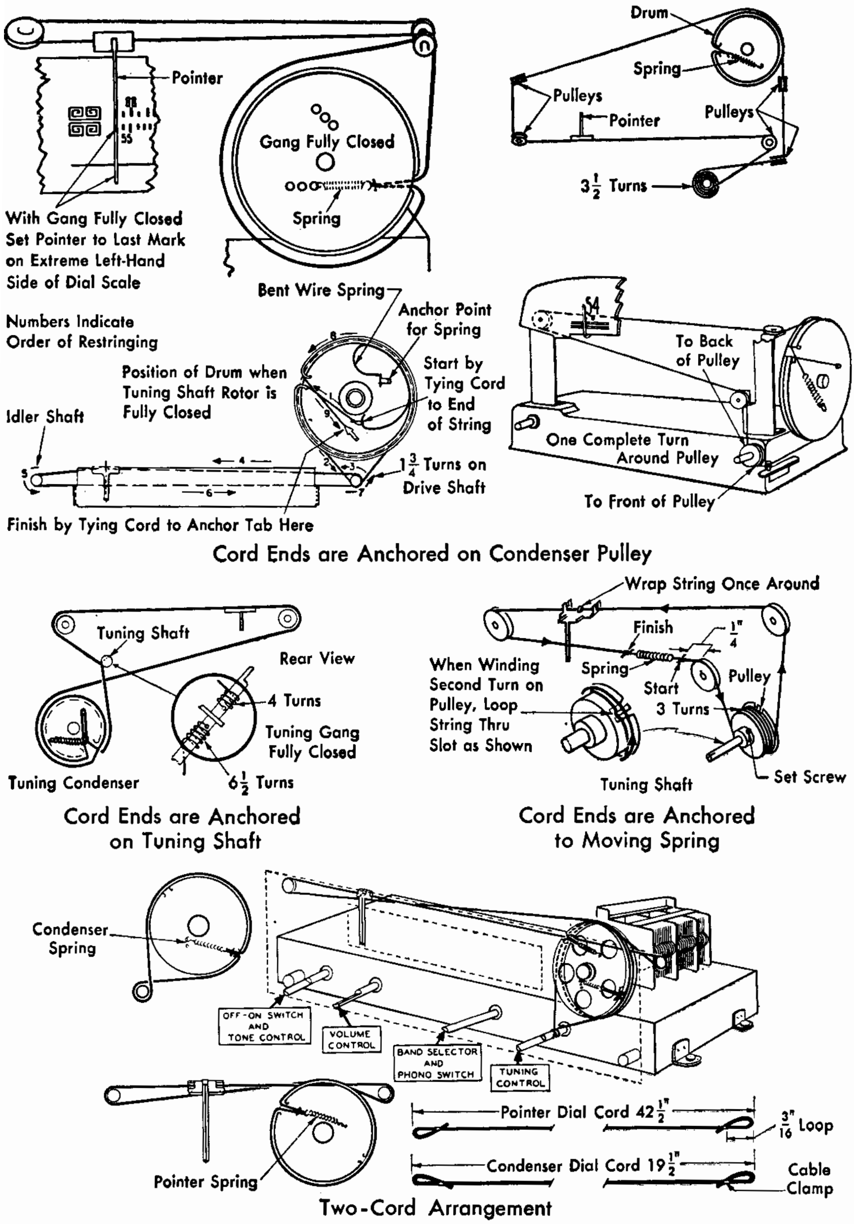


Fig. 5. Variations of slide-rule dial-cord systems, with restringing data for each. Small metal clamps or clips, available from jobbers, can be used in place of knots to form loops in ends of dial cords, as at lower right. The clamps are squeezed tight with pliers

the direction of tuning action, run the cord around the tuning-knob shaft the other way.

In a few systems, the ends of the dial cord are anchored to the tuning shaft or to a spring that moves with the dial cord. These are just as easy to restring as conventional systems because the ends of the cord will still be in their correct positions even if the cord breaks. Usually the cord will still be on some of the idler pulleys, so that with a bit of study you can figure out the restringing procedure. Always use square knots for tying, and apply cement to each knot when the job is done.

Many f-m/a-m receivers have a separate gang tuning condenser for f-m. These sets usually have two separate dial-cord systems. They may look complicated at first glance, but actually are just two entirely separate simple systems mounted close together. Usually only one cord breaks at a time. After replacing this, examine the other cord and replace it if there are signs of wear.

Dial-cord Stringing Guides. Handy books to keep with your supply of dial cords are Howard W. Sams "Dial Cord Stringing Guides," now available in several editions to cover practically all modern sets. The first edition shows 552 different dial-cord arrangements used in receivers put out during the period from 1938 to 1947, and other editions cover more recent sets. In each, an index of receivers by make and model number refers you immediately to the correct restringing diagram for the set at hand. The time saved on just one intricate job can more than pay for these handy pocket-size books.

Dial-cord restringing diagrams are sometimes included in the service manuals put out by manufacturers for individual sets, and will also be found in compilations of service data, such as "Rider's Manuals" and Howard W. Sams "Photofact Folders." Although practically any dial-cord restringing job can be figured out correctly after making enough tries at it, a diagram from one of these sources allows you to do the job right the first time.

Cord-restringing Hints. When restringing a system having a number of idler pulleys, pieces of Scotch tape or adhesive tape can be placed over the cord at each pulley and shaft during the stringing operation, so that the cord cannot come off the pulleys if you accidentally drop or loosen it during the final tying operation.

A 6-inch piece of stiff wire with a loop or eye at one end makes an excellent threading needle. Use it to lead the end of the cord around the various pulleys and bends.

When working on a complicated restringing job without a diagram, use cheap wrapping cord for experimenting. When you are sure you have it right, use this cord as a guide for cutting the exact length of dial cord needed.

Permeability Tuning. In some modern sets, coils rather than condensers are adjusted by the tuning knob. Powdered-iron slugs or cylinders are moved in and out of the coils to vary the inductance, giving what is known as permeability tuning. A dial-cord system is generally used to move the slugs in and out of the coils in unison when the tuning knob is turned.

The inductance of each coil is a maximum when its slug is entirely inside the coil, and a minimum when the slug is entirely outside the coil. Maximum inductance corresponds to the lowest frequency, 540 kc. Therefore, set both slugs entirely inside the coils after restringing a permeability-tuning job, then place the pointer at 540 kc on the dial for the initial check. Final adjustments sometimes require special aligning procedures as given in service data for the set.

Endless Belts for Tuning Drives. In place of friction or gear drives, quite a few older sets used endless belts. These went around a small pulley on the tuning-knob shaft and around a large pulley on the tuning-condenser shaft. Sometimes an adjustable or spring-tensioned idler pulley presses on the belt to keep it tight. These belts take a lot of punishment and therefore break quite often.

Replacing Dial Belts. When dial belts slip or break, replacement is required. New belts can usually be obtained individually or in kits of assorted sizes from jobbers. If the old belt is not available, determine the correct length with a strip of paper pulled tight in the exact position to be taken by the belt. Measure the total length that goes around once without overlapping, and order a belt having this same length and the required width to fit easily into the pulleys on the set.

Material from which you can assemble an endless belt to any required length is available at jobbers. The ends join with a simple zipper-like connector.

Trimmers for Tuning Systems. Modern television and radio sets are made on fast-moving assembly lines, some of which turn out as many as three sets per minute. Workers on these lines cannot take the time to position each part and wire precisely, and the parts themselves may vary in electrical value. After a set is completed, however, a few simple screwdriver adjustments during the alignment procedure take care of all these variations. These adjustments are made on trimmers, which are small adjustable condensers or coils built into the set for exactly that purpose.

Trimmers are intended for adjustment only by servicemen, not by the user of the set. For this reason, they usually have screwdriver adjustments rather than knobs. Some even have intricate shafts requiring special aligning screwdrivers or wrenches, to discourage tampering. Many set owners have in the past thrown receivers completely out of alignment by changing the screwdriver adjustments without knowing what they were doing.

Trimmer condensers are named according to the type of insulation between their plates. Examples are mica, ceramic, and air trimmer condensers. Trimmer coils use powdered-iron slugs that can be moved in or out of a small coil by means of a screwdriver or wrench adjustment; these are known as permeability-tuned trimmers. Each type of trimmer will now be taken up in turn, along with its troubles and remedies.

Mica Trimmer Condensers. These are the commonest type of trimmer you will encounter in radio and television sets. Construction is essentially as shown in Fig. 6A. The adjusting screw moves the spring-brass upper plate toward or away from the fixed metal plate. When the two plates are closest together, the capacity is a maximum since there is only the mica sheet between the blades. The farther apart the plates are, the lower is the capacity.

When a larger variation in capacity is needed, two or more pairs of metal plates are used. Here alternate plates are connected together, and all plates are separated from each other with mica sheets.

A trimmer condenser can short-circuit if a mica sheet breaks away and allows adjacent plates to touch each other. Excessive solder on the trimmer terminals can run down between the plates and likewise cause a short circuit. Dirt between the condenser plates provides leakage resistance that offsets the mica insulation and causes trouble in some circuits.

When you suspect that a trimmer condenser is defective, measure between its terminals with an ohmmeter after first disconnecting all leads temporarily from one of the terminals. The reading should be infinity if the trimmer is good. Any reading lower than about 50 megohms very likely means dirt between the plates or defective mica insulation. A zero or near-zero reading indicates a short circuit. Once you know what the trouble is, you can usually fix it yourself. A broken mica sheet can be replaced with mica from an old trimmer, if the adjusting screw is taken out temporarily.

With age, the adjustable plates of a trimmer condenser may lose their springiness, so that the condenser drifts out of adjustment frequently.

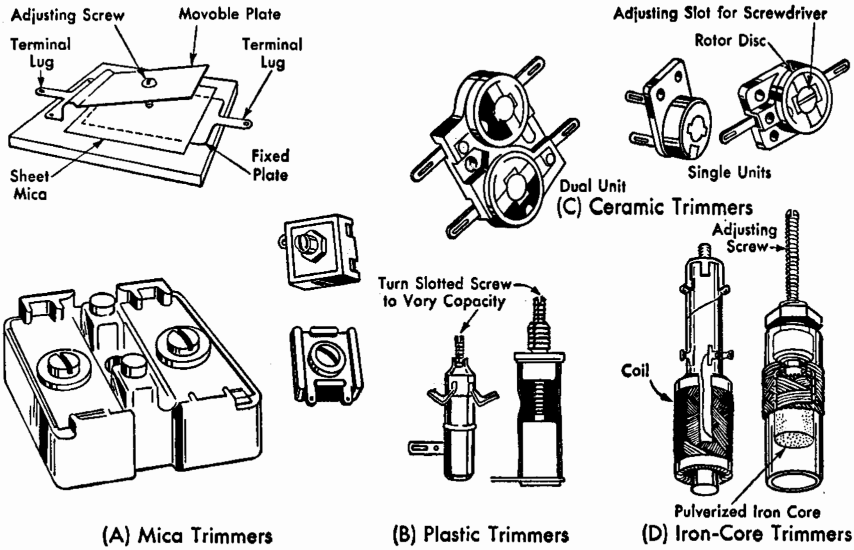


Fig. 6. Examples of trimmers used in receivers for adjusting tuned circuits

This can usually be fixed by loosening the adjusting screw all the way and bending the adjustable plate outward so as to increase the spring tension.

Air Trimmer Condensers. In television and f-m receivers you will occasionally encounter midget versions of regular tuning condensers, with screwdriver or wrench adjustments in place of knobs. These are air trimmer condensers, and are used for making very small but critical changes in capacity in high-frequency circuits. Except for adjusting during alignment, about all you will have to do to them is clean or blow out dust from between the plates.

Air trimmers are also made as concentric meshing cylinders of slightly different diameters. An adjusting screw moves one set of cylinders in or out from between the other set. Capacity is a maximum when the cylinders are meshing all the way with each other, just as for rotors and stators of regular tuning condensers. Sometimes a plastic material is used between the plates to increase the capacity, as in Fig. 6*B*.

Ceramic Trimmer Condensers. Adjustable condensers using silvered ceramic disks in one of the arrangements shown in Fig. 6C are known as ceramic trimmers. The ceramic disks are each silvered on one side and mounted in such a way that rotation of the rotor disk changes the capacity between the terminals of the unit.

In addition to changing in capacity when turned, some ceramic trimmers also change in value in a definite way with temperature. This characteristic is used to compensate for other changes with temperature in receivers. A zero temperature coefficient means that there is no change in value with temperature. A negative temperature coefficient means that capacity goes down when temperature goes up.

Ceramic trimmers are not likely to give trouble. If you have to replace one for any reason, get an exact duplicate from the manufacturer of the receiver, to make sure that you get the right temperature-coefficient characteristic. Of course, if there are identifying numbers on the unit, a replacement having that same number will be satisfactory.

Permeability-tuned Trimmers. A representative example of this type of adjustable coil is shown in Fig. 6*D*. Trimmers of this type are widely used in television receivers, and are now replacing trimmer condensers in practically all television and radio i-f transformers. Permeability trimmers are adjusted with screwdrivers or wrenches inserted through holes in the shield can. Here again, troubles are rare. Where necessary, replacement must be done with parts obtained from the manufacturer because standard parts are rarely available. The complete unit is then replaced. Broken leads at terminals are perhaps the commonest trouble. These can be spotted by visual inspection and can generally be repaired by resoldering.

Permeability-tuned trimmers are tested with an ohmmeter in the same way as are coils. All leads are disconnected from one terminal, and the trimmer is then measured with a low-resistance range of the ohmmeter. The reading should be close to zero. A high or infinite reading indicates a break in the winding.

Adjusting screws of permeability-tuned trimmers are sometimes anchored with cement to prevent loosening. A drop of acetone will generally loosen the cement in a few minutes and permit readjustment.

In some television receivers, the slug of a permeability trimmer is slid in and out simply by moving the bent end of the shaft, which projects out of the rear of the chassis through a slot.

Automatic Tuning. Millions of sets now in use have automatic tuning systems that tune in a station accurately almost instantly when a button is pressed. There may be anywhere from four to twelve pushbuttons, each with an identifying tab giving the call letters of the station that it brings in. The listener can thus change quickly from station to station without bothering with accurate tuning, to find out what is on the air and to choose the most interesting program. Manual tuning requires human intelligence to know when the station is tuned in properly, whereas automatic tuning requires no intelligence on the part of the operator.

Automatic tuning had a peak of popularity between 1937 and 1942. Today only a few models of home radios are made with pushbuttons, but practically all auto radios and most television receivers have some form of instantaneous automatic tuning. Adjustment and repair of these tuning systems are important parts of receiver servicing.

A pushbutton or station-selector knob produces the required tuning action in one of three different ways: (1) by switching in preadjusted coils or condensers to give what is known as *electrical pushbutton tuning;* (2) by rotating the regular tuning condenser to the correct setting for a desired station by means of levers, gears, or cams, to give *mechanical pushbutton tuning;* (3) by starting a small electric motor that drives the tuning condenser to the predetermined correct setting for a desired station, to give *motor-driven tuning.*

A modification of the second method involves rotating the tuning knob manually, with semifixed stops or detents at or near the correct position for each station. One example of this is the Du Mont Inputuner for television sets. The servicing problem associated with each type of automatic tuning system will now be taken up.

Electrical Pushbutton Tuning. In this system, each pushbutton usually operates switches that insert preadjusted trimmer condensers in the two tuned circuits of the receiver, as in Fig. 7. The switching is usually done

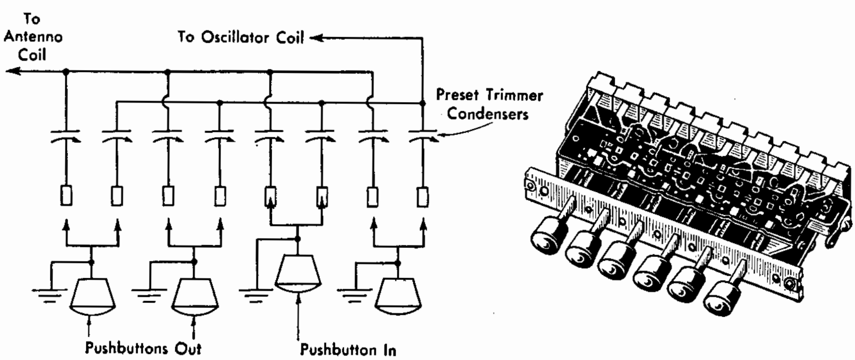


Fig. 7. Circuit and example of electrical automatic pushbutton tuning system

with a latching type of switch. Pushing in any button lifts a latch first to release whichever other button is in, then lowers the latch to hold in the button that was pushed.

Sometimes permeability-tuned trimmers are used in place of condensers for the oscillator tuned circuit because they are less likely to drift away from the correct settings. Newer sets often use permeability tuners that require only one adjustment for each station and have no trimmer condensers.

Provision for Manual Tuning. Sets with pushbutton tuning practically always have provisions for manual tuning as well. This requires some form of transfer switching that disconnects the gang tuning condenser when changing from manual to automatic tuning. Sometimes an extra button, usually labeled MANUAL, is provided on the pushbutton assembly for this purpose. Sometimes the band-changing switch or radio-phono switch on the set has an extra position for this change-over.

A few radio sets have only pushbutton tuning. These generally employ a ratchet-type switch that changes a station each time it is pressed, in a definite sequence that repeats itself. The floorboard tuning button used in some car-radio installations is an example of this type.

Pushbutton-trimmer Adjustment Procedure. New pushbutton-tuned receivers require setting up of pushbuttons. This cannot be done at the factory because radio station frequencies are different for each community. This adjustment procedure takes only a few minutes once you know how, and is well worth mastering now.

Old sets need adjustments of pushbuttons whenever a customer moves to a different community, whenever a customer changes his mind about which stations he wants tuned in by buttons, and when trimmers get out of adjustment because of natural aging or vibration.

The following adjustment procedure applies in general to all sets using pushbuttons for switching trimmer condensers or slug-tuned coils into each of the two tuned circuits of a broadcast receiver. With minor variations to be given later, this procedure also applies to all other types of pushbutton tuning systems.

1. Turn on the set, tune in a station manually, set the volume at normal listening level, and allow the set to warm up for about half an hour.

2. During the warmup, assign one station to each button and insert the call-letter tabs appropriately in the heads of the buttons or in the panel slots provided for this purpose. Sheets of these tabs, containing call letters of all stations in the country, are furnished with new sets.

If a customer has moved without saving unused tabs, get an extra set from the nearest distributor. Check with the customer for preferences as to the stations that you set up on buttons. In general, give preference to the strongest local stations for pushbuttons, since weak or distant stations require more critical tuning and since even slight drifting of trimmer settings would be immediately noticed.

When assigning stations, observe the tuning ranges of the trimmers associated with each button. These will either be printed alongside the adjustments or given in the operating instructions and the service manual for the set. Thus, if the two adjustments for a certain button are marked 700 to 1,250 kc, you would choose for this button a station whose frequency is in the range, such as 1,010 kc.

3. Tune in the first station on your list manually, note the nature of the program, then change to automatic tuning and push in the button assigned to that station. Adjust the oscillator trimmer for that button until the same station is heard, then adjust the other trimmer, usually called the antenna trimmer, for maximum volume. The oscillator trimmer is easily identified because several stations will be heard one after another as its screw is turned. The other trimmer for a button will be the antenna trimmer; this has much less effect on tuning. Readjust the oscillator trimmer carefully so the station comes in clearly with maximum volume. Repeat for each other station in the same way.

This is all there is to setting up pushbuttons. Any variations required are almost always given in the instruction leaflet coming with the set, so there is no need to go into them here.

Permeability-tuned coils of all kinds require many more turns of the adjusting screw than do trimmer condensers. Any kind of screwdriver or tool that fits can be used here, whereas trimmer condensers require a special screwdriver made of insulating material or at least a very short, small screwdriver having little metal. Just touching the screw of a trimmer with a large screwdriver will change the tuning, so that any adjustment you make with a big screwdriver will be wrong when the tool is removed.

Trimmer adjustments are usually accessible from the back of the cabinet. In a few sets, however, they are behind a removable cover plate on the front of the set.

Pushbutton-trimmer Troubles. If a pushbutton does not bring in its station correctly, careful readjustment of its trimmers will usually clear up the trouble.

Poor, dirty, or corroded contacts come first in the list of actual troubles. Loss of spring tension can often be corrected by bending contacts appropriately and carefully with tweezers or long-nose pliers. Dirt on contacts can be removed by brushing with a special contact-cleaning fluid or with carbon tetrachloride. Pushbutton switching contacts are not nearly so critical in broadcast sets as they are in television sets.

A loose or broken spring in the latching bar mechanism that holds in one button and releases other buttons can also make trouble. A bad spring should be replaced if at all possible. Get an assortment of dial-cord springs if the original spring is missing, and try different ones until you get one that works right in the latching system.

Broken contacts, broken insulating material, and major mechanical defects in a pushbutton switching mechanism are generally impossible to repair. Replacement of the entire switch is hardly warranted, since the replacement job would invariably cost the customer more than the price of a new set. If the trouble occurs on only one button, you can put a black station tab on that button and reassign its station to an adjacent button, giving up the station used least by the customer. If all buttons are affected, it is generally best to recommend that the customer give up pushbutton tuning and use only manual tuning.

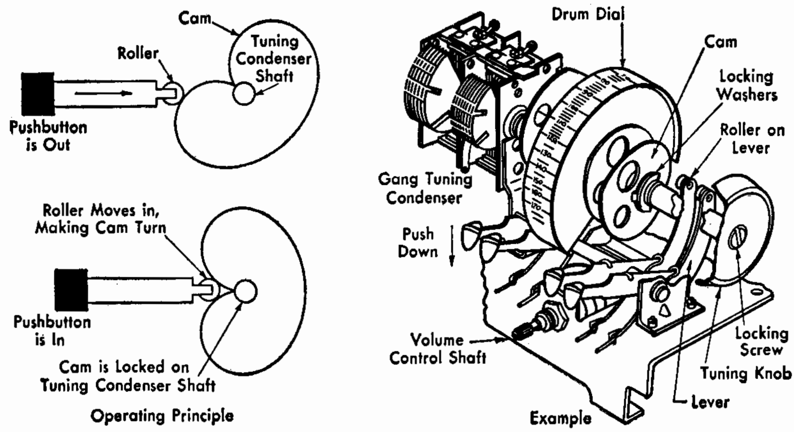
Loose Buttons. Pushbuttons are generally held in place by friction between the flat moving shaft and a slot molded into the plastic button. Sometimes there are springs inside the buttons also, much like those in certain types of control knobs. Looseness can generally be cured by placing a small piece of Scotch tape over the end of the shaft before pushing on the button.

If the looseness is due to a missing spring, you can generally find a satisfactory replacement spring in the Walsco assortment sold for control knobs. Missing buttons must usually be obtained from the manufacturer of the set, since they are not ordinarily sold separately.

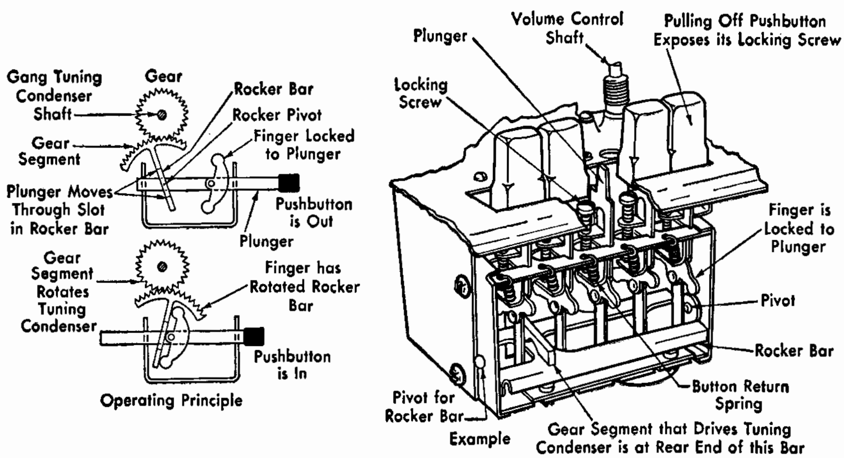
Broken Leads. Electrical pushbutton tuning involves a large number of connecting leads and soldered joints, each of which can give trouble. Gentle probing with a small stick of wood will invariably locate the trouble.

With permeability tuning, the coil leads are extremely fine wire that is easily broken. A repair can usually be made by soldering in a piece of fine new wire as a splice. Be sure to clean all wires thoroughly before soldering.

Mechanical Pushbutton Tuning. In mechanical automatic tuning systems, the gang tuning condenser is turned to the position for reception of a desired station by pushing a preset button all the way in. The listener



Cam and Lever System



Rocker Bar System

Fig. 8. Operating principles and examples of two common types of mechanical automatic tuning systems. These were at one time widely used in home radios, but now are chiefly in auto sets

still does the actual manual work of tuning, and the buttons therefore require considerably more pushing force than do those for electrical systems. The tuning mechanism merely serves to convert the straight pushing motion to rotary motion and stop the motion at the correct point.

The two most common mechanisms used to provide mechanical pushbutton tuning are shown in Fig. 8. Since these rarely give trouble, there is no need to understand in detail how they work. From a servicing standpoint, you need only know how to set up the buttons to the desired stations.

Modern mechanical pushbutton tuning systems require no screw adjustments such as are needed with electrical systems. Instead, they have locking screws that are loosened for setting up stations, then tightened again.

Two systems of locking are used in modern sets. In one type, the buttons are individually locked. In the other type, there is only one locking screw, in the center of the tuning knob, and this knob is located on the right-hand side of the cabinet rather than in front. Each system will be taken up separately now, since the button setup procedures are slightly different.

Individual Locking Screws. If a set has mechanical pushbutton tuning and a conventional tuning knob on the front panel, you can be quite certain that there will be individual locking screws for each pushbutton. These will either be above, below, or behind their respective buttons but will not be visible. To get at the screws with a screwdriver, you will either have to pull out the pushbutton, remove the decorative panel surrounding the pushbuttons, or remove the station call-letter tab from the center of the button, depending on the make of set. In still another variation, the button itself is turned counterclockwise to unlock and clockwise to lock; for this, the button will be round rather than square, and the station tab may not be in the center of the button. Careful inspection or pulling of the buttons will show you which method is correct for the set at hand.

To set up a station on a button, hold that button in firmly all the way, loosen its locking screw with a screwdriver of appropriate size, manually tune in the station desired for that button, tighten the locking screw, and remove the screwdriver before releasing the button. Repeat for each other button in turn to complete the job.

With mechanical tuning, any station in the broadcast band can be assigned to any button. It is logical to arrange the stations on the buttons in order of frequency just as they are on the tuning dial, with the lowest frequency assigned to the left-hand button in a horizontal row or to the top button in a vertical row.

After setting up an individual button, check your work by tuning away from that station manually a few times and pushing the button to see if it brings in the station accurately. Readjust if necessary; the button must be held in firmly throughout the entire adjusting procedure to get an accurate setup, and the initial manual tuning in of the station during the adjustment must be done accurately if the button is to be accurate.

Station call-letter tabs are set in either before or after the adjusting procedure. These go inside or alongside the button, just as for electrical pushbutton tuning.

Single Locking Screw. To set up the buttons on a set that has a tuning knob on the side of the cabinet with a screw in its center, first loosen the locking screw. Hold a button down firmly, tune the receiver manually and accurately to the station desired for that button, then release the button. Repeat for each other button in turn, then tighten the locking screw to complete the job. Be careful not to touch buttons once they have been set up, until the whole job is done and the locking screw is tightened. You need to do this job only once to appreciate that it is just as easy as it sounds here.

Once the locking screw has been tightened, you can check your work by pushing in each button in turn. If any station does not come in clearly, loosen the locking screw, retune correctly while holding down that button firmly, release the button, then tighten the locking screw. Your other adjustments will not be disturbed if you are careful not to touch the other pushbuttons during this readjustment.

Servicing Tips. When mechanical pushbutton tuning systems work too hard, inspect carefully to see whether any parts are binding. Try oiling the bearings of the tuning-condenser shaft and the bearings for the shaft extension into the pushbutton unit. Inspect the dial-cord system carefully, to see if it is placing too heavy a load on the buttons because of binding or friction.

If moving parts and bearings are covered with dust, clean by brushing thoroughly with carbon tetrachloride. Pipe cleaners and old toothbrushes are also handy for applying the cleaning fluid and getting off old grease. Even toothpicks come in handy for picking out hardened bits of grease. Apply a very thin coat of Lubriplate or an equivalent high-quality grease to each bearing or sliding part, but do not overlubricate. Too much grease serves only as a base for more troublemaking dust.

If buttons refuse to come out after being pushed, look for weak, broken, or missing springs and replace if necessary. Correct replacements can usually be found from Walsco assortments for dial-cord stringing purposes. If springs are good, clean the entire sliding mechanism of the sticking button with carbon tetrachloride and a brush. A little oil after this may help, and will do no harm in this part of the set. Here again, if major troubles develop, it is usually better to recommend use of manual tuning rather than replacement of the entire tuning mechanism. Actually, most people use manual tuning most of the time anyway, ignoring the buttons after the novelty of having them on a new set has worn off.

With mechanical tuning, the dial pointer and tuning condenser move each time a button is pressed, whereas neither moves with electrical pushbuttons.

Older sets used various other mechanical or motor-driven mechanisms to provide automatic tuning. Adjusting procedures for most of these can be found in service manuals or in the section on automatic tuning in "The MYE Technical Manual," published by P. R. Mallory & Co., Inc., and available at most jobbers. The majority of these special drives have long since gone out of commission, however. Customers use manual tuning because of the impossibility or high cost of getting needed parts. Leave these systems alone when you run into them.

Ratchet-switch Mechanisms. A number of auto-radio sets use a solenoid-operated switch that inserts the correct preadjusted trimmers into the tuned circuits. Each time the actuating button or knob is pressed, the solenoid pulls in a lever that advances the switch one position, to tune in the next station. Since the stations are always changed in a definite sequence, the knob may have to be pressed a number of times to change to a new desired station. Initial setup procedure for these sequence tuner mechanisms is essentially the same as for electrical pushbutton tuning, involving individual adjustments of trimmer condensers or slug-tuned coils.

One position of the rotary switch usually provides for manual tuning. Some sets have separate dial lights on the dashboard corresponding to each station, which light up to indicate the station being received. Others have a rotary dial on the dashboard for this purpose, operated by the same solenoid or by a separate solenoid.

To set up a ratchet-switch tuner, push the button repeatedly until the mechanism arrives at the manual position, then tune in the first desired station manually. Now push the button until the desired switch position for that station is reached. Be sure that the range of its trimmers includes the frequency of the desired station. Now adjust the trimmers or slug-tuned coils just as for electrical pushbutton tuning systems. Repeat for each other station in turn. Always check manufacturer's instructions when available, because they sometimes contain short cuts that speed up your work.

A few table-model sets used a modification of ratchet-switch tuning to give a choice of six pretuned stations but no manual tuning. Rotating the single drum-tuning knob on the front of the set turns it on and changes volume, while pushing down on the drum operates the ratchet switch that changes to the next station in the sequence. Here no solenoid is needed, because the listener provides the motion needed to advance the tuning switch one position. Trimmer adjustments located under the chassis are the same as for other electrical pushbutton tuners.

Television Remote Controls. A few television receivers have provisions for operating the main controls remotely through a cable that plugs into the set. At the other end of the cable is a small control box that can be set on the arm of a chair or on some convenient table. One knob or button on the remote control serves to close the circuit to a motor or electric solenoid that moves the station-selector switch in the set. The operation of a television remote control is therefore similar to electrical or motor-driven automatic tuning systems used in radio sets.

Some television remote controls provide only for changing stations, while others permit controlling sound volume and picture quality also. Zenith has a three-wire cable about 15 feet long for operating a reversing motor added to their turret tuner for changing stations only. Philco has an eight-wire cable about 30 feet long, for changing stations, fine tuning, adjusting contrast, adjusting volume, and turning the set on or off.

When any of these systems develop trouble, get the manufacturer's service manual for the set. When writing for it, specify that you need the remote-control data also.

F-M Receiver Tuning Systems. To cover its tuning range of 88 to 108 mc, a frequency-modulation receiver generally uses a conventional gang tuning condenser in a smaller size. Some f-m sets use a conventional permeability tuning system having smaller parts, or one of the entirely new systems for varying both inductances and capacities simultaneously. Each of these manual-tuning arrangements will now be taken up in turn, along with the problems you are likely to run into with them.

F-M Gang Tuning Condensers. Except for having smaller and fewer plates, an f-m tuning condenser is very much like those with which you are already familiar. The condenser shaft is turned by a simple dial-cord arrangement to obtain slow motion of the pointer during tuning. This is essential because f-m tuning is much more critical than for broadcast receivers.

Unless an f-m set is tuned exactly to the mid-point of the dial range over which the station is heard, there will be distortion. This distortion is most noticeable during the louder portions of a program. It is almost hopeless to attempt to tune in accurately during faint musical passages.

Most f-m receivers will drift to some extent during a warmup period that may be anywhere from 30 seconds to 5 minutes or more. Therefore, wait for a minute or two at least after turning on an f-m set before trying to tune it accurately.

F-M Tuning Troubles. Some of the more expensive f-m receivers have an automatic-frequency-control circuit that corrects for tuning drift once a station is approximately tuned in. Even these sets drift considerably during the first minute after being turned on, but after this period of warmup they are somewhat easier to tune in accurately.

One fairly common complaint with f-m sets is howling when the volume is turned up. This is due to vibration of the tuning mechanism by sound waves from the loudspeaker. There is not much you can do about it if the trouble always existed in the set. The fault lies in poor mechanical design by the manufacturer. However, if the trouble develops after a set has been in use for some time, check the tuning system carefully for loose parts. With gang tuning condensers, be sure the unit is floating properly on its rubber mounting. Be sure the condenser shaft is not rubbing against some part of the chassis or cabinet and picking up vibrations.

Fortunately, howling due to vibration usually occurs only when the volume is higher than the normal listening level for a home, and the set is perfectly all right for normal use.

Since f-m receivers operate at much higher frequencies than broadcast sets, dust, dirt, and poor connections on gang tuning condensers are far more serious than in broadcast sets. Clean the dirt out from between the plates with a tire pump. The plates are usually too close together to get anything between except possibly a feather. Wipe dirt carefully off all insulation on the condenser, and clean the rotor wiping contact just as for regular condensers.

Dial-cord restringing problems are exactly the same as for broadcast-band condensers, except that now the pointer is set at about 88 mc (or channel 200) on the f-m dial when the plates are fully meshed, and above 108 mc (above channel 300) when fully unmeshed.

F-M Permeability Tuning. Problems here are essentially the same as for permeability tuning in broadcast sets. The powdered-iron slugs are moved in and out of coils by dial cords. Again the lowest frequency is obtained when the slugs are fully inside the coils. Restringing of broken dial cords will generally require the manufacturer's service manual for the set, because tuning is critical and there is the same possibility of vibration as with gang tuning condensers. It is perhaps fortunate that very few f-m sets use permeability tuning.

Television-receiver Tuning Problems. Because the maximum number of stations to which an ordinary vhf television receiver must be tuned is only 12, some form of instantaneous switch tuning is almost always used.

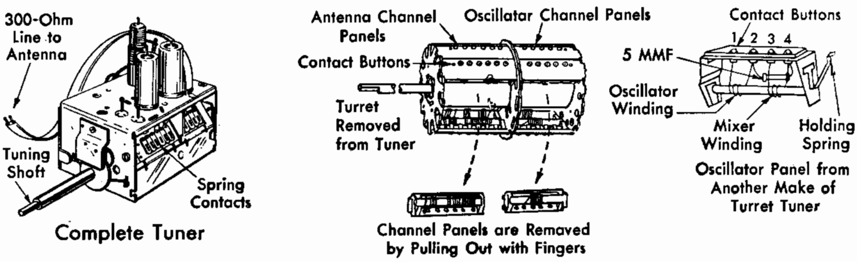


Fig. 9. Example of turret tuner for television sets, showing arrangement of removable panels containing coils for each channel. Turning the tuning shaft moves a different pair of panels against spring contacts that connect to receiver circuits

This is usually either a 12-position rotary switch or a turret tuner. A few makes of sets have 12 pushbuttons that serve to insert the correct values of inductance or capacity or both into the tuned circuits of the receiver.

A rotary switch makes the connections to the required coils and condensers for bringing in a desired station, whereas a turret tuner actually moves the desired coils and condensers into the circuit. The turret tuner has 12 sets of coils and condensers mounted on disks or a drum in such a way that rotation of the entire turret disk or drum places the desired set in the receiver circuits, as in Fig. 9.

A few television receivers have continuous tuning. This can use a gang tuning condenser or a permeability tuning system, but most often it has a variable inductance such as the Du Mont Inductuner. Here there is one coil for each tuned circuit. A slider moves along the turns of the coil to change the amount of inductance and thereby tune to a different channel.

Television Tuner-switch Arrangements. Switches like those used for changing bands in all-wave receivers are widely used in television receivers for tuning to one of the twelve channels. An example is shown in Fig. 10. These switch systems, together with the associated oscillator, mixer, and r-f amplifier tubes, form the head end of a television receiver. This is usually made and installed as a separate unit called the tuner or front end.

Practically all television receivers have three tuned circuits, because most sets have an r-f amplifier stage ahead of the mixer. This means that there will be three sets of coils and condensers (r-f, oscillator, and mixer) for each channel, whereas broadcast receivers generally have only two sets.

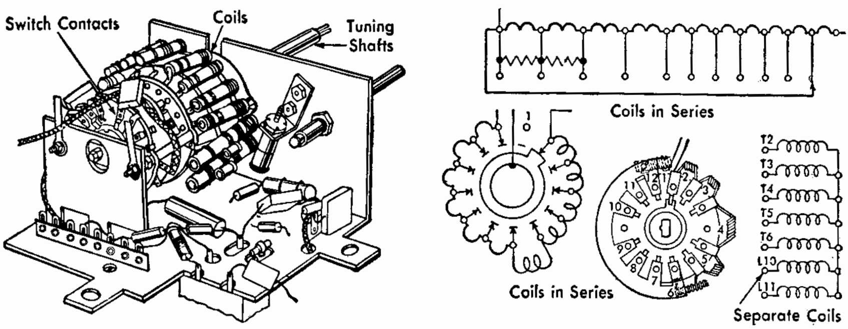


Fig. 10. Switch-type vhf television tuner, and coil-switching systems used in these tuners

Two distinct circuit arrangements are used with switch tuning. In one, the coil and condenser switched in at each setting act independently to provide the total inductance and capacity required in the three tuned circuits. Here, adjustments can be made for one channel without affecting the other eleven channels, since there is a separate coil for each channel.

In the other switch-tuning arrangement, each switch setting serves to add inductance or capacity to that provided by other settings, so that a given coil may be used on six or even more channels. Thus, the switch may insert exactly the right coil for channel 2 (the lowest frequency) and add small coils in parallel for each other channel. The same condenser is then used for all channels.

In another set, the switch may insert the right condenser for channel 13 (the highest frequency) and switch new coils in series with the tuned circuits for each other channel. With either cumulative system, a change in any one channel affects other channels and therefore requires complete realignment. Cost of manufacture is lower, but adjustments by the serviceman become more complicated when the tuning coils are in series.

At the high frequencies involved in television reception, coils in tuned circuits have only a few turns. For the highest-frequency channel (No. 13), there is just a fraction of a single turn. This means that the slightest bending of one of these coils, accidentally or intentionally, will disturb the alignment of the tuning system.

Be careful not to let tools slip in the vicinity of the head end. Never push wires hard enough to bend them permanently when probing for loose connections. When defective parts are replaced, the leads for the new part should be cut to the same length as for the old part and arranged in as nearly the same position as possible. Such care is not necessary in all television circuits, admittedly, but if you get the habit of doing this always in television sets, you will not be introducing new troubles when you replace a bad part. Without special test equipment, it is extremely difficult to locate a trouble that is due simply to a connecting lead having been moved ⅛ inch during a repair job.

Tuner-switch Troubles. Poor, dirty, or corroded contacts are a major problem in television tuners. If they occur only on one channel, look for trouble in the parts associated with that channel. When a poor contact is due to loss in spring tension, careful bending of the contact arm or the contact with long-nose pliers will usually cure the trouble. Erratic jumping of the picture, with or without associated noise from the speaker, is one symptom of a poor contact in the tuning circuits. Sudden drifting slightly out of tune is another.

Fortunately, electrical failures in the front end are largely tube failures. The great bulk of tuner repairs are mechanical adjustments or replacements which are needed because of the rough treatment tuners get in use.

Tuner switches are so designed that their self-wiping contacts keep themselves clean if the switch is placed in a protected place, such as inside a closed cabinet or under a chassis. The greatest threat to satisfactory operation is rosin on the contacting surfaces. Therefore, when soldering connections to the switch lugs, heat the lug and wire quite hot by means of the iron before applying the rosin-core solder. Now when the solder is applied, it will quickly flow around the wire, forming a perfect joint with a minimum of solder. By keeping the quantity of solder small, the chances for the rosin to spatter or flow onto the contacts are minimized.

The tuner stationary contacts for meeting the channel strip contacts get even more wear than the contacts for individual channels. The replacement of these contact springs takes a lot of time, and has become a minor art in some shops.

Dirty contacts can often be cleaned with carbon tetrachloride applied with a small brush. Corroded contacts may require gentle scraping or sanding with fine sandpaper. All work on contacts must be done very carefully, so as not to disturb other parts. After cleaning, contacts may be lightly lubricated with a light grease, such as Lube-Rex or Lubriplate.

With some wafer-switch types, carbon tetrachloride and lubricant can be mixed half and half, placed in an atomizer, and the mixture sprayed into the tuner without removing it from the cabinet. The selector is rotated during this operation. After spraying, the cleaner evaporates, leaving the lubricant. When using inflammable cleaners, be sure they have completely evaporated before the set is turned on.

Perfectly clean and good contacts can also cause trouble. Here the trouble is due to shifting of the exact point of contact, and the symptom is frequent need to reset the fine-tuning control. About all you can do is try to increase the spring tension on the contacts in the channel that is causing trouble, or twist the contact arms slightly so as to change the point of contact. This is chiefly a manufacturer's design problem and will be most troublesome on older or cheaper sets.

In any tuning system involving switches, the tuning shaft may become hard to turn or even actually frozen. This can usually be cleared up by cleaning the shaft bearings with carbon tetrachloride, wiping carefully, then applying fine machine oil and working it in by turning the switch.

To obtain good contacts, the manufacturers generally use strong springs for positioning a switch at each channel setting. The shock of tuning through the mechanical stops or detents in each position sometimes throws coils out of adjustment. Loose coils can therefore be suspected, but poke carefully when hunting for them.

Pushbutton Television Tuning. Here, pushing of a button gives the same switching action as a rotary switch. The switching mechanism is essentially the same as that used for electrical pushbutton tuning of broadcast sets.

Pushbutton tuning has the same contact troubles and the same remedies as band-switch tuning. The only new problem here is loss of tension in the pushbutton-releasing springs and sticking or locking of some or all buttons. These troubles are purely mechanical, and are generally easy to fix once you examine the mechanism carefully to see exactly where the trouble is.

Adjustments for television pushbutton tuning are generally made by the manufacturer, and should not be touched unless you are certain they need changing and you have the manufacturer's instructions for this on hand.

Television Turret Tuning. A disk or drum that actually moves coils and condensers in and out of tuned circuits is known as a *turret*. Quite a few sets use this type of tuning. In some sets the coils themselves can be easily inserted and removed from the turret, since they are mounted on individual fiber panels and are held in only by their own spring contacts.

Some turret-tuner sets may have only the coils needed for the stations that are on the air in a given locality. If a new station comes on the air and the customer wants to receive it, get the required new coil from the nearest distributor for that set, and insert it into the empty space provided for that channel.

Poor contacts are one cause of trouble in turret tuners. Remedies are the same as for the switch systems already covered.

Continuous Tuning for Television. Gang tuning condensers for television sets will almost always be three-gang units. There will usually be two sections for each gang, one covering channels 2 to 6 and the other covering the higher channels, all on the same rotor shaft. In addition, there may be a hollow shaft around the main tuning shaft to provide fine tuning, particularly if the main shaft has detents or stops that set it approximately to the correct position for each channel.

Tuning from channel 6 to channel 7 moves a cam that operates a switch for changing tuning-condenser sections. This same switch action is used in some of the other continuous-tuning arrangements also.

Gang tuning condensers will have trimmers and adjustable slug-tuned coils somewhere in the circuit for adjustment purposes, just as in ordinary broadcast sets. Adjustment procedures are always given in service manuals.

With continuous permeability tuning, movements of powdered-iron slugs change the inductance of surrounding coils. Troubles here can be due to cracked slugs or coil forms and to mechanical defects in the slug-moving mechanism.

A typical example of tuning with adjustable coils is the Du Mont Inductuner. Here there are three adjustable coils on one shaft: one for the r-f amplifier plate load circuit, one for the mixer grid circuit, and one for the oscillator tuned circuit. Imperfect trolley contact with the wire of the coil can give trouble much like that of contact troubles with switch tuning.

Permeability Tuning for Television. Continuous manual tuning of television receivers can also be obtained by an arrangement for moving powdered-iron cores inside the tuning coils, as in Fig. 11. Here the only troubles are mechanical, since there are no switch contacts in the entire tuner.

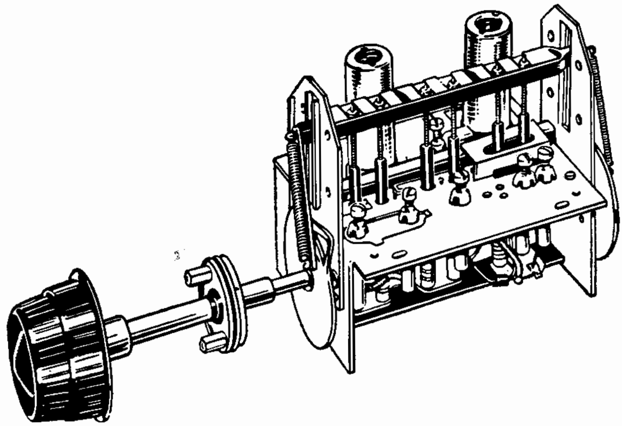


Fig. 11. Permeability tuner for vhf television receivers. Slugs move up or down in the coils when the tuning shaft is turned

Just as with all other television tuners, adjustments require special test equipment, hence should not be attempted until you have the necessary equipment. Full instructions for making the adjustments are given in the manufacturer's service manuals for the sets.

QUESTIONS

1. Give a cause and a cure for noise heard when the tuning knob of a radio set is touched.
2. How can dirt be removed from between the plates of tuning condensers?
3. When tuning-condenser plates are completely unmeshed, should the dial read around 540 kc or around 1,600 kc?
4. If the complaint is a slipping dial cord in a set that is around four years old, what should be done?
5. Why shouldn't ordinary cord or fishline be used in place of regular dial cord?
6. What type of knot should always be used when tying new dial cords?
7. About how long should a set be turned on for warming up before pushbuttons are adjusted?
8. What is the purpose of the screw in the center of the tuning knob in some radio sets that have mechanical pushbutton tuning?
9. Is it normal for f-m radios to drift in tuning somewhat right after they are turned on?
10. If an f-m radio always howled when the volume was fully advanced, can much be done about it by a serviceman?

18

REPAIRING AND REPLACING

Loudspeakers

Importance of Loudspeakers. Radio sets reproduce in a home the sounds being produced before a microphone many miles away. A television set does the same thing and also shows what is producing the sounds.

The part that converts amplified audio-frequency signals into these sounds is the loudspeaker, more often called simply the *speaker*. No matter how perfectly the tube circuits in a receiver are operating, the sounds heard will not be right unless the loudspeaker also is in good operating condition.

In this chapter you will learn how to recognize speaker troubles, how to make adjustments and repairs, and how to order and install new speakers. In addition, you will get a general idea of how speakers work, to help you in recognizing their troubles.

Getting Acquainted with Speakers. The construction of a typical speaker in its simplest form is shown in Fig. 1. The large paper part that sets air in motion is called the *cone* or sometimes the *diaphragm*. Attached to the center of the cone is the voice coil that moves the cone back and forth in response to audio signals from the receiver output circuit.

The current-carrying voice coil is positioned in an air gap through which passes a strong magnetic field. In one common type of speaker, called a *permanent-magnet dynamic speaker*, or simply a *p-m speaker*, this magnetic field is produced by a permanent magnet. In the other common type, the *electrodynamic speaker*, the magnetic field is produced by a large field coil that carries direct current. Examples of both types appear in Fig. 1.

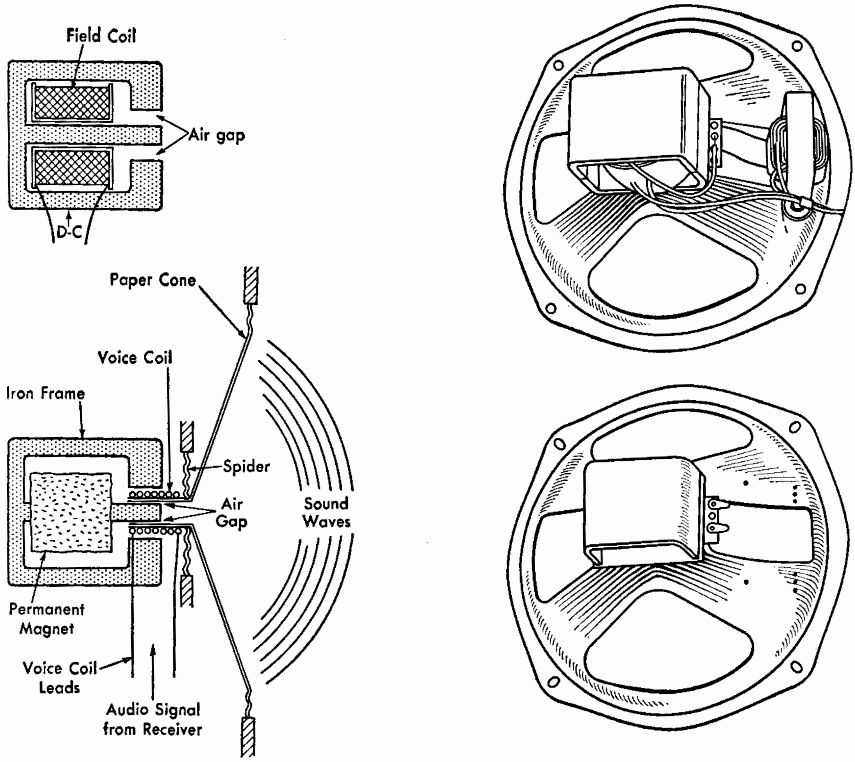


Fig. 1. Speaker details. Either a permanent magnet or a field coil can be used to supply the required magnetic field, but most speakers made today use permanent magnets. Complete unit at upper right has field coil, while that below has permanent magnet. Output transformer is already mounted on upper unit, and transformer mounting holes can be seen in corresponding position on lower unit

How Speakers Work. When current is sent through the voice coil, this coil becomes an electromagnet that has a definite magnetic polarity depending on the direction of the current. The magnetic field of the speaker also has a definite polarity. When both the voice coil and the speaker field have the same polarity, a repelling action is obtained because like poles repel, and the voice coil moves outward, as in Fig. 2A.

When the audio signal reverses its direction of flow, the voice coil changes its magnetic polarity. Now there are unlike poles and they attract each other, so that the voice coil is pulled inward, as in Fig. 2*B*. The cone is rigidly attached to the voice coil and hence moves out and in also.

Since an audio signal is changing its direction of flow thousands of times per second, the voice coil and cone must vibrate back and forth at this same high rate. As a result, the speaker produces essentially the same sound waves that act on the microphone in a broadcast studio.

The greater the strength of the audio signal at a particular instant, the greater is the strength of the voice-coil electromagnet produced by this signal. A stronger magnet has greater attracting and repelling power, and therefore a stronger audio signal makes the cone vibrate farther in and

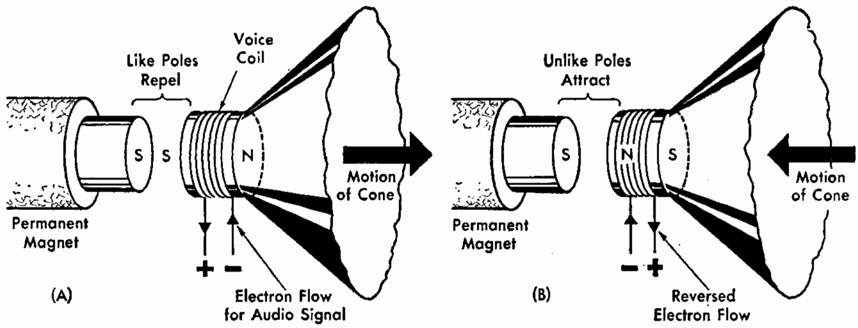


Fig. 2. The voice coil of a speaker reverses its direction of motion whenever the polarity of the audio signal reverses, thereby producing sound waves

out. The resulting sound waves are then stronger, and the sound is louder.

Summing up, the number of vibrations of the cone corresponds to the frequency of the audio signal. The distance or amplitude through which the cone vibrates corresponds to the loudness of the program.

Cone and Voice-coil Troubles. The complete cone assembly of a typical speaker is shown in Fig. 3, along with the speaker frame into which this assembly fits. The cone is made from stiff paper and is attached to the speaker frame only around its outer edge. The cone is always fastened at its rim with a special type of cement that can be loosened with acetone or a similar cement solvent, since speaker repairs sometimes involve removing and replacing the entire cone without damaging it.

The voice coil is wound on a thin paper, fiber, or aluminum cylindrical form that is just the right size to move in and out through the air gap without touching either the central pole piece or the outer pole pieces. In the assembled speaker, the voice coil is positioned accurately in the air gap by the paper cone and by a flexible support called the *spider*. This spider is so constructed that it keeps the voice coil centered while still permitting in-and-out movement of the voice coil. The name spider is used because in old speakers this part had cutout slots somewhat resembling the legs of a spider.

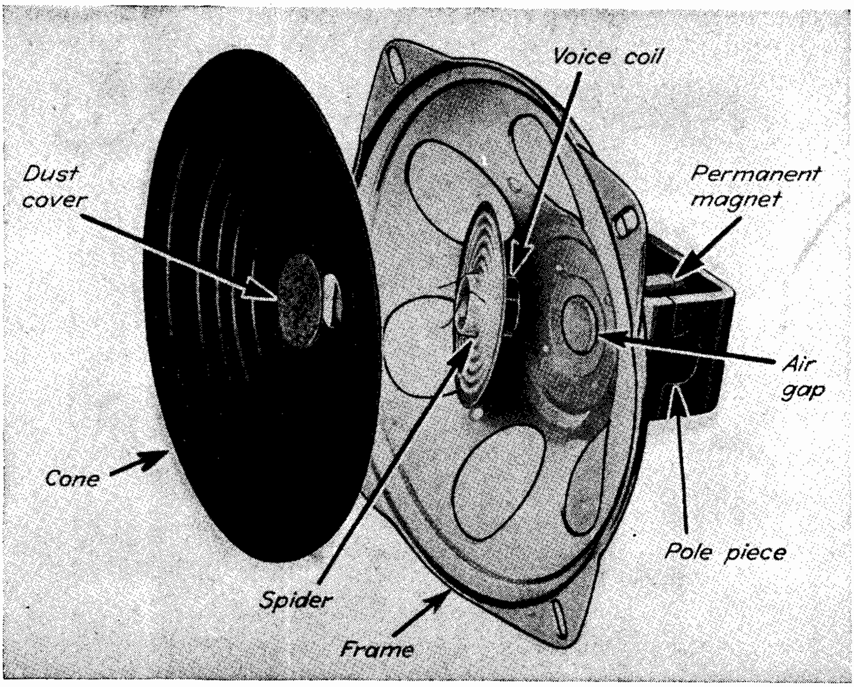


Fig. 3. How a typical modern speaker looks when taken apart for repair. (Cletron photo)

Types of Spiders. In practically all speakers made since about 1940, the spider is a springy corrugated paper washer outside the voice coil, like that in Fig. 3. This corrugated external spider is either cemented directly to a circular portion of the speaker frame or is fastened to the frame with two screws that permit recentering.

Older external spiders, like those shown in Fig. 4A, are attached with bolts that can be loosened for recentering the voice coil or for replacing the cone assembly.

A third type of spider, used extensively in older speakers, is the internal spider in Fig. 4*B*. This is held in position with a single screw that threads into the central core of the speaker.

Voice-coil Leads. The two wire leads of the voice coil are brought out through holes in the cone. Since the voice-coil wires are thin and extremely fragile, they are anchored to the surface of the cone with speaker cement

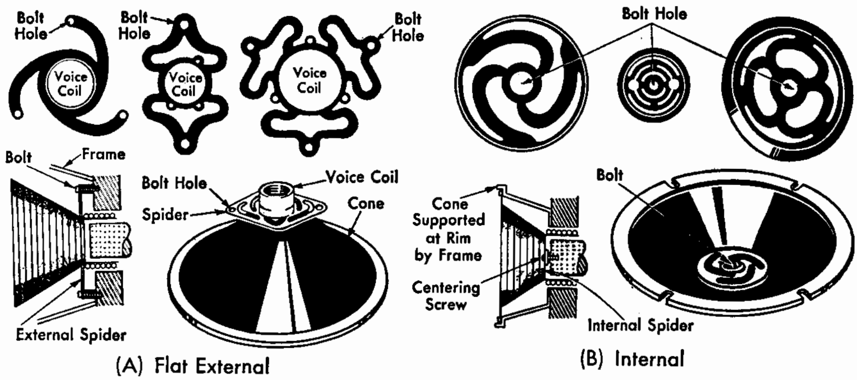


Fig. 4. Types of adjustable spiders found in speakers and methods of mounting each

on the inside. Stronger flexible wires are soldered to the voice-coil leads on the outside of the cone. Flexibility is highly important for these leads because they bring audio signals to a cone that is vibrating thousands of times per second for all the hours during which the receiver is in operation.

Speaker Troubles. The three commonest types of troubles you will encounter today in speakers are broken cones, off-center rubbing voice coils, and dirt in the air gap. In each case it is possible to make the necessary repair or replacement yourself according to instructions given here.

Speaker repairs do require considerable time, patience, and skill, however, along with special equipment in some instances. Since a number of firms do this type of repair work for servicemen at reasonable prices, it is strongly recommended that you send out speakers for repair whenever possible. The procedure for doing this will be taken up later in this chapter.

Although some firms promise 48-hour repair service on speakers, shipping time adds considerably to this figure, and there is the nuisance of packing the speaker for shipment. Receiver manufacturers take still longer to make speaker repairs, and mail-order radio-supply firms may require 30 to 45 days for speaker-repair service, even though their rates are extremely reasonable. On most repair jobs the customer is not willing to wait this long. It then becomes justifiable and essential to make the repair yourself if possible.

Repairing Broken Cones. Chattering or rattling heard along with a program can be caused by a rip or tear in the cone, a loose seam in the cone, loose outer edge of the cone, loose dust cover, loose voice-coil joint, loose voice-coil leads, or spider troubles.

Rip or Tear in Cone. A torn cone can often be repaired with special speaker cone patches and speaker cement. A repair made with Scotch tape may be effective in dry weather but is likely to work loose in damp weather. Some types of this tape become brittle and dry out with age. Recommend replacement of the entire cone assembly when you encounter a speaker tear in a high-quality set, because almost any repair will affect the tone quality of the speaker.

Short tears or rips in the cone can sometimes be repaired by applying speaker cement to the torn edges and pressing them together with your fingers for a minute or so until the cement hardens. Do not smear cement carelessly over the cone, because this stiffens the cone and may affect the tone quality. Longer tears can be repaired the same way if a bit of fluffy absorbent cotton is worked into the tear along with the cement.

When an inexpensive or emergency repair is called for, making the hole bigger is often the best possible repair. Cut away the torn edges carefully with a sharp knife so they do not rub against each other when the cone is vibrating. Cut a little bit beyond the end of the tear to make a rounded hole that will not tear further, and apply a drop of speaker cement at each end of the tear as a double precaution against spreading of the tear. As long as the hole does not throw the voice coil off center, its effect on the tone quality of an inexpensive table-model radio is not likely to be noticed. The hole merely reduces loudness, because the cone now has a little less area for moving air.

Since cones dry out and become brittle with age, it is frequently more desirable to replace a damaged cone than to repair it. The tone quality of the speaker can often be improved appreciably by a new cone, because modern cone materials give better performance than some of the older types.

Loosened Seam in Cone. Speaker cones that are made from a flat sheet of paper will have a glued seam running outward like a spoke. In compact table-model radios with closed backs the air inside becomes quite hot and may dry out the glue sufficiently to permit the seam to open. The result is a peculiar and characteristic sound, something like that of a bumblebee, heard along with the program. There may also be some distortion of the program.

An open seam is easily fixed by working speaker cement inside the seam with a brush and pressing the seam together until the cement takes hold. Wait about five minutes for the cement to set solid before trying the speaker again.

Loosened Outer Edge of Cone. Heat can loosen the glue around the outer edge of the cone, where the cone is supposed to be firmly anchored to the speaker frame. A buzzing sound heard along with the program is again the symptom. To check for this, press against the cone from the back to see if you can push it away from the frame anywhere along the outer rim. Sometimes the cone is loose at only one spot, but more often it will be unglued or about ready to get loose all the way around if the glue has weakened anywhere. Speaker cement applied under the cone rim is the remedy.

If the entire outer edge of the cone is loose, check centering of the voice coil before re-cementing. If the voice coil rubs, insert speaker shims as described later to recenter it, then go ahead with cementing of the cone.

Loose Dust Cover. All modern speakers and many older types have a paper or felt cap cemented to the inside of the cone to keep dust and iron particles out of the air gap. If this cap gets loose enough to vibrate, it can cause a peculiar buzzing sound. To fix this, apply speaker cement to the loose edges of the dust cap, being careful that no cement gets down into the air gap, and press the dust cover back into position. This repair will also prevent dust particles from getting into the air gap.

Removing Dust Cap from Speaker. The dust cap must be removed in order to recenter the voice coil or remove particles from the air gap, and must always be replaced after the work has been completed. Although it is possible to loosen the cap with cement solvent, a safer procedure is to pry and tear out the cap carefully with a small screwdriver and throw it away. This eliminates the danger of surplus solvent loosening the cone–voice-coil joint. A new cap is then put on when the job is done.

To loosen the cement that holds the dust cap in position, apply cement solvent carefully around the edges of the dust cap with the brush that comes inside the bottle of solvent. Repeat this five times or so at intervals of about a minute while going ahead with other work, before even trying to loosen the cap. Now push gently and carefully under the edge of the dust cap with a toothpick or other blunt sliver of wood to see if the cement has loosened sufficiently to remove the cap. If not, apply some more solvent. Patience is what counts here; the cap will tear if you attempt to force it off too soon.

Be extremely careful not to damage the speaker cone while working on the dust cap. Always apply the solvent with the brush, never putting on more than the dust cap and cone will absorb. Pouring the bottle of solvent into the cone may get the cap off more quickly but is likely to ruin the voice coil and will certainly loosen the joint between cone and voice·coil in modern speakers.

Extra dust caps can be obtained from jobbers for a few cents each. It is a good idea to keep an assortment of a dozen or two of these on hand, because they are quite fragile and easily torn, even though you are patient and careful. Remove all parts of the old cap before putting a new one on.

Loose Voice-coil Joint. In loudspeakers made before about 1940 the voice coil and cone were factory-assembled as a single unit, using glue that rarely came loose. Modern speakers employ a two-piece construction, however. The joint between voice coil and cone is made with regular speaker cement that can be loosened with a speaker cement solvent such as acetone. This joint can therefore get loose just as easily as any other cemented joint. The repair is done with speaker cement but is rather difficult because the loosened seam is hard to get at from either the front or back of the speaker. Extreme care must be used to avoid getting cement into the air gap around the voice coil.

Sometimes it is necessary to take out the entire cone as described for replacing cones, and do a complete regluing job. Removing a cone of this type without damaging it is quite a job, however, so time and money may be saved by installing an entire new cone or having the work done for you.

Loose Voice-coil Leads. The two very fine wires running from the voice coil to anchoring holes on the cone are cemented to the cone during manufacture. If this cement gets loose because of heat or because of solvent used carelessly by a previous serviceman, the wires can vibrate enough to cause a faint sizzling sound. To repair, apply speaker cement to the leads and press them back against the cone.

Spider Troubles. In general, damage to the spider cannot be repaired, and replacement of the entire cone assembly is therefore required. Loose screws on the spider may be the cause of rattling, however. Here tightening of the screw should fix the trouble.

Modern corrugated spiders are cemented to the speaker frame around their outer edge, and this cement joint sometimes gets loose. The chances are that there would be no noticeable trouble until the spider loosened completely from the frame, at which time there would be rubbing of the voice coil and loud rattling. Re-cementing of the spider involves removal of the cone, a job that is best done by a speaker-repair service. Here again it may be better to put in a new cone assembly because the loosened voice coil may have rubbed enough to damage itself before the customer stopped using the set.

Detecting Off-center Voice Coils. When a voice coil is sufficiently off-center so that it rubs against the pole pieces, a raspy scraping sound will be heard along with the program. There may also be noticeable distortion of loud bass notes. To test for proper centering, the front of the speaker must be accessible. With the set turned off, press evenly but gently on the outside edges of the cone with your fingers so as to move the voice coil in and out. Listen carefully for a scraping sound as you do this. Sometimes you can even feel the vibration as the voice coil rubs against a pole piece. On a good speaker, nothing will be felt or heard when moving the cone.

Particles of dirt or metal in the air gap of an older speaker having an open internal or external spider can give the same rubbing sound during this test. On these speakers always examine the air gap carefully and clean it out before deciding whether or not the voice coil needs recentering.

Recentering Modern Voice Coils. The corrugated paper spiders used with modern voice coils in both p-m dynamic and electrodynamic speakers rarely give trouble when properly installed. These spiders are generally glued to a ring-shaped supporting surface mounted on the frame of the speaker. The voice coil itself is rigidly glued to the center of the spider. There is thus no simple means of adjusting the spider when the voice coil gets off-center.

It is technically possible, if one has hours of time and patience, to loosen the cement around the outside of the speaker cone and at the cone–voice-coil junction with cement solvent, lift out the cone undamaged, then loosen the cement around the outer edge of the corrugated spider with solvent so that the voice coil can be recentered. The spider and cone are then reglued. This job is extremely difficult, however. It is far better to consider an off-center voice coil as being unrepairable in modern speakers.

Modern speakers are also made with adjustable corrugated spiders. Here a metal clamping ring and two bolts hold the outer rim of the corrugated spider securely against the speaker frame, serving in place of cement. This permits easy adjustment if the voice coil requires recentering. The recentering procedure is then exactly the same as for older types of adjustable spiders.

Recentering Adjustable Voice Coils. When the voice coil is rubbing against the pole pieces in an older type loudspeaker having an adjustable spider, a good recentering job can be done rather easily, provided the voice coil is not warped out of round. All you need for this job are recentering shims and the appropriate size of screwdriver or wrench for loosening and tightening the spider adjusting bolts. If the speaker has a dust cap over the voice coil, you will also need cement solvent for removing the cap and speaker cement for replacing it.

Choosing Shims. Nonmagnetic metal shims are best for speaker work. These shims are obtainable in sets containing four each of several different thicknesses. Each thickness is usually a different color.

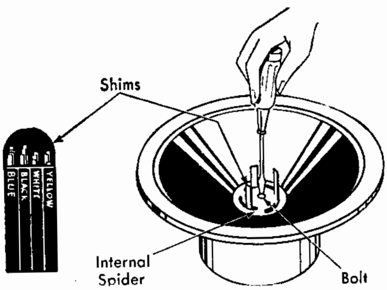


Fig. 5. Use of shims for recentering the voice coil of a speaker hoving an internal spider

Steel shims are not recommended because they occasionally have sharp corners that rip into the voice coil. Furthermore, being of harder steel than the central pole piece, they can scrape off particles of steel that will give the same annoying trouble as iron filings. Steel shims are strongly attracted to the pole pieces in p-m dynamic speakers, to such an extent that it is sometimes difficult to get the shim into the air gap. Celluloid or plastic shims are not too desirable, either, because these materials may be softened by the cement solvent.

In an emergency you can cut suitable shims yourself from stiff paper for temporary use. You will have to try different thicknesses of paper, starting with business calling cards, until you find the thickness that just allows four strips to go in snugly without forcing.

The shims used for centering a particular voice coil should all be the same thickness. Use either three or four shims, spacing them equal distances apart in the air gap, as shown in Fig. 5. Choose a thickness that will allow all to go in snugly without forcing.

Before inserting shims, loosen the bolts that hold the spider. With an inside spider, this merely involves loosening the bolt in the center of the pole piece with a screwdriver or socket wrench, depending on the type of head on the bolt. External spiders will usually have two or three bolts holding them in place. A thin flat wrench inserted through holes in the frame of the speaker is generally best for loosening these. Sometimes, however, there is room enough to use a miniature socket wrench. Inside spiders will have holes appropriately located to permit insertion of shims.

Recentering Procedure. The procedure for recentering a speaker that has bolts on the spider is (1) remove the dust cap if present; (2) loosen the bolts that hold the spider; (3) insert speaker shims to center the voice coil with respect to the center pole piece; (4) tighten the spider mounting bolts firmly; (5) remove the shims; (6) test for rubbing by moving the cone carefully in and out with your fingers. Be careful not to push the cone to one side yourself during this test.

If the voice coil still rubs, repeat the procedure, being sure to get one of the shims in at the exact point where the rubbing is worst. Try using the next thicker size of shims if you can get them in without forcing.

Oftentimes the voice coil will automatically recenter itself when the spider mounting bolts are all loosened and then carefully tightened, without using shims. Another trick worth trying in an emergency is applying pressure to the cone with one hand at various points until you find a position and pressure wherein the voice coil can be moved in and out with the other hand without rubbing, then tightening the bolts. This is not easy, however, because the cone is likely to shift when you move the speaker to tighten the bolts. Overcorrection is sometimes required to allow for slack in the spider that is taken up when you remove your hand from the cone.

When testing a recentered voice coil for rubbing, bear in mind that dirt particles in the air gap cause much the same rubbing sensation as actual rubbing of the voice coil. Dirt in the air gap is quite common in older speakers, so always clean out the air gap before recentering the voice coil the second time.

How to Clean Air Gaps. Ordinary nonmagnetic dirt will usually work its way out of an air gap if you place the speaker face down on a clean part of your workbench and tune in a program with fairly loud volume. Gentle tapping of the back of the speaker magnet assembly with the wood handle of a screwdriver will help, but be sure it is gentle. Never hammer on a p-m speaker, because each shock causes a permanent magnet to lose a little of its strength. Shaking the speaker or dropping it onto the bench from a height of an inch or so also helps to make the dirt particles work themselves out of the air gap.

Demagnetizing with A-C. Magnetic particles like iron filings are much more difficult to remove since the magnetism of the permanent magnet or electromagnet holds them in place. Even when the electromagnet is deenergized by turning off the set, there is enough residual magnetism in the pole pieces to hold the iron filings inside the air gap.

With an electrodynamic speaker, magnetic particles will fall out if you remove residual magnetism. This can be done fairly easily by applying an a-c voltage to the field coil. With the receiver disconnected from the power line, locate and disconnect the two leads that go to the speaker field coil and temporarily connect these directly across the 117-volt a-c power line. Use a spare line cord for this purpose, and wrap the two joints roughly with friction tape before plugging into the power line.

With a-c applied to the field coil, and with the speaker face down on your bench, tap the back of the speaker magnet frame a few dozen times with a screwdriver handle. The a-c demagnetizes the pole pieces twice in each cycle while it is reversing their polarity. The tapping makes the metal particles slip slightly each time the magnetism is zero, until eventually they fall out. This may take as much as five minutes of tapping. When all particles are out, as determined by examination or feel, restore the original field-coil connections.

Cleaning P-M Speaker Air Gaps. With p-m speakers there is no way of removing magnetism. Here it is generally necessary to remove the cone and voice coil to remove magnetized particles from the air gap. This is another job that is best done by specialized speaker-repair services, who will treat it as a cone-replacement job and put in a new cone and voice coil after cleaning out the air gap.

Once the voice coil is out, a pipe cleaner can be run through the air gap all around to remove the dirt and filings. Scotch tape folded over a speaker shim with the sticky side out can be run around the gap to pick up any remaining magnetic particles. Compressed air is also used in the specialized shops to blow out magnetic particles by brute force after the voice coil is removed.

If you can get a strip of Scotch tape to go into the air gap between the voice coil and the central pole piece and can maneuver this tape all the way around so that it picks up any particles adhering to the pole piece, there is a chance that you can clean the gap without removing the voice coil. Usually it is not possible to get in the Scotch tape, however.

Loose Voice-coil Turns. When the turns of fine wire on the voice coil get loose, the speaker will sound and feel much the same as if it had an off-center voice coil or a lot of dust in the air gap. You cannot see these turns when the speaker is assembled because they are in the air gap and on the outside of the voice coil. Suspect loose turns if the voice coil cannot be recentered and there is nothing in the air gap. The only satisfactory remedy here is replacement of the entire cone–voice-coil assembly. The loose wire will usually have stretched a bit, making the voice coil oversize, so that recentering would be impossible even if you did successfully remove the voice coil and re-cement the turns in position.

Replacing Speaker Cones. Replacement of a speaker cone is always considered to mean replacement of the entire cone–voice-coil assembly. The first decision to be made is whether to have the cone replaced or replace the entire speaker. An entire new speaker in the popular 5-inch size can actually be cheaper than the charge for repairing the cone. Even where a new speaker costs several dollars more than the repair charge, it may still be better business for you to put in the new one. You save all the time and bother of packing the speaker for shipment or taking it to a local repair service. You also save the expense of shipping charges or your own transportation costs.

Ordering New Speakers. Since speakers vary greatly in size, in locations of mounting holes, and in electrical characteristics, time will be saved if you can get an exact-duplicate speaker from the manufacturer of the set (ordering through his nearest distributor) or from a jobber. When ordering, specify whether the speaker is electrodynamic or p-m dynamic, give the make and model number of the receiver, and give the greatest outside diameter of the speaker in inches. If you have access to the service manual for the receiver, look up the manufacturer's part number for the speaker and give that also. It may pay to ask whether there is a credit allowance for turning in the old speaker, because some manufacturers have their own speaker-rebuilding service.

If the speaker is oval, measure two ways, to give the maximum and minimum diameters of the speaker frame. Common sizes of oval speakers are 2 by 3, 4 by 6, 5 by 6, 5 by 7, and 6 by 9 inches.

The speaker is mounted on the receiver chassis in most table-model and midget receivers. Here the depth dimension and the locations of the mounting holes may also be important. Similarly, if the output transformer is mounted on the old speaker, it is desirable to have corresponding mounting holes on the new speaker. Many replacement speakers have one or more sets of holes drilled for output transformers to simplify replacement problems. In all these cases it is best to take the old speaker in to your jobber and ask to have it duplicated. Catalogs do not usually give sufficient information on these details.

If you are replacing an electrodynamic speaker, the new unit should have the same field-coil resistance as before. You can measure the resistance of the old coil with an ohmmeter if the coil is undamaged, or obtain the field resistance from the service manual for the set.

Output-transformer Considerations. If the old output transformer is going to be used with the new speaker, the voice-coil impedance rating must also be considered. This impedance cannot be measured with an ohmmeter because it represents the opposition that the voice coil offers at audio frequencies. Fortunately most manufacturers have standardized on 3.2 ohms as the voice-coil impedance for small speakers in ordinary radio sets and in most television sets. Catalogs sometimes designate these as 3–4-ohm voice coil, and abbreviate voice coil as V.C. Most older speakers have this same voice-coil rating, particularly in smaller sizes of speakers, so it is pretty safe to assume 3.2 ohms unless otherwise indicated.

Larger speakers in older sets used voice-coil impedances of 6 to 8 ohms. Using a 3.2-ohm speaker in place of 6 to 8 ohms would make a difference in tone and volume because of improper matching, but cause no other damage. Chances are that the customer will not even notice the change in tone unless he is extremely music-minded, or he may even prefer the new tone. With larger speakers, the safest procedure is to get an exact-duplicate replacement from the manufacturer, as already recommended.

It is often desirable to replace the output transformer along with the speaker, particularly if the transformer is mounted directly on the old speaker. The new transformer will usually have universal mounting brackets or standard mounting tabs that can be bolted to holes provided for the purpose in the new speaker, simplifying your replacement problems. Furthermore, you will be sure that the new transformer matches the new speaker since you would order both for 3.2-ohm voice coils. To order the output transformer, all you need to specify is the type of power output tube used in the receiver.

When you send the old speaker to the set manufacturer or distributor for trade-in, be sure to give the model number of the receiver from which the speaker came. All other information needed by the manufacturer can be obtained from the old speaker.

Wattage Ratings of Speakers. Although catalogs usually give wattage ratings of p-m speakers and electrodynamic speakers, you can generally ignore these when ordering new speakers for replacement purposes. If you get the right diameter of speaker, the chances are that the wattage will also be right.

The wattage rating of a speaker refers to the power-handling ability of the voice coil. The higher the wattage rating, the greater the volume at which the loudspeaker can be safely operated without risk of burning out the voice coil or tearing loose its turns.

The speaker wattage rating is generally the same as the receiver power-output rating in watts, so this receiver rating can be your guide for ordering the new loudspeaker. The higher the wattage rating of the speaker, the more it will cost. A typical audio wattage rating for speakers in table-model sets is 2½ watts.

Mounting the New Speaker. With large speakers that are separately mounted on the inside of the cabinet, your only concern about size is that the outside diameter be the same as the old unit and the mounting holes be in the same locations. It is standard to have four mounting bolts on the cabinet for speakers. New speakers come with slotted holes that allow considerable leeway as to positions of the mounting bolts.

The new speaker should be bolted tightly to the cabinet, and there should be a lock washer under each nut to prevent loosening by vibration. If some lock washers and nuts are missing when the receiver comes to you, replace them from your own stock. You can get assortments of commonly used sizes of nuts, bolts, and washers from your jobber to take care of requirements like this.

New speakers usually have terminal lugs for connections. If the old speaker has a socket or plug mounted on it for disconnecting purposes, as is often the case in large sets that have separately mounted speakers, transfer this socket or plug to the new speaker. If there is no convenient way of mounting this connecting unit directly on the new speaker, let it hang loose, using long enough leads from it to the speaker so the plug and socket do not bump against anything.

Tape exposed terminals if there is a possibility that the terminals or their bare wires can touch each other. Tape is essential if the speaker has a field coil, because the terminals of the field coil are often at a high voltage with respect to the chassis.

With sets having a single p-m dynamic speaker it does not matter how you make voice-coil connections. In larger sets having two p-m dynamic speakers, however, voice-coil connections must be such that both speakers push and pull the air in unison (in phase). If one cone pushes outward while the other is moving inward, they will cancel each other's work to a certain extent and will not sound right. Reversing the connections to one of the voice coils will cure this condition.

If you make a careful diagram of connections before removing the old speaker and connect the new speaker the same way, the two speakers would be in phase if using an exact-duplicate speaker. If in doubt, make temporary connections and try reversing the voice-coil leads a few times until you decide which sounds best as you walk around the front of the radio.

A flashlight cell can be used to check phasing of two speakers. When you connect the speakers to the cell instead of to the set, both cones should move in the same direction if the voice coils are connected together right.

Hum-bucking Coils. An electrodynamic speaker will usually have an extra coil wound around the central pole piece next to the field coil at

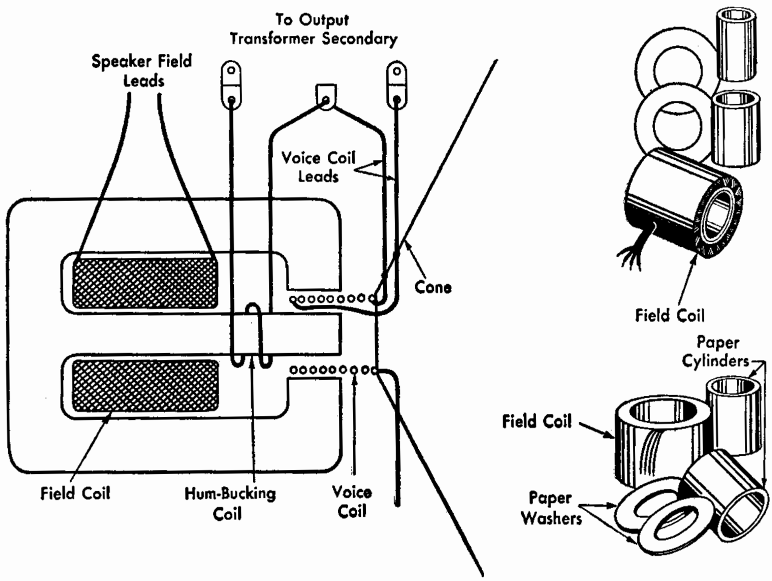


Fig. 6. Hum-bucking coil on an electrodynamic speaker, and two examples of replacement field coils for such speakers

the voice-coil end, as shown in Fig. 6. This is known as the hum-bucking coil. It serves to counteract the small amount of alternating current that flows through the field coil in most receivers along with the required direct current. Any alternating current in the field coil makes the strength of the magnetic field vary, producing hum.

The hum-bucking coil generally has from five to ten turns of insulated wire, and is connected to the voice coil rather than to the field coil. Any magnetic field changes due to a-c in the field coil produce a hum voltage in the voice coil and also in the hum-bucking coil. With a properly designed hum-bucking coil these two hum voltages are equal. Therefore, when the voice coil and hum-bucking coil are connected in series with opposite polarity, the hum voltages cancel or buck out each other, and no hum current flows through the voice coil. On the other hand, if the voice-coil connections are reversed, the hum voltages will aid each other, and excessive hum will be heard.

If you get excessive hum after installing a new cone in an old electrodynamic speaker, try reversing the connections to the voice coil. If the hum increases, the original connections were right, and something else is causing the hum. If the hum decreases, the original connections were wrong. Be sure you are actually reversing voice-coil connections; trace the leads carefully from the speaker cone to the two terminals on the speaker frame, and reverse the connections to these terminals at the back of the speaker. The bare flexible wires that go to the speaker cone are not touched.

Magnet Weight. Practically all modern p-m dynamic speakers have permanent magnets made from Alnico V, a hard crystalline metal that provides a strong magnetic field. The greater the amount of Alnico V used, the stronger is the magnetic field and the greater is the volume obtained with a given set. This is why catalogs sometimes give magnet weight as one of the speaker specifications. Speakers for ordinary home radio receivers seldom have magnets weighing more than 2 ounces, but large high-fidelity speakers for good f-m receivers and custom-built installations can have magnets weighing 15 ounces and more.

When you have a choice of two different magnet weights, bear in mind that the heavier magnet will give a bit more volume without distortion. You then have to decide whether this extra volume will be appreciated enough by the customer to justify the extra cost to him. In most cases it will not, because few sets are operated at their maximum volume level.

Field-coil Troubles. The commonest field-coil trouble is an open coil, due to breaking or burning up of the wire with which the coil is wound. A break may occur at the joints between the ends of the coil wire and the insulated leads that come out of the coil. The only other trouble you are likely to encounter in field coils is shorted turns, in which the insulation on the coil wire is damaged to the extent that adjacent turns or adjacent layers of wire on the coil touch each other.

Testing Field Coils. The quickest way of checking for an open field coil is to turn on the receiver and bring a screwdriver or other iron tool carefully up to the center pole piece. This can be done without removing the dust cover. If current is flowing through the field coil as it should, the screwdriver will be attracted. If the field coil is open or if some other trouble in the receiver blocks the flow of current through the field coil, there will be no magnetic attraction.

If making this test on a speaker having no dust cover, it is a good idea to place a cloth around the blade of the screwdriver. Without the cloth, the screwdriver blade may be attracted so strongly that it will chip particles of metal out of the pole piece, and these will get into the air gap.

After testing a good speaker with your screwdriver, you may find that the screwdriver is magnetized sufficiently to pick up iron and steel screws and nuts. This is sometimes useful, but more often is a nuisance because the screwdriver blade picks up particles of iron from your workbench. You can remove the magnetism by tapping the screwdriver blade a few dozen times on a vise or other hard object. Another way to demagnetize a tool is to place it inside the loop of an electric soldering gun and then slowly pull out the tool while current is on.

Residual magnetism in an electrodynamic speaker will cause a slight pull on a screwdriver even with no field current flowing, particularly when the center pole piece is exposed. The difference in pull is so great, however, that just one test on a good speaker will teach you what to expect. Make the screwdriver test on an electrodynamic speaker first with the set turned on, then with the set turned off, and note the difference in the magnetic attraction.

Testing Field Coils with an Ohmmeter. The ohmmeter section of your multimeter will tell you positively whether or not a field coil is open.

To test a field coil, first disconnect the coil from the receiver so you will not also be measuring the electrolytic filter condensers. If there is a plug for speaker leads, pulling it out will do the job. If there is no plug, temporarily unsolder one field-coil lead from its terminal in the receiver. Clip one ohmmeter lead on this disconnected field-coil lead and place the other ohmmeter lead on the other field-coil terminal. Set the multimeter to the 10,000-ohm range or any higher range, and note the reading. Be sure it is connected to the field coil and not to the hum-bucking coil that is located at the voice-coil end of the field coil. A reading below 5,000 ohms means the field coil is not open, while an infinity reading means the field coil is open.

Recognizing Shorted Turns. Neither the screwdriver test nor the ohmmeter will reveal shorted turns positively. Shorted turns do not generally change the resistance of the field coil enough to permit comparing the measured value with that given on a circuit diagram.

Shorted turns make the field coil get hot and will eventually char the insulation on the coil. Field coils are normally quite warm, however, so it will take a bit of coil-feeling experience before you can judge by heat alone whether shorted turns are a possibility. Even here, a short elsewhere in the set can cause field-coil overheating, so do not blame the field coil too soon. Replace a smoking or too-hot field coil only after clearing other parts of suspicion. Shorted paper condensers and shorted electrolytics can cause overheating and shorted turns in a field coil.

Repairing Open Field Coils. Chances are about 50–50 that the break in an open field coil will be at or near the points where the coil ends join the external leads. Carefully cut the insulating paper wrapping of the field coil with a sharp knife or a razor blade, to expose the joints. If a break is then visible, you will usually be able to repair it. Carefully scrape insulating enamel from the field-coil wire for about half an inch, remove surplus solder from the external lead and clean it up, then wind the field-coil wire once or twice around the end of the external lead and resolder the joint. Be extremely careful not to apply force to the fine field-coil wire while doing all this, because if you break the wire inside the coil, a repair will be impossible. If necessary, splice in an extra length of fine wire.

After making a field-coil repair, be sure to anchor the external leads with adhesive tape so that pulling on them will not strain the fine coil wire. Put the insulating paper back in position over the joint, and anchor it there with speaker cement. Another way of holding the insulating paper in position is with brown kraft paper having a sticky coating on one side like Scotch tape; this is often called masking tape because it is used by painters. Black electrical Scotch tape (No. 33) can also be used. Do not rely on transparent Scotch tape, because the heat of the field coil will eventually weaken it. Electricians' black friction tape is undesirable because of its messy appearance, but can be used in an emergency. Wrap it around the entire field coil several times, then cover it with speaker cement to prevent the tape from getting loose when hot.

If the break in the field coil is not visible when you remove the outer insulation, you can either put in a new field coil yourself or have one installed by a speaker-repair service (provided the core is not welded into position), or install an entire new speaker. Shorted turns require the same replacement of the field coil or the complete speaker because the insulation on the coil wire will be damaged to such an extent that repair is impossible.

Installing a New Field Coil. If the magnetic frame at the back of a speaker is held together by bolts, replacement of the field coil is usually not too difficult. If the central pole piece has been pressed into the frame by powerful tools during manufacture, speaker-repair shops can often get it apart with their special tools, but the job would be impractical for you. If the assembly was done by welding, repair is just about impossible, and a new speaker will be required.

If the speaker at hand is held together by bolts and you wish to replace the field coil yourself, remove the bolts and tap gently with a stick of wood until the center pole piece comes out. The dust cap will have to be removed from the front of the cone, because the pole piece generally comes out from that end.

With the pole piece out, slide the old field coil out of the frame. When doing this, note carefully the positions of any spacing washers, and make a sketch showing the exact position of the hum-bucking coil if there is one. Work slowly and carefully when removing the field, because installation of the new field is simply the reverse of the removing procedure.

Before driving out the center pole piece, scratch a line across its back end as a guide for replacing the piece exactly the same way. This can save you the job of recentering the voice coil.

Field-coil replacement is recommended only as an emergency measure. Your time is valuable, and without special tools you are often handicapped. It will invariably be cheaper in the long run to have the work done outside.

Ordering a New Field Coil. Three dimensions and the resistance value in ohms must be specified when ordering a new field coil. The dimensions are the inside diameter, the outside diameter, and the length or height of the coil. The resistance value is usually given on the circuit diagram of the receiver. You can measure the coil dimensions yourself with a ruler.

Universal replacement field coils are available from some jobbers. These come with extra washers to adjust the length of the coil, and several different paper cylinders that can be placed inside the coil to make it fit smaller pole pieces, as also shown in Fig. 6. Thus, one size of coil can be used on a pole piece ranging from ½ to ¾ inch in diameter by using these cylinders, and can replace a coil anywhere between ⅝ and ⅞ inch in length by appropriate use of the washers. These universal coils often have extra leads going to taps, and some have two separate windings that can be connected either in series or in parallel to give different resistance values.

Field-coil Replacement Services. Your local parts jobber generally has made arrangements for repairing any speakers that are brought to him. When you bring in an electrodynamic speaker, be sure to give him the make and model number of the receiver, because he needs this to determine what the resistance of the new field coil should be. Mail-order radio-supply houses provide this same speaker-repair service, or you can send the speaker directly to one of the firms specializing in speaker repairs. In each case, be sure to include make and model number of the receiver. It is best to have the cone and voice coil replaced at the same time, especially on older sets, to ensure good-as-new performance. However, before ordering a complete repair job, look up the price of a new speaker; it might possibly be less than the repair charge on smaller speakers.

Magnet Troubles in P-M Speakers. Loss of magnetism with age or through mishandling is about the only trouble that can occur in the magnetic-field structure of a p-m dynamic speaker. There is no reliable way in which you can check the magnetism, because it rarely gets weak enough to be revealed by the screwdriver test. Distortion and loss of volume are symptoms of a weak magnet. Many other receiver defects can cause the same symptoms, however, so do not suspect the speaker until you have checked everything else first.

It is impossible to remagnetize a p-m speaker without costly special equipment. This is done by specialized speaker firms as a part of their complete repair service, and the cost is low enough to be justified on large and expensive speakers. With small and inexpensive speakers, a new one is your best bet.

Never try to take apart the magnet frame of a p-m speaker. The mere act of taking out the magnet may reduce its magnetism so much that the speaker is worthless. Similarly, if the magnet does get loose and fall out, do not try to cement it back in position because the magnetic field will be too weak; put in a new speaker.

Speaker-cone Replacement Services. Replacement of a speaker cone is a delicate job involving special experience and tools if done quickly and correctly. It is strongly recommended that you send out all speakers for repair, or else replace with new speakers. Doing this will save you time and money, and will ensure satisfaction for your customer.

Mail-order radio firms have established price schedules for repair services on different sizes of speakers. Place the old speaker in a box of convenient size, without any particular attempt to protect the cone since it will be replaced anyway. Stuff in a few crinkled newspapers to keep the speaker from bouncing around in the box, then ship by express prepaid or parcel post to the selected firm. Attach to the outside of this box an envelope containing your order blank and a check or money order for the specified amount. A separate three-cent stamp is required on this envelope if you are using parcel post. For express mailing, place the envelope inside the box; attach it to the speaker with Scotch tape or string so it does not get thrown out with the packing material.

At the time of publication of this book, speaker-cone replacement service was offered by a number of firms. Your jobber will usually be able to give you addresses. Before sending out your speaker, however, it is recommended that you write for instructions and prices from the firms nearest you. Price lists are needed to help you choose between repairs and a new speaker.

QUESTIONS

1. What are the three commonest troubles in modern speakers?
2. How can the dust cap be removed from a speaker?
3. What are the steps in recentering the voice coil in a speaker having an adjustable spider?
4. When recentering a voice coil, is it essential that all four centering shims be the same thickness?
5. Why is it usually better for you to install a new speaker instead of repairing the old one?
6. What is the voice-coil impedance of the ordinary small modern speaker?
7. Are the speaker and output transformer wattage ratings usually about the same for a given radio set?
8. Should a speaker in a console be bolted tightly to the cabinet?

19

Replacing Phono Pickups and Needles

Phonograph System. In a modern phonograph system, the needle is mounted in a phono-pickup cartridge that serves to convert needle movements into corresponding audio-frequency electrical signals. These signals travel through a shielded wire line to the audio amplifier, where radio tubes boost the strength of the audio signal sufficiently for driving the speaker. The resulting in-and-out movements of the speaker cone then produce sound waves corresponding to the sounds stored on the record.

A combination radio-phono console has an automatic record changer and uses the regular audio amplifier of the receiver for playing records. The radio-phono switch provides a quick means of connecting either the phono pickup or the output of the second detector to the input of the audio amplifier.

How a Crystal Pickup Works. The commonest type of phono-pickup cartridge found in modern phonographs is the crystal cartridge, an example of which is shown in Fig. 1. It contains two flat slabs of Rochelle salt, a special kind of crystal, mounted as shown in Fig. 2. This crystal generates electricity when twisted or strained. Tinfoil layers on the crystal pick up the resulting voltage, and wire leads going from the foil to the cartridge terminal make this signal voltage available for amplification. The back end of the crystal is anchored firmly, and the front end is left somewhat free to be twisted back and forth by the needle chuck and needle.

Every time the needle moves sideways it twists the crystal slightly out of shape, and the crystal sends out an electrical impulse. When the needle is following grooves corresponding to a musical composition, the pickup changes these vibrations into corresponding electrical signals.

Record Troubles. Although worn needles are the commonest trouble in modern phonographs, worn or defective records often cause distortion and

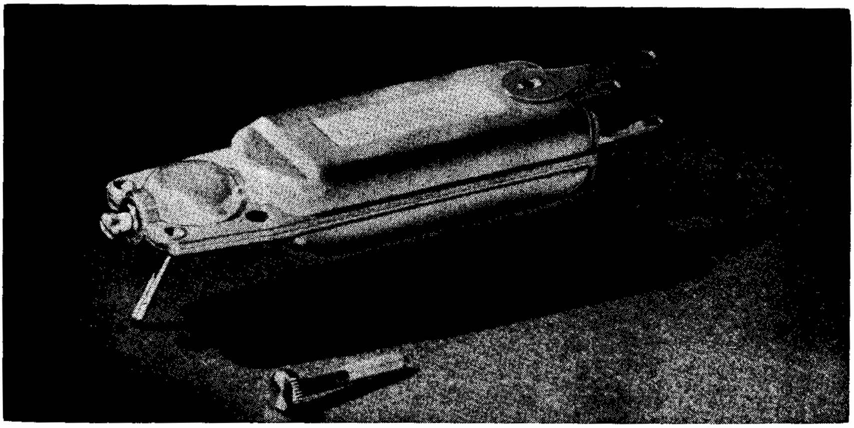
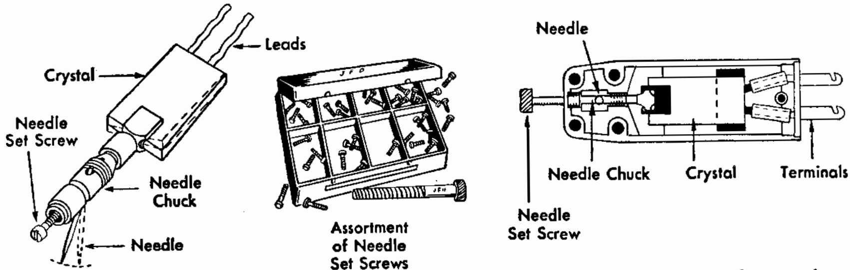


Fig. 1. Crystal phono pickup cartridge. If the needle-holding screw has a knurled head, replace it with a slotted-head screw when installing a long-life sapphire needle; assortments of such screws are made by Walsco and available from jobbers along with other needed Walsco hardware assortments for servicing. A long-life needle will ruin records if its position is changed after being used for a while

scratch noise. The common faults of modern phonograph records will be taken up first, because an understanding of these faults will many a time clear the phonograph of suspicion in a few minutes.

Records now being made for general use in homes can be classified into three distinct groups according to their speed of operation and required radius of needle point. Standard 78-rpm (revolutions per minute) records that date back to the beginnings of phonographs are made from either shellac or plastic in 10- and 12-inch diameters for regular records and in 7-inch diameter for children's records. These require a needle-point radius of about 0.003 inch.

The long-playing (LP) records developed by Columbia for operation at



How a Crystal Pickup Works

Bottom View of Crystal Cartridge

Fig. 2. Getting-acquainted information on crystal phono pickups

33⅓ rpm come in 7-, 10-, and 12-inch diameters, are made only from plastic, and require a 0.001-inch needle-point radius.

The thin, big-hole 45-rpm records developed by RCA come only in 7-inch diameter, are always made from plastic, and require the same 0.001-inch needle radius as LP records.

Characteristics of these three basic types of modern records are summarized in Fig. 3. Each type will be considered separately now, since their requirements and troubles differ considerably.

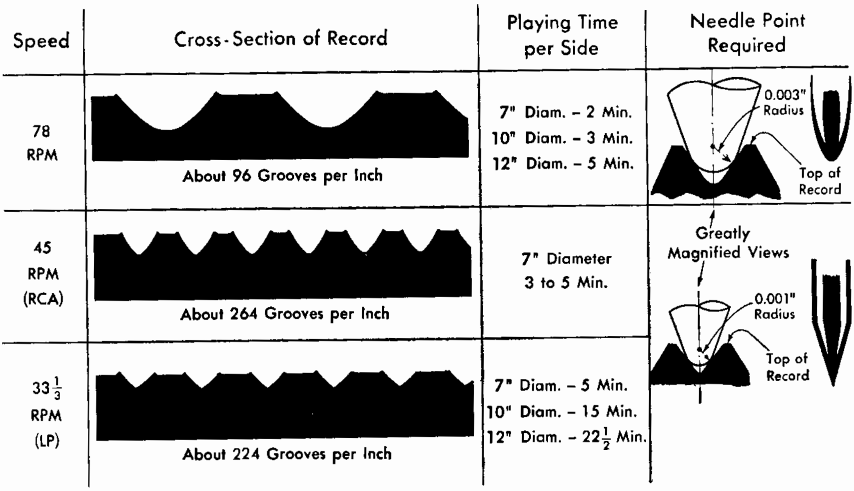


Fig. 3. Comparison of characteristics and needle-point requirements of modern records

Standard 78-rpm Shellac Records. This type of record, made from hard shellac in the 10-inch diameter size that plays for approximately three minutes, is by far the commonest of them all. As made today for use on record changers, it has a starting spiral at the outer edge and a changer-tripping spiral between the end of the record and the center hole. More expensive unbreakable versions are made from plastic but are otherwise essentially the same as the shellac records.

Older 10-inch records do not have these spirals and hence will not operate record changers. Furthermore, when record changers were just coming into use and the industry had not yet standardized on a tripping spiral, several different kinds of spirals were placed on records. Some will trip modern record changers and some will not. When a customer complains that some records will not trip the changer, the fault may be in the record rather than the changer.

Faults in New 78-rpm Records. Record changers are designed to handle a standard size of record. They may therefore give trouble when records are too thick or too thin, too wide or too narrow, have an off-center hole, or have too shallow a tripping groove. Some types of changers are more sensitive than others to certain of these faults in record manufacture.

With older changers, the unplayed records are supported by horizontal blades that move in and out with a slicing motion to drop the bottom record off the stack. With these changers, the edges of records should be smoothly rounded for satisfactory operation. Jagged, imperfect edges on records make slicer blades chip the records as they swing inward to separate the bottom record from the stack and drop it onto the turntable. Chipping can also be due to improperly adjusted slicer blades on the changer. However, if records of correct size and correctly rounded edges get through the changer undamaged, the trouble is due to faulty records. The only thing you can do is advise the customer to inspect records more carefully before buying them.

Records that are too thick or too thin will also make trouble in some changers. Changers are designed to push off or separate a record of standard thickness. If two excessively thin records are together, the second one may get in the way of the changing mechanism and cause jamming and breakage. On the other hand, superthick records will get sliced off in a slicer-type changer because the blades cannot separate far enough to accommodate the record.

Another trouble with 78-rpm records on record changers is slippage between the top record on the turntable and those under it. The record that is being played then turns too slowly, and the sound is badly distorted. Slipping can be caused by burrs or pressed-out portions around the center hole of the record or by warping of the entire record. Sanding off the burr is a cure but messes up the appearance of the record. Excessively shiny labels or improperly mounted labels can also cause slippage.

New records are often warped or curved because of improper manufacturing techniques or careless storing in record shops. It is sometimes possible to straighten warped records by placing them on a plate-glass window or mirror set horizontally in bright sunlight or heated in some other way, but this is a tedious and not always successful process.

Even new records that look perfect can sound horrible. This is because of faulty original recording by the manufacturer, faulty material in the records, faulty pressing of records at the factory, or because the manufacturer is using his master pressing dies far beyond their useful life.

Life of 78-rpm Records. The useful playing life of a 78-rpm record depends on many technical factors, as well as on how much distortion and noise the listener will tolerate. Records definitely do wear out, sometimes after only a few hundred plays and should then be discarded or replaced.

Worn-out records make needles wear faster, and sound so bad that they discourage the customer's interest in records entirely. Thus, it is good business for you to give advice on the selection, care, and replacement of records when opportunity permits.

The heavier the needle pressure on a record, the greater is the wear on the record. Records played on old phonographs will wear out much faster than those used only on modern electric phonographs having lightweight cartridges.

Worn-out needles can damage records badly. Worn needles cannot follow the fine wiggles corresponding to high frequencies, and consequently gouge out the high-frequency wiggles so that the record loses high notes and gets noisier.

An improperly adjusted phonograph tone arm can cause excessive record wear. Improper mounting and adjustment of the cartridge, the needle, and the tone arm are possible sources of trouble. The turntable itself should be level.

Any record that is cracked or chipped at a point over which the needle passes should be replaced or discarded. Flaws can cause chipping of sapphire needles, excessive wear of other needles, and damage to the cartridge.

Plastic Records. In recent years, some 78-rpm records and all 45- and 33⅓-rpm records have been made from a more or less unbreakable plastic material. Plastic records are a great improvement as regards surface noise, and can also be better musically. The commonest plastic material used is Vinylite.

Plastic records have one drawback. The material used develops a very high electrostatic charge when rubbed. Even removing the record from its paper envelope provides enough friction to build up a charge of over 10,000 volts—harmless, it is true, but able to attract dust particles. Wiping plastic records with a brush or cloth only makes the matter worse, because the wiping action produces still more electrostatic charge. Blowing the dust off these records is about the only way you can get rid of dust.

Plastic records can develop such high charges when rubbed that they stick together on a dry day and will not drop properly on a record changer. A cup of steaming hot water alongside the records will quickly dissipate such strong charges. Very dirty records can be brushed or wiped in the presence of steam also, but of course will attract dust particles again just as soon as they are dry. Dirt can also be removed with soap and warm water, but this is recommended only as a last resort. Handle plastic records with care, preferably by the edges only, and return them to the original envelope or album immediately after playing.

Plastic records of all types can develop characteristic clicking and popping sounds. Fortunately, however, these clicks and pops are chiefly higher audio frequencies which are not reproduced by the average commercial radio phonograph. Only on high-fidelity expensive sets will you encounter this complaint.

Long-playing 33⅓-rpm Plastic Records. Long-playing (LP) microgroove records, brought out first by Columbia, are molded from abrasive-free nonbreakable vinyl plastic. These records have much thinner grooves than standard records, require a playing speed of 33⅓ rpm, and require 0.001-inch needle radius. With over twice as many grooves per inch as are on standard records and with a slower playing speed, a 10-inch LP record can play over five times as long as a comparable standard 10-inch record. The 12-inch LP record gives up to 22½ minutes per side, so that one record can provide 45 minutes of music. The 7-inch-diameter LP record provides 5 minutes of playing time per side.

With LP records the needle pressure should be somewhere between 6 and 8 grams (about ⅕ ounce). Excessive weight on the sharp LP needle will damage the record surface.

Some phonographs designed for playing both LP and standard records have sliding weights or other mechanical means of changing needle pressure, along with two different sizes of needles. Sometimes the needle-changing mechanism is linked with the weight shifter, so that it is impossible to play with improper pressure. Other changers use two tone arms, each having the correct needle and weight for one type of record. Still other changers use the same light needle pressure on 78-rpm records as is required for 33⅓- and 45-rpm records.

Use of Universal Needles. Cheaper single-record players, particularly those made for children, often use the same needle as well as the same weight for all three types of records. This needle has a compromise shape and radius of point that gets sounds out of the records well enough to satisfy the children. The needle is known as a universal needle, and is even found on cheaper three-speed record players. It is not recommended for those who appreciate good records and good music.

Life of LP Records. In general, LP records and their needles can be expected to last as long as comparable standard records. The sharper needle is compensated for by the lighter needle pressure, so wear on record grooves remains about the same, and records themselves last about as long as 78-rpm plastic records. This is worth remembering because customers often ask such questions.

Seven-inch 45-rpm Plastic Records. This vinyl plastic record, introduced by RCA Victor, is distinctly different from all other records. The center

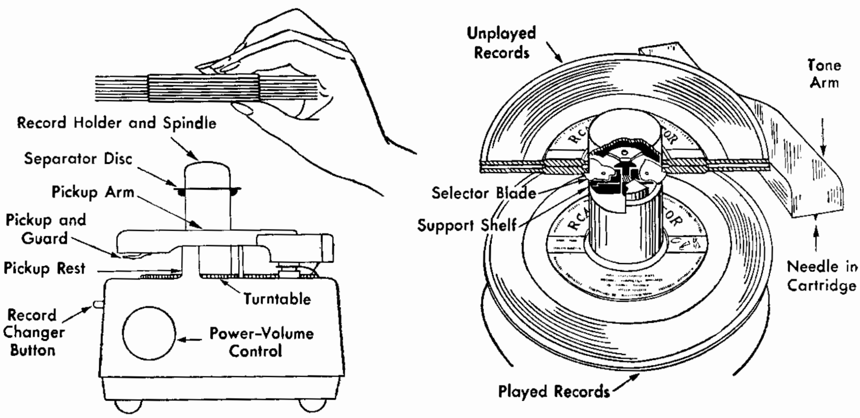


Fig. 4. Details of 45-rpm records and record changers

hole is very much larger—large enough, in fact, so that the entire record-changing mechanism fits inside the center hole of the changer. Playing speed is 45 rpm, and grooves are smaller and closer together much as on LP records, so that each side of the record can provide up to five minutes of play. Most 45-rpm records have the same playing time as a 10-inch 78-rpm record (about 3 minutes), however, since the same musical selection is on both. These records use the same 0.001-inch-radius needle as the LP records, and a needle pressure of about 5 grams which is slightly less than for the LP records.

All 45-rpm records are designed with a shoulder near the center and a much thinner playing surface, as in Fig. 4, so that playing surfaces of adjacent records do not touch while the records are on the changer or in storage. The large center hole and the small size of the record together permit easy and careful handling, so that fingers need never touch the delicate playing surface of the record.

Phonograph Needles. You will probably be asked more questions about phonograph needles than any other topic connected with record changers, because high-pressure advertising has quite confused the general public on this subject. So many different types of needles are on the market today to fit the three types of records and the dozens of different pickups that even you may become confused yourself when ordering a replacement. Therefore, after first considering the questions of needle radius and permanent needles, each type of needle will be taken up in turn.

Long-life Needles. Despite advertising and catalog claims, there is no such thing as a permanent needle. All needles will wear out eventually, even those with diamond points.

Needles having tips made from hard metal alloy, sapphire, or diamond are more properly called long-life needles. In general, these needles are good for somewhere between 50 and 5,000 plays, depending on the needle and the way in which it is used.

The term *permanent needle* was originally used to indicate one that was built into the pickup and could not be replaced except possibly by the factory. Pickups with nonreplaceable needles are still quite widely used, but the needle points in these are subject to the same wear and life limitations as replaceable needles.

The idea of not having to change needles has always had a strong appeal for the general public. Nevertheless, the playing of shellac records produces the same grinding action on the needle as would be obtained by holding that needle against a grindstone. The harder the point of the needle, the more records it takes to grind the needle down, but eventually the needle will be worn down.

Diamond-point Needles. The hardest material used today for phonograph needle points is the diamond. Diamond points were heretofore used chiefly in broadcast stations, in professional sound studios, and by high-fidelity enthusiasts. Today, however, diamond-point needles are rapidly becoming popular for home use too, because they serve as insurance against damage to records by worn needles of other types. A diamond-point needle today costs from $10 to $20 and can be expected to last ten to twenty times as long as a sapphire point. Since sapphire needles cost $1 to $2 each, the cost per play is just about the same for both types.

Sapphire-point Needles. The needle point most used today for record changers in homes is a natural or synthetic sapphire jewel point. Even on shellac records a good sapphire point will give at least 250 plays satisfactorily for a high-fidelity system, considering a play to be 5 minutes of use, such as one side of a 12-inch 78-rpm record. In average home radios where the higher frequencies that represent surface noise and scratch are not reproduced, a sapphire point may give as many as 1,000 plays before the customer begins to be bothered by the noise and distortion. If used only on plastic records, still more plays can be expected, since these records have no added abrasive.

A sapphire needle point is generally transparent, with little or no color. It can thus be easily distinguished from metal points.

Metal Alloy Needle Points. Many of the needles used in record changers today have metal alloy points of one kind or another, to provide a hardness far greater than that of steel needles but somewhat below that of sapphire-tipped needles. Osmium and iridium are two of the metals used for needle points. Sometimes this type is called a rare-metal needle. Playing life varies greatly. A connoisseur of music may replace an osmium-tipped needle after only 50 plays. Children, teen-age jukebox lovers, and other noncritical listeners may not be bothered by the noise and distortion of a worn osmium-tipped needle until about 500 records have been played. By this time, of course, the needle will have worn so much that it has done serious damage to the records.

Chrome-plated Steel Needles. These are conventional steel needles of the type used on most orthophonic phonographs, with a plating of chromium on the point that greatly increases playing life. In general, they are good for 5 to 50 plays, depending on pickup pressure and other factors. These are used chiefly on orthophonic phonographs having horns and on children's electric phonographs having crystal cartridges.

Steel Needles. An ordinary steel needle should never be used to play more than one record. The point wears rapidly, and excessive playing results in depositing steel material in the grooves and damaging the records.

Noise-suppressing Needles. An odd-shaped needle having a horizontal portion, such as those shown in Fig. 5, is less responsive to the noise in records than a straight needle. Noise suppression usually also means suppression of such higher frequencies in music as may also be present on the record, but the average listener does not miss these high frequencies.

Bamboo, Cactus, Thorn, and Fiber Needles. All of these needles are made from soft materials and are used to reduce high-frequency response, noise, and record wear. They are unsuitable for record changers, because the maximum life is one play and they often wear out even before the record is completely played. Despite claims of old-timers, these needles generally give a low quality of reproduction and cause considerable distortion. Resharpening devices are available for certain types, but as a serviceman you should recommend changing over to a good long-life needle.

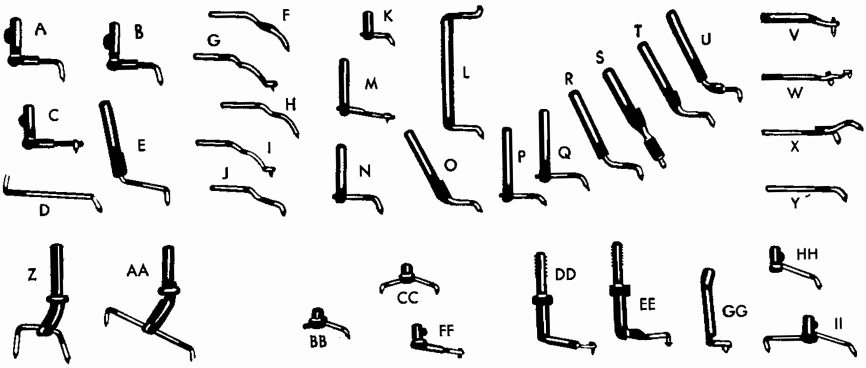


Fig. 5. Replacement needles for modern phonographs. Practically all modern needles have bent shanks for suppressing record noise. (Jensen illustration)

Needles in Three-speed Changers. Modern record changers are generally built to play all three types of records. This means that they have provisions for two different needle points, with 0.001- and 0.003-inch radius.

The commonest arrangement in three-speed changers is the two-needle turnover cartridge having a 0.001-inch point on one side and a 0.003-inch point on the other. The user turns the cartridge over by flipping a handle or lever when the needle on the other side is desired. Usually one needle position is marked 78 and the other LP, but occasionally only a red dot is used to identify the 0.001-inch LP needle. The needles can usually be replaced separately.

Another fairly common arrangement has a tilting cartridge and one of the two-headed needles shown in Fig. 5. Here the entire needle must be replaced when one of the points is worn. Sometimes the cartridge-tilting lever also shifts a weight at the back of the tone arm to give increased pressure for 78-rpm records, but more often now the same needle pressure is used for both types.

How to Tell When Needles Are Bad. The most reliable symptom of a worn-out needle is distorted reproduction heard through the loudspeaker. This will be most noticeable on the inside grooves of records containing brass instruments of an orchestra or other music having a large amount of high-frequency energy. It is a good idea to keep on hand one record of this type just for testing needles, pickups, and audio amplifiers. Once you become thoroughly familiar with the way the music on this record should sound, you can use the record for test purposes.

The condition of the needle point can also be determined by examining it with a low-power microscope or with a ten-power magnifying glass. A worn-out needle will appear to have a flat spot at the tip when viewed from the side, as shown in Fig. 6. Badly worn needles will also have shoulders; by this time, the needle will have done considerable damage to records. Whenever in doubt, replace the needle.

The first effect of a worn needle is loss of the higher frequencies, because the worn needle no longer follows the fine wiggles corresponding to these frequencies in the grooves. With a little more wear, buzzing sounds are heard during loud portions of the record, and distortion becomes severe.

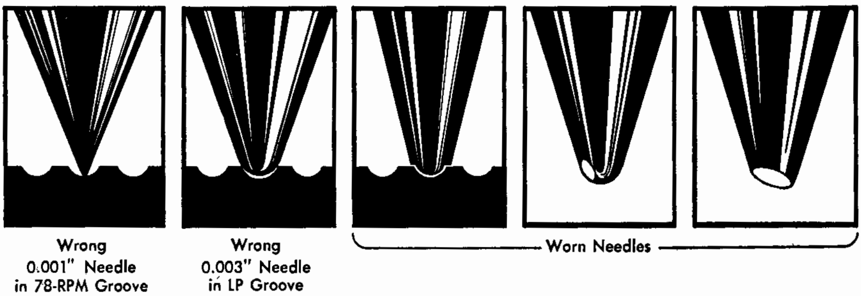


Fig. 6. An LP needle will gouge out the bottoms of grooves if accidentally used on 78-rpm records. A 78-rpm needle will ride the corners of LP grooves and may damage the record. Also shown are worn needles as they appear under a microscope; these will damage records even though they still feel sharp and look sharp to the naked eye

Factors Affecting Number of Plays from Needle. A worn needle will be noticed much sooner in a phonograph system having a wide frequency range than in the ordinary home radio phonograph, because the cheaper systems never do reproduce the high frequencies whose loss is the first sign of wear. Thus, the satisfactory life of a needle depends first of all on the quality of the phonograph on which the needle is used.

The second intangible factor in needle life is the personal preference of the listener as regards the amount of noise and distortion he will tolerate. Lovers of classical music will usually be bothered sooner by needle wear than those who listen to popular music. A glance at the customer's record library will therefore tell you a lot.

Beware of musically minded customers who are too fussy. Some will never be satisfied even when you get their system working at the limit of its capabilities, because the memory of how it worked long ago does not take into account subsequent wear on records.

Whenever an unusual scratching noise or distortion is noted, the phonograph should be stopped and the needle point carefully examined. Any needle can suddenly get damaged, by flaking of the rare metal tip, chipping of the sapphire tip, or bending through careless handling of the tone arm. Continued use will ruin records. Always emphasize to your customers that the cost of a new needle is insignificant in relation to the cost of their record library.

A 0.001-inch-radius needle made for 45- and 33⅓-rpm records should never be used on 78-rpm records. This needle is too sharp for 78-rpm grooves, as indicated in Fig. 6, and will gouge out the grooves. In addition, the fine needle point will be worn by the shellac in 78-rpm records, so that it becomes useless for the less abrasive plastic records it is intended for.

Conversely, a 0.003-inch needle can damage LP grooves, so be sure you are using the right needle when using or working on a phonograph. Once you have handled both sizes of needles a few times, you will be able to identify the needle-like sharpness of the 0.001-inch needle by touch.

Needle Talk. An annoying characteristic of some needles is the sound heard directly from the needle rather than from the loudspeaker. The sound that you hear when playing a phonograph with the amplifier off or the loudspeaker disconnected is due entirely to needle talk. The needle and pickup vibrate and produce weak sound waves.

Needle talk is sometimes annoying to a customer who sits close to the radio, but ordinarily has no effect on the quality of reproduction. Some types of cartridges and needles have more needle talk than others, so changing cartridges is a possible remedy if the customer wishes to go to this expense. Usually, assuring the customer that needle talk is normal for some cartridges will be all you have to do. Needles with horizontal bends or knees rarely have noticeable needle talk.

Checking Needle Pressure. In view of the increasing importance of needle pressure for proper playing of LP and 45-rpm records, you will find it desirable to check needle pressure whenever replacing a cartridge or when you suspect that the pressure may be wrong. Several types of scales are available for this purpose. For LP and 45-rpm records a special gram scale is needed, because scales graduated in ounces for standard records cannot measure accurately the light needle pressures now required.

To use the flat-spring type of gram scale, first set the pointer to zero. Lift the tone arm slightly off the rest post of the changer and place the needle point in the dimple in the pointer spring. Lift the tone arm approximately half an inch by raising the scale slowly, as in Fig. 7A, and note the reading. Lower the scale slowly half an inch and note the new reading. The value halfway between these two readings is the needle pressure. The difference between the two readings is the vertical friction of the tone arm hinge.

For 0.001-inch-radius needles on one Philco changer for LP records, the instruction manual specifies that the needle pressure should not be less than 5 grams nor more than 7 grams, and the vertical friction should

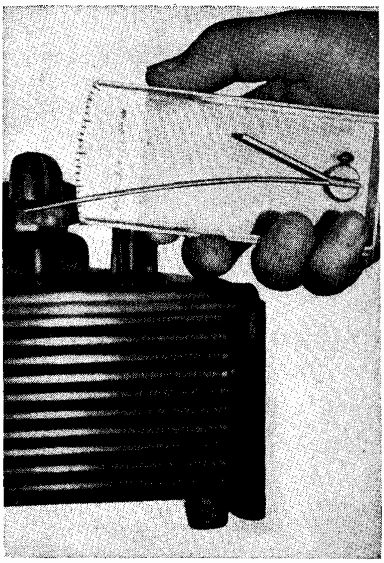


Fig. 7A. Measuring needle pressure with a gram scale. The correct pressure for most LP record players and changers is between 5 and 7 grams. (Philco photo)

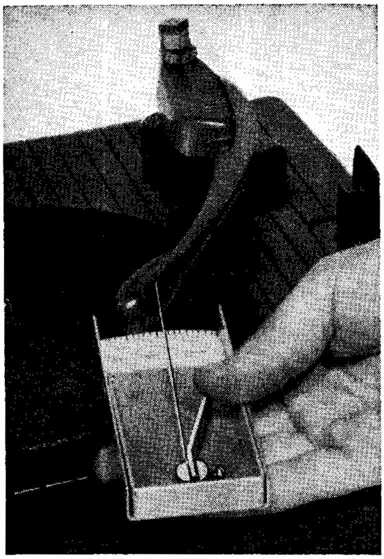


Fig. 7B. Measuring horizontal friction of tone arm. Three nuts serve as weights at rear of tone arm to balance it. Under 3 grams is correct. (Philco photo)

not be more than 2 grams. Instructions for correcting wrong needle pressure are usually given in the service manual for the record changer.

Measuring Horizontal Friction. Skating of a needle over the grooves of a record is generally due to excessive friction in the horizontal bearing of the tone arm or to spring action of the shielded wire running through the tone arm to the cartridge. These factors become important in shallow-groove records, because it takes very little force to make the needle skim across the shallow grooves.

To check horizontal friction, place a weight on the back end of the tone arm and move the weight out or in until the tone arm is balanced in a horizontal position. On short tone arms, it may be necessary to attach a strip of wood temporarily with Scotch tape so you can get the weight far enough back for balance. The horizontal friction can then be measured with a gram scale, as shown in Fig. 7*B*. Move the tone arm toward the center of the turntable with the spring of the scale, and note the reading on the scale while doing this. For the Philco LP changer this reading should not be more than 3 grams at any time.

Some 78-rpm changers have a spring tension that swings the tone arm inward; here the needle will skip grooves if the spring tension is too great. The exact tension is not critical, and can be checked by feel once you have balanced the tone arm horizontally. This spring rarely causes groove skipping, because it acts only near the start of a record.

Never Save Worn Needles. As a needle of any kind wears, it develops flats on two sides of the point where contact is made with the two walls of the record groove. If a needle is removed, then for any reason put back in again, the chances are that the needle will be turned slightly different from its original position. As a result, the sharp needle edges will then gouge out the record grooves and ruin the record in a single playing.

Therefore, throw away every needle that is taken out of a cartridge, preferably bending first with pliers to ensure that it cannot be recovered and reused by someone else later. For this same reason, do your examining of needles while they are still in the cartridge, unless the needle is one of the newer types that can be inserted in only one position. Only needles with flats or aligning keys can be replaced safely after inspection.

Ordering New Needles. New needles can be ordered by specifying the make and model number of the cartridge and indicating whether sapphire or rare-metal tip is desired. With cartridges designed to take either 0.001- or 0.003-inch needles, you must also specify which radius is desired. If the pickup originally had a universal needle for all records and the customer was satisfied with its performance, order the same type.

Replacing Needles. For most phono-pickup cartridges, removal of a worn needle and installation of a new needle are done in much the same way as needles are changed on old orthophonic phonographs. If the needle-holding screw has a knurled head, loosen by turning counterclockwise with the fingers. If the head is slotted, use a small screwdriver. Remove the old needle and throw it away, then insert the new needle and tighten the screw firmly again. Avoid excessive tightening force, as tightening twists the crystal element, and excessive force may crack it. Some of the commonest types of needle mounts are shown in Fig. 8, along with needle-replacing instructions.

Some long-life needles have threaded shafts, and are locked in place by

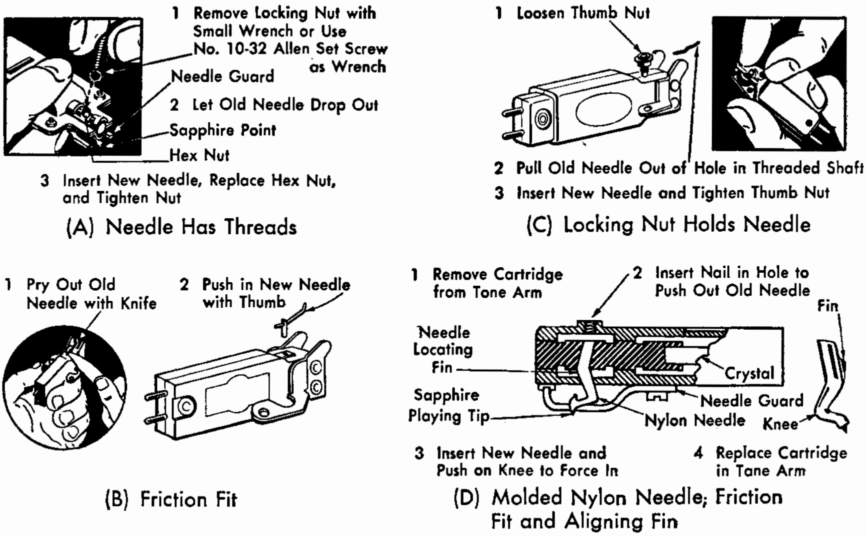


Fig. 8. Examples of procedures for replacing long-life needles in phono cartridges

a nut after the needle is inserted. Here the nut must be removed before the needle can be taken out.

Self-aligning Needles. Newer self-aligning needles with specially bent shanks are held in place by friction alone, and have a projection or flat on the shank so they can be inserted only one way. These can usually be pried out with a knife or pulled out with a pair of pliers or even stiff tweezers. If too tight to be pulled out, however, remove the cartridge from the tone arm first. This is done with a small, short screwdriver by loosening the two screws that hold the cartridge in the tone arm. Removing the cartridge generally exposes a needle ejection hole at the top. Push a small nail or a piece of stiff wire into this hole to push out the old needle, holding your hand underneath to catch the needle as it pops out. Sometimes the old nylon needle can be pulled out with long-nose pliers or pried out with a knife, making it unnecessary to remove the cartridge from the tone arm.

After removing a worn self-aligning needle, insert the new needle with your fingers and turn it gently until you can feel the aligning key dropping into the correct slot. If you study the position of the old needle carefully before removing it, you should have no trouble getting the new needle in correctly. When it is aligned properly, push the needle in as far as it will go with your fingers.

Never apply pressure on the point of the needle. If the needle has a knee or bend, take a small screwdriver and place one corner of it on top of the knee, then press straight down hard until you feel the tapered needle slide into its chuck as far as it will go. Be extremely careful not to damage the point of the needle.

Nonremovable Needles. A few cartridges have permanently attached needles that cannot be removed by the customer or serviceman. The needle points on these do not last any longer than corresponding points of replaceable needles, however.

In a few instances the manufacturer has facilities for installing new needles at the factory. The cost of this is generally about the same as the price of an ordinary new needle. The cartridge cannot ordinarily be sent directly to the manufacturer, however; it must be taken to a distributor or jobber, who holds it until he has enough of that type to justify a bulk shipment to the manufacturer for installation of new needles.

If needle-replacing service is not conveniently available, an exact replacement means buying and installing an entire new cartridge with needle. Before ordering this, however, find out if a cartridge with a replaceable needle can be obtained for that phonograph. This may cost the customer a bit more initially, but future needle-replacing costs will be much lower.

Care of Crystal Cartridges. Dropping or rough handling of a crystal cartridge can change its tone quality, cause loss in volume, and even break the crystal element. Customers should therefore be cautioned to keep record changers in proper adjustment. At the beginning of a record, the needle should be lowered into the starting groove easily and without a severe drop. On manually operated phonographs, the pickup should be handled gently and should be properly supported by a suitable rest when not in use.

Heat and moisture are bad for crystal pickups. Using or leaving a phonograph in direct sunlight is a sure way of ruining the crystal element. Leaving the phonograph alongside or on top of heating units and radiators is equally bad. Nothing much can be done about excessive moisture from a preventive standpoint, except to explain that the fault is with the climate rather than the cartridge.

Testing Crystal Cartridges. If reproduction sounds distorted after a new needle has been installed and you suspect that the crystal cartridge may be at fault, disconnect one lead of the cartridge and make a quick check of cartridge resistance with the highest range of your ohmmeter. A reading of less than 0.25 megohm definitely means cartridge failure because of excessive heat or humidity. A good new crystal cartridge will generally read higher than 2 megohms in resistance. This ohmmeter test is not always reliable, however; the only sure test is to try a new cartridge.

A crystal pickup cartridge is always connected across a resistor in the audio amplifier. The value of the resistor is usually 0.5 megohm, but can be anywhere from 0.25 to 1 megohm. Decreasing this resistance value reduces the bass response so there will be less booming on low notes. Increasing the resistance value gives more booming bass, which is liked by many.

For a quick test of a suspected cartridge, remove the leads from the cartridge and attach them to a cartridge that you know to be good. It must, of course, also have a good needle. With a record spinning on the turntable, hold the cartridge at approximately the correct position with your fingers for a few moments and listen to the reproduced sound from the speaker. If it sounds good now and then as you get the correct angle and pressure, you have proved that the audio amplifier and everything else except the old cartridge are good. Replacement of the cartridge with the correct new type is then the next step.

Keep one good crystal cartridge on hand for test purposes, with a needle in it that you know is good. This cartridge will not give you perfect results on every phonograph because cartridges are generally designed to match a particular phonograph system, but it will serve adequately for test purposes.

Replacing Crystal Cartridges. A replacement cartridge should have very much the same output voltage and tone response as the old cartridge. This is necessary to make the new cartridge match the design of the audio-frequency amplifier in the set.

A replacement cartridge must also have the same dimensions, mounting holes, and weight as the old cartridge so that it can be installed properly in the tone arm and provide the right needle pressure to give good reproduction and trip the record changer.

It is generally not practical to make an exact-duplicate replacement of a crystal cartridge. So many different sizes and types of cartridges have been used that not even jobbers keep them all in stock. Furthermore, newer cartridges are very often better than old ones because of improvements in design and manufacture during recent years. For this reason, manufacturers of replacement cartridges have each standardized on a reasonable number of types that will prove satisfactory for replacing almost a hundred different older cartridges. Some manufacturers put up a complete assortment in a convenient pack with a chart showing which older cartridges each one will replace.

It is usually desirable to use a new crystal cartridge that has approximately the same frequency range as the old one. A wider-range cartridge should be put in only at the request of the customer, after obtaining his agreement to accept additional needle scratch along with the higher frequencies.

If replacing an old cartridge that has no number or one for which no replacement is listed, you can generally get along by finding one that will fit mechanically, has a voltage output of at least 2 volts, and is fairly low in price so that it has a correspondingly narrow frequency range. You risk more trouble by installing an expensive cartridge than a cheap one, because the extended high-frequency response of high-quality cartridges means additional needle scratch from the well-worn records in most homes.

Heat- and Moisture-resisting Crystal Cartridges. In locations along the seacoast and in towns like Baltimore and Washington that are famous for high humidity, ordinary crystal cartridges do not last long. In these locations, it is best to use one of the new cartridges having ceramic rather than crystal elements. These closely resemble crystal cartridges but have a new type of piezoelectric material in them that is unaffected by heat, moisture, or dryness. They can be obtained in various models to replace a large number of conventional crystal cartridges.

Installation of New Crystal Cartridges. Cartridges are generally held in position inside the tone arm with two screws. Modern cartridges have terminal pins for clip-on connections that can be removed with the fingers. Thus, removal of the old cartridge is simple.

Before installing a new cartridge, push the connecting sleeves onto its pins. If the connecting sleeves are too tight for the pins of the new cartridge, spread them apart a bit with a screwdriver. If too loose, squeeze them with pliers. Be sure the wires cannot vibrate loose. Be sure also that the grounding braid metal does not touch the terminal for the inside wire of the cable. The grounding braid should go to the cartridge terminal that connects to the metal housing of the cartridge. Careful examination will show which one this is.

Older crystal cartridges use soldered connections. Unsolder the leads from the old cartridge carefully so as not to break the wires, remove surplus solder from the leads, loop the leads around or through the terminals of the new cartridge, and squeeze with long-nose pliers to get a good mechanical joint. Be sure the metal braid lead goes to the terminal connected to the case of the cartridge. Finally, solder the connections. Use a hot and clean soldering iron, and do not hold it on any longer than is necessary to make a solid joint. Never mind about beauty on these soldered joints. Heat is bad for crystal cartridges, and holding the iron on the terminal just a fraction of a second too long can ruin a new cartridge.

After connections have been made to the new crystal cartridge, hold it in position inside the tone arm and put in the mounting screws. This is much harder than it sounds, because you cannot usually lift the tone arm up high enough to see what you are doing. The mounting screws are small and difficult to insert in the holes, especially if you have big fingers. The job can be greatly simplified with beeswax, chewing gum, or putty, however. Put a small piece in the slot of the screwhead so the screw will stick to the end of the screwdriver. A drop of speaker cement can be used in place of gum, but requires waiting a few seconds for the cement to harden enough to hold the screw.

New cartridges often have a clip-on metal guard that protects the needle from damage during shipment and installation. Leave this on until the cartridge is installed and connected, then be sure to remove it.

Replacing Special Types of Pickups. Although the crystal pickup is by far the commonest, a number of other types are in use. In general, the needle and cartridge replacement problems are essentially the same as for the types already covered. For this reason, you need only have a general knowledge of these separate types, principally so you can recognize them and discuss them intelligently with a customer.

Variable-reluctance Pickups. In the modern version of the magnetic pickup as made by GE and others, the only moving part is the needle

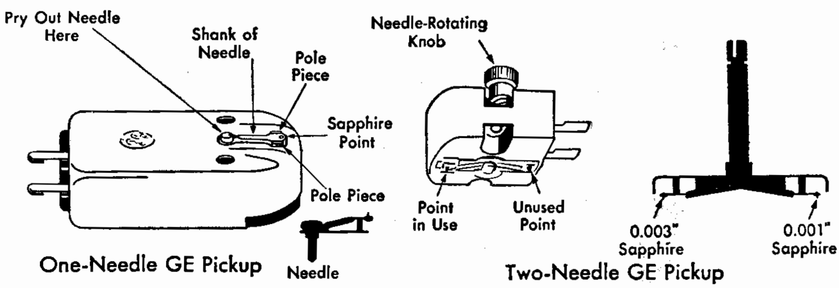


Fig. 9. Two types of GE variable-reluctance phono pickups and their needles

itself, as shown in Fig. 9. As the needle point wiggles in the record grooves, the flexible steel shank of the needle moves back and forth between the pole pieces. The coil and the tiny permanent magnet inside the pickup are so arranged that needle movements vary the number of magnetic lines of force passing through the coil. This induces the desired audio voltage in the coil.

Three distinct types of GE cartridges are in use. The first to be made had a permanently mounted needle, which meant replacing the entire cartridge when the needle wore out. The second type of cartridge, interchangeable with the first, has a needle that is easily changed, as shown in Fig. 9. Newer GE cartridges for three-speed phonographs have two different needle points, either of which can be set between the pole pieces by pushing down a knob and then rotating it half a turn.

The output voltage of GE pickups and all similar types is extremely low, being only about 0.01 volt as compared to 2 or 3 volts for crystal cartridges. One extra stage of amplification, called a preamplifier, is therefore required with variable-reluctance pickups. On sets designed to use this pickup, this extra stage is built in. It provides far too much amplification for crystal cartridges, so changing from magnetic to crystal would result in excessive volume and bad distortion. This emphasizes again the importance of using the correct type of replacement cartridge always.

Cleaning GE Pickups. Pickups of the GE type require occasional cleaning of the air gaps between the needle and the pole pieces. Fuzz and dirt particles accumulating here can be rubbed off with the fingers or blown off. Iron filings are more persistent, but can be removed easily by threading Scotch tape through the air gap a few times to pick up the particles, as in Fig. 10.

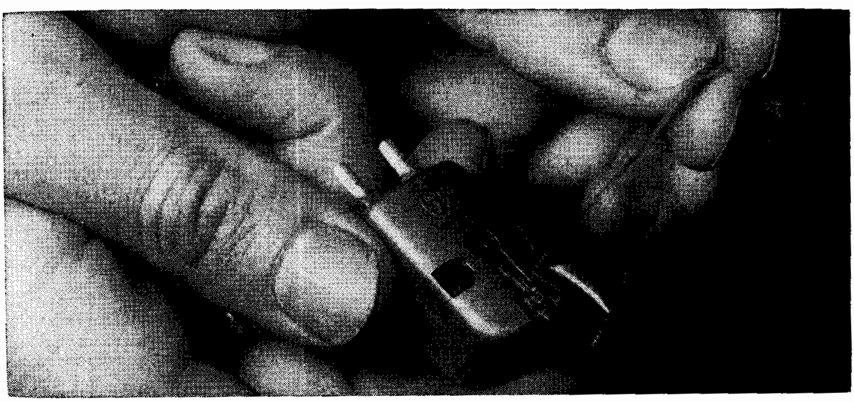


Fig. 10. Cleaning dust and iron particles from air gaps around needle point in a GE cartridge by sliding in a piece of Scotch tape. (GE photo)

Watch for iron-filing trouble when there are children in the house, because children pick up iron particles when playing in sand and transfer these to the records. Since the pickup has a permanent magnet, it collects these, and there is soon a bridge of iron around the needle to neutralize its action and cause distortion.

Zenith Cobra Pickup. In the Cobra pickup, the needle moves a steel vane back and forth near a coil that is connected into an r-f oscillator circuit. Vibrations of the vane make the oscillator output current vary at an audio rate, producing a modulated r-f signal. The oscillator also acts as a detector, and delivers the desired audio voltage. This voltage is weak, only about a hundredth of a volt, so a second triode section in the tube is used to amplify it. The double-triode tube for the Cobra pickup will be found in the record-changer compartment, either above or below the changer itself.

The needle in early Cobra pickups was not replaceable; hence the entire cartridge must be replaced whenever the needle point becomes worn. You can usually assume that a Cobra cartridge needs replacement in any set that has been in use for over a year. However, do not overlook the fact that a bad tube or some other defect in the Cobra oscillator-amplifier circuit can also cause trouble.

Tuned-ribbon Pickups. The needle point here is permanently attached to a small piece of magnetic material that is supported by two thin metallic ribbons; hence the entire pickup must be replaced when the needle is worn.

Strain-gage Pickups. In this type of pickup, a small piece of resistance wire is stretched under tension between two points, and the needle is attached to the middle of the wire by a lever system. Movements of the needle make the wire stretch alternately one way and then the other, varying the resistance of the wire at an audio rate. The electric current that is being sent through this wire by a d-c voltage source thus varies at an audio rate also, to give the desired audio signal. The needle will usually be permanently attached, so that the complete pickup must be replaced when the needle is worn. In the Capehart pickup, a coating of resistance material on a small insulating beam is used in place of resistance wire.

Dynamic Pickups. The operation of a dynamic pickup is much like that of a dynamic speaker. The needle of the pickup moves a coil positioned in the field of a permanent magnet. Movement of the coil by the needle results in an audio voltage. The sapphire-tipped needle is replaceable. Pickups of this type require a special transformer, generally located right in the radio set, so again the replacement must be with an exact-duplicate unit.

Repairing Pickup Leads. The shielded lead going from the radio set to the pickup is a fairly common cause of trouble. The insulation around the central wire can deteriorate so that electrical leakage through it causes distortion. Connections can go bad at either end, particularly at the pickup, and result in low volume or even no signal at all.

When the wire itself is in bad shape, replacement is the best procedure. You can get shielded phono-pickup wire for this purpose from a jobber. Do not remove the old wire until you have the new wire at hand, because the path of the wire through the tone arm and the record-changer mechanism is critical. The best way is to put in the new wire at the same time that you remove the old wire, loosening and tightening the wire clamps one at a time inside the tone arm and under the changer.

Improper soldering to shielded wire is a common cause of trouble, particularly when plastic insulation is used on the inner wire. The plastic melts from the heat of the soldering iron, allowing the outer wire to touch the inner and cause leakage or a short circuit. The actual defect cannot be seen, hence is difficult to locate. To avoid such trouble, use the method shown in Fig. 11 for connecting a shielded cable.

First, push the shield back from the end of the wire about 1½ inches to produce a bulge. Bend the wire almost double at this point, and use an ice pick or other sharp tool to spread the shield wires at the top of the bulge. When the hole is big enough, pull out the inner wire through it. This leaves the empty end of the shield as a convenient lead for making connections. It is long enough so that heat of a soldering iron will not melt the insulation. The method is much faster than unraveling the braided shield.

The procedure for soldering to the standard type of male plug used on record-changer leads is also shown in Fig. 11. Considerable practice is required to make a neat joint having no excess solder, so do not be discouraged if you have trouble the first few times.

Make soldered connections to shielded wire as quickly as possible, to minimize chances for melting the insulation. If there is any doubt in your mind about the quality of your work, cut off the entire end of the wire and start over.

Some pickups use two unshielded insulated wires. The safe procedure is to replace with identical wire or with something you know to be equivalent.

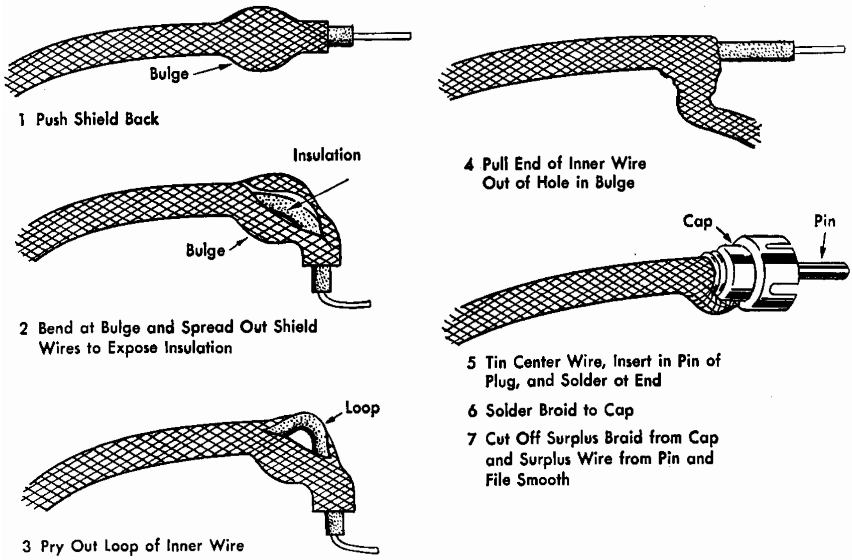


Fig. 11. Method of preparing shielded wire for connecting to a phono pickup

Phonograph Troubleshooting. There are a few common causes of record-changer trouble that you can spot and fix yourself if you know what to look for. Some of these have already been taken up in connection with records, needles, pickups, and pickup connections. Here are a few others.

Complaints about scratch noise, distortion, low volume, and rumble in a modern radio-phono console can be due either to the records, the needle, the pickup, the pickup connections, the record changer, the amplifier, or the loudspeaker. If the radio set works satisfactorily, the amplifier and loudspeaker can be cleared of suspicion, since they serve for both the radio and the phonograph.

Leveling the Turntable. For satisfactory operation, a record changer must be supported on springs in a perfectly level position. If not level, the needle cannot ride the grooves properly, and there will be excessive needle and record wear. In addition, operation of the changer may be affected. A small pocket level can be placed on the turntable to check levelness in two directions at right angles to each other.

A level turntable is absolutely essential for playing LP records because they have such light needle pressure. Never increase needle pressure to cure skipping grooves, because this will cause rapid wear of needle and records alike. If the turntable proves to be level, the trouble is generally due to binding of the pickup arm. Be sure the pivot for the arm is free from dirt and is well oiled.

The bracket that supports the tone-arm pivot shaft may have to be bent slightly to decrease friction. Vertical friction as measured with a gram scale at the needle should not be more than 1 gram, and horizontal friction not over 3 grams. Pickup leads can cause excessive friction, so try bending and moving them. A worn or damaged needle can cause groove skipping, as also can worn records.

On sliding-drawer changers, the check for levelness should be made with the door almost closed, since that is the position in which the changer is played. The drawers generally tilt downward slightly as they are pulled out.

Record changers may be leveled by squeezing or stretching the supporting springs under the changer base with pliers or by any other suitable means. Mechanical ingenuity comes in handy here.

Curing Hum. Rubber washers are generally used between the motor mounting bolts and the changer base underneath. If the rubber hardens or if the bolts are tightened excessively, motor vibration may be transmitted to the frame and thence through the turntable to the record and needle to cause hum. A defective pickup wire or interchanging of connections at the pickup can also cause hum by allowing the magnetic field of the motor to act on the inner wire of the shielded cable. If the hum stops when you short the pickup terminals with a screwdriver while the needle is resting on a stationary record, motor vibration is the probable cause. Examine the motor mounting, and replace the rubber washers if necessary. You can get new ones from a jobber.

If the hum is still heard with pickup terminals shorted but disappears when you short the shield to the inner conductor at the other end, the trouble is in the shielded cable somewhere. Shorting the cable at the receiver end calls for a piece of very fine bare copper wire that you can wrap around the male prong and still insert it in the socket on the set. It is normal to get a loud hum whenever you pull this cable out of the socket, the same as when you disconnect the pickup at the other end of the cable. You will also normally get a loud hum when you touch the pickup terminal that goes to the inner wire.

Checking Turntable Speed. The record changer enters into the picture when it fails to turn the record at the correct constant speed. The motor and the rubber-faced drive pulleys under the turntable are the chief causes of trouble here.

Suspect the motor if the record is running too slow, which causes sounds to be lower in frequency than they should.

Turntable speed is easily checked by placing a stroboscopic disk on the turntable and illuminating it with a light bulb. A neon lamp is even better as a light source. When speed is correct, the bars or dots on the rotating disk will appear to stand still. Speed-checking cardboard disks are often given free as souvenirs by manufacturers, but can also be purchased from jobbers for a dime or so. If speed is off, check alignment of the motor shaft, be sure all its mounting bolts are tight, and check for excessive friction anywhere in the changer wheels and gears. As a last resort, place a few drops of fine oil on each bearing. Avoid overoiling, as oil collects dust and ruins rubber parts on the changer.

A rumbling sound can be due to a flattened portion of the rubber drive wheel that presses against the inside of the turntable rim in most changers. This is cured by replacement of the rubber ring on the wheel. In an emergency, the trouble can sometimes be cured by taking the rubber wheel off, turning it inside out, and replacing it.

QUESTIONS

1. Name three different record defects that can make a 78-rpm record changer appear to be defective.
2. What type of needle point is most used on record changers?
3. How can you tell when a needle is ready for replacement?
4. How is needle pressure measured?
5. What type of cartridge can be ruined quickly by excessive heat?
6. List the steps followed in replacing a pickup cartridge of any type.
7. How can the air gap in a variable-reluctance pickup be cleaned?
8. How is the shield removed from the end of phono-pickup wire when making a connection?
9. What record-changer trouble can occur when the turntable is not level?
10. How can a turntable usually be leveled?

20

Repairing Cabinets

Why Cabinet Repairing Is Important. A bright new scratch or scar on the cabinet of a television or radio set that you are returning will be spotted faster than anything else you do to that set. Such damage is heartbreaking to the housewife, and yet accidents are bound to happen no matter how careful you are in handling sets and in working on them in your shop. By learning how to repair accidental damage to cabinets, you can avoid this embarrassing situation.

Since prevention is always better than cure, this chapter starts with suggestions for protecting and handling cabinets while in your care. These suggestions are important to you financially, because the repair of cabinets is often a slow and time-consuming process for which you cannot charge if you did the damage yourself.

It takes only a little extra time and effort to polish the cabinet and clean the chassis after you have repaired a set. As a serviceman, you are expected to make the set perform as well as when new. When you also make it look like new, you have done the unexpected, and the housewife will undoubtedly mention this to her friends. This can lead to more repair jobs for you.

Avoiding Damage to Cabinets. The biggest risk of damage to table-model cabinets is right in your own shop. Never pile sets up on your bench because tools may slip, the sets may bump and scratch each other, and some may even fall onto the floor. Never put table-model sets on the floor, because in this location you are eventually bound to trip over one or drop something on it.

Shelves are the best place for table-model cabinets when not working on them. A plain bookcase-like arrangement will do if the back is covered with plywood to prevent knobs and small parts from dropping off behind.

Oftentimes you will want to store a set without putting the knobs back on, while awaiting the required new parts.

Later, when the volume of your business justifies a bit more expense, you may wish to install a wall outlet at the back of each shelf compartment, for operating repaired sets at low volume a day or two to make sure that no new troubles develop.

Shelf-construction Hints. When building shelves, consider the possibility that you may have to move them some day to another location. You can either build in sections that will go through a standard door or assemble the shelves with wood screws so you can take them apart without damage to the wood.

When carrying table-model sets in your car, always arrange them so they cannot bump against each other or fall down. Winding the line cord around the set horizontally is one way of obtaining a rubber cushion when it is necessary to put the sets close together in the car. Be sure the plug on the cord cannot gouge a hole in the cabinet. Newspapers or a blanket are safer for separating sets.

How to Move Consoles. With consoles it is usually best to leave the cabinet in the customer's home. On those occasional jobs where it becomes desirable to remove a console cabinet to your shop, such as for repairs to the cabinet itself, use standard furniture-moving techniques. This means wrapping a heavy blanket or commercial furniture-protecting pad around the cabinet and strapping it in place. Do all this before attempting to move the cabinet out of the room, because it is just as easy to damage the cabinet in the home as on the outside.

If the cabinet is heavy, do not try to lift it yourself. Get help. Do not try to move a large cabinet with an ordinary car; this is a job for a small truck or a station wagon. Even small consoles are difficult to get into an ordinary car without risking damage to the cabinet.

If the cabinet must be tied in place in the truck, use wide straps for this purpose. Wire or rope may cut through the pad and damage the cabinet. If using an open truck, be sure waterproof canvas is available to cover the set in case of rain or snow. Remove all loose objects that might damage the cabinet while the car or truck is in motion.

Cabinet-handling Mistakes. Common sense is just about all that is needed to prevent damage to cabinets, and yet cabinets are damaged by careless servicemen every day. They do this by placing the chassis carefully on top of a console cabinet and then accidentally bumping the chassis so its sharp edges gouge deeply into the finish. They damage cabinets by placing heavy or sharp tools on them. They damage cabinets by leaving a hot soldering iron near the cabinet on a crowded bench and later pushing the iron accidentally against the cabinet. Every one of these accidents can be avoided by using common sense.

A cabinet should never be placed near a hot radiator or other source of heat. Too much heat will damage the finish and may even dry out the glue at the joints of the cabinet. Excess moisture is equally damaging to the finish, and can swell the veneer as well as damage delicate coils in the chassis itself. Therefore, never leave sets in a damp location or near open windows.

Materials Needed for Cabinet Repairs. Complete kits containing the essential materials and tools for making minor cabinet repairs are quite inexpensive, and last a long time. Repair kits developed especially for use by servicemen are available at jobbers. Although the contents of the kits vary somewhat with different manufacturers and with their cost, they will usually include furniture polish, scratch stick or scratch-removing polish, spirit stain (several shades), ivory enamel, alcohol, French polishing pad or felt, sandpaper or garnet paper, fine steel wool, and several small brushes.

Larger kits include an assortment of different shades of stick shellac, along with shellac rubbing fluid, an alcohol lamp, and a spatula for applying the shellac. In addition, larger kits may contain additional shades of spirit stain, touchup enamels and lacquers, a polishing cloth, and wood glue. Refills can be obtained for the kits, and the most used items can be bought separately in larger quantities. It is suggested that you start with a small kit and defer getting the largest cabinet-refinishing kit until you really feel the need for it.

General Cabinet-renewal Procedure. Most cabinets can be made to look like new merely by cleaning and polishing. This takes only a few minutes and yet makes a tremendous improvement in the appearance of the cabinet.

Cleaning a Wood Cabinet. Although wood cabinets are usually maintained in good condition by the housewife along with her other furniture, it is remarkable how the appearance of an older radio cabinet can be improved just by properly applying a special scratch-removing cream polish. This fills the multitude of minor scratches in the lacquer or varnish, removes any dirt that may have been overlooked by the housewife, and at the same time produces a high luster.

Always have two soft polishing cloths on hand, one for applying the polish and the other for rubbing the cabinet to a high gloss. Cheesecloth is ideal. Pour a teaspoonful or less of the polish on the cloth, fold the cloth into a flat pad, then rub the surface of the cabinet until all dirt and grease have been removed. All rubbing should be done in the direction of the grain of the wood. Do one surface at a time, allow about a minute for it to dry, then take the other cloth and rub with the grain until a high polish is obtained.

The cloth used for applying the polish can be used over and over again, because its cleaning and polishing ability increases with the number of times it is used. Wash the cloth occasionally in warm water to remove the dirt it has picked up. Keep this cloth in a paper bag when not in use, so it will stay clean.

The cream-base scratch-removing polish provides the final finish itself but is usually effective only on very shallow scratches. Being neutral in color, it can be used on any color of finish.

Scratch-removing polishes that contain a colored stain are more effective on deeper scratches. These polishes come in a dark shade for walnut and mahogany and a light shade for maple and other light-colored finishes. Apply with a cloth just as for the cream polish, rub the surface thoroughly dry with the other clean cloth, then apply any ordinary good-quality wax furniture polish to produce the gloss of a new cabinet.

Cleaning Plastic Cabinets. When plastic cabinets are dirty, they can be cleaned by scrubbing with soap and water or with Bon Ami and water. Use a stiff brush if necessary, but work carefully at first until you are sure it will not scratch the surface. Rinse with clear water, and allow to dry. A coat of Simoniz wax can then be applied and polished with a chamois or any clean, soft cloth to restore the original luster. Plastic cabinets are easily scratched, so never use an ordinary rough cleansing powder on them.

It is good business to carry a small bottle of cream-base polish in your tool kit along with a polishing cloth. Go over a wood cabinet lightly with this after you have finished putting the chassis back, to remove any finger marks, and see what a good impression it makes on the housewife.

Use of a Scratch Stick. Another good item to carry in your toolbox is the scratch stick shown in Fig. 1. This contains solid stain at one end and a felt cork in a bottle of liquid at the other end. It is used for touching up minor scratches when you do not intend to do a complete repolishing job, and is also handy for making quick emergency repairs of unexpected scratches. To use, rub the solid stain lightly over the scratch until it is filled, then buff the area of the scratch with the felt on the other

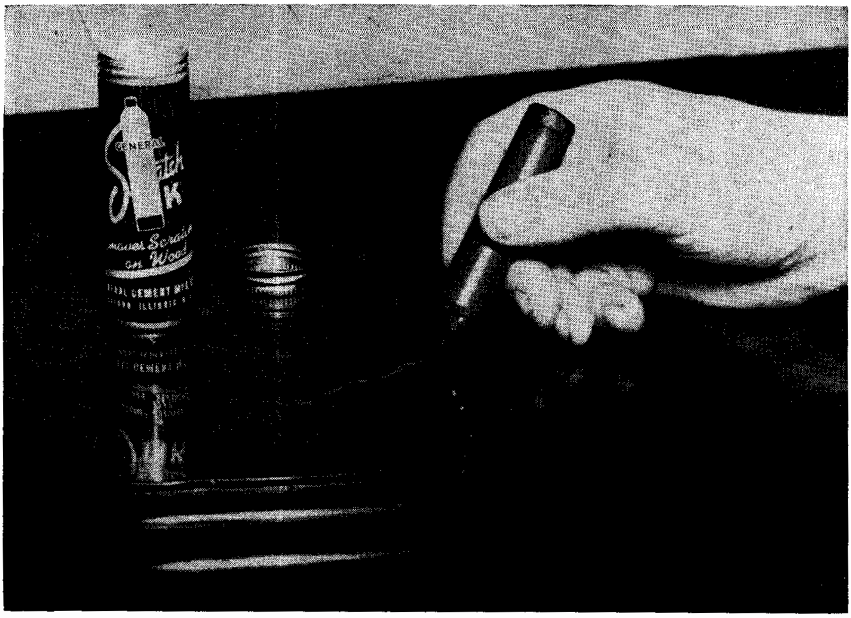


Fig. 1. Using a scratch stick to touch up scratches on a wood cabinet. (General Cement photo)

end. Remember that this is for emergencies and minor scratches only; it is not practical where there are a great many scratches or when the scratches go deep into the finish.

Repairing Holes, Gouges, and Other Damage to Wood. Serious damage to a cabinet can be repaired by building up the wood with stick shellac. Scrape out the damaged region first or clean with gasoline to remove dirt and old wax.

To fill in a hole with stick shellac, first select the proper shade of shellac. It is better to use a lighter shade than a darker one because the shellac can be darkened with stains if necessary. The shellac will also darken somewhat with application of heat.

Stick shellac is applied with a spatula that has been heated in the blue part of an alcohol flame. Larger furniture-repair kits contain an alcohol lamp for this purpose. Alcohol is required because it deposits the least amount of carbon on the blade.

After the spatula blade is hot enough to melt the shellac, quickly wipe it clean with a soft cloth and touch the shellac stick to the blade as in Fig. 2, so that some of it melts. If the shellac bubbles as this is done, the blade is too hot; wait until it stops bubbling. Now allow the hot shellac to run off the knife into the depression in the wood, as in Fig. 3. If the shellac will not flow freely, reheat the spatula and repeat the process.

When the scratch is completely filled, allow the shellac to harden thoroughly. The surface of the shellac can be smoothed with the hot blade, provided care is used so the blade does not damage the adjacent finished surface. If pinholes appear in the shellac, reheat with the blade to melt what is in the hole and allow it to flow together.

Fig. 2. Applying stick shellac to blade of spatula after heating the blade in the flame of an alcohol lamp, for use in filling deep gouges in a cabinet. (General Cement photo)

Excess shellac may be cut off with a razor blade, but it is better not to overfill the patch. After the shellac has hardened, moisten a piece of felt with shellac rubbing fluid and rub the repaired region until it is perfectly level, as in Fig. 4. On a large patch, use 7/0 garnet finishing paper and a sanding block for preliminary leveling, with a few drops of fine oil or furniture polish on the paper. Work carefully here because this paper will also cut down the surrounding finish.

The two requirements for a successful repair with stick shellac are a close color match with the original finish and a patch that is perfectly level with the surrounding areas.

If the correct shade of stick shellac is not at hand, two colors may be mixed together on the hot knife to obtain the perfect match. To complete the stick-shellac repair, clean the surface thoroughly and apply a wax polish.

Fig. 3. Spreading molten shellac into deep scratch with spatula. (General Cement photo)

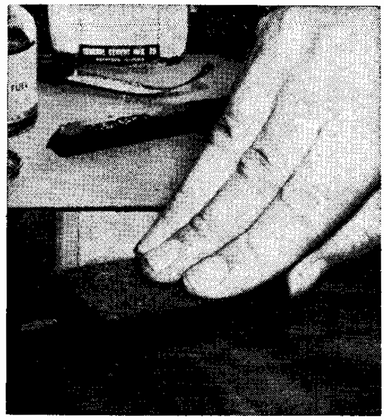


Fig. 4. Rubbing hardened stick shellac in scratch with felt pad moistened with shellac rubbing fluid, to make the repair level with the surrounding finish. (General Cement photo)

Refinishing Painted Plastic Cabinets. Ivory radio cabinets are sometimes made of brown plastic on which has been placed a coat of ivory lacquer. Chips and scratches therefore leave an unsightly brown spot. This damage can be easily repaired by using a touchup lacquer enamel after smoothing the injury with fine sandpaper or steel wool.

Cabinet-repair kits usually contain several shades of ivory enamel, to match almost any cabinet. Intermediate shades are obtained by mixing a few drops from each bottle together on a piece of glass or in a saucer. After the patch has dried thoroughly, rub lightly with steel wool to blend the new and old finishes together, then polish the entire cabinet with a cream-base polish.

Repairing Cracked Plastic Cabinets. Plastic cabinets that have cracked but are not completely shattered can occasionally be repaired with the special plastic or Bakelite cements that are available for this purpose. Work the plastic cement into both surfaces of the crack as in Fig. 5, allow to dry, apply another heavy coat of cement to one of the surfaces, then clamp the two surfaces together or hold them together with large rubber bands until the joint has set and is thoroughly dry. Wipe excess glue off the surface of the cabinet before it hardens. Stick shellac can then be used to fill in nicks and replace lost chips. Excess shellac or hardened glue should be removed with a sharp razor blade, and the cabinet then polished with cream-base polish.

Fig. 5. Applying special plastic cement to a crack in a plastic radio cabinet. To be effective, the cement must be worked into the crack. (General Cement photo)

Badly cracked cabinets should be replaced rather than repaired. New cabinets can be obtained for this purpose from some jobbers and distributors. The new cabinet need not be the same color and shape, but must fit the chassis and have holes for controls in the right positions.

Replacing Speaker Grille Cloth. Grille cloth serves the dual purpose of improving the appearance of the set and protecting the speaker. When this cloth is damaged to the extent that it is in need of replacement, remove the old cloth and scrape clean the surface to which it had been glued. Order a piece of new cloth from a jobber, cut it down to the correct size, then coat the inside surface of the cabinet with grille cloth fabric cement and apply the cloth. A small tack or even a thumbtack in each corner of the cloth will help to hold it in position until the cement has set. Watch the cloth for the first few minutes to make sure it does not loosen and wrinkle.

The pattern of cloth you get does not usually matter, because material sold for replacement purposes will harmonize with almost any cabinet.

QUESTIONS

1. Name three ways in which cabinets might become scratched in your own shop.
2. Make a dimensioned sketch of a shelf that will fit a particular location in your shop or basement, for storing table-model radio cabinets.
3. What precautions should be followed when moving a heavy console cabinet from a home to your shop?
4. What type of polish can be used to improve the appearance of almost any wood cabinet?
5. What is a scratch stick and how is it used?
6. How is stick shellac used to fill a gouge in a wood cabinet?
7. What can be done when the paint chips off an ivory-painted brown plastic cabinet?

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INSTALLING AND REPAIRING

Radio Antennas

Importance of Antennas. Getting good radio reception is no mystery. It requires three things. The first is a good set in good working order. The second is an antenna good enough to pick up sufficiently strong signals for that set in its particular location. The third is a means of minimizing the effects of interfering electrical noises if they are present.

Extra Profits from Antennas. A defect in the antenna system of a radio set can make just as much trouble as a break in the wiring of the set itself. The customer will complain that the set does not work right, and your job will be to find and fix the trouble. If the defect turns out to be somewhere in the antenna system, you charge just as much for making the repair as for locating and fixing a defect in the set itself.

Built-in Loop Antennas. Most of the radios made today have built-in loop antennas. These sets are ready to play just as soon as the line cord is plugged into a wall outlet. On a good set, a loop antenna brings in just as many stations as did a high outdoor antenna on a receiver 20 years ago. Today, however, very few people listen to distant broadcast stations because local stations carry the same network programs as are on distant stations.

For the average listener located in or near a fairly large city, a loop antenna brings in satisfactorily all the stations he wants. A better antenna is not required unless the listener has special preferences or is located in the country beyond the service range of the local stations he wants to hear.

Types of Loop Antennas. In table-model sets a flat pancake-type loop like that in Fig. 1 is widely used. These loops are usually on the back cover of the set, and must therefore be removed to get at the tubes and the chassis. The loop may be made from insulated wire, spaced bare wire, or metal foil stamped into the back cover.

A loop antenna replaces one coil of the first r-f transformer in the radio set, or sometimes both coils. A loop may thus have two, three, or more leads going to the chassis. These leads take a lot of punishment during normal servicing of a set, and often break. You will be able to repair many a set by resoldering a broken loop-antenna lead, so always inspect these leads carefully after you remove the back cover.

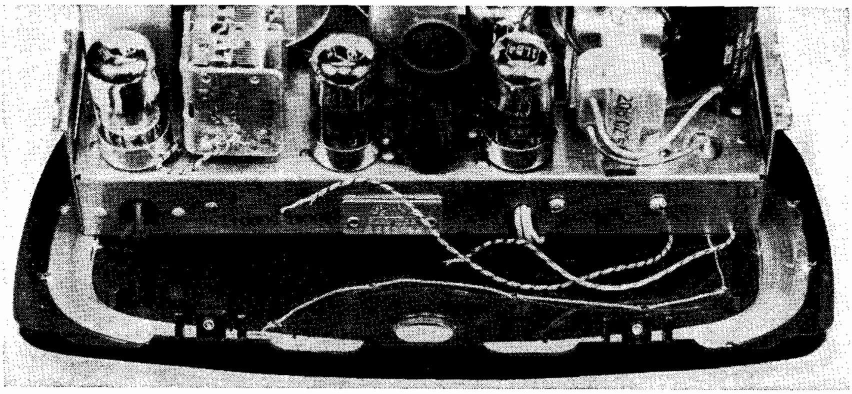

Fig. 1. Loop antenna glued to plastic back cover of three-way portable radio. If the glue weakens, the turns of wire in the loop get loose and may break. (Howard W. Sams photo)

On console sets and in some table-model sets the loop antenna is usually larger and is often wound more like a coil. In addition, the loop in consoles is sometimes supported by pivots so that it can be rotated to get maximum pickup from a particular desired station.

Loop Antennas Favor Two Directions. A loop favors stations located in line with the turns at the bottom of the loop. You can demonstrate this yourself by tuning in a weak station and rotating the loop or the entire table-model set to see how it affects volume.

A loop receives equally well from two directions. You cannot tell whether it is pointing directly toward or directly away from the station being received, but for radio reception no one cares anyway. On big sets having rotatable loops, adjust the loop for best reception of the weakest station the customer wants to hear regularly.

Replacing Loops. Since a loop antenna is actually a part of the receiver circuit, a damaged loop should be replaced with an identical unit to ensure best results. This means ordering from the manufacturer of the set.

Fortunately, loops do not often need replacement, even though they often need repair.

Several types of replacement loops are also available from jobbers. Keep one of each type on hand, as loops for table-model sets are now fairly well standardized. Try several of them when in need of one for testing a set, and use the one that works best.

In small table-model sets the loop is necessarily quite close to the metal chassis. The large amount of metal in the chassis often neutralizes most of the directional effect on the loop, so do not expect smaller sets to show much change in volume as you rotate the set. The closeness of the loop to the chassis is taken into account when designing a set, so do not change the method of mounting the loop.

Loop Connections. Loop antennas in console sets and in many table-model sets have leads that go to screw terminals on the chassis, for convenience in disconnecting the loop and removing the chassis. Make a habit of examining these screw connections whenever working on a set. Tighten the screws if necessary. Where plugs and jacks are used in place of screws, examine the leads carefully at this point for breakage. Be sure each plug is tight in its jack. When disconnecting the antenna, pry out each plug with a small screwdriver instead of pulling on the wires, to avoid breakage.

Some loop antennas are cemented to the inside of plastic radio cabinets. These loops frequently get loose, as also do pancake loops on back covers. Use plastic cement or even speaker cement for remounting loose loops.

Loops for Portables. On battery portable receivers, loop antennas are often concealed under the fabric covering on the hinged cover of the set. The covers are designed to stay upright while the set is in use, to get the loop away from the metal chassis and obtain maximum signal pickup. The directional characteristics of a loop will be still more noticeable now.

Effect of Metal Objects on Loops. Radio waves are blocked by large areas of metal. For this reason, sets with built-in loop antennas will not generally work well in steel-framed skyscrapers, in rooms using metal lath as a backing for plaster, in metal-covered house trailers, or in railroad cars. Radio waves will pass through glass, however. For this reason, some portable receivers have detachable loop antennas with rubber suction cups, and sufficiently long connecting leads so that the antenna can be attached to the window glass in a railroad car or even in a home.

If the antenna is not removable, the set can be placed directly in front of the window to obtain satisfactory reception of at least a few stations.

Since windows face in various directions, some windows will give better results than others, depending on the location of the station that is tuned in.

Loops in Carrying Straps. Camera-size and vest-pocket-size radios are too small for an effective built-in loop. Instead, these have the loop-antenna wires concealed in the shoulder strap used for carrying the set. One vest-pocket radio uses as its antenna the two wires that go from the set to the tiny earphone that fits inside the ear of the user. The signal pickup action here is more like that of an ordinary wire antenna than a loop.

Iron-core Loops. Newest of built-in antennas for portable and table-model radios is one consisting simply of wire wound around a pencil-size core of a new powdered-iron magnetic material. One name for this material is ferrite; hence this antenna is sometimes called a ferrite-core loop. The iron core serves to multiply the sensitivity of the loop many times, making it just as effective as the larger pancake-type loops.

The new pencil-size loops have about the same directional characteristics as larger loops also. Servicing problems are likewise the same, as iron-core loops have essentially the same leads and connections as the others. An example of an iron-core loop installation is shown in Fig. 2.

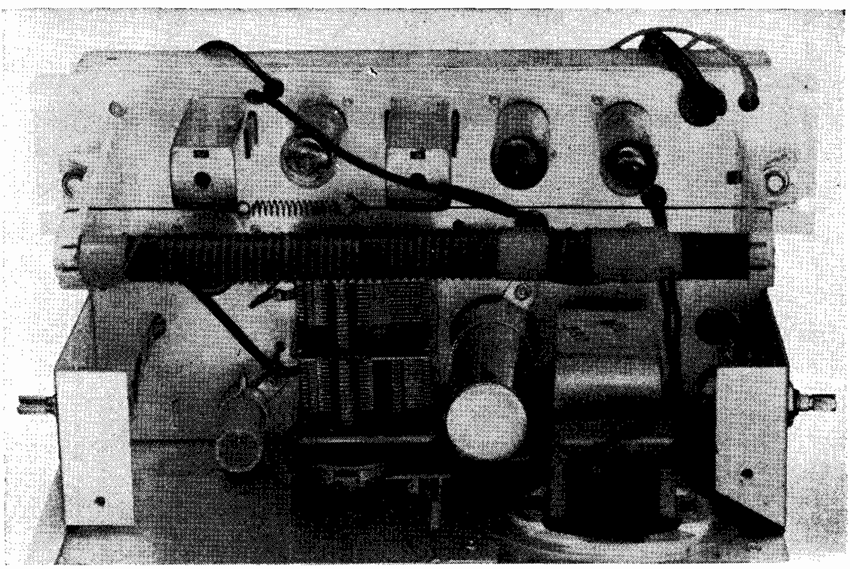

Fig. 2. A long ferrite-core coil running across the entire back of the chassis serves as the antenna in this Jewel three-way portable radio. (Howard W. Sams photo)

Terminal-shorting Bars. Sets having more than two antenna terminals will sometimes have a metal shorting link or bar that can be used to connect together two adjacent terminals when using one type of antenna. Loosening the terminal screws permits swinging the bar up out of the way when individual terminals are required for another type of antenna system. Instructions for using the bar are usually printed on the chassis or back panel of the set.

Loop antennas sometimes have back-terminal screws with or without a shorting bar, to permit connecting an external antenna when greater signal pickup is required. These extra terminals and bars provide no servicing problems, once you know what they are for.

Effect of Home Lights on Radio Volume. Frequently the loudness or volume of a radio set will change when a light switch in the house is turned on. Sometimes the volume goes up, and sometimes it goes down. Though seemingly mysterious, the explanations in each case are simple and logical.

If the volume drops when an extra load is placed on the power line by turning on a light or an electrical appliance, the explanation is generally a drop in the line voltage at the radio set. When the extra load is removed, the voltage goes back to normal and so does the volume. Old and weak rectifier tubes tend to emphasize the change in volume here, so putting in a new rectifier tube may clear up this particular trouble. Actually, the fault lies in the power-line wiring in the home or even in the power system outside the home. Technically, engineers say that power-line regulation is poor because the lines are overloaded.

If the volume goes up when a light is turned on, the explanation is generally that the radio set is being operated without a ground or with a poor ground, and the receiver is obtaining its ground connection through the power line. Turning on a light switch connects more wiring to the electrical system of the home in the immediate vicinity of the radio set, thereby causing a change in signal strength. The house wiring may also be serving as an antenna for picking up radio signals. Here again, turning on a light switch changes the antenna-ground system that is serving the radio.

Most radio sets have a condenser connected between one of the line-cord wires and the chassis of the set. Since one of the wires in the electrical system of the home is grounded, reversing the line-cord plug changes the effective connection of this condenser and may change the interaction of the house wiring and the radio set. It is always a good idea to try reversing the plug when something seems wrong with the antenna system of a set.

Ground Connection for Receiver. A good ground connection will usually clear up a complaint of changes in volume when house lights are turned on or off, provided the receiver has a ground terminal for this purpose. This ground connection should preferably be directly to a cold-water pipe or to a rod driven into the ground. Use a ground clamp for making the connection, to be sure there is good contact to the pipe. Do not attempt to solder a wire to a pipe or a rod because a radio soldering iron is not heavy enough for use on pipes. Try several different grounds if the first one does not seem to work. The ground wire should not be any longer than is necessary.

Never connect a ground wire directly to the chassis of a universal a-c/d-c set unless a ground terminal is provided. On many of these sets the chassis is electrically hot for one position of the line-cord plug, and a ground will blow the house fuse.

The above steps need be taken only when the customer is complaining specifically and definitely about the change in volume when a light is turned on. In the great majority of cases, no ground connection is needed for a radio set. A ground is unnecessary for a loop antenna but is definitely desirable with outdoor antennas when the customer wants quieter and more reliable reception of distant stations.

Built-in Hank Antenna Wire. Many table-model radio sets come with a permanently attached hank of insulated wire. This may be wound on a cardboard form or simply wound on itself and tucked inside the cabinet. When this wire is unwound and stretched around the room in one of the ways shown in Fig. 3, good reception will be obtained on local stations in most locations, and quite a few distant stations will be picked up at night if the set is fairly good. The higher the wire, the better the results, but satisfactory results are usually obtained even with the wire run around under the rug on the floor. This is the easiest and quickest way to install it, hence is worth trying.

Although it is desirable to run as much of the hank antenna wire as possible in a straight line, this is generally not possible in the average room. Therefore, do not worry if you have to get quite a few bends and turns in it under a rug or in running it around a room just above the baseboard. To get height, try running the wire around a window frame. A still better arrangement is to run the wire inside the wood molding used around rooms near the ceiling in older homes or even to attach the wire neatly where wall and ceiling meet. Use insulated staples for holding the wire neatly against wood baseboards or window frames. These staples are available in various colors to match the color schemes of rooms.

Curiously enough, most sets that come with hank antennas will sound worse rather than better when connected to a longer antenna. The sets

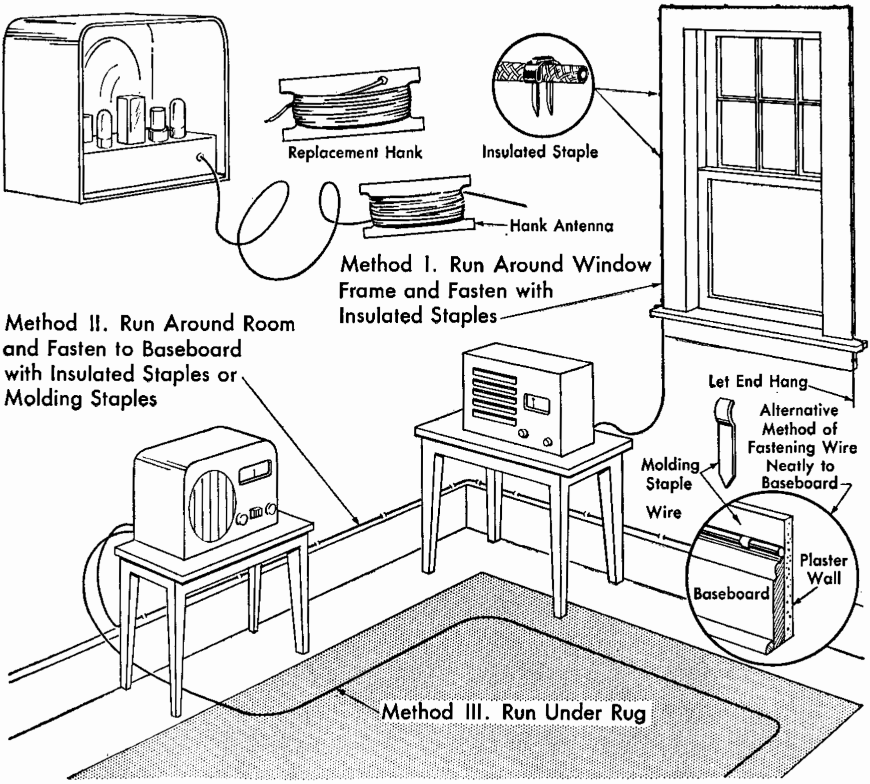

Fig. 3. Different ways of installing indoor hank antennas for a-m radio sets

are designed to operate best on fairly weak signals, and often develop a lot of troubles when hooked to a better antenna or used too close to a powerful station. If you encounter a complaint of squealing or of interference between several stations, try shortening the hank antenna. This can be done simply by winding the wire around your fingers, without actually cutting the wire.

A hank antenna wire should not be connected to any metal object. Be especially careful to keep it away from radiator pipes or other grounds, because some troubles that develop in universal sets can make the antenna electrically hot. A ground connection would then burn something out in the set or even blow the house fuse.

When the insulation on a hank antenna wire gets worn or damaged, replace the entire wire. You can get replacement hanks of plastic-insulated wire 25 feet long, made up on cards exactly for this purpose. Do not splice the new wire to the old one at the back of the set. Instead, remove the chassis from the cabinet, unsolder the old wire, and solder the new wire in its place to give a professional repair job.

Simple Outdoor Antenna. The simplest and most used outdoor antenna for homes is the inverted-L antenna shown in Fig. 4. It has a long horizontal antenna wire mounted high in the air, sometimes called the flat top. The insulated lead-in wire runs more or less vertically downward from one end of the flat top to the antenna terminal of the radio set. On the outside of the house at the point where the lead-in wire is run through a wall or window, a lightning arrester is mounted and is grounded to a nearby water pipe or to a rod driven into the earth below. An outdoor antenna is needed only for very old a-m sets, however, or for modern sets in far-out rural locations.

Every outdoor antenna installation will be different, because homes and their surroundings are different and because customers have different preferences as to locations of receivers in homes. The important factors to be considered when planning the location of an inverted-L antenna are

1. The antenna wire itself should be high enough to give several feet of clearance as a minimum over everything in the line of the antenna, and still more over metal roofs and other large metal objects.
2. The antenna and the lead-in should be kept away from power lines, telephone lines, and trees. Power lines carry a lot of interference that can be passed on to the antenna and receiver. More important yet, the antenna should be located so that it cannot possibly fall on power lines, and so power lines cannot fall on it.
3. Locate the antenna so that one end permits a fairly direct run of lead-in wire down to a window near the receiver location in the home.
4. Choose a location having existing supports for the antenna or permitting use of masts as supports.
5. Choose a location that permits a neat and inconspicuous outdoor installation which does not impair the appearance of the house. This means keeping the antenna at the back of the house as much as possible, so it does not show from the front.

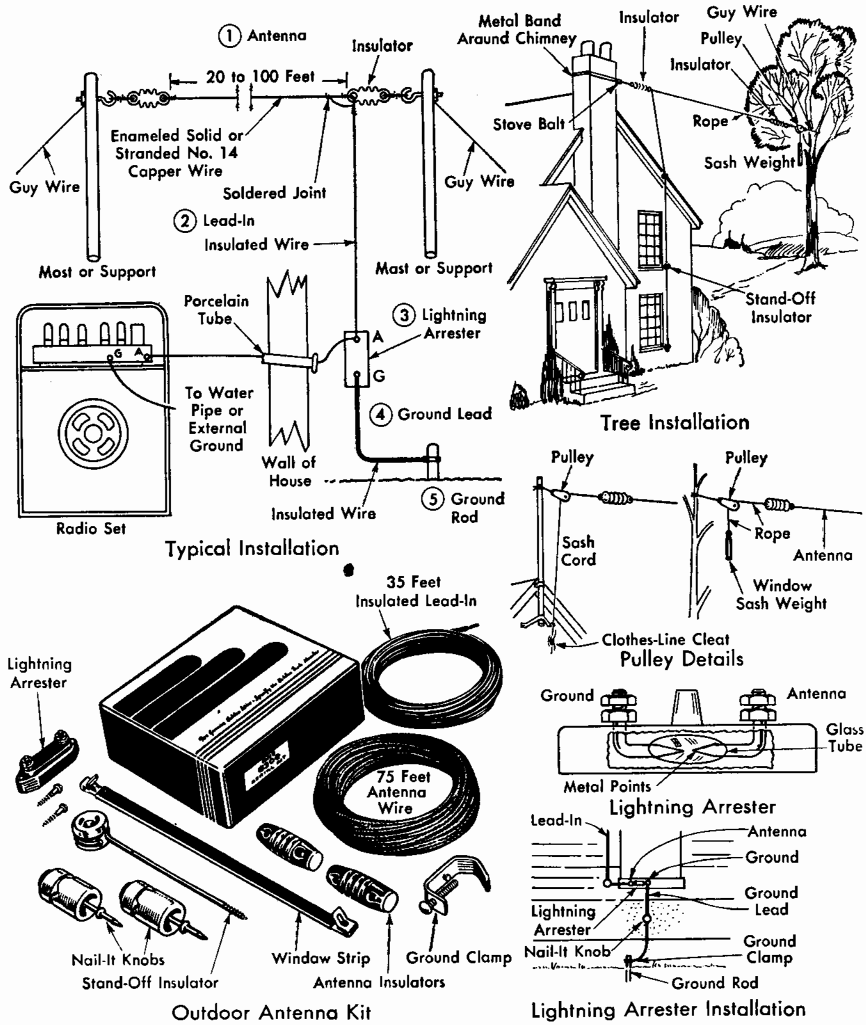

Fig. 4. Practical ideas for outdoor a-m radio antenna installations

Regulations. Many communities have local ordinances governing outdoor antenna systems. You can find out what these are from a local electrical inspector or fire-insurance inspector. The rules generally specify lightning arresters and ground rods. They also usually specify a minimum clearance of antennas on flat roofs, so firemen do not hang themselves when dashing across the roof at night during a fire.

Permission. If your customer is renting, be sure that he obtains permission from the owner for erection of the antenna in the location planned.

If this matter is ignored and the owner objects just as you have finished the job, you may have to take it down again and fill up all screw holes, with a slim chance of collecting for this extra work and for the original installation.

Likewise, if it is convenient or necessary to run the antenna onto the property of a neighbor, be sure the customer obtains permission first from that owner.

Length of Inverted-L Antenna. A good average length for the horizontal antenna wire is about 50 feet. This can be as little as 20 feet or as much as 100 feet and still be satisfactory, however, so you have considerable leeway in your choice of convenient supports for the horizontal wire. Use No. 14 or larger enameled copper wire, either solid or stranded. Bare copper wire is all right when new, but corrodes rapidly.

Complete antenna kits like that in Fig. 4 are convenient to order and make a good impression on the customer. The ground rod must be purchased separately if needed. You may also need a few more nail-it knobs, to anchor the lead-in wire securely.

With an inverted-L antenna the lead-in picks up signals, too. If there are some nearby radio stations, the total length of the antenna and lead-in combined should be kept down to a hundred feet or less to prevent the signals of these local stations from interfering with reception of desired distant stations.

Connecting Antenna to Lead-in. To eliminate roof-top soldering, prepare the antenna and lead-in beforehand in your shop. Attach an insulator to one end of the antenna wire but leave the rest of the wire coiled. Thread one end of the lead-in wire through the same end of the insulator, wrap the wire around itself a few times to provide strong mechanical anchorage for the lead-in, then solder the lead-in to the antenna as shown. Be sure to remove enamel before soldering, being careful not to nick or weaken the wire. Leave sufficient slack so there is no strain on the soldered joint.

Choosing and Mounting Antenna Masts. Television antenna masts and mounting brackets can be used for radio antennas. Guy wires will usually be needed with these masts to resist the pull of the horizontal antenna wire. For short masts you can sometimes use galvanized steel pipe to get rigidity without use of guy wires.

Attach the mounting bracket first if it is separate from the mast. Use wood screws when mounting on wood. Use special masonry bolts for brick. Installation procedures are the same as for television antennas.

Anchoring to Chimneys. The chimney is a convenient and proper support for one end of the horizontal antenna wire, if the job is done right. Use a galvanized steel strap around the chimney, as shown in Fig. 4. Never wrap wire around the chimney because it may cut through the chimney during storms.

Erecting the Antenna. When all mounting brackets and anchor points are installed, carefully unroll the coils of antenna and lead-in wire. Avoid kinks. Attach the lead-in end of the antenna wire first, using a foot or so of surplus antenna wire between the insulator and the anchor point. If using a mast at this end, you can attach the wire before you raise the mast into position.

Getting the other end of the antenna wire attached and taut presents a bit more of a problem, especially if the horizontal antenna wire is fairly long. Sometimes you can use the guy wire to pull the mast erect against the pull of the antenna wire. Some brackets have a tilting feature that makes this the easiest way.

If the mast is higher than you can conveniently and safely reach, you may wish to use a pulley and rope for erecting purposes, as shown in Fig. 4. Use strong rope, such as braided sash cord, and anchor the lower end securely to any convenient point near the base of the mast. This has the advantage of permitting easy lowering of the antenna at any time for changes or repairs. It also has the least risk of falling during this tough part of the installation job.

Chances are you will have misjudged the distance when cutting the antenna to length the first time. The horizontal antenna wire should be fairly tight and yet should sag some, to allow for contraction of the wire in cold weather. If too long, you can always shorten the antenna wire. If too short, use a longer piece of spare antenna wire between the insulator and the mast.

Use galvanized steel wire for guy wires. It is not necessary to use insulators in the guy wires. Turnbuckles in the guy wires are optional but are convenient for straightening the mast and tightening the wires after the job is all done. Large galvanized screw eyes are usually adequate as anchors for guy wires.

Installing the Lead-in. Leave enough slack in the lead-in wire between the antenna and the first fastening point on the house so it will not be broken by antenna movements during windstorms. From that point down, anchor the lead-in to the house with insulators often enough so the wire cannot flap against the house during a strong wind. Two-piece porcelain nail-it knobs grip the wire as well as hold it away from the house. Television twin-lead standoff insulators can also be used, if squeezed first with pliers so they grip the wire. Run the lead-in along the eaves and around window frames to give a neat-appearing job, with the wire running straight up and down rather than diagonally across large areas of wall.

Installing Lightning Arresters. An outdoor antenna installation must have a lightning arrester properly installed as required by the fire underwriters, or otherwise the fire insurance of the homeowner may not be valid. A high outdoor antenna may act as a lightning rod and attract lightning. Unless there is a direct path for this lightning to ground, it may choose a path through the radio set to ground and melt the antenna coil in the set or even start a fire.

One type of lightning arrester has two sharp metal points facing each other inside a small glass tube that has been evacuated or filled with gas, as shown in Fig. 4. One of these points is connected to the lead-in wire, and the other is connected to ground. The spacing between the points is such that radio signals cannot jump across the gap to ground; hence they take the desired path through the rest of the lead-in to the receiver. A lightning discharge involves such high voltage that it easily bridges the gap between the sharp points and travels harmlessly through the lightning arrester to ground.

Mount the lightning arrester on the outside of the building at the point where the lead-in enters the building. Without cutting the lead-in wire, remove insulation for an inch or so, and wrap the bare wire once around the antenna terminal of the lightning arrester.

Use leftover insulated lead-in wire to connect the ground terminal of the lightning arrester by as direct a path as possible to a good ground. An outdoor water faucet can be used if directly below the lightning arrester. If no pipe is handy, use a ground rod made for this purpose, and connect to it with a ground clamp if there is no screw terminal on the ground rod.

There are dozens of different types of lightning arresters. All serve the same purpose of providing a direct path to ground for the effects of lightning, without providing a path for radio signals. Instead of sharp points in a vacuum, the lightning arrester may contain a resistor, a small neon tube, a piece of carbon, or simply an air gap between its terminals.

A lightning arrester should have a resistance higher than 1 megohm between its terminals when disconnected. If appreciably lower when measured with an ohmmeter, replace the lightning arrester.

Getting the Lead-in Wire into the House. A flat insulated metal window strip is the easiest way of bringing a lead-in wire into the house. The strip lays on the window sill, and the window fits down over it. The lead-in wire is inserted in the Fahnestock spring clip at the outside end after removing an inch of insulation from the end of the wire. A similar connection is made for the wire going to the receiver.

For this wire inside the house, use something having the same color as the walls or woodwork inside so the wire is as inconspicuous as possible. Tack the wire to the baseboard with insulated staples or anchor it with metal strips that slip down between the baseboard and the plaster wall.

If the customer objects to the use of a window strip or if the window has metal weather stripping, bring the wire in through a porcelain tube inserted in a hole of appropriate size drilled through the window frame. Slope the tube upward into the house if drilling from the outside, so rain cannot enter the house through it. Porcelain tubes long enough for this purpose can be obtained from jobbers.

In a brick house the drilling of a hole for a porcelain tube will be difficult. In this case it may be easier to bring the antenna lead-in through a basement window, then run the wire under the floor to the radio location and bring it up through a small hole in the floor. If you use modern small plastic-covered wire, this hole can be made with a long ⅛-inch drill so that it is hardly noticeable. Drill downward through the floor from above, as close to the baseboard as possible. At the basement window you can use a window strip or porcelain tube, as you prefer.

Ground Connection for Receivers. With modern sets it is rarely necessary to have a ground connection, even though a ground terminal is provided for this purpose. However, since an outdoor antenna would be installed today only to get good distant reception and since a ground connection will improve distant reception, try one temporarily at least.

A cold-water pipe inside the house can be used as the ground for a receiver, or a ground wire can be run out to the ground terminal of the lightning arrester. Keep this ground wire at least 3 inches away from the antenna lead-in wire. Use a separate window strip for the ground wire.

If using a porcelain tube, it is permissible to run both ground and lead-in wires through the tube. The wires can also be run through the same hole in the floor, since they are together here for only a few inches.

Use a grounding strap or ground clamp when making ground connections to a pipe of any kind.

Hardware used in installing antennas should withstand weather conditions for many years. Unprotected iron or steel leaves conspicuous brown streaks and stains as it rusts away. This is particularly objectionable to customers having white painted houses. The highest grade of galvanized hardware should be used, with brass or galvanized screws and bolts throughout.

Demonstrating Effectiveness of Outdoor Antenna. To check the performance of an outdoor antenna installation, tune in a fairly distant station at normal volume. Now disconnect the lead-in at the set and connect a 10-foot piece of wire instead to serve as antenna. With a sensitive modern receiver the background hiss or noise will increase when using the short antenna on the floor.

The explanation of this increase in noise is simple. Modern sets have automatic volume control (avc) that makes the set more sensitive when weak signals are being received. When a short antenna is used, signals are weak, and hence receiver sensitivity is higher, so that the noises originating in the set itself are amplified enough to be annoying. When a longer outdoor antenna is connected, signals are stronger, and receiver sensitivity is lowered, so that internal receiver noise is reduced or eliminated.

A well-installed long outdoor antenna makes distant reception more enjoyable by keeping noise at a minimum, but does not necessarily make the distant station louder. The avc system of the set keeps all programs at approximately the same loudness.

If signal strength with an indoor antenna is so weak that it is outside the control range of the avc system, there will definitely be an increase in loudness also when the outdoor antenna is used. The outdoor antenna will therefore bring in more stations at enjoyable listening loudness.

F-M Antenna Problems. Most frequency-modulation receivers are provided with a built-in loop antenna and provisions for an external antenna. The loop is smaller or has fewer turns than a broadcast-band loop, because the 88–108-mc f-m band is so much higher in frequency than the 540–1,600-kc broadcast band (0.54–1.6 mc). There may even be a long, narrow loop made by shorting one end of a length of 300-ohm twin-lead and connecting the other end to the two antenna terminals of the set, as in Fig. 5A.

Another type of built-in f-m antenna made from twin-lead is the folded dipole, shown in Fig. 5*B*. This is strung out around the cabinet and tacked or stapled to the cabinet.

Bending a folded dipole to keep it inside a console reduces its pickup of signals. Better results can be obtained by stretching out the antenna and fastening it to the wall of the room or even under the rug.

Height generally improves signal pickup. A folded dipole strung between rafters in the attic should therefore give the best pickup of any indoor

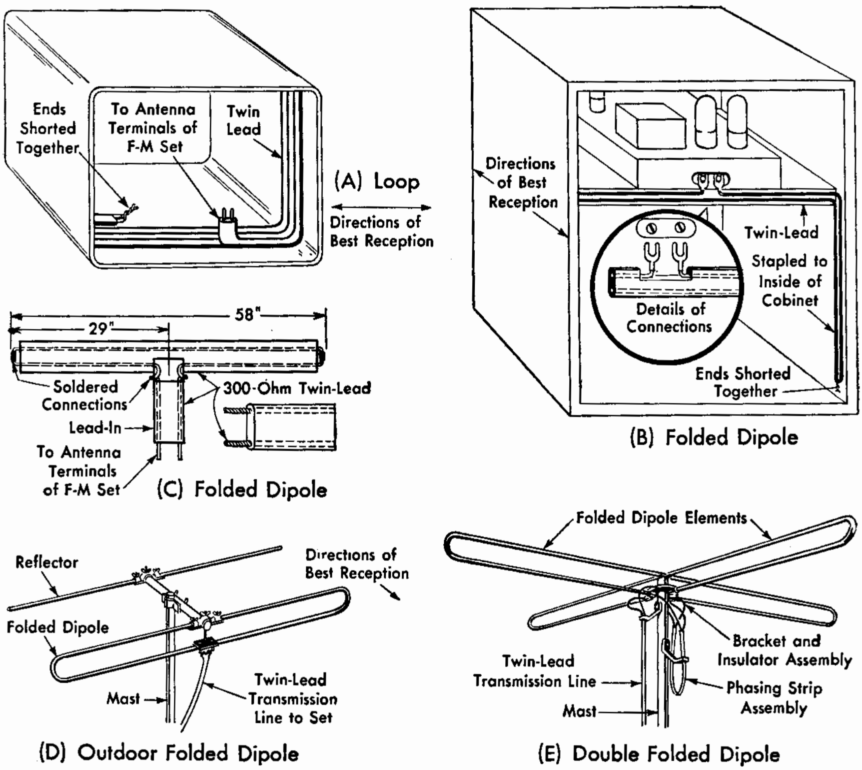

Fig. 5. Examples of antennas used with f-m radio receivers

f-m dipole made from twin-lead. Such a dipole, easily assembled from twin-lead, is shown in Fig. 5C. This antenna also works well when spread across the top of two adjoining windows, with the transmission line or lead-in coming down between the windows.

Running twin-lead transmission line down to the set from the attic involves the same techniques as for television antennas. The solution is different for every house. Often the only way is to bring the line out through an attic window so it can run down outside the house.

If the received f-m signal is weak, orientation of the f-m antenna will help to give maximum pickup of the signal. Tune the set to the desired station and rotate the antenna until background noise heard with the program is a minimum.

Roof-top F-M Antennas. Outdoor antennas for f-m receivers are very similar to those used for television, since the f-m band is between television channels 6 and 7. That in Fig. 5*D* is used when all of the stations to be received are in approximately the same direction from the receiver. That in Fig. 5*E* receives equally well in all directions and is hence used when the receiving location is between two or more f-m stations. Installation procedures for outdoor f-m antennas are the same as for television antennas.

Antenna Troubleshooting. When making a service call at a home, form the habit of looking over the outside of the house first to see if there is an outdoor antenna. If there is one, and the lead-in comes down the front of the house, note if there are any obvious breaks or defects in it. See if the flat-top portion is clear of surrounding objects. Sometimes it can sag enough to rub against a part of the house and cause trouble. Of course, you would not do more than look as you walk up the path, until you have announced your presence and obtained permission to check the antenna.

Inside the house, check the performance of the set first of all. If you verify the complaint as a dead set, weak reception, or reception with noise, be especially thorough with your inspection of the antenna system both inside and outside the house. If you find a defect in the antenna system and the installation of the antenna is more than about five years old, it is usually better to replace the entire antenna system than attempt a repair.

With all-wave and doublet antennas particularly, transmission-line insulation becomes brittle and deteriorates through exposure to weather. Soot and dirt collect on the insulators of all outdoor antennas and may cause excessive leakage.

Practical Troubleshooting Hints. The best test of an antenna system is to try the receiver with another antenna, such as 25 feet of insulated wire strung over window frames temporarily. If the set works better with this indoor wire than with the existing antenna system, you can be pretty sure that the customer's antenna system is defective and in need of replacement.

If loud crashing noises are heard with a radio program and you suspect a loose connection in the antenna system, turn up the volume while the receiver is tuned between stations. Now shake or pull each portion of the antenna lead-in and the ground wire inside the house and at all conveniently accessible points outside. If this locates a poor joint, a break in a wire, or damaged insulation, make the required repair or replace the antenna system.

The soldered joint between the antenna and the lead-in of an inverted-L antenna is a frequent troublemaker. Resoldering here calls for lowering the antenna wire, as it is usually impractical to resolder this joint up in the air.

QUESTIONS

1. Draw a sketch showing the two directions from which a loop antenna gives best reception.
2. Is a ground connection ordinarily needed on a modern radio receiver?
3. Under what conditions are outdoor antennas needed today for a-m radio sets?
4. Are lightning arresters needed with an outdoor antenna that is higher than the peak of the roof?
5. Name two ways of bringing an antenna lead-in wire into the house.
6. What is the best location inside a home for an f-m radio antenna?
7. Will a television antenna that is designed for use on television channels 6 and 7 be satisfactory for an f-m radio?
8. Name three possible troubles in an outdoor antenna system.

22

INSTALLING AND REPAIRING

Television Antennas

Importance of Good TV Antennas. The picture on a television receiver screen can be clear only if a strong signal gets to the receiver. In the early days of television, a roof-top antenna system was needed. As receiver designs improved and television stations boosted their power, indoor antennas gave good results at more and more television receiver locations. At the same time, good reception with outdoor antennas became possible at greater and greater distances from the transmitter.

Technical improvements will extend the range of good reception for indoor antennas still more, but there will always be a far-out fringe area around a station where outdoor antennas are needed. This is why you need to know how to install and adjust both indoor and outdoor television antennas.

Simple Dipole Antennas. The simplest television receiving antennas are the plain dipole and the folded dipole.

A plain dipole antenna has two rods placed end to end, separated at the center by an insulator as in Fig. 1. A coaxial transmission line connects to the rods at the center and brings the signals down to the receiver. This dipole is the basic antenna used in many of the more complicated television antenna systems today.

A folded dipole is a single rod bent back on itself at each end as in Fig. 1. The twin-lead transmission line connects to the ends of the rod. This dipole is easier to mount rigidly, uses a cheaper transmission line, and works well over a wider range of frequencies. For these reasons the folded dipole is also widely used in television antenna systems.

Dipole Lengths. Both types of dipoles have one best length for each television channel, as indicated in Fig. 1. Channel 2 thus requires the longest dipole arms, and channel 13 the shortest.

In the so-called fringe area, just beyond normal reception range from a television station, it is generally necessary to use a separate dipole antenna for each station. The dipole would then be cut to exactly the correct length for the station frequency.

In good-reception areas, a compromise length of about 40 inches for each arm of a dipole brings in all stations fairly well. When separate antennas are used for high and low bands, two compromises are used, one for the low-band stations (channels 2 to 6) and another for the high-band

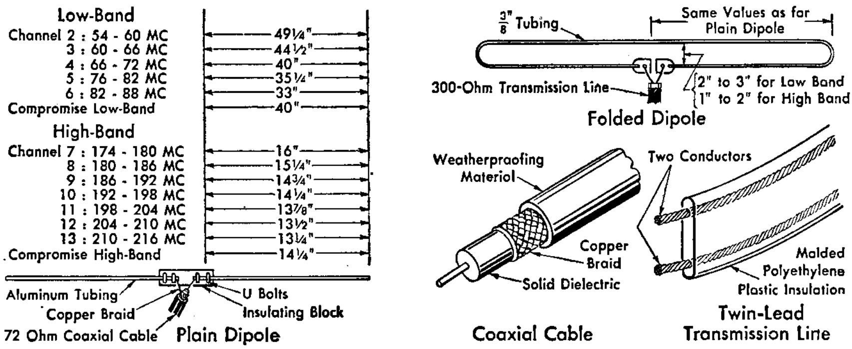

Fig. 1. Types of dipole antennas and transmission lines that form the basis for practically all vhf television receiving antenna installations. Both dipoles receive best broadside, which is at right angles to their sides

stations. The high-band antenna is generally placed above the other on the same mast. The two antennas may have individual transmission lines or may be connected together with a critical definite length of line for use with a common transmission line.

Directional Qualities of Dipoles. All dipole antennas are directional. This means that they respond best to signals arriving from certain directions. A dipole having the right length for a signal receives that signal best at right angles to the dipole. Signals of other frequencies may come in best slightly off from right angles to the sides of the dipole. This is why rotation or orientation of a television antenna for best reception is so important.

When receiving direct signals from a nearby television station or when receiving a signal that is bent downward after passing over a hill, the antenna is aimed at the station. A compass and map are needed for rough orientation when the transmitting antenna cannot be seen.

When a reflected signal is the best that can be obtained, aim the receiving antenna at the hill serving as reflector.

Antenna Matching. The impedance of a plain half-wave dipole is about 72 ohms, while that of a folded dipole is about 300 ohms. The transmission line should have approximately the same impedance as the antenna. Maximum signal power is transferred from the antenna to the line when the impedances are equal or matched. Similarly, the transmission-line impedance should match that of the television-receiver input.

Most television receivers have 300-ohm inputs. The lowest-cost transmission line is twin-lead, which also has a 300-ohm impedance. This is why the 300-ohm folded dipole is used so much in television antennas and twin-lead is used far more than any other type of transmission line.

When impedance values do not match, it is possible to use an impedance-matching arrangement between the different impedances and get good results. Devices made for this purpose can be obtained from jobbers, but are needed only for special installations. An example would be a location requiring 72-ohm shielded coaxial cable to minimize pickup of noise interference. With this cable, commonly called coax, a matching device is needed if the receiver has only 300-ohm input. At the antenna end of coax no matching device is needed if a plain dipole is used.

Coax is much more expensive than twin-lead, hence is used only when absolutely necessary.

Shielded 300-ohm twin-lead line is also made for use in noisy locations, but may be more costly and more difficult to obtain than coax.

Use of Reflectors and Directors. A metal rod placed a definite distance back of a folded dipole as in Fig. 2A acts as a reflector. This means that the rod absorbs signals that get past the dipole and reradiates them back to the dipole. When the spacing between reflector and dipole is correct, the reflected signal adds to that arriving directly, and a stronger signal goes down the transmission line. A reflector also serves to suppress undesired signals coming from the back.

A metal rod placed ahead of a dipole as in Fig. 2*B* is called a director. Its length and position are such that it reradiates the desired signal to give addition of signals at the dipole.

Directors and reflectors may be used with plain dipoles if the lengths and spacings are as in Fig. 2*C*. A reflector is always slightly longer than the dipole, and a director is always slightly shorter than the dipole.

Still greater pickup in the desired direction can be obtained by using additional directors, as in Figs. 2*D* and 2*E*. Any antenna having a reflector and one or more directors is commonly called a *Yagi antenna*.

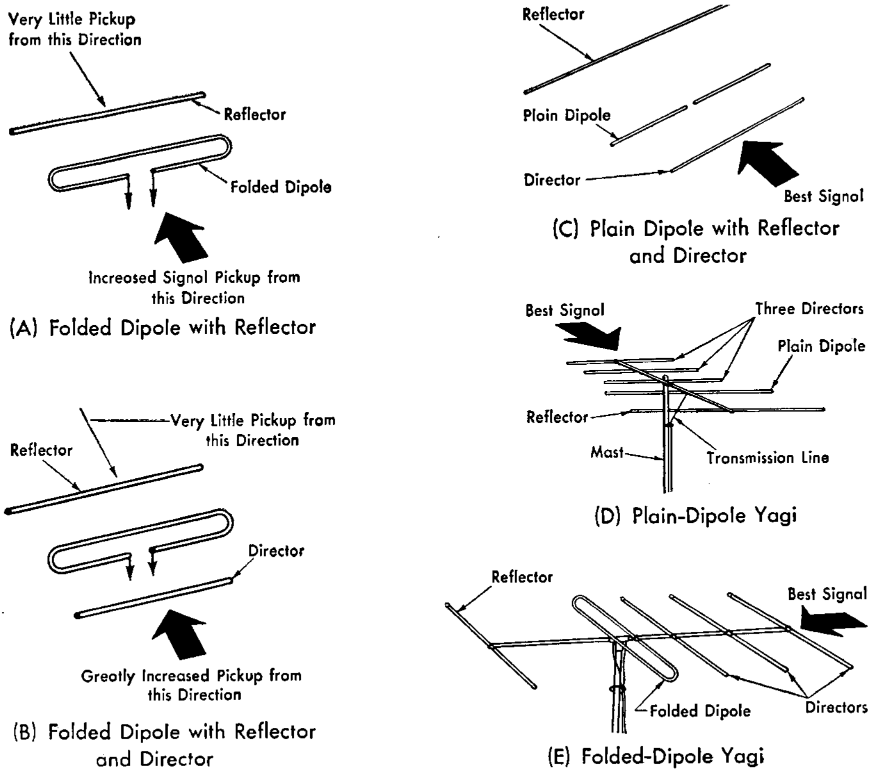

Fig. 2. Use of reflectors and directors with dipoles to improve signal pickup in one direction and reduce it in the opposite direction

Antenna Gain. Although at first glance it might seem that every home has a different kind of television antenna, all are basically a combination of the dipole, reflector, and director elements just described. The different shapes and arrangements are used to give different compromises of the three important antenna characteristics: gain, directivity, and frequency response.

The higher the gain of an antenna, the better it will pick up weak signals in fringe areas. Highest gain is obtained by designing the antenna to receive only one channel rather than all twelve and by narrowing the angle over which signals are received best. A high-gain antenna must therefore be aimed or oriented much more accurately than a simpler low-gain antenna.

Antenna gain is expressed in decibels, abbreviated as db. The gain in db tells how much better the antenna is than a plain dipole cut for that channel. A gain of 0 db means the antenna has the same gain as a dipole. The gain of the average roof-top antenna is different for each channel and may range from 0 to about 6 db. More elaborate antennas for fringe areas may have gains of 10 db or higher at the channel for which they are designed, but very low gains on other channels.

Fringe and Superfringe Areas. In city and suburban areas within about 25 miles of a station, antenna gains under 5 db are usually adequate. In the fringe area, normally thought of as the region between about 25 and 50 miles away from the station, gains up to 10 db become necessary. In the superfringe area beyond this, gains up to 15 db or higher become necessary just to receive one station. With such high-gain antennas, good reception is being obtained even out as far as 150 miles from a station.

Examples of some of the commercial antennas available at jobbers are shown in Fig. 3. These and many variations of them are all combinations of plain or folded dipoles and reflectors.

Common Types of Antennas. The folded-dipole and reflector arrangement of Fig. 3A is highly popular for close-in locations, being low in cost and easy to erect. It is usually cut for best reception in the low band, hence may not work well enough on some of the high-band channels.

Adding short batwing loops at an angle as in Fig. 3*B* improves high-band performance of the folded dipole. Still better is use of a separate high-band folded dipole ahead of the low-band unit as in Fig. 3*C*. The two dipoles must be connected together by a definite length of twin-lead, as specified in installation instructions that come with the antenna kit, to ensure best results. On low-band stations the signal is received by the longer folding dipole working with the reflector. On high-band stations the signal is received by the shorter folded dipole, with the longer folded dipole then serving as reflector.

Arranging dipole rods as if they were along the surfaces of two cones gives the highly popular conical antenna of Fig. 3*D*. This may have two, three, or even more rods on each side, and may have a single solid-rod reflector in place of the two-rod conical reflector shown. The reflector can even have three rods on each side. Conical antennas give fairly good results on all bands, as also does the double-V arrangement of Fig. 3*E*.

When high-band stations are a different direction than low-band stations, two antennas that can be aimed in different directions as in Fig. 3*F* are usually used. The small high-band antenna is usually placed above the other on the mast, hence the name *piggy-back*. If connected together correctly according to instructions, the two antennas work fairly well with a common transmission line. Better results are obtained with separate transmission lines going to a double-pole double-throw slide switch at the receiver. The switch must be operated by the listener when changing from low-band to high-band stations or vice versa.

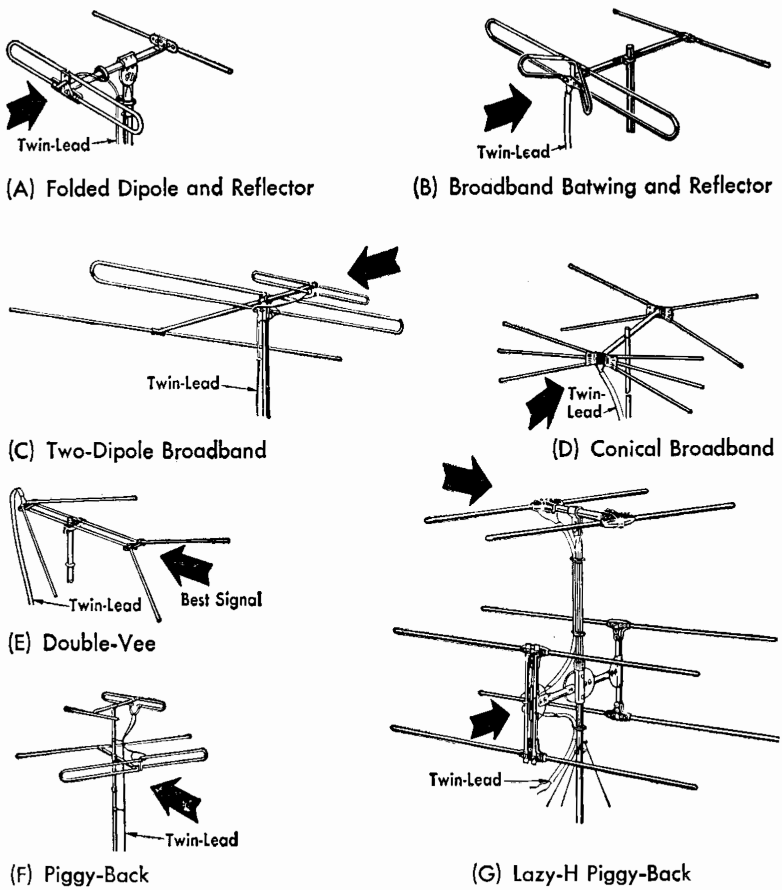

Fig. 3. Examples of commercially available vhf television antennas for normal service areas

Two plain dipoles mounted one above the other and connected together by vertical rods are sometimes used when greater gain is needed. This arrangement looks like the letter H lying on its side, hence is often called a *lazy-H antenna.* The example in Fig. 3G also has a lazy-H reflector and a piggy-back plain dipole with reflector for the high band.

Stacked Arrays. Two or more identical antennas stacked one above the other and connected together by carefully cut lengths of transmission line are called a *stacked array*. The more antennas in the stack, the higher is the gain. In superfringe areas, stacked arrays give surprisingly good results on the channel for which they are designed, if mounted on a sufficiently tall mast or tower.

Types of Masts. Masts which do not require guy wires are called self-supporting. This type of mast is usually limited to about 15 feet in height, unless you use a heavy, rigid pole or fabricated steel tower. Self-supporting masts are widely used because they give a neat and strong installation with a minimum of labor, and can be used where guy wires are not allowed.

Guyed masts are useful when extra height is needed. With extra mast sections and guys, you can obtain heights up to 30 feet or even more. Since guyed masts are light in weight, they can be erected on roofs. The height of the building is then added to that of the mast.

The strain or tension on guy wires should be kept at a minimum. If the wires are correctly located, there is no reason to make them so tight that they sing like violin strings. Make them only tight enough to provide adequate sideways support for the mast.

Antenna Rotators. In locations where stations are in different directions and no single antenna position brings them all in satisfactorily, an antenna rotator may be the best solution. This is a reversible geared-down electric motor that mounts on the mast and is controlled remotely from the receiver to turn the entire antenna.

Two types of rotator systems are available. The simpler and less expensive type has just a start-stop-reverse switch on the control unit. This does not tell which way the antenna is pointing at any instant; hence the user must run the antenna back and forth while watching the screen until the best possible picture is obtained for that channel.

More satisfactory are rotators having a control unit that tells the general or exact direction in which the antenna is pointing. This eliminates searching for the best position. Once the correct setting of the control is found for each channel, changing the antenna direction is just as easily done as tuning the receiver to a different channel.

Installing Rotators. Installation instructions come with each rotator. In general, the motor unit is clamped to the top of the antenna mast and has an upward-projecting shaft on which the antenna itself is mounted. Special flat insulated cable made for rotators, having three or more wires, is run from the motor to the control unit. Order the type of cable specified in the installation instructions, estimating the length needed just as when installing transmission line. This cable is supported by standard twin-lead standoffs and is kept at least 6 inches away from the transmission line. The control unit has a line cord that is plugged into any a-c wall outlet to get power for the motor.

With some types of rotators, enough extra transmission line is needed around the motor to permit rotating the antenna a full 360 degrees. These rotator motors have stops that permit only one complete rotation, as otherwise the transmission line would get wrapped around the mast too much. Other motors have slip rings for the antenna connections; hence the

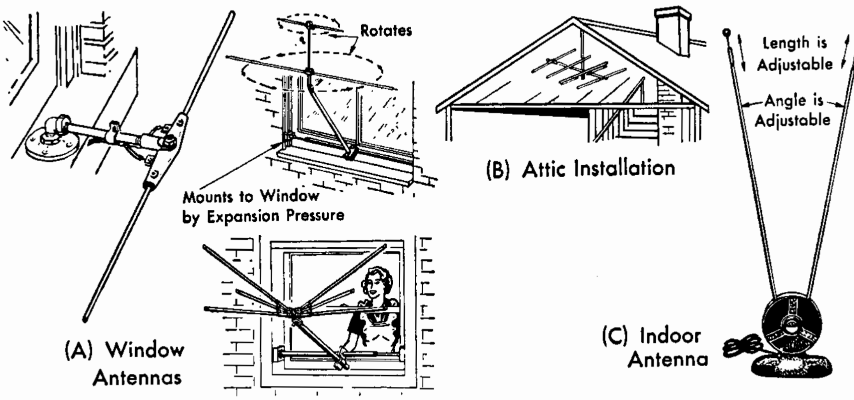

Fig. 4. Types of antennas that can be used where outdoor antennas are not permitted

antennas can be turned around and around as much as desired without tangling the transmission line.

Window and Indoor Antennas. Because of restrictions on apartment-house antenna installations, special television antennas have been designed for use on the window sill or inside the apartment proper. These rarely perform as well as a good outdoor antenna, but are certainly worth trying in strong-signal areas. They give best results with receivers having high sensitivity. Commercial television receivers of different makes vary greatly in sensitivity, so do not expect indoor antennas to work equally well on all makes of sets.

Examples of window-mounted antennas are shown in Fig. 4A. Most of these have a horizontal telescoping bar which is extended to press against the sides of the window sill, thus mounting without bolts. The antenna itself is designed so that it may be oriented within limits. Window antennas are satisfactory where the window is facing the station, but will not work as well if the signal is obstructed by the building. Most window antennas have rotating or swivel joints to permit orienting for best reception.

In homes having sufficiently large unused space in the attic, good results can often be obtained with an ordinary outdoor antenna mounted upside down from the peak of the roof as in Fig. 4*B*. A floor-mounted mast is equally good. The antenna and transmission line are then fully protected from the weather and should last much longer than if outdoors. Large metal objects and house electrical wiring should be kept at least a few feet away from the antenna.

Indoor antennas are usually a dipole with individually adjustable arms, as in Fig. 4*C*. Rotating the antenna on its base and adjusting lengths of the arms give maximum pickup on the station desired. The antenna is usually set on top of the television set. The arms are set at a V angle, as a compromise between height and spread.

The primary limitation of indoor antennas is the loss of signal due to building walls. Reception is therefore affected by the number of walls the signals must pass through and the wall construction. It is difficult to eliminate ghosts with this type of antenna since no reflector is used. The fact that the antenna length can be tuned to each station helps to overcome signal losses, however.

The best placement of an indoor antenna must be determined by trial. Experience will show where these antennas can be used successfully in a given city. In general, they are all right for close-in locations in cities having only one television station or perhaps two stations situated near each other on adjacent or nearly adjacent channels in the same band. Play safe and always warn the customer not to expect too much from an indoor antenna.

One or more indoor antennas are handy on top of the service bench. They bring in sufficient signal for troubleshooting or for running a set after repair to see if new troubles develop. Every shop should also have a good outdoor television antenna or even several antennas, so that final tests of a receiver can be made with an antenna approximating that used by the customer.

Built-in Antennas. As an added sales feature, many manufacturers are building antennas inside television receivers. Some may give acceptable results in a few locations. Others are nothing more than two pieces of wire tacked inside the cabinet, and give poor results almost everywhere. You can always safely recommend that an outdoor antenna will work better unless the receiver is close to a station.

Two-set Installations. More and more homes are keeping their old small-screen television receiver when buying a large-screen set. To use two sets with the same antenna, a coupler unit is needed. This is mounted at the back of one of the sets and connected to the existing antenna. Transmission lines to the two receivers are then run from the two pairs of terminals at the bottom of the coupler. The coupler prevents the two receivers from interfering with each other and maintains correct impedance match. There is some loss in signal strength, however, when using two receivers on one antenna. Separate antennas for each give the best results.

Never connect two sets directly to the same transmission line without checking operation of both sets thoroughly on all combinations of all channels. Technically, it is possible for such a direct connection to cause interference patterns on the picture when both sets are in use and tuned to different channels.

Antenna-installation Requirements. Installation of outdoor antennas, particularly for f-m and television, involves construction work rather than actual servicing. It generally requires a ladder, special tools for drilling holes in brick and cement where necessary, and a certain amount of ability to work safely and without fear on roof tops. Some men like this outdoor work better than others. Here are some factors that may help you decide now whether or not you want to put up outdoor antennas.

For antenna work, two ladders are usually needed. One should be a two-section aluminum or magnesium extension ladder having an over-all length of at least 24 feet. The second should be a single-section ladder 12 or 14 feet long, provided with roof hooks. These grip the top of steep-peaked roofs, so the ladder can be used for climbing from the eaves to the peak, as in Fig. 5. All ladders should be equipped with pads to prevent slipping and to protect roofing material. Metal ladders are more expensive than wooden ones but are light in weight, easy to handle, withstand abuse, and are long-lasting. A roof rack on your car or truck is all that you need for carrying the ladders to jobs.

For television antenna work, you will need a helper to watch the set while you adjust the antenna position, and a self-powered telephone system for communicating with your helper while making this adjustment. All these things call for an investment that you must weigh against the amount of antenna work you can get.

It may actually be better for you in the long run to pass antenna installation jobs on to others. There is nothing wrong with saying to a customer that you are not equipped to do the work. You can then recommend someone else who you know is reliable. Get acquainted with other servicemen in your vicinity as soon as possible. It pays, because if you pass on jobs to them, they will try to help you in other ways.

Fig. 5. Use of double-extension ladder and single ladder with roof hooks to get up to the chimney of a house safely for installing a television antenna. (RCA Victor photo)

Starting an Antenna Installation. When you arrive at a home to install a television antenna, present your business card at the front door and explain the reason for your visit. If your car is parked in the driveway, ask permission to leave it there. Enter the home only on request and only if a member of the customer's family is present.

The television set will usually be unpacked and already in the customer's preferred position. Make tactful suggestions for a change of location only if the choice is obviously bad. Bright glare from a window right behind or alongside the set would be one reason for suggesting a change. Lack of a nearby wall outlet for a-c power would be another.

If the set is still in its shipping carton, unpack it first of all. When taking the set out of its carton, look for an instruction sheet, as it may describe some special installation procedures.

When a set is too large or too heavy to be lifted out of its carton, lay the carton on its side and cut off or pry open the bottom flaps. The carton can then easily be lifted off the set.

Plug in the set, turn it on, and try it out. Without an antenna you should at least get a raster of white lines on each channel. Better yet, connect an indoor antenna temporarily for a more thorough preliminary check of the set. If the set does not work, fix it or get it fixed before even starting on the antenna. Bad tubes are the commonest trouble in new sets. Oftentimes the trouble is simply a tube that is not all the way down in its socket.

There is no point in putting up the antenna if the set needs to be taken back to the shop for repairs, as you would have to put the ladders up again later anyway to orient the antenna.

Once the set is working, leave it on all through the installation. This may show up defects that can be fixed right away, saving a service call.

If the television set is a console that includes a record player, this portion has probably been screwed tightly to the base to prevent movement. In some cases the springs on which the record player floats are tied down by screws. If so, these screws should be removed. Detailed instructions for removing or loosening hold-down shipping screws are generally printed in the installation instructions that come with the set or on tags attached to the set.

Planning Your Work. With the receiver location decided on, the transmission-line route comes next. For most jobs it is best to bring the line up behind the set from the basement. This is the easiest route from an installation standpoint and is preferred by the customer because no line is exposed in the living room. Check the basement layout, choose the point of entry for the line from the outside, and estimate how much line will be needed from that point to the set.

As the next step, study all sides of the house and the roof for antenna mounting possibilities. It is not always necessary to install the antenna on the highest peak of the roof, but it should be put as high as is convenient. If the roof is metal or slate or if a neighboring roof is slate, however, it may be necessary to get the antenna well above the roof level. Extra height is of no particular value as long as a good picture is obtained, free of flashing white dots called snow.

Keep the antenna well away from possible sources of interference. If the street at the front of the house has heavy traffic, an antenna location well to the rear of the house will be preferable. In the average residential area there is not enough traffic to make interference a problem, however.

Though power lines do not ordinarily cause interference, keep the antenna well away from power lines because of the possible shock hazard during installation or if the antenna falls during a storm. Likewise, the television transmission line should never be run over or under a power line.

Do not mount a television antenna mast on a soil pipe that projects above the roof, no matter how convenient this may be. Vibration of the mast in heavy wind would be transferred to the pipe and would eventually cause the roof to leak near the pipe.

Apartment-house Installations. The best place to locate an antenna at an apartment house is usually the parapet, since the transmission line must be run down the outside wall. There are certain fire regulations which must be followed on all installations where the roof may be used for fire fighting. Check with your local fire department to determine the local requirements.

In general, an apartment-house antenna must be located at least 8 feet above the roof to avoid possible injury to a person. No guy wires should be attached to the roof or other structure in the area that may be used by firemen, unless the wires are at least 8 feet above the roof at all points.

Transmission line should be supported by an insulator at least once every ten feet or at each floor level. Where line is run on the roof surface, it should be protected against mechanical injury. All transmission line and ground wires carried above a flat roof should be at least 8 feet above the roof surface. No wires should cross a public street.

Antenna Mounts. Examples of television antenna mounting methods are shown in Fig. 6. If it is necessary to mount the antenna on the roof, try to locate it on the overhang so as to avoid damage from leaks. Whenever the antenna is mounted on the roof, a layer of roofing compound should be applied to the roof under the mounting bracket and the mounting bolts should be covered with tar after they are tightened.

One drawback of mounting the antenna on the chimney is soot collecting on the antenna. On the other hand, the chimney is one of the highest spots on the building and chimney-type mounts are convenient to use. Chimney mounts are popular with both servicemen and customers, even though in colder sections they may need frequent cleaning and replacement.

Rustproof material should be used where possible for antenna system hardware, so rust stains do not mar the customer's house.

Walk on the roof as little as possible. Any damage that you may accidentally do can be charged to you.

It is best to notify the owner before you go up on any roof. If the building is rented or is an apartment, see the landlord or building superintendent. Get permission in writing if possible. This may save you embarrassment and money later.

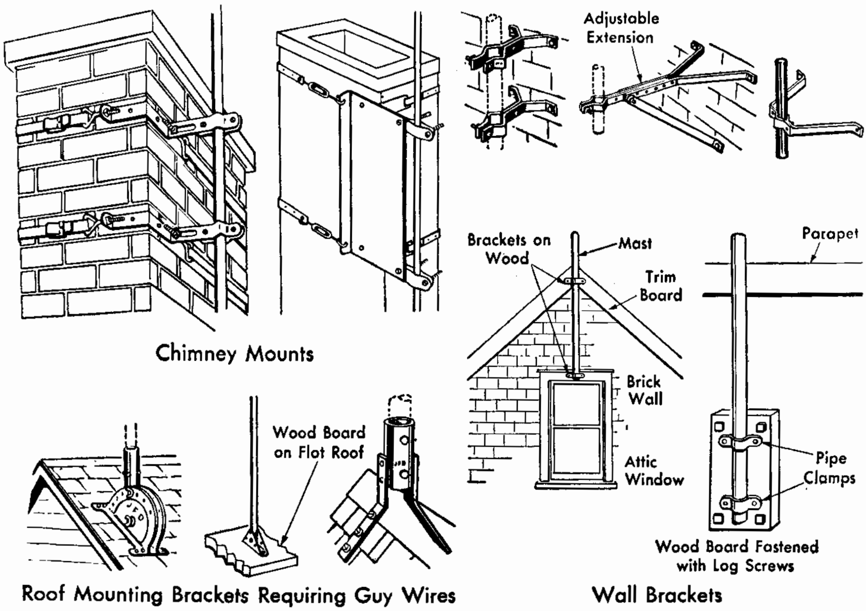

Fig. 6. Examples of the three commonest types of antenna mounts. Many other types of brackets and antenna hardware are also available at jobbers

Observe Safety Precautions. Never underestimate the importance of observing routine safety precautions to protect your own life as well as others. Most accidents are the result of carelessness or overconfidence.

Climbing and roof work are dangerous. Make sure your ladder is on secure footing before going up. Avoid precarious positions, especially when working near the edge of a roof. See that tools and materials are placed where they will not endanger yourself or others.

Wear shoes which will give good traction when climbing steep roofs. Be extremely cautious if the roof is wet or icy. Always keep one hand free for climbing the ladder. Always face the ladder when going up or down, as in Fig. 7. When mounting tall ladders, keep your eyes on the ladder rails and rungs instead of looking into the sky, to prevent losing balance. Lash metal ladders to the house with rope whenever possible, because even a light gust of wind can blow down aluminum or magnesium ladders.

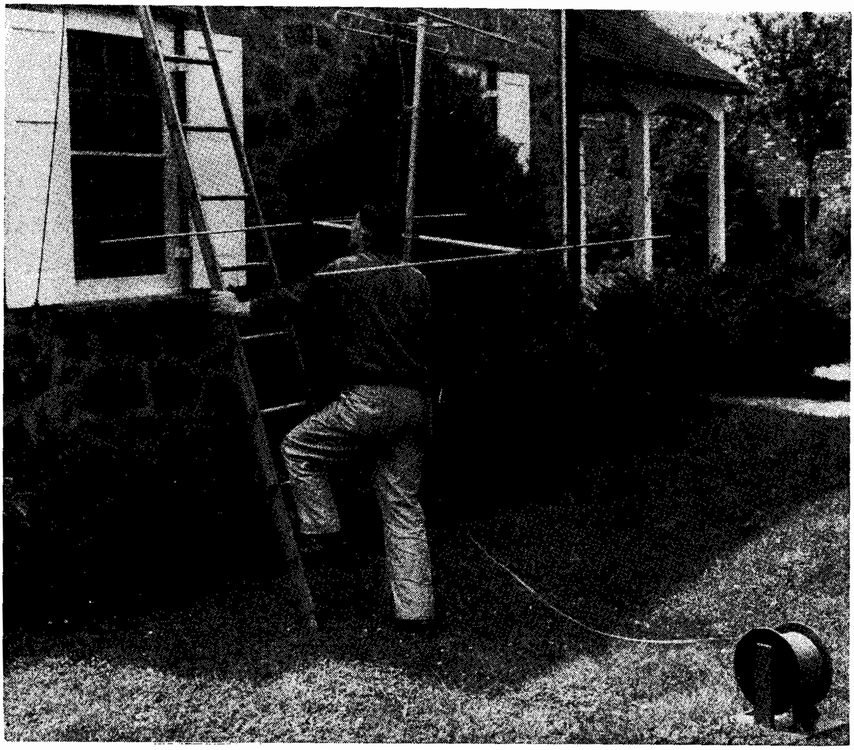

Fig. 7. Correct method of carrying an assembled antenna up a ladder. Face the ladder and use one hand for gripping the ladder. (RCA Victor photo)

Never ask for or accept the help of bystanders or members of the customer's family, because you may then be liable for their safety and for damage they do.

Be extra careful when handling metal ladders, masts, and antennas in the vicinity of power lines and other overhead wires. Keep as far away from wires as possible.

If the job calls for additional help, get it. No job is worth a broken arm or leg. No customer appreciates having his living room turned into an emergency ward.

If on a metal ladder while drilling holes, drill slowly and no deeper than necessary. If applying too much pressure at the instant when your drill goes through the wood, the drill may also go through electrical BX cable that happens to be just at that point. This means sudden death if the drill contacts the hot wire inside the cable, because the metal ladder completes the path from the drill through your hands and heart to ground.

There is no danger if you watch what you are doing, because it is easy to feel the change in pressure as the drill breaks through the wood. A hand drill is better here, because an electric drill can bite through the BX before a careless user realizes that the hole is drilled. Several fatal electrical accidents have occurred when electric drills were used on metal ladders.

Installing the Antenna Mount. Chimney mounts require no drilling. If using a two-strap mount, place one strap near the top of the chimney and the other 12 to 18 inches below. Adjust each strap carefully so that it is level all around the chimney. The straps should be over the bricks, not over the mortar between bricks. Straps generally are longer than necessary, so surplus length should be cut off after the straps are secured in their buckles. Tightening the bolts or turnbuckles on the straps makes the mount ready for the antenna mast.

Wall brackets are fastened in place with large wood screws or square-headed lag screws. Always drill a small hole in wood first, so the screw can be turned in easier. Never drive a screw in place with a hammer, as such screws will pull loose easily.

On brick or masonry homes, it is often possible to mount the brackets on the wood roof trim and on window frames, to avoid having to put screws into the bricks. On some jobs, however, it will be necessary to mount one or both brackets on a brick wall. A hole must be drilled in the masonry for each mounting screw and a special soft lead anchor sleeve inserted. Various types of anchors are available at jobbers and hardware stores for this purpose, and are easily installed once the holes are made.

The simplest yet hardest way of making a hole in brick is with a star drill and hammer. The star drill is turned slowly with one hand while pounding on the drill with a hammer. For brackets, always drill in the middle of a brick, not in the mortar between bricks. Screws anchored in mortar may work loose because water seeps in around the drilled hole. Holes can be made safely in mortar only for standoff insulators, as there is no strain on them.

A slow-speed electric drill and a carbide-tipped masonry drill greatly speed up drilling holes in brick walls. A 600-rpm drill is best. At least

100 feet of heavy extension cord will be needed with the drill, to reach an a-c wall outlet.

Installing the Antenna. Television antennas come disassembled, but assembly is easy. Put the antenna together on the ground and clamp it tightly to the top of the mast. Where spacings are critical in the more complicated arrays, instructions are included and should be followed carefully. Next, connect the transmission line to the antenna. To prevent the

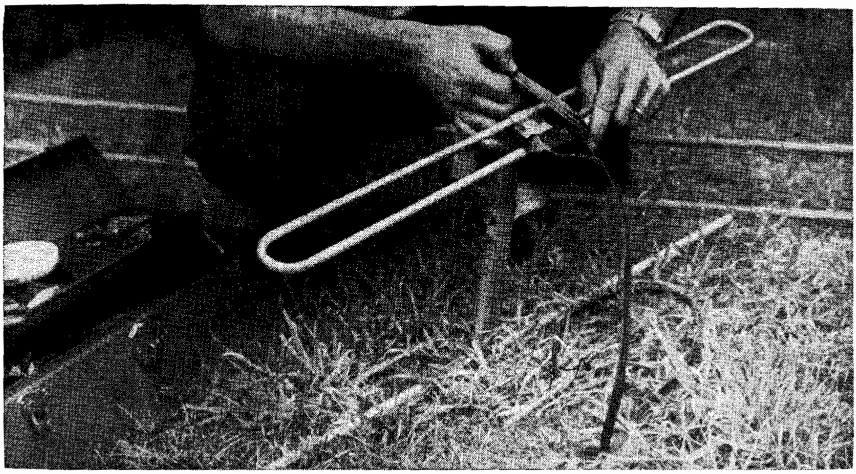

Fig. 8. Taping antenna connections with No. 33 Scotch electrical tape to give added strength against breakage by the wind. (Minnesota Mining & Mfg. Co. photo)

line wires from bending back and forth in the wind and eventually breaking at the terminals, tape the connections with No. 33 Scotch electrical tape as in Fig. 8.

Attach several line standoff insulators to the mast and insert the line in them on the ground, since this will be difficult to do once the antenna is up. Now carry the assembled antenna up to the mounting site, insert the mast in the brackets and tighten only partially now, to hold up the mast yet permit turning later during orientation.

Installing the Transmission Line. The transmission line should take the most direct route consistent with good appearance, because extra line costs money and increases line loss. Where auto-ignition interference is a problem, however, it may be better to have a longer line run to keep the antenna away from the street.

Transmission line should not be run diagonally down the side of a house because of appearance. Whenever possible, the line should be run straight down so that rain, sleet, and snow will have less tendency to cling to it. If a horizontal run is necessary, it should be made under an eave or other protection. Suggestions for locating transmission lines are given in Fig. 9.

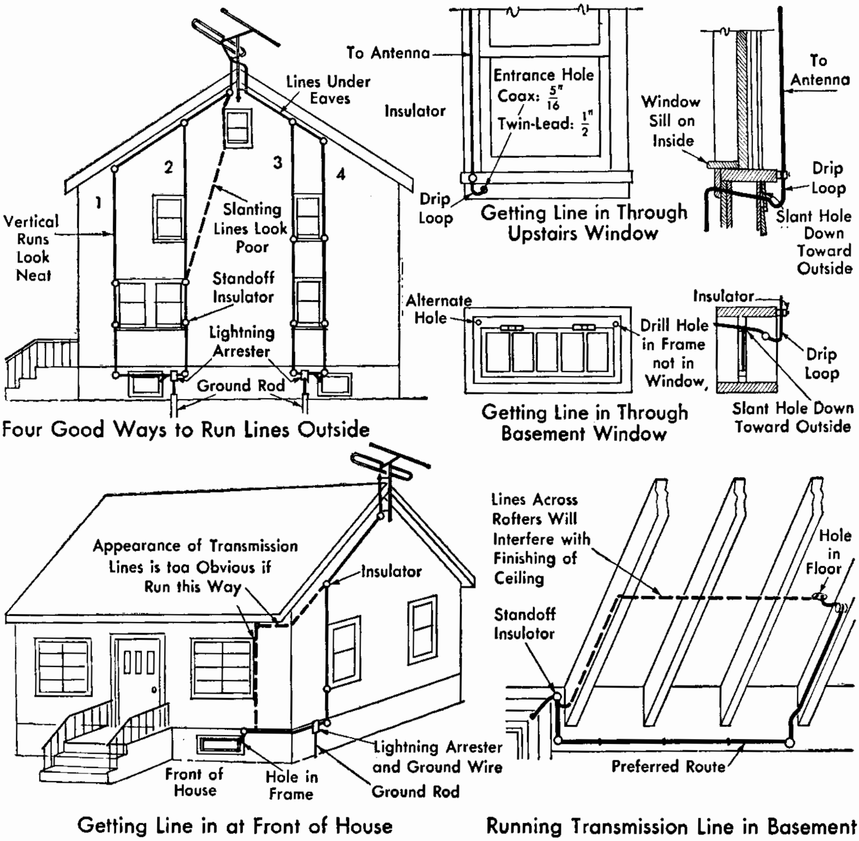

Fig. 9. Preferred routes for transmission line outside a house and in the basement

Line should not be run down the front of a building unless absolutely necessary, since it will detract from the appearance of the building and the installation. Where entrance through the front of a building is necessary, consider the possibility of running the line down the side of the building and then around to the front. An alternative is running it down the side to the basement. Once in the basement, the line can be run easily to any downstairs room.

The line can enter the house through a basement or first-floor window sill or go right through the house wall into the basement as in Fig. 10. Where the line enters the building, leave a loop to allow water to drip off.

Twin-lead can be brought in over a wood window sill where necessary, as in rented rooms, provided it will not be crushed and broken as the window is opened and closed. Generally, it is better to pass the transmission line through a hole.

Fig. 10. Drilling a hole through the wall of a house into the basement for bringing in the television transmission line. (RCA Victor photo)

Fig. 11. Drilling a hole in the floor close to the wall behind the selected receiver location, for bringing up the transmission line from the basement. (RCA Victor photo)

In drilling entrance holes, use a ½-inch bit for twin-lead and a 5/16-inch bit for RG-59/U coaxial cable. The hole should be made through the window sill or sash in as inconspicuous a spot as possible. Slant the hole slightly downward toward the outside, so that any moisture will run out of the house. Where a hole is drilled through the floor, it should be as close to the wall as possible, as in Fig. 11.

Do not hang the transmission line on water pipes or other metal fixtures. Staple or tack the line at least every 3 or 4 feet inside the house. Keep it at least 4 inches away from other wiring. Run the line on the sides of floor joists wherever possible, to allow the basement ceiling to be finished later if desired. Make cross runs at right angles to the joists along the wall of the building. At the set, leave at least 3 feet of extra line to permit moving the set away from the wall for cleaning or for servicing. Arrange the extra line carefully back of the set, as bunching of twin-lead can cut down signal strength.

Twin-lead should be twisted about once per foot outside the house to minimize flapping in the wind. Twisting may also reduce pickup of ignition interference a bit, though this is open to question.

Where twin-lead goes over the edge of a building, use long standoff insulators to keep the line from rubbing. If there is no way to mount an insulator, protect the line by wrapping with electrical Scotch tape, so the insulation on the line will not wear through at the point where it touches the building edge.

Supports. Outside the house, twin-lead should be supported about every 8 feet by insulated standoff insulators. Some of the available types are shown in Fig. 12. On horizontal runs the standoffs should be about 4 feet

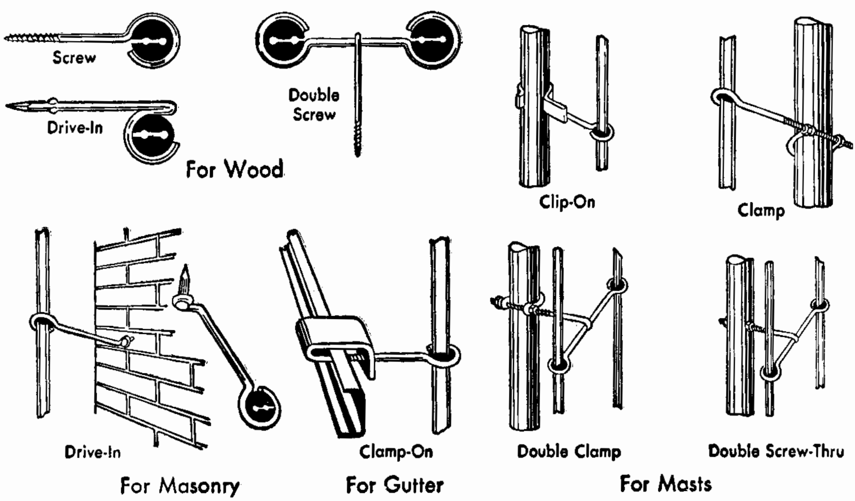

Fig. 12. Types of standoff insulators that are available for use with twin-lead and coax. Double types are used when high-band and low-band antennas have separate lead-ins or when power line for antenna rotator must be brought down along with transmission line

apart. After the line is inserted in the slot of the standoff insulator, the metal band around the insulator should be squeezed inward with combination pliers. The insulator then grips the line and prevents it from sliding.

Short runs of line inside the living room can be made by stapling the line to the molding. Staples or nails should be carefully placed so they do not short or damage the two conductors.

Coaxial cable may be allowed to touch a building, since the outer conductor is a shield which is connected to ground. It may even be taped directly to the mast, saving the cost of insulators. Standoff insulators should be used only to provide proper support and a neat appearance. Either twin-lead standoffs or electrical nail-knob insulators can be used. Hammer the nail type lightly to avoid crushing the cable.

After holes are drilled for twin-lead or coax, pull the line through to the set from the outside of the house, then estimate the amount required to

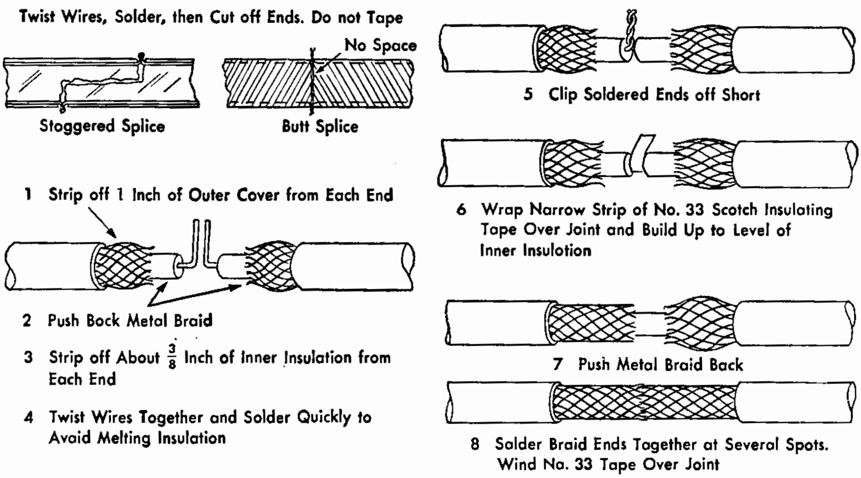

Fig. 13. Two methods of splicing twin-lead, and eight steps in splicing coaxial cable

reach the antenna. This minimizes waste of line because only about half the total length has to be estimated. Do not fasten any line inside the house until the antenna is up, however.

Splicing of twin-lead or coax should be avoided because every splice is a possible point of trouble. When necessary, however, use the procedures shown in Fig. 13.

Protecting against Lightning. A television antenna system must be grounded for protection against lightning. Where the antenna and mast are insulated from each other, both must be protected from lightning. This is done by connecting the mast directly to ground and using a lightning arrester on the twin-lead transmission line. Examples of lightning arresters for twin-lead are shown in Fig. 14.

When an antenna is used with coaxial cable, connect the cable shield to the mast at its upper end, and ground the cable shield somewhere near its lower end. This will ground the entire antenna system, and a lightning arrester will not be needed.

It is permissible to ground the antenna system to a soil pipe only if you are certain it gives a continuous path to earth. Use a metal grounding strap around the pipe to ensure positive contact.

Use No. 14 or larger bare or insulated wire for ground connections. Run it in as straight a line as practicable to the ground, on the outside of the building. Bare solid aluminum wire is widely used for grounding pur-

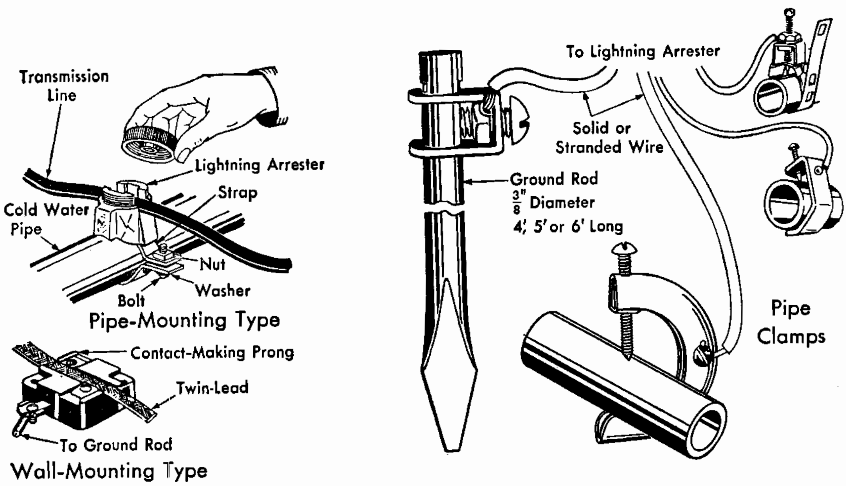

Fig. 14. Examples of lightning orresters, ground rods, and pipe clamps

poses because it is easy to handle. It can be nailed or stapled directly to the house, without insulators. A ground rod is usually required, as outside water pipes are rarely in the right location.

Orienting the Antenna. To orient an antenna efficiently, it is desirable to have two men, one on the roof and one at the set, with a system of communication between them. Portable sound-powered telephone systems are made especially for this purpose and are widely used by servicemen. Each man wears a telephone-operator type of headphone and mouthpiece. Up to 200 feet of two-conductor wire can be used between the units. No batteries are needed.

When two or more stations are to be received, orientation will often involve finding the best compromise direction that gives good signals, as free from reflection ghosts as possible, for all of the stations. This means that reception of all stations must be checked after each change in antenna direction.

When two men are orienting an antenna, they should talk to each other continuously. This allows the man on the roof to know from moment to moment whether reception is getting better or worse. Talking also lets the man at the receiver know the approximate direction in which the antenna is pointed, so he can identify the best position.

If signal strength is low and twin-lead is used, try wrapping a piece of tin foil around the line near the receiver and moving it back and forth while watching reception on the high-frequency stations. After a spot has been found which produces the best results on one station, check the other stations. Sometimes two or three pieces of tin foil can be used, each at the best position for one station. Once the best position on the line is found, the foil should be cemented in place with a few drops of speaker cement. Technically, the band of foil corrects line mismatch that can occur on high-band stations when the line has the correct impedance for low-band stations.

One-man Installation of Antennas. The real problem here is orienting the antenna. Perhaps the best one-man orienting procedure is installing an antenna rotator temporarily in such a way that you can rotate the mast while watching the picture. When the best possible orientation for all channels is found, you merely go up to the roof and mark the mast position precisely, then remove the rotator and complete the installation. One large service organization actually does this on some calls. The rotator is used at the bottom of the mast rather than at the top, so that the mast need only be raised a few inches to take out the rotator.

Several types of meters and instruments are available for roof use to aid one man in orienting a television antenna. As a rule these require frequent trips down to the set to check pictures, in order to eliminate ghosts. The meter cannot distinguish between a direct signal and a reflected ghost-producing signal.

In general, no meter can be as good as a pair of experienced eyes at a receiver. Meters should thus be considered only for occasional use, in emergencies, when reorienting an antenna, or when one man of an installation crew is sick.

Customer Instructions. While showing a customer how to adjust his newly installed television receiver, tune to all the stations one by one and point out any ghosts or interference patterns that cannot be improved. Explain how ghosts are produced by reflected signals arriving a bit later than direct signals. Often the reflection occurs off buildings near the transmitter, and nothing can be done about it. If the antenna has been oriented to favor one station at the expense of another, this, too, should be pointed out.

Repairing Television Antennas. When antenna trouble is suspected, make sure the transmission line is not loose or shorted across the terminals at the back of the set. Check also the soldered connections for the short piece of transmission line running from these terminals to the tuning unit inside the set. Jiggle the transmission line to check for an intermittent connection.

If transmission-line connections at the set are good, disconnect the line and try an indoor antenna. This can be a plain or folded dipole made from twin-lead for test purposes, or one of the commercial V-shaped indoor antennas. If better reception is obtained with the temporary indoor antenna, the regular antenna system is definitely at fault. Another way of checking a suspected antenna system is to connect it to a spare or test receiver that is known to be good.

If the antenna system is found to be defective, check the lightning arrester by disconnecting it from the circuit. If this clears the reception, clean the arrester with a damp rag and recheck, or better yet, replace it.

Connections at the antenna itself come next. This usually means ladder work. Check line connections to the antenna for breaks, shorts, or corroded joints. Check the orientation of the antenna by comparison with other antennas in the neighborhood, to see if it is way out of line. Wipe off soot and dirt from all insulating blocks on the antenna.

If the trouble still exists, it is probably in the transmission line. The quickest check for this is to connect in a new length of transmission line temporarily. It is better to replace a bad line than to repair it. There is very little difference between final costs of repair and replacement, and a new line will give much longer service.

QUESTIONS

1. Will the impedance of a folded dipole match the impedance of ordinary twin-lead transmission line?
2. When a reflector is used with a folded dipole, which should face in the direction of the desired stations?
3. When separate antennas are used for low-band and high-band vhf television reception, which band will have the larger antenna?

4. Above what height does a mast usually require guy wires?

5. Can antennas that are built into television-receiver cabinets be counted on for good, reliable reception?

6. Why should antennas be kept away from power lines?

7. Why is it bad practice to mount an antenna mast on a soil pipe projecting above the roof?

8. Examine 25 television antenna installations on private homes in your neighborhood, and answer the following:

a. How many were mounted on chimneys?

b. How many were mounted on the side of the house?

c. How many were mounted directly on the roof of the house?

d. How many had guy wires?

e. How many had separate high-band or uhf antennas?

9. Why is it bad practice to accept help from bystanders when installing an antenna?

10. Why should aluminum or magnesium ladders be lashed to the house in some way whenever possible?

11. Why shouldn't transmission lines be run down the front of a building?

12. Is a lightning arrester needed when using twin-lead transmission line with a roof-top television antenna?

13. Why is it better to replace a broken transmission line instead of repairing it?

14. If an indoor television antenna works better than the customer's outdoor antenna, is there likely to be a defect in the outdoor antenna?

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