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This student instruction manual was developed as a part of "A Study of The Effectiveness of a Military-Type Computer-Based Instructional System When Used in Civilian High School Courses in Electronics and Auto Mechanics." (VT 006 916). The material emphasizes a troubleshooting strategy for repair of equipment based upon a logical and systematic gathering of symptoms, analysis of these, knowledges of pyramidial structure of the equipment design, coupled with a strategy for isolation of the malfunction by levels from major subsystem to section to component, removal and replacement or direct repair of the component, and finally, an operational check to determine that the equipment is performing satisfactorily. The manual includes materials sufficient to train a person with aptitude but no previous electronics training to a level of an outside repairman, and is designed to encompass 12 to 16 weeks depending upon the ages, intelligence, and cultural background of the student. A portable television set is used as the vehicle for the instruction. Workbooks for students and course guides for the instructor are also available. (HC)

Attachment to Final Report for Project No. 5-1332

PRACTICAL ELECTRONICS

SOS

TECHNICAL INSTRUCTION MANUAL

PREPARED FOR

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
U.S. OFFICE OF EDUCATION

GRANT NO. OEG 1-6-000242-0618

BY

SYSTEMS OPERATIONS SUPPORT, INC.

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PREFACE

This "Electronics Methodology" book was written in conformance with some of the selected criteria for "SNAP" type programmed instruction books as developed previously for various military training courses. In conformance with the principle of utilizing the optimum approach in terms of both subject matter and the characteristics of the student body, the reading level, type of language and the format used have been varied between sections of this document. For example, one section on troubleshooting is clearly a scrambled book. Another is very "SNAP"-like. If the text were written for a younger or less mature group, the incremental steps would be smaller, etc.

Application of this text to a high school population introduces a methodology for technical courses which emphasizes a troubleshooting strategy for repair of equipment based upon a logical and systematic gathering of symptoms, analysis of these, knowledge of the pyramidal structure of the equipment design, coupled with a strategy for isolation of the malfunction by levels from major subsystem to section to component, removal and replacement or direct repair of the component, and, finally, an operational check to determine that the equipment is performing satisfactorily. For purposes of illustrating the technique, a Zenith portable TV set has served as the vehicle for description of the system, the circuits and the troubleshooting strategy. The overlays for the "SMART" Trainer for this electronics course have been based upon a view of the overall block diagram

for this set, plus views of four functional subsystem areas of it. This written document is divided into four volumes or sections -- "The TV Story," "Schematic Symbols and Color Codes," "Within-Stage Troubleshooting" and "Resistance Readings; Their Calculation and Interpretation." In addition, there are workbooks for the students and course guides for the instructor. Sufficient materials are available to take a man with aptitude but no previous electronics training through to a level of at least an outside repairman.

Since the backgrounds of the students at the initial participating high schools -- the Murrell Dobbins Technical High School, Philadelphia, Pa. and the Upper Bucks County Technical-Vocational High School, Perkasie, Pa., in most cases include a year of previous training in electronics, some of the course material, such as the "Schematic Symbols and Color Codes" need not be used. For purposes of this experiment, the application of the methodology will take some 60 hours, due to this previous subject matter knowledge. Students in the experimental groups are expected to reach a high level of troubleshooting proficiency based upon this instructional system. If the course were to be given to a completely naive group in electronics, it would encompass some 12 to 16 weeks, depending upon the age, intelligence and cultural background of the students. It would, of course, have to include training in various physical dexterity skills, such as wiring and soldering, which the present student body is presumed to have already had.

The development of this document was performed under sponsorship of the U. S. Office of Education, in conformance with the Vocational Education Act of 1963 (P.L. 88-210, Sec. 4(c) as Project 5-1332 entitled "A Study of the Effectiveness of a Military-type Computer-based Instructional System When Used In Civilian High School Courses in Electronics and Auto-mechanics." The Project Director in the USOE Division of Adult and Vocational Research is Dr. Sidney C. High and the cooperating schools are as cited beforehand.

As Principal Investigator for this Research Project, I would like to thank Messieurs C. D. Fink, R. M. Gebhard, H. B. Rozran and R. C. Trexler and the other contributing members of the SOS staff for their efforts in the production of this document.

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BOOK I

THE TV STORY

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THE TV STORY

A. INTRODUCTION

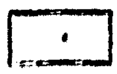
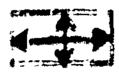
This is a story about how TV's work. You've probably watched TV all your life. We're going to talk about the insides of TV, the "guts" of it. You probably don't know much about that, not many people do. Yet, if you are going to troubleshoot and repair TV sets, you'll have to learn something about how they work. As you read this, you will be asked to fill in some blanks, or to select among some things the best one answer to some questions we will ask you. You should be able to answer the questions with little trouble. If you have trouble, go back and re-read. It might be that you have forgotten. Be sure to write in the answers that you are sure of. If you write them in, it helps to make the facts stick in your mind. OK, let's begin.

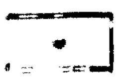
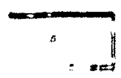
TV's come in all sizes, shapes and colors. Some are portable; some are in combination with stereos; some work off of batteries. We cannot tell you how every TV works. That would take longer than either you or we have to spend. What we will tell you about is how a particular TV works, and ask you to believe that all similar TV's work just about the same way. We are going to be talking about a black and white, tube type, portable television receiver. The circuit functions in this type of TV can be found in other TV's of the same type.

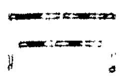
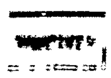
By function, we mean the performance of specific operations, not a mathematical expression like $Y = X_2$. For instance, our larynx or voice box produces the sound which our mouths and lip and tongue

convert to speech. The function of the larynx is to produce the sound. Similarly, two different TV's will have circuits which perform the same function or operation, but will not necessarily have identical parts in them. The circuit arrangements of the parts may be quite different but their functions may be identical. So, when we talk about circuit functions, we will be describing the net effect of the parts which are assembled in the set to produce the desired function.

B. CONTROLS:

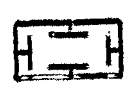
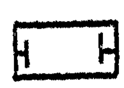
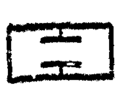
In all modern television sets, the picture is drawn by a pencil point of light. This pencil point beam of light is projected against the face of the picture tube, . It can be deflected (moved) up or down or to the right and left, .

Just as a pencil can be sharpened to make a fine line, so can the beam of light in the picture tube be focused to produce a tiny, fine spot  or a soft, round one .

When the spot is tiny and fine, a sharply-defined, clear-cut, distinct line can be drawn . If the spot gets soft and round, a blurry indistinct line is drawn . In order to make a beam of light pen point sharp or soft, an adjustment called a focus adjustment or control is used.

There are several methods used to focus a picture tube: (1) Electrostatic, which uses an internal grid in the tube called a focus grid. The type of adjustment used in conjunction with this type of focusing is either a focus control or a multi-position terminal strip. This provides a means of placing different voltage potentials on the grid which control the focus; (2) Electromagnetic focus, which

consists of a coil around the neck of the picture tube, thus providing a magnetic field. This magnetic field is varied by an adjustment called a focus control; (3) Permanent magnetic focus -- this is a permanent type magnet around the neck of the picture tube. Its magnetic field is varied by an adjustment screw on the magnet. The type of focus adjustment which we will be concerned with is the multi-position terminal strip type because the Zenith T.V. Set we are using incorporates this type.

Now, in order to deflect (move) this spot of light up or down and right or left on the picture tube, there must be some means to control this: (1) One way is called Electrostatic Deflection and makes use of internal deflection plates in the picture tube. Two sets of plates are used to move the beam in the picture tube. The placement of the plates are in parallel and at right angles to each other in sets of two, as shown here  (Plates). The plates that are at right angles to the other  are the plates used to vary the spot of light from right to left, and the plates that are horizontal  vary the spot of light up and down; (2) the other way of varying the spot and the way we are concerned with, is called Electro-magnetic Deflection. Here, two pairs of coils called the yoke are placed around the neck of the picture tube and these coils control the movements of the spot up or down and left or right. As the name implies, a magnetic field controls the movements. This is the type of deflection we will be using. The two types of deflection, then, are ________________ and ____________________.

Yes, we use electro magnetic in this case.

Again, let us get back to the focusing, if we put a varying current input through these coils, a varying magnetic field will result. This magnetic field will push and pull the spot up or down and left or right. If this magnetic field were to be varied extremely fast in a uniform manner in all directions, an illusion that the whole face of the picture is lighted would occur. This is called a raster. If this spot is not finely focused, the picture tube face appears to be blurry. In other words, we should get a raster which looks like we drew a bunch of orderly lines called scanning lines, .

In order to keep these lines orderly, we are provided with different types of controls. By the way, there is a term used to define this orderly logical fashion which is called "Aspect Ratio;" and it denotes the ratio of the picture width to the picture's height. Now we are concerned with controls; however, these controls are: (1) Vertical Size, usually located in the back of the T.V., which controls the scanning lines in such a way that if an image were on the screen, it would look too tall or too short (an adjustment to correct this condition can be made); (2) Vertical Linearity (this also is in the back of the T.V.) controls the scanning lines in such a way that if the picture were compressed at the top or bottom, this would correct this condition; (3) Vertical Hold (this is in the front of the T.V.) control adjusts the up and down movements, called rolling, so that the picture can be made stationary to the viewer; (4) Horizontal Width (located in the back of some T.V. Sets and eliminated on some others) controls the horizontal dimensions by either squeezing or lengthening the scanning lines.

In the Zenith, a sleeve which moves in and out of the yoke is used to control the width; (5) Horizontal Linearity (located in the back of the T.V.) controls the distortions in the horizontal scanning, and this distortion is depicted by the scanning lines being squeezed more on either side of the picture tube. (There isn't any control like this on the Zenith T.V. being used); (6) The Horizontal Hold (located in the front of the T.V.) adjusts the picture, so that it is stationary and not moving from side to side or appearing like venetian blinds to the viewer; (7) The Brightness (located in front of the T.V.) controls how bright the face of the tube is. In other words, how bright the face of the picture tube is illuminated. It is sometimes called the static condition of the picture tube; (8) The Contrast (located in front of the T.V.) controls the shades of grays in the picture; this is referred to as the dynamic conditions applied to the picture tube; (9) An A.G.C. (Automatic Gain Control) (located in the back of the T.V.) is sometimes incorporated in T.V. Sets to compensate for various signal strengths; that is, if you are in an area where the signal is very strong or weak, the A.G.C. can be decreased or advanced to retard or aid the signal; (10) The Volume Control (located in front of the T.V.) adjusts the loudness of the sound; (11) The Buzz Control (located in the back in some T.V. Sets) is used to reduce intercarrier Buzz and distortion and is used in the T.V. studied here; (12) Another control sometimes used and located on the neck of the Picture Tube is called a Centering Control, and it is a ring with two tabs. The purpose of this control is to center the picture by moving it left or right and up or down; (13) It should be mentioned that the Yoke has another function and that is to control the tilt in the picture,

so if the picture looks like it is going up hill or down hill, the Yoke can eliminate this problem; (14) The Channels are selected by a 13-position switch on the front of the T.V. This controls a coarse tuning of the channels. Another control used in conjunction with the Channel Selector is a control used to align the sound with the picture. This is called a fine tuner.

We won't ask any questions at this time because, in most cases, you are familiar with these controls, and, for the others, we have more explaining to do.

C. SYMPTOMS ANALYSIS

When you turn a set on, you get a picture and sound. If you don't have one or the other, that's a symptom. Symptoms can localize the TV trouble to the "sound" parts or the "picture" parts...they're in separate areas of your TV. When you've used a symptom to localize the trouble, you've made a diagnosis.

This overview of a TV set is given so you will know what symptoms to look for. Sound and picture are pretty obvious...so are the others when you know what to look for.

After you turn the TV on, you tune to a channel. Your TV selects a certain channel (or broadcasting station) out of all those that are broadcasting in your area at the same time. The broadcast SIGNAL contains both picture and sound and something else. We'll get to the something else later. If you're missing both picture and sound, that's a symptom. This SYMPTOM is different from the ones for a

missing picture <u>or</u> for missing sound. This means you can localize the trouble in your set with this SYMPTOM.

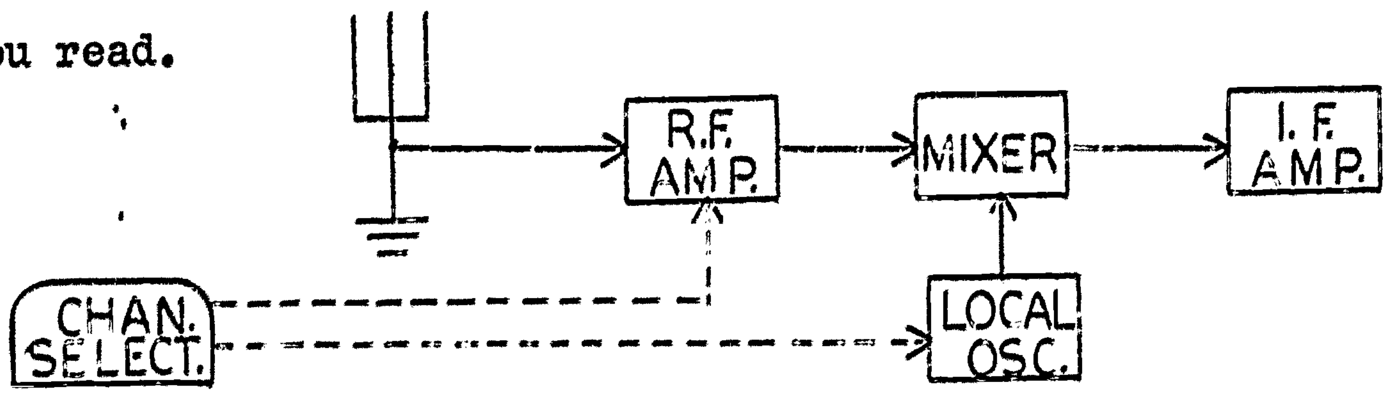
We're going to talk about this area now...it starts with the antenna (often a rabbit ear) that picks up all broadcast signals and goes through the TUNER (selects one station's signal) to the point where the picture part of the signal is separated from the sound part.

Let's say a couple words about the antenna. Rabbit ears (some sets have two; the one you will work with has only one) are OK in cities near the broadcast station. The signal doesn't have to travel far and is strong enough to be picked up by small rabbit ears inside the building. Farther away from the station, outside antennas are needed, and the antenna has to be rotated for best signal. Sometimes reception can be improved by moving rabbit ear antennas around to different locations in the room.

So these are the ways of bringing a broadcast signal up to the strength needed. Once the antenna picks up broadcast signals, they are sent to the TUNER. The tuner chooses the broadcast signal that the channel selector is set to. It amplifies that signal which you want and no other...and that's how it tunes...all the other signals come in to it from the antenna but only one gets amplified enough to be useable in the TV. But this signal needs still more amplification. However, before it is amplified, it's going to have to be cut down in frequency, but it will still contain the original information of the station that sent it. It's going to be brought down to an intermediate frequency (IF) and this IF will have the same

intelligence (information riding on its signal that the RF signal had). And regardless of what its exact RF frequency was (each station has a different RF frequency), it will be beat down to one same IF frequency, but the intelligence will be the intelligence from that RF signal. (We want only one IF because it's cheaper to build an amplifier that has to amplify only one frequency rather than several.)

Here is how the TV set brings any one of several RF frequencies down to one intermediate frequency (IF). Watch this block diagram as you read.



Here are two new circuits, the OSCILLATOR and the MIXER. We talked about the channel selector tuning the RF tuning circuit. Well, it also tunes the OSCILLATOR (that dashed line means a mechanical connection...like a metal shaft going right into the electronic circuit. The solid lines represent an electronic signal...of any type. The arrow shows the direction of flow.)

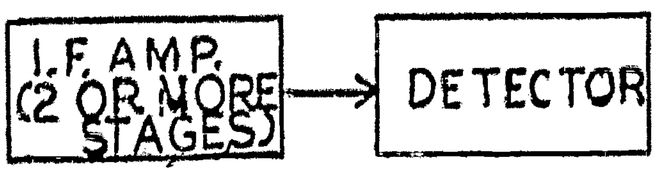
When the RF is mixed with the oscillator signal, you get a signal which is the difference between them. If the RF was 1000 (Note: these numbers are only for easy arithmetic since the actual frequencies are much higher) and it is mixed with an oscillator signal of 600, the difference is 400 (IF). Now you can see how

we can always get the same IF. We control both the RF and the oscillator with the same channel selector. When the channel selector is set on number 5 that tunes in an RF of 1020, say. So, we have the same channel selector shaft set the oscillator for 620 and we get _____ as the difference. All the channels are set in a similar way -- to get the same IF for any RF. Now we amplify this IF with an amplifier designed for that one frequency. OK?

Now we've gone from Antenna to IF amplifier. This is the area of the set which contains the malfunctioning part when you get the symptom that both sound and picture are missing. Get it? After the sound and picture separate, they go their separate ways. If you get a symptom that the sound is bad but the picture good, the malfunction is in the sound circuits, not here. If both sound and picture are missing, look here for the trouble.

Now let's separate out the sound, picture and that something else (which is the synchronizing signal for the picture).

After two or more stages (tubes) of IF amplification, the signal is sent to the detector.



The detector detects the video, sound and something else from the IF which has been riding on the IF signal, and throws away the IF. The RF and IF are just carriers to bring the other signals through the air from the station and then to the detector. They've done their job now, so we don't need them anymore.

The video amplifier is a combination amplifier of video and rejector of sound and the something else. The video is sent directly to the picture tube from the video amplifier. The sound is shunted off to the sound circuits, and from there to the loud-speaker. And that leaves us with the "something else" which is called the synchronizing pulse or sync signal.

This is the one you know least about. You can't see it or hear it on the T.V. set. But you can see what happens when it is malfunctioning (another symptom). The picture will twist, rock and roll when the malfunction is in the synchronizing circuits. The synchronizing signal is supposed to keep the picture straight, and when it doesn't, you'll know it. There are several synchronization symptoms. Twist is one; roll is another and each can help you diagnose the trouble to a particular area (a group of parts attached to the tube). There are two kinds of sync (synchronizing) pulses: Horizontal and Vertical. The horizontal pulses synchronize the sweep of the picture across the picture tube. The vertical pulses are used to synchronize the up and down action of the picture.

Synchronize means "make things work together". The things being made to work together in this case are the picture on your TV and the picture coming from the TV camera in the broadcasting studio.

The picture you see is actually the path of a spot of light that starts at the upper left hand corner of the screen and moves in a slightly slanted straight line across to the right, and then

jumps back to a point slightly below where it started and traces another slightly slanted path. It keeps doing this until the whole face of the tube has been covered. The light moves so fast that you can't see it move. The horizontal circuits control how fast and how straight the path is from left to right. The vertical circuits control how fast the spot moves toward the bottom. Of course the spot is changing its intensity as it moves, according to the strength of the video.

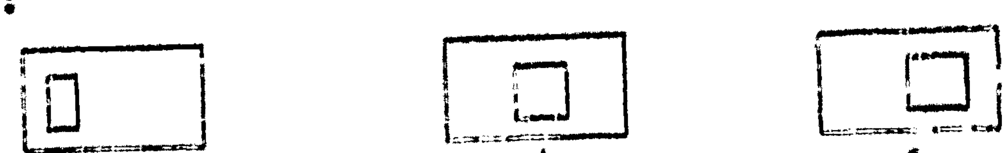
The horizontal oscillator produces the signal which moves the spot from left to right. Without a vertical oscillator, the picture would be reduced to one straight line across the middle of the picture tube. The vertical oscillator produces the signal which moves the spot from top to bottom. Without the horizontal oscillator, the picture would be one straight vertical line in the center of the picture tube face.

Now, the T.V. receiver oscillators do this regardless of whether a picture is sent or not. When you tune in a "blank" channel, you see the RASTER produced by this moving spot controlled by horizontal and vertical oscillators. To put a picture on, the horizontal and vertical oscillators have to be synchronized or locked into the rate produced by the TV station. So, the sync signals obtained from the transmitted TV signals are used to control the frequency of the horizontal and vertical oscillators. In American TV receivers, there are 525 slanted lines on the picture tube. When TV was still under development, engineers found that if all the lines were placed on the screen one after the other,

there was a disagreeable flicker noticeable. They found they could eliminate this flicker by "interlacing" the lines. That is, instead of line "two" following line "one," they made line "three" follow line "one." When all the odd-numbered lines were on (called the odd field) they started the even field with line "two," then "four," etc. They wound up with two fields, odd and even, interlaced like your fingers would be if you clasped your hands together. Again, all this happens so fast you can't see the separate fields, but they are there.

If the vertical sync pulses should fail to control the vertical oscillator, the result would be a "rolling" of the picture, vertically. If the horizontal circuits failed to sync, the picture would appear to be a series of dark bands, diagonally across the screen, either from left to right or right to left.

The picture might be synchronized with the TV station in vertical and horizontal, but it may look strangely distorted. The distortion could be due to a misadjustment of linearity controls. Linearity is keeping known proportions constant wherever the picture may be on the screen. Let's see some examples. Fig. 1 shows a square located in the center of the picture tube. If we could see the same square on the left and right, they would look like this:



a b c

Fig. 1

Notice that it seems to get thin on the left and fat on the right, but that the height stays the same. This is a case of horizontal

non-linearity, and is caused by the spot moving faster at the right hand side of the screen than at the left.

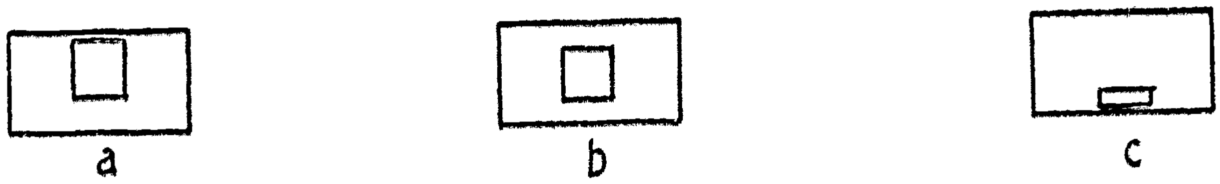


Fig. 2

Figure 2 shows a case of vertical non-linearity. The square looks tall in "a" but short in "c." This is caused by the spot moving more rapidly downward at the top than at the bottom, crowding more lines together at the bottom and spreading them out at the top. There are two controls that work together in adjusting the vertical presentation -- the vertical height and vertical linearity. (This affects the top of the picture most.) The height control is for changing the whole picture displaced, as in Fig. 2. But the bottom of the picture is usually affected more than the top.

Many sets are so badly adjusted in height, that tops of heads are cut off or feet are missing. Usually adjusting height will require an adjustment of vertical linearity and vice versa. It's important to use a test pattern to make these adjustments because it is standard and does not require the judgment as to goodness of proportion you would have to use otherwise.

Some sets have both horizontal linearity and width controls. These serve the same function but are not so closely related as are the vertical.

Each time a complete field is placed on the screen, the spot puts on 262.5 lines. So each even field has 262.5 lines and each

odd field has the remaining 262.5 lines. There are thirty even and thirty odd fields each second, interlaced. It takes 1/60th of a second to put one field on the screen. Therefore, in one second, the spot will run through 60 x 262.5 = 15,750 lines.

You have seen that the sync signals are needed to get the picture on the tube at the right time and place. But there are more than sweep voltages and video needed. To see what else is needed, we're going to consider the picture tube itself. The spot of light that moves across the tube face is actually caused by a stream of electrons striking a phosphorescent surface on the inside of the tube. You can't see the electrons themselves, but when enough of them strike this surface at a high enough speed, the surface produces light. The electrons themselves are boiled off of a piece of metal inside the neck of the tube called a cathode. The cathode is heated by a heater carrying an electric current. These electrons would just hang around the cathode if it weren't for some other things in the tube. One of these is the first anode located just ahead of the cathode toward the tube face. This anode is connected to a positive voltage and attracts the negative electrons toward it. It also tends to concentrate the electrons into a beam. But the beam might not have enough push to get to the phosphor if it weren't for the second anode. This is a conductive coating on the inner surface of the sides of the tube. It's connected to an extremely high voltage, between 12,000 and 20,000 volts, for example, and is high enough to pull the beam to the phosphor, and high enough to put you on the floor or worse.

DANGER, you can't see the voltage, even though it's there. The beam striking the phosphor produces a bright spot. But in order to produce a picture, the spot must vary in shades of gray. To get this, another element is inserted between the first anode and the cathode. This is the control grid. It has a negative voltage on it. By changing the amount of negative voltage with respect to the cathode, the number and speed of the electrons in the beam can be changed. Since the spot brightness will vary with number and speed of electrons striking the phosphor, it is clear that the grid can be used to produce the grays that are needed for the picture. The cathode can also be used for this purpose, and many TV's are so designed that the video is placed on the cathode, rather than on the grid. This kind of control just changes the number of electrons "boiled off" in each split second of time.

We have noted that the spot must be moved from left to right and top to bottom, and that the horizontal and vertical circuits are responsible for doing it. These circuits are connected to coils, two sets of wire surrounding the neck of the TV tube. Together, they are called the YOKE. When a varying current flows through the horizontal deflection coil in the yoke, a varying magnetic field builds up which changes the path of the electron beam within the tube and the spot moves from the middle of the tube in a horizontal direction. The path that the spot follows depends upon the strength and direction of the magnetic field, and, therefore, the current in the coil. The vertical circuit works the same way

causing another varying magnetic field to move the spot in a vertical direction, according to the strength and direction of the varying current in the vertical coil.

The horizontal and vertical circuits control the movement of the spot through the magnetic fields set up by the yoke.

You might ask where the high voltage comes from which is needed to pull the beam to the phosphor. It comes from the horizontal circuits almost as a by-product.

The horizontal output stage is connected to the horizontal deflection coils of the yoke by means of a transformer. One end of this transformer is connected to a high voltage rectifier. When the current in the horizontal deflection coil stops, the magnetic field it produced collapses and sends a high (about 2000 volt) voltage pulse back to the transformer. This is stepped up because of the high number of turns in the primary and is converted to direct current by the high voltage rectifier. The resulting high voltage is then applied to the picture tube.

Another effect of the collapsing field is a series of oscillations in voltage. These oscillations would get into the current producing the horizontal sweep, and the result would be vertical bars at the left side of the picture. To prevent this from happening, a circuit called a damper is used. The damper removes all but the first of these oscillations. It also provides a higher source of voltage for use in other parts of the receiver, called a "B+ boost."

You will recall we said that the signal strength received at the location of the receiver from different stations depends upon distance from station and direction of antenna. It would be inconvenient if you had to adjust the volume and contrast or brightness controls each time you changed stations because one station was weaker than another. So automatic gain control circuits (AGC) were developed. This circuit senses the strength of the signal and automatically adjusts the amount of amplification given to it as it passes through the tuner and IF amplifier stages.

The AGC receives its signal from the video detector stage. If this signal is very strong, it sends a voltage to the tuner and IF amplifier which reduces the strength of the signal received. If the signal is weak, it sends a voltage back which increases the strength. The net effect is a rather constant strength of detected video. Keyed AGC makes use of the horizontal sync pulses, in that it is only during the interval of the horizontal sync pulses that AGC samples are taken from the video signal. Therefore, noise pulses occurring any other time cannot contribute to AGC action and the operation is more satisfactory.

Remember that the TV signal contains sound, sync and picture portions. We now have to describe how the sound gets to the speaker. Remember the sound follows the same path as the picture, until it gets to the output of the video amp. Here it is prevented from getting into the TV picture and is sent to the sound limiter. The sound portion of the TV signal is an FM signal. That is, the sound intensity and frequency are all carried by changes in fre-

quency, rather than in amplitude. The picture signal consists of all amplitude changes.

The sound circuits convert the FM signal into an audio signal for the speaker to reproduce as sound. Since the sound signal may have gotten some amplitude variations in it, the first thing to do is to eliminate them. This is done in the sound limiter. The next step is to convert the FM signal into an audio signal. This is done in the sound discriminator. The resulting output is a weak audio signal, which is then amplified in the sound output stage, passed through a volume control and fed to a speaker for reproduction.

All voltages needed by the receiver for its operation are supplied by the line cord, plugged into the wall outlet. Some sets use transformers and vacuum tube rectifiers to produce the voltages from the AC line. Other sets do not. These use semi-conductor diodes for rectification. All sets require some amount of filtering of the power supply ripple left in the voltage after it has been changed to DC. Filaments may be supplied by transformer windings, and when they are, they are connected in parallel. When the transformer is missing, the filaments are connected in series. In this case, a failure of one filament disconnects all filaments from the source.

Now let's summarize:

The antenna makes it possible to receive stations better than without it. The tuner selects the channel to watch, amplifies the selected TV signal and converts it to an IF signal for use by the

IF circuits. The IF now contains the same information it had when it was received, but at the new frequency. The IF circuits amplify the signal and pass it to the video detector which removes the IF frequency, leaving only the information that was riding on the IF signals. The video is amplified and passed to the picture tube. The sound is passed to the sound circuits, and the sync pulses are sent to the sync separator. Horizontal and vertical sync pulses are separated out to lock in the oscillators producing the vertical and horizontal deflection voltages. These are applied to the deflection coils, which drive the video horizontally and vertically. The horizontal circuits also produce the high voltage needed by the picture tube to produce the spot. The AGC circuits compensate automatically for differences in received signal strength, and the sound circuit converts the FM sound signal into an amplified audio signal for the loudspeaker. Power is obtained from AC line cord and is converted to DC for use by the receiver. Now let's see what happens after this in the next section.

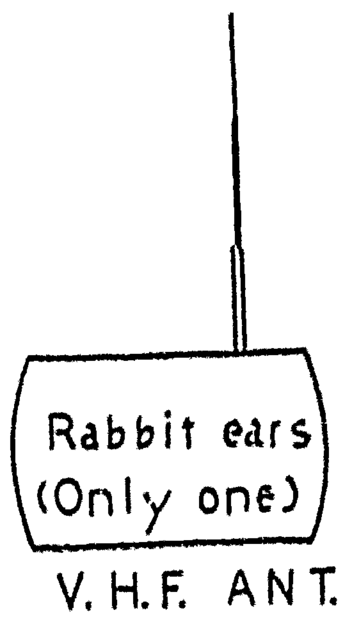
D. THE VISUAL STORY

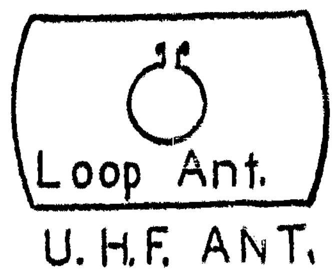
You will recall that during the normal broadcast day, TV stations in any given area are transmitting at the same time. A natural question to ask is how can we receive any signal at all? The answer follows:

1. Antenna. The antenna receives the television signal and passes it to the tuner. The Zenith TV has two antennas.

The rabbit ears (some sets have two telescoping sections like this (V) and that is why they were called rabbit ears. This set has only one.) are used for channels 2 - 13 (VHF) which stands for very high frequency. The loop is used for channels 14 - 83 (UHF which means ultra high frequency and is higher in frequency than very high frequency). The quality of the reception often depends upon the placement of the antenna.

Q. By moving the antenna into various positions, the quality of the picture can be improved. True or false. (When you have answered, turn to the next page.)





If you said true, you are right.

If you said false, re-read the last paragraph.

When the VHF channel selector (that's sometimes called the channel switch, or tuning control) is tuned to channels 2 - 13, the UHF antenna will have no effect on the picture. When the channel selector is placed at the UHF position, the rabbit ears will have no effect on the picture. Why should that be so? Think about this question for a minute; then look at the answer below.

The channel selector switch disconnects the rabbit ears when tuned to UHF and disconnects the loop antenna (and UHF tuner about which you'll hear more later) when tuned to channels 2 - 13.

Some TV's receive UHF and VHF on the same antenna. An external antenna mounted on the roof of the house can be used for improved reception in locations where reception would be poor for inside antenna.

Q. Such locations are sometimes called:

1. Binge
2. Fringe
3. Hinge

1. No, a binge is slang for too much of something.
2. Right, as the word suggests, it is at the edge or outer limits of the TV signal.
3. No, a hinge is used for hanging doors on cabinets.

2. UHF Tuner. When the VHF channel switch is tuned to UHF, the UHF tuner is connected to the VHF RF amplifier. At the same time, the VHF Antenna is disconnected from the VHF RF Amplifier.

Signals from channels 14 - 83 are then received from the UHF antenna. You then use the UHF channel selector to tune one of the UHF signals in. This signal is amplified and converted into a lower frequency signal. It is then fed into the VHF RF amplifier, at the connection where channel one would be connected. No stations broadcast on VHF channel 1. This conversion to a lower frequency is done the same way it is done in converting the VHF RF frequency to a single IF frequency. (Remember your earlier lesson on this?) Don't confuse the two frequency conversions. We'll talk about the conversion to IF a little later.

Now some questions. Circle the right answer.

1. The rabbit ear(s) are used for VHF, UHF, in the Zenith TV N-6 series used.
2. The VHF antenna is connected to the VHF RF amplifier when the VHF channel switch is tuned to UHF, channel 2. (Select one)
3. The UHF channel selector switch can only select a channel when the VHF channel selector is in the UHF position. True, False
4. All UHF channels are converted to a single VHF frequency. T, F
5. UHF is higher than VHF. True, False

Go to the next page for answers.

Answers:

1. VHF
2. Channel 2
3. True
4. True
5. True

If you missed any of these questions, re-read the material and get it straight in your head before you go on.

We left the signal at the VHF RF Amplifier -- regardless of whether it came from VHF or UHF, that's where it stopped, right? Right. OK.

The VHF RF amplifier makes the signal bigger; that is, it amplifies it. The amount of amplification carried out here varies somewhat. We want a certain signal strength out of this amplifier, but the signal strength depends on such things as antenna positioning, distance from the station, etc. So, weak signals are amplified more than strong signals to bring all signals up to the same strength. The amount of amplification is controlled by the AGC or Automatic Gain Control circuits. We'll talk about this AGC circuit later. For now, remember that the RF amplifier is one circuit where the amount of gain or amplification is controlled.

Do you remember your lesson on operational controls and adjustments? Remember when the picture got too dark -- it was overloaded when the instructor misadjusted the AGC. When your set is too close to the broadcast station, you have to reduce the signal into this amplifier by putting H pads next to the antenna.

OK, that's the story on the VHF RF amplifier.

Circle these statements true or false:

1. The RF amplifier makes the signal bigger when it is smaller than the desired output strength. True or False.
2. The RF amplifier is one of the places where the AGC controls amplification. True or False.

Answers:

1. True
2. True

Did you get these right? Don't go on if you missed either one. Re-read the material and get it straight before you try the next step.

3. Mixer. The signal from the RF amplifier is sent to the MIXER. The mixer receives the amplified selected TV signal from the VHF RF amplifier and another signal from the VHF oscillator. The mixer combines these signals to produce an IF (Intermediate Frequency) signal which is sent to the Video IF stages. The actual frequency of the TV signal being sent to the Mixer from the VHF RF Amplifier depends upon the channel selected (UHF is connected in the position where channel 1 would be). The video IF stages are tuned to only one frequency (45.75MC). In order to amplify all channels equally well, we must have a constant frequency coming out of the mixer. This is done by varying the frequency of the VHF Oscillator. Each time a different channel is selected, the VHF Oscillator's frequency is also changed, so that when its signal is mixed with the TV's signal, the result is an IF with the same frequency, which is the difference between the TV frequency and the oscillator frequency. That is, with an RF of 54MC, the oscillator would run at 99.75MC to produce a difference of 99.75-54 equals 45.75MC. IF.

Here are some more questions:

1. You need a constant IF out of the MIXER because the IF Amp amplifies only one frequency. True or False.
2. The MIXER mixes RF and IF signals. True or False.
3. If the RF Amplifier frequency is 54MC and the oscillator frequency is 109.75 megacycles, the IF frequency from the MIXER is ________.
4. Is the frequency in the above example the correct IF frequency for TV sets? Yes or No.
5. The IF is the same, regardless of whether you are tuned to UHF or VHF. True or False.

Answers:

1. True (but actually the IF amp more than a single frequency)
2. False
3. 55.75MC
4. No
5. True

If you missed any, check yourself out before going on. Notice that the last question goes back to the earlier subject of how UHF is converted to a VHF (channel 1) frequency by the same process of mixing frequencies as is done in the MIXER, but it is not done in <u>this</u> MIXER.

4. <u>Video IF Amplifier</u>. The IF signal from the MIXER is sent to the VIDEO IF AMPLIFIER. Even though it is called VIDEO IF, the sound and sync signals are also present.

The VIDEO IF AMPLIFIER amplifies these signals. A lot of amplification is needed so there are three stages of IF amplification. (Other sets may have more or less.) Each stage makes the signal bigger than the last. Also there is AGC action here, just as there was in the RF amplifier. It is needed here because the amount of gain (amplification) is not controlled well enough in the RF amplifier.

Questions:

1. VIDEO IF AMPLIFIER stages amplifies only video. True or False.
2. Only one VIDEO IF carrier frequency is amplified in the VIDEO IF AMPLIFIER. True or False.
3. All TV sets have three stages of VIDEO IF amplification. True or False.
4. VIDEO IF AMPLIFIER stages amplify UHF more than VHF because UHF has a higher frequency. True or False.
5. AGC action takes place in the RF amplifier and IF Amplifier. True or False.

Answers:

1. False
2. True
3. False
4. False
5. True

Get them all right? Good. If not, read the material until you do. Can you answer all questions asked so far correctly? Be confident that you can before going on. Then, go man, go!

5. Video Detector. The VIDEO IF AMPLIFIER sends the amplified IF signal to the VIDEO DETECTOR. The VIDEO DETECTOR removes the IF from the rest of the signal (which contains the video, sound and sync signals). Here again those three signals are together, even though this is called the VIDEO DETECTOR. The output of the VIDEO DETECTOR is applied to two places:

1. Video amplifier
2. AGC - Sync clipper

This input to the AGC - sync clipper -- helps to eliminate any noise riding on the video signal that might cause distortion in the picture. If this noise were left on the signal, it would cause the picture to jump, roll and tear. The video amp inputs include sound, video and sync signals.

Questions:

1. Can you answer all previous questions correctly? Yes or No.
2. Video, sound and sync signals go through the VIDEO DETECTOR. True or False.
3. The output of the VIDEO DETECTOR is IF (45.75 megacycles) True or False.
4. The noise would cause the picture to be very sharp if left on the signal. True or False.

Go to the next page after you have made your answers.

Answers:

1. Yes
2. True
3. False, The IF is removed.
4. False, It would cause it to jump and roll and tear.

Could you answer the first question with a yes? Be sure of yourself before you go on. Did you have any trouble? Re-read the material if you missed any of the questions and don't understand the explanation given after the answer.

6. Video Amplifier. The detected video signal is sent to the VIDEO AMPLIFIER. Here the signal is amplified, and the sound, picture and sync signals are separated. The picture signal is sent through the CONTRAST control to the picture tube. The sound signal is sent to the SOUND LIMITER, and the sync. signal is applied to two places: (1) AGC Input and (2) The sync separator input.(All of these are parts of the sync clipper tube.)

We won't ask any questions here, so long as you understand that the sound, picture and sync signals are separated here and sent to three different places.

7. AGC. The Automatic Gain Control receives its signal from the VIDEO AMP. It is this input to the AGC which the AGC samples to see if the amount of gain should be increased or decreased in the earlier stages of amplification which it controls. This process of taking a signal sample and using it to control amplification

earlier in the signal path is called feedback. This signal represents the average signal strength for the channel and the location of the set. As the signal changes in value, the AGC produces a voltage which is fed to the IF and RF amplifiers in order to maintain a constant average detected signal. The AGC samples the video at a specific time. That specific time is the time of the horizontal pulse, one of the two sync signals. Without AGC, you would have wide variations in picture quality as you change from channel to channel, or as the atmospheric conditions changed. The AGC automatically solves the problem. In some TV's, the AGC voltage is sampled at the video detector stages and fed back to the RF and IF stages.

The variations in amplitude of the signal to the picture tube cause the variations from black to white of the spot (called picture detail) appearing on the picture tube. Varying the CONTRAST control produces greater or less difference in the shades of gray possible in the picture. Varying BRIGHTNESS control produces changes in the intensity of the picture and is useful to correct for varying ambient (surrounding) viewing conditions. Remember, adjustment of one makes it necessary to re-adjust the other usually. The BRIGHTNESS control makes the spot brighter and is connected directly to the picture tube at the same place the picture signal comes into the tube.

Another control voltage coming to the picture tube is an internal focus adjustment which is factory adjusted. The "adjustment" is

done by selecting one of three voltage taps. Like focusing a camera, you can make the spot sharper with this adjustment, but you would not normally do anything about this, since the factory has already selected the best tap for the particular receiver. Other manufacturers use different circuits to accomplish the same function.

This completes the signals and control concerned with putting the spot of light of varying brightness onto the picture tube, so let's ask some questions:

1. The spot of light can get brighter when:
    a. Brightness control is moved.
    b. Signal strength from video amplifier changes.
    c. Both (a) and (b).
2. The FOCUS control is factory adjusted. True or False.
3. The CONTRAST control changes the shades of gray. True or False.
4. A faulty CONTRAST control could keep the spot from getting on the picture tube. True or False.
5. The AGC controls the amount of amplifications in the VIDEO DETECTOR. True or False.

Answers:

1. c
2. True
3. True
4. True. The signal from the video amplifier goes through the CONTRAST control on the way to the picture tube. If the control is

faulty, it could stop the signal from getting through; however, it doesn't always eliminate the brightness from the screen of the tube.

5. False. In some TV's, it is sample from the detector.

8. Sync Signal Flow. Now let's go back to the VIDEO AMPLIFIER. We've followed the picture (video) signal through the VIDEO AMPLIFIER to the picture tube and we've finished with it. We'll take up the sound later -- and it's pretty simple. But now we'll talk about how the spot of light is moved around on the picture tube in both the horizontal and vertical directions! These are control signals which synchronize the movement of the spot of light to a spot of light moving in the camera in the broadcast station. Get that? There is a camera in the broadcast station; you've probably seen them on some TV shows. Those cameras break up the picture they see into a moving spot of light of varying brightness. As that spot moves, so we want the spot to move on our TV picture tube. That's what the sync signals are for. Now let's see where we get the sync signal.

The signal, AGC and sync, which is taken from the VIDEO AMP, as you will remember, goes to the same tube, including SYNC CLIPPER and AGC. In this set, then, the AGC and SYNC CLIPPER are in the same tube. Each signal is put on a control grid, one to each half of this tube; both the AGC and the SYNC CLIPPER have separate input grids. Remember this signal includes the sound, picture and sync signal. The SYNC CLIPPER side of the tube clips off everything

but the sync signal. This signal contains both horizontal and vertical sync signals. (Notice how we can talk about a signal one time and later find out it is composed of more than one signal.) Now this sync clipper also splits off the vertical sync signal and sends it to the VERTICAL OSCILLATOR and sends the other sync signal to the HORIZONTAL AFC (Automatic Frequency Control).

If you've got all this, try to do these questions before we follow the vertical and horizontal sync signals to their destinations.

Questions: Answer True or False.

1. The AGC separates the horizontal and vertical sync signals.
2. The SYNC CLIPPER sends Video to the VIDEO AMPLIFIER.
3. The SYNC CLIPPER sends vertical pulses to the VERTICAL OSCILLATOR.
4. The AGC receives Video and Sync pulse signals only during the time of the horizontal pulses.
5. TV cameras are in TV stations.
6. The brightness of the spot of light on the picture tube is controlled by the horizontal sync pulse.
7. There is no video in the horizontal pulses sent to the HORIZONTAL AFC.
8. Horizontal and Vertical Sync pulses are used to make the spot of light move on the picture tube exactly the same way the spot moves on the TV camera at the station.

If you had trouble with these questions, re-read the material before you look at the answers. Then turn the page for the correct answers.

Answers:

1. False
2. False
3. True
4. False, it receives them all the time, but the AGC action takes place only during the horizontal pulse.
5. True
6. False
7. True, remember video is removed by the SYNC CLIPPER.
8. True

We're getting close to seeing how the whole TV works now. Before you go on, make sure you have everything straight, so you aren't carrying any misconceptions into this final phase. Be sure; then go on.

9. Deflection Circuits.

9.1 VERTICAL OSCILLATOR

OK. Let's take the vertical signal out of the SYNC CLIPPER. We said it went to the VERTICAL OSCILLATOR. It does, and that's what we want to talk about now. The signal from the SYNC CLIPPER causes the VERTICAL OSCILLATOR to run at the frequency of the vertical sync signal, and that is the rate the TV camera is running. If it were not for this vertical sync signal, the VERTICAL OSCILLATOR would run at a frequency lower than the frequency of the vertical sync signal. The vertical sync frequency is 60 cps. This means the VERTICAL OSCILLATOR will run at 60 cycles per second

when there is a vertical sync signal applied to it. What do you think the vertical OSCILLATOR would do if you were tuned to a channel which is not receiving a broadcast signal? Would it run at its own rate? Yes, it would. Its rate is slightly less than 60 cycles per second. But it runs, regardless of whether a sync signal is applied or not. That's important.

Mark the following questions True or False:

1. The VERTICAL OSCILLATOR runs only when the vertical sync signal is applied to it.
2. The VERTICAL OSCILLATOR runs at the rate of the sync signal, when the sync signal is applied to it.
3. The vertical sync signal runs at the rate of the TV camera's vertical signal.
4. The frequency of the VERTICAL OSCILLATOR is less than that of the vertical sync pulse, when there is no vertical sync pulse applied.
5. The frequency of the vertical sync pulse is 600 cycles per second.

Turn the page for the answers.

Answers:

1. False
2. True
3. True
4. True
5. False

Now if you're all straight on these questions, we'll take up an adjustment that controls the frequency of the VERTICAL OSCILLATOR.

It is called the VERTICAL HOLD control. You've worked with this in the adjustment lesson plan and you'll remember that you can change it so that the picture rolls in either direction.

This control can change the natural frequency of the VERTICAL OSCILLATOR and is normally adjusted, so that the vertical sync signal can lock the frequency into its own frequency. This just means that the natural frequency of the vertical oscillator has to be fairly close to 60 cps (the vertical sync frequency) in order for the Vertical sync signal to control it.

Now, here's a thinking man's question: When you move the VERTICAL HOLD control one way, then the other, the picture rolls in one direction and then the other, but through a certain range of control turning, the picture stays steady. Why do you suppose that is?

9.2 VERTICAL SIZE control

Remember, the VERTICAL SIZE control can change the height of the picture on the picture tube. In addition, it can shrink the picture at the top and stretch it out at the bottom. Also remember that the distortion is greater at the bottom when this control is moved. This size control causes its effects by changing the amplitude of the output from the VERTICAL OSCILLATOR (not the frequency, but the amplitude). Increasing the amplitude of the VERTICAL OSCILLATOR output signal increases the height of the picture, but, unfortunately, this causes the distortion you get at bottom and top. You have to use the vertical linearity control to correct this distortion. But the VERTICAL LINEARITY control affects the signal at the next stage we will be talking about... the VERTICAL OUTPUT stage.

9.3 VERTICAL OUTPUT

The VERTICAL OUTPUT receives its signal from the VERTICAL OSCILLATOR and amplifies it. The VERTICAL LINEARITY control makes the amplification linear. If this control is out of adjustment, the top of the picture looks distorted. It is used in combination with the VERTICAL SIZE control to get a picture of the right height which is also undistorted at top and bottom.

Here are some questions:

1. The VERTICAL SIZE control and VERTICAL LINEARITY control tend to compensate for each other. True or False.
2. The VERTICAL LINEARITY control adjusts VERTICAL OSCILLATOR. T or F
3. The VERTICAL LINEARITY control mostly affects the <u>bottom</u>, <u>top</u> of the picture. (pick one)

Turn the page for answers.

Answers:

1. True
2. False
3. Top

OK? Let's push on to the end of the line for vertical pulses.

9.4 VERTICAL DEFLECTION COILS

The output of the VERTICAL OUTPUT stage is sent to the VERTICAL DEFLECTION COILS on the YOKE on the neck of the picture tube, to move the spot of light in the vertical (up-down) direction. It should move the spot, by electromagnetic action, down the tube at a steady rate. When it gets to the bottom, it should snap back. It moves down sixty times a second because that's the frequency of the vertical sync pulse. When there is no station tuned in, it moves down slightly less of ten because it operates at the natural frequency of the VERTICAL OSCILLATOR. This distance it moves is controlled by the SIZE control, and the spot will move at a steady rate each time it goes down, if the linearity control is properly adjusted. There is just one more thing to say about the vertical pulse. It concerns the snap back of the spot from the bottom to the top of the picture. We want the set to be "blanked out" during this time, so that the spot is not seen going back.

9.5 BLANKING

The same old vertical sync pulse (from the sync clipper) is used to "blank out" the set. For blanking, it goes

from the SYNC CLIPPER directly to a grid in the picture tube that does the blanking. It works so that this grid stops the spot of light during the time the spot is going back.

Let's have a few more questions, now:

1. A YOKE is
   a. Something funny.
   b. The yellow thing in an egg.
   c. A bunch of coils hanging around the neck of a picture tube.
2. The VERTICAL DEFLECTION COIL is separate from the HORIZONTAL DEFLECTION COIL in the YOKE. True or False.
3. The spot of light moves down the picture tube regardless of whether the sync pulse is present or not. True or False.
4. If the sync pulse is not present, any picture you have will roll. True or False.
5. The blanking pulse is applied to the YOKE. True or False.
6. The blanking pulse comes from the VERTICAL OSCILLATOR. True or False.

Turn the page for your answers.

Answers:

1. That question was a "yoke."
2. True
3. True
4. True
5. False
6. False

If you got all the questions right, you're ready for the horizontal--that's moving the spot of light across the picture tube from left to right.

We were just back at the SYNC CLIPPER for a blanking pulse. You remember that that is where the vertical pulse was separated. Now we're going to talk about what's left.

9.6 HORIZONTAL AFC

The other pulses from the SYNC CLIPPER are applied to the HORIZONTAL AFC (Automatic Frequency Control). This AFC is one of the circuits which controls the frequency of the HORIZONTAL OSCILLATOR. This oscillator is controlled indirectly, rather than directly, as the VERTICAL OSCILLATOR was. (Early TV sets had direct control in the Horizontal, but it was found that unwanted noise would accidentally trigger the horizontal oscillator, in addition to the sync pulse doing it, and produce a bad picture. So newer sets have this indirect control.)

We're going to talk about this indirect control now. This AFC is part of a feedback loop, just like the AGC was. In the AFC circuit, the horizontal sync signal from the SYNC CLIPPER is compared to the signal being produced by the HORIZONTAL OSCILLATOR. The AFC produces a voltage signal as the result of this comparison. The size of the signal produced is proportional to the amount of the difference between the sync signal frequency and the HORIZONTAL OSCILLATOR frequency. This voltage from the AFC is fed to the HORIZONTAL CONTROL circuit. The HORIZONTAL CONTROL amplifies the voltage and passes it to the HORIZONTAL OSCILLATOR. The frequency of the HORIZONTAL OSCILLATOR is controlled by this voltage. The HORIZONTAL OSCILLATOR will run at its own frequency when the sync signal is not controlling it.

9.7 HORIZONTAL HOLD CONTROL

There is a HORIZONTAL HOLD CONTROL which varies the frequency of the HORIZONTAL OSCILLATOR, so that it stays within range of the synchronizing control circuits. When it is misadjusted, the picture will twist because it is not synchronized to the frequency of the horizontal signal coming from the broadcast station.

9.8 HORIZONTAL OUTPUT

The signal from the HORIZONTAL OSCILLATOR goes to the HORIZONTAL OUTPUT stage, where it is amplified. From the HORIZONTAL OUTPUT, it goes five places. One of these is the feedback to the AFC we've already talked about.

The second is the AGC. The signal out of the HORIZONTAL OUTPUT goes to the AGC circuit. This is the AGC, not the AFC, we're talking about now. It is this signal that tells the AGC circuit "now is the time to sample the video". Remember the AGC samples only during the Horizontal sync pulse, and this signal tells the AGC when that time is.

Would you like some questions now? No? OK, we'll go on.

The third place a signal from the HORIZONTAL OUTPUT goes is to the HORIZONTAL DEFLECTION COIL in the YOKE, but it goes through the horizontal sweep transformer, sometimes called the flyback transformer. At the deflection coil, it makes the spot go back and forth 262.5 times during the time it takes the spot to get from top to bottom once. That spot is painting, just like lines in a book.

The fourth place the signal from the HORIZONTAL OUTPUT goes is the HI VOLTAGE RECTIFIER. Here the horizontal pulse is turned into the very high voltage needed for the picture tube. Watch out! That's 13.5 kilovolts in the set you have. Here's an interesting point: This rectifier uses the HORIZONTAL DEFLECTION COIL to help produce the high voltage!

The fifth place is the DAMPER. This circuit produces a fairly high "B plus boosted voltage for use in several stages of the set, including the HORIZONTAL OUTPUT tube itself.

Now we really must have some questions because you've gone through the whole process for putting a picture on the tube.

1. The HORIZONTAL AFC compensates automatically for changes in received signal strength. True or False.
2. The HORIZONTAL OSCILLATOR runs at 60 cps. True or False.
3. The output of the HORIZONTAL OUTPUT will produce 262.5 lines each time the VERTICAL OSCILLATOR produces a signal that sends the spot down the picture tube once.
4. The H.V RECTIFIER produces a 13.5KV D.C. for use by the picture tube.
5. The AFC is concerned with <u>frequency</u> or <u>amplitude</u>. Pick one.
6. The AGC is concerned with <u>frequency</u> or <u>amplitude</u>. Pick one.
7. The VERTICAL OSCILLATOR is controlled indirectly, and the HORIZONTAL OSCILLATOR is controlled directly. True or False.
8. The AGC is part of a feedback, but the AFC is not. True or False.
9. The AFC is part of an indirect control of the HORIZONTAL OSCILLATOR. True or False.
10. The HORIZONTAL HOLD control affects the frequency of the HORIZONTAL OSCILLATOR. True or False.
11. The HORIZONTAL OUTPUT sends its signal to five places. True or False.
12. The HORIZONTAL DEFLECTION COIL serves two purposes. True or False.
13. The HORIZONTAL DEFLECTION COIL is part of the YOKE, just as the VERTICAL DEFLECTION COIL is. True or False.
14. The H.V. RECTIFIER includes the HORIZONTAL DEFLECTION COIL. True or False.

15. The H.V. RECTIFIER produces the high voltage needed to make the picture tube operate. True or False.

16. The DAMPER produces the high voltage needed for the picture tube to operate. True or False.

17. The B/ voltage on the HORIZONTAL OUTPUT comes from the DAMPER. True or False.

18. I think I've got the Technical Story right so far. True or False.

Sketch space - Don't guess. Figure it out. Lead is cheap.

Turn the page for answers.

Answers:

1. False. It compensates for frequency, not amplitude.
2. False. The VERTICAL OSCILLATOR operates at 60cps.
3. True
4. True
5. Frequency
6. Amplitude
7. False. Other way around.
8. False. Both are part of feedback circuits.
9. True.
10. True
11. True
12. True. Horizontal deflection. High voltage production.
13. True. It just has an extra job in producing high voltage.
14. True
15. True
16. False
17. True
18. If you said true, you're pretty good. If you said false, you're modest, or you need another "go round." We suggest you "go round" right now, while you've got a hold on the whole thing. You're close to having it straight, and you might as well come out knowing this. It is the basis of all troubleshooting, and you'll need it. There's no point in faking this when you're so close to having it right. Go ahead. Go back now. It will go rapidly and easily. Go now -- now, do it -- now!

E. TV SOUND AND POWER

1. Overview. This is a story about how TV sound and power are produced. You have learned already how the picture gets onto the picture tube. When you have finished this material, you will have a fairly good idea of how the whole TV works. As you read this, you will be asked to fill in some blanks, or to answer some true or false questions. You should be able to answer these questions with little difficulty. If you have trouble, go back and read the material again until you can answer the questions. OK, let's begin.

The signal the TV set receives contains three types of information: picture, sound and sync. Each of these types of information is required to obtain a good picture with sound.

..... The picture information puts various shades of gray on the picture tube.

..... The sync information makes it possible to arrange the shades of gray into a reproduction of the picture the TV camera sees at the TV station.

..... The sound information makes it possible for you to hear what is being said.

All the circuits in the TV set need power to operate. The power used comes from the house wall outlet into which you have plugged the line cord. This power that comes from the wall outlet is AC power, and it cannot be used directly by the TV circuits, except for the filament circuits. It has to be changed into a form

which the circuits can use. This is done by the TV power supply and other special circuits which you will learn about.

We will talk about the sound circuits first and see how the sound signal is changed into something which you can hear.

2. TV Sound. Let us begin at the output side of the VIDEO DETECTOR. The signal out of the VIDEO DETECTOR contains sync, sound and picture information. The signal, still with its three types of information, next goes to the VIDEO AMPLIFIER.

..... The picture information, after being amplified by the VIDEO AMPLIFIER, goes through the CONTRAST CONTROL and then to the PICTURE TUBE.

..... The SYNC INFORMATION goes to the sync clipper after amplification.

..... The sound information also is amplified in the VIDEO AMPLIFIER.

After emerging from the VIDEO DETECTOR, the sound, picture and sync information are sent toward the TV picture tube. However, between the VIDEO DETECTOR and the PICTURE TUBE (in the VIDEO AMP STAGE), there is a circuit called a "trap." This "trap" is tuned to 4.5 MC, and, therefore, is called the 4.5 MC trap. This trap allows the picture and sync information to pass through it to the picture tube. The sound information is trapped by the 4.5 MC trap and is sent to the SOUND LIMITER. Thus --

..... The 4.5 MC trap prevents sound information from getting into the PICTURE TUBE

..... The 4.5 MC trap sends the sound information on to the SOUND LIMITER.

When we talk about <u>limiting</u> something, we mean keeping it within certain bounds. If you put a rope on a dog and tie it to a tree, the dog can only go as far as the rope will let it. That's putting an outside or maximum limit on how far the dog can go from the tree. If you put the rope through a long pipe, the dog couldn't get completely back to the tree. That would be putting a lower or minimum limit on the dog's movement.

The function of the SOUND LIMITER is to limit or restrict the amplitude of the signal output from the VIDEO AMPLIFIER. You remember that the signal is amplified in the VIDEO AMPLIFIER. The signal output varies in frequency (which we want), but it also varies in amplitude or strength. We want to get rid of these amplitude variations. To do that, the signal is passed through the SOUND LIMITER. Here, all portions of the signal above a certain strength are chopped off.

Now some questions. Answer True or False.

1. The 4.5 MC trap removes the sound signal from the video.
2. The sound signal into the SOUND LIMITER is at a constant amplitude.
3. The output of the SOUND LIMITER is a constant amplitude.

Go to the next page for the answers.

Answers:

1. True
2. False
3. True

The function of the SOUND LIMITER is to remove the amplitude variations from the 4.5 MC sound signal output from the VIDEO AMPLIFIER. This function is required, so that a frequency modulated signal <u>without amplitude</u> variations can be sent to the SOUND DISCRIMINATOR.

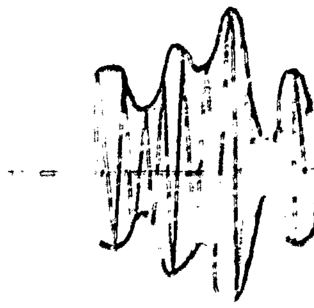
Do you remember what a frequency modulated sound signal is? Well, even if you do, a little review won't hurt.

First think about the <u>carrier</u>. For Channel 2, this is a radio signal of a frequency of 59.75 MC. Left by itself, it would just go through 59.75 million oscillations each second. That's pretty monotonous.

So, let's think about a man speaking into a microphone in the TV station. Let's say he's reading a news bulletin. He speaks loudly and softly; in other words, he varies the strength or amplitude of his voice. At the same time, he speaks in a low tone and then in a higher tone; in other words, he varies the pitch or frequency of his voice.

Speech contains both amplitude and frequency changes. By connecting a microphone through certain circuits, the speech will affect only the frequency of the 59.75 MC sound carrier, <u>NOT</u> the amplitude of the carrier.

C. W.



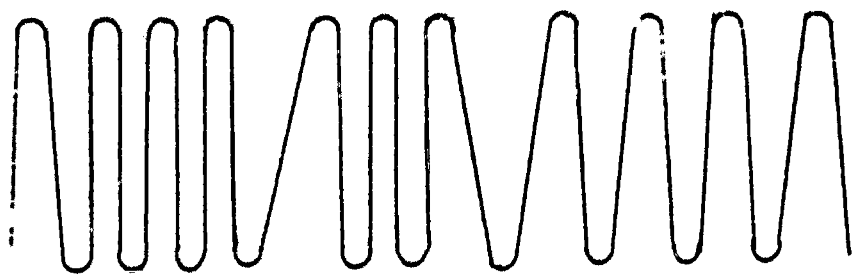
Speech Signal

In frequency modulation, two things happen --

..... The frequency of the carrier is changed in proportion to the amplitude changes of one's voice.

..... The frequency of the carrier is changed at a rate which is in proportion to the tone or frequency changes of one's voice.

When a TV newscaster talks into a mike, amplitude changes in his voice produce frequency changes in the carrier; frequency or pitch changes in his voice produce changes in how often the frequency changes (rate of change). The results on the carrier is to make it look something like an accordian bellows, squeezing and pumping away.



So much for the review of frequency modulation. Now, sound is transmitted on a FM carried signal which is received by the TV set, right along with the picture and sync signal. The original FM signal has a high frequency which is removed in the MIXER stage. In its

place, an intermediate frequency signal is produced (just as with the picture carrier) which then is amplified in the IF AMP stages. The signal then goes to the VIDEO DETECTOR stage, where the sound carrier is mixed with the video carrier. This produces a 4.5 MC sound carrier, which is still frequency modulated exactly like the FM carrier that first entered the TV.

We described how the amplitude of the sound signal was limited in the SOUND LIMITER. This signal, then, is sent to the SOUND DISCRIMINATOR. It is called a discriminator because it can tell the difference, or discriminate, between signals of different frequency. As the sound signal changes its frequency, the discriminator produces a voltage output which is proportional to changes in the frequency of the signal output.

We have described the function of the SOUND LIMITER and the SOUND DISCRIMINATOR. But, in some TV's (like the one you're studying) the SOUND LIMITER isn't completely effective. That is, it does not remove all the amplitude variations from the amplified carrier signal. In such cases, the SOUND DISCRIMINATOR, if it is of the "gated beam type," provides some of the limiting action. Putting it another way, in some TV's, the gated beam SOUND DISCRIMINATOR performs some of the limiting action. In such TV's, the SOUND LIMITER cannot be said to perform limiting all by itself.

There are other types of discriminators which are incapable of performing limiting action. Such discriminators would produce distorted outputs if their inputs were not adequately limited.

We will not study these types of discriminators now. For now, remember that a "gated discriminator" can, and does, do part of the limiting of the carrier signal.

Now for some questions. Answer True or False.

1. The SOUND DISCRIMINATOR produces an output which is proportional to the amplitude of the input signal, rather than the frequency.
2. The original sound carrier is removed in the MIXER.
3. The 4.5 MC sound carrier from the VIDEO AMP is removed by the SOUND LIMITER.
4. The primary function of the SOUND LIMITER is to limit the amplitude of the sound coming out of the loudspeaker.
5. Some types of discriminators are sensitive to amplitude variations in the FM input.
6. The gated beam type of SOUND DISCRIMINATOR provides some of the limiting action as well as discrimination.
7. The greater the amplitude of the modulating audio signal (like a voice) the faster will the changes in frequency occur.
8. The greater the frequency (pitch) of the modulating audio signal (voice) the faster will the changes in frequency occur.
9. The original sound information, such as a voice speaking, is the output of the SOUND DISCRIMINATOR.
10. The Sound Carrier is mixed with the video carrier in the VIDEO DETECTOR to produce the 4.5 MC sound carrier.

ANSWERS

1. False, just the reverse.
2. True, the original sound carrier is at an RF frequency.
3. False. If it were true, the SOUND DISCRIMINATOR would have nothing to work with.
4. False
5. True
6. True
7. True
8. True
9. True
10. True

These were rather difficult. If you missed any of these, go back and read the material again. When you are sure you can answer them correctly, continue with the lesson.

The signal out of the SOUND DISCRIMINATOR is an audio frequency voltage. The amplitude of this voltage changes in direct relation to changes in the frequency of the FM signal, which is fed into the SOUND DISCRIMINATOR. The output of the SOUND DISCRIMINATOR is sent through the VOLUME CONTROL and then to the SOUND OUTPUT.

As you know, varying the position of the VOLUME CONTROL changes the loudness of the sound coming out of the loudspeaker. Changing the position of the VOLUME CONTROL CHANGES the amount of signal which is allowed to pass through the VOLUME CONTROL. When the volume is up high, about all the signal is allowed to pass through;

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when the volume is turned down low, only a little of the signal gets through.

The signal output from the VOLUME CONTROL is sent to the SOUND OUTPUT stage. In this stage, the signal is amplified and then sent to the loudspeaker.

The LOUDSPEAKER converts the electrical audio frequency signal into a mechanical movement ... it causes the loudspeaker cone to move in and out. This mechanical movement vibrates the air, and sound waves are made. This is what we hear.

Let us now summarize the TV sound channel ....

1. The sound signal is received by the TV, right along with the picture signal, as a frequency modulated signal.
2. The RF carrier signal, which is carrying the sound signal, is removed in the MIXER, and a new lower frequency FM sound carrier is added. This new frequency is the IF signal.
3. The new FM sound carrier is sent to the VIDEO IF AMPLIFIERS in which it is amplified, and sent to the VIDEO DETECTOR.
4. In the VIDEO DETECTOR, the sound carrier and the picture carrier signals are mixed to produce a 4.5 MC FM sound signal. This signal is sent to the VIDEO AMPLIFIER.
5. In the VIDEO AMPLIFIER, the signal is again amplified. The picture signal is then allowed to pass onward to the picture tube. The sound signal is prevented from getting into the picture tube by the <u>4.5 MC</u> trap. This trip channels off the sound signal and sends it to the SOUND LIMITER.

6. The SOUND LIMITER removes any amplitude variations which might have entered the FM sound signal. In other words, it limits the amplitude of the signal. This limited sound signal goes then to the SOUND DISCRIMINATOR.

7. The SOUND DISCRIMINATOR produces an audio frequency output. The amplitude of this output depends upon the amount the input signal frequency has changed from 4.5 MC. This audio output is sent to the VOLUME CONTROL.

8. The volume or strength of the signal is varied by the VOLUME CONTROL. This control determines the amount of audio signal which will get through the control. This signal goes to the SOUND OUTPUT stage.

9. The SOUND OUTPUT stage amplifies the signal and sends it to the LOUDSPEAKER. In the LOUDSPEAKER, the electrical audio signal is converted into sound waves.

INPUT
↓
PICTURE, AUDIO AND SYNC SIGNALS
↓
MIXER
↓
VIDEO IF AMPLIFIERS
↓
VIDEO DETECTORS
↓
VIDEO AMPLIFIER
↓
4.5MC Trap → picture and sync signals
SOUND LIMITER
↓
SOUND DISCRIMINATOR
↓
VOLUME CONTROL
↓
SOUND OUTPUT
↓
LOUDSPEAKER

3. The TV Power Supply. As you know, electrical devices need a source of power. Some portable TV's are battery operated. Most TV's have a linecord which must be plugged into a wall outlet. For the Zenith portable TV you are studying, the power to operate the circuits in the set comes from a wall outlet. This power enters the TV through the line cord.

The voltage that is available at a wall outlet usually has a voltage of between 110 and 120 volts. This is an AC voltage which has a frequency of sixty cycles per second. Now, TV circuits need a different type of voltage to operate. Some circuits can use directly the 120 volts AC which comes from the wall outlet. Other circuits need voltages which, depending on the particular TV set, may go higher than 20,000 volts. Some TV circuits operate on AC current, while others need DC current. How are all these voltage and current requirements obtained?

Low Voltage Circuits:

A TV power supply can be divided into two classes, the low voltage supply, and the high voltage supply. You have already learned something about the HV supply in an earlier lesson, and you will learn more later on. For now, we will discuss the low voltage circuits.

There are two principle objectives of the low voltage circuits:

..... they supply the current needed to heat the filaments of the vacuum tubes. This is what makes the tubes light up.

..... they supply the direct current voltage needed for the vacuum tube plates and for the bias supplies.

Some TV's are designed so that all the heaters (or filaments) are connected in parallel. This is possible when all the tube filaments require the same voltage. In such TV's, the filament voltage comes from a special filament winding on the TV power transformer. A different winding on the power transformer supplies a higher voltage to a rectifier tube. This arrangement is used to produce the voltage needed for the tube plates. (As you should remember, a rectifier tube is used to change AC current into pulsating DC current.)

Some TV's, like the one you will work with, do not have a power transformer. In such TV's, the tube filaments are connected in series. With this arrangement, the same current flows through all tubes. Furthermore, if one filament fails (burns out, for example), no other filament can get its current. As a result, all the tubes will go out. This filament arrangement is knows as a series string type of filament supply. Capacitors are used in the string to prevent high frequency signals from being transferred from one tube to another.

When the TV set is of the transformerless type, one side of the AC line is connected to the TV chassis. In such cases, it is very important not to touch the metal chassis since you may be shocked by the AC. The on/off switch might only disconnect one side of the line. So, be careful. Before working on such TV's, be sure not to touch the chassis when the set is plugged in.

Fuses: As you know, fuses are used to protect electrical equipment. A fuse is usually inserted in the power line of a TV.

This fuse will open and interrupt the current if a short circuit in the TV causes an unusually large amount of current to flow. This protects the parts of the TV set which might otherwise be damaged by excessively high current.

A DC voltage is needed for the plate and biasing circuits. This DC voltage can be obtained in a variety of ways. In a TV set which has a power transformer, a vacuum tube rectifier might be used. In a transformerless type TV, a semiconductor diode might be used. Sometimes these diodes are called silicon diodes. These silicon diodes function as rectifiers. That is, they have the capability of conducting current in one direction better than in the reverse direction. As a result, when an AC voltage is applied to a silicon diode, the output is a voltage which pulses in one direction. This is called pulsating DC.

Pulsating DC voltage cannot be used directly. It must be smoothed out a bit. This is done by a filter network consisting of electrolytic capacitors (they look like tin cans) and iron-core coils. (Such coils are called "chokes.") The voltage available after such filtering is a DC voltage which is steady or smooth enough to be used by the TV. This DC voltage is then distributed over wires to the individual circuits which need it. Its voltage is about 130 volts DC.

Now for some questions:

1. In series string filament circuits, all heaters get the same current.
2. In a transformerless set, one side of the AC line is grounded to the chassis.

3. The fuse protects parts from damage by opening, when excessive current flows.

4. Silicon diodes produce a steady DC voltage.

5. A filter network is needed to get rid of pulses in the plate supply.

Answers:

1. True
2. True, so be careful
3. True
4. False
5. True

Did you get them all right? Good! Let's go on.

Some TV circuits need a voltage which is higher than the 120-130 volts, which can be obtained by simply rectifying the 60 cps line voltage. Most of these circuits use what is known as the "B plus boost voltage." This is a voltage which is higher than 130 volts, but which is not as high as the voltage used by the picture tube. The B plus boost voltage is obtained as a by-product of the DAMPER circuit.

You will recall from the technical story on TV video, that the DAMPER was needed to remove the oscillations produced by the current in the HORIZONTAL DEFLECTION COIL. The tube in the DAMPER circuit is actually a rectifier tube. So, the DAMPER circuit produces a DC voltage which is higher than the 130 volts plate supply voltage. The B plus boost voltage is obtained by adding together the 130 volt plate supply voltage and the voltage obtained from the DAMPER.

The picture tube needs a very high voltage, something around 20,000 volts. This voltage is used by the picture tube to draw the electron beam to the face of the TV tube. The picture tube voltage is produced by the HIGH VOLTAGE RECTIFIER. The collapsing current in the HORIZONTAL DEFLECTION COIL produces a voltage in the HORIZONTAL OUTPUT TRANSFORMER (or flyback transformer) which is stepped up even higher by another transformer winding, which is connected to the HIGH VOLTAGE RECTIFIER. As a result of this action, a high AC voltage is produced (the frequency is the same as that of the horizontal sweep ... 15,750 cps). This AC voltage is rectified by the HIGH VOLTAGE RECTIFIER, and the result is a very high DC voltage. This voltage is sent to the picture tube.

Now how about trying some more questions:

1. The HIGH VOLTAGE RECTIFIER produces a high voltage called B plus boost.
2. The silicon rectifier produces DC from an AC of 15,750 cps.
3. The DAMPER is needed for B plus boost only.
4. The low voltage supply produces most of the DC voltage needed by plate and bias circuits.
5. The on/off switch cannot affect the output of the HIGH VOLTAGE RECTIFIER.
6. The current through the filaments is a DC current.
7. A failure of a part in the LOW VOLTAGE supply might blow the fuse.
8. Filtering is needed in the low voltage supply to remove AC pulses.

9. B plus boost is higher than the low voltage supply but lower than the HIGH VOLTAGE supply.
10. The HIGH VOLTAGE supply needs the line cord to be connected to the wall outlet, in order to produce the right amount of voltage.

Answers:

1. False
2. False
3. False, it removes the unwanted oscillations, remember?
4. True, the B plus boost produces the rest.
5. False, if off, the whole set is off. Right?
6. False, the current is AC
7. True
8. True
9. True
10. True

If you missed any of these questions, go back and study the material some more.

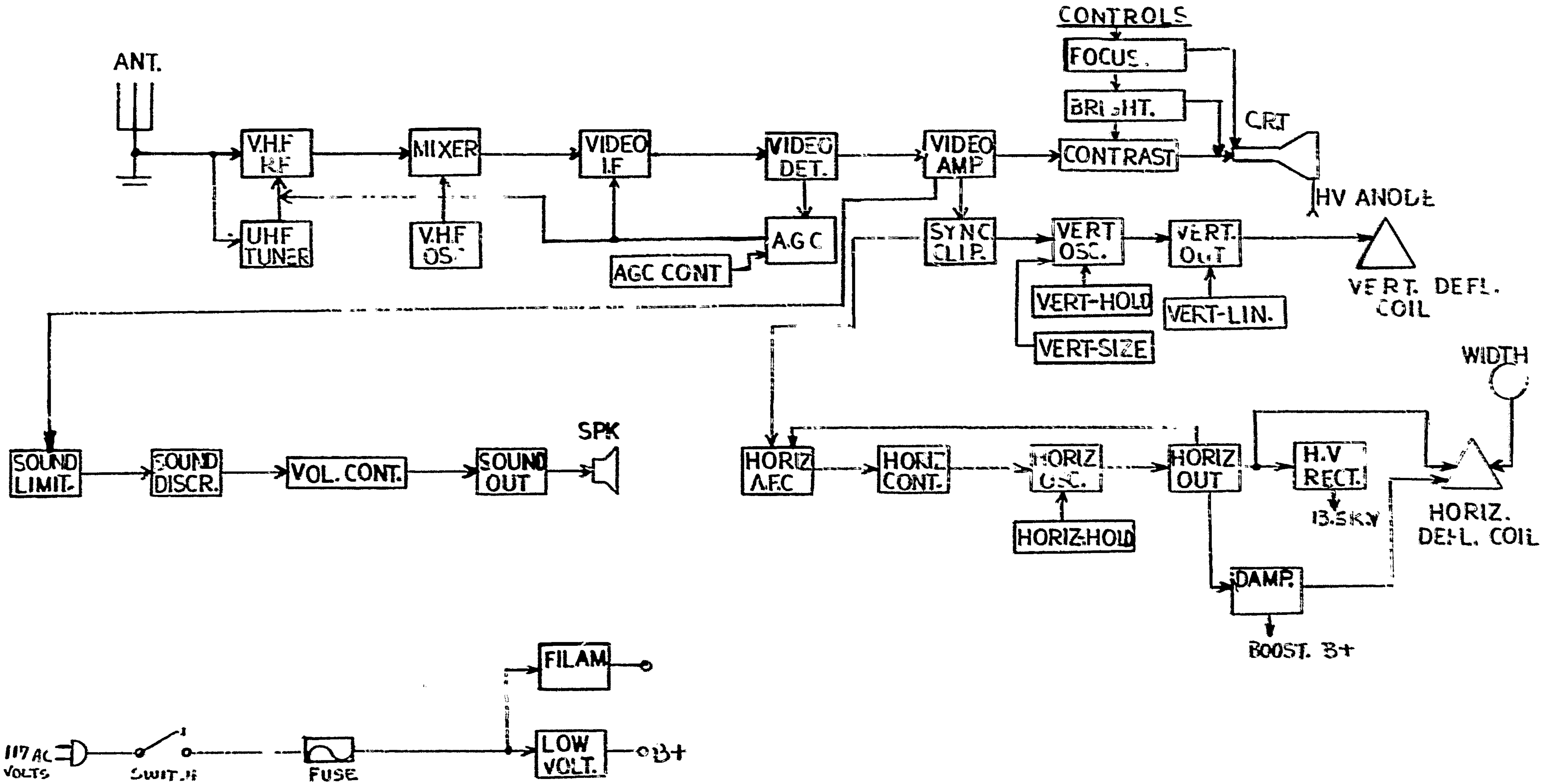
A few more words are in order about power supply problems. As the phrase "power supply" suggests, the object is to supply voltages and currents to a number of different circuits. Each circuit to which a voltage is supplied constitutes a "load" on the supply. When a part fails in one of those circuits, the effect is sometimes, but not always, to <u>increase</u> the load on the power supply. There is a limit as to how much a power supply can

give. When one circuit takes too much, there is less available for the other circuits. These other circuits will then operate below their tolerable limits, and the resulting effects will be noticeable. Usually troubles that originate in the power supply affect many circuits.

Were you able to answer all questions correctly? Do you understand? If you have had trouble, go back and re-read the material. This concludes the material on sound and power circuits.

Now, when you watch the late show on TV, you can amuse yourself during the commercials by thinking about all the things the circuits inside your TV set are doing to produce the picture you are viewing and the sounds you are hearing.

- - -



TV BLOCK DIAGRAM

FUNDAMENTALS OF PRACTICAL ELECTRONICS

BOOK II

Schematic Symbols and Color Codes for Electronic Parts

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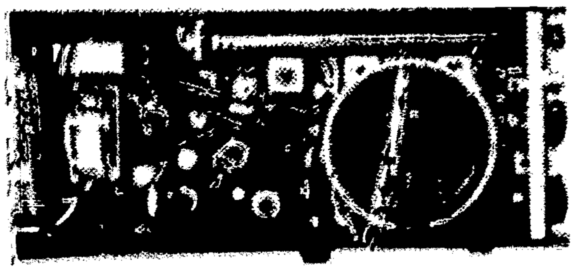
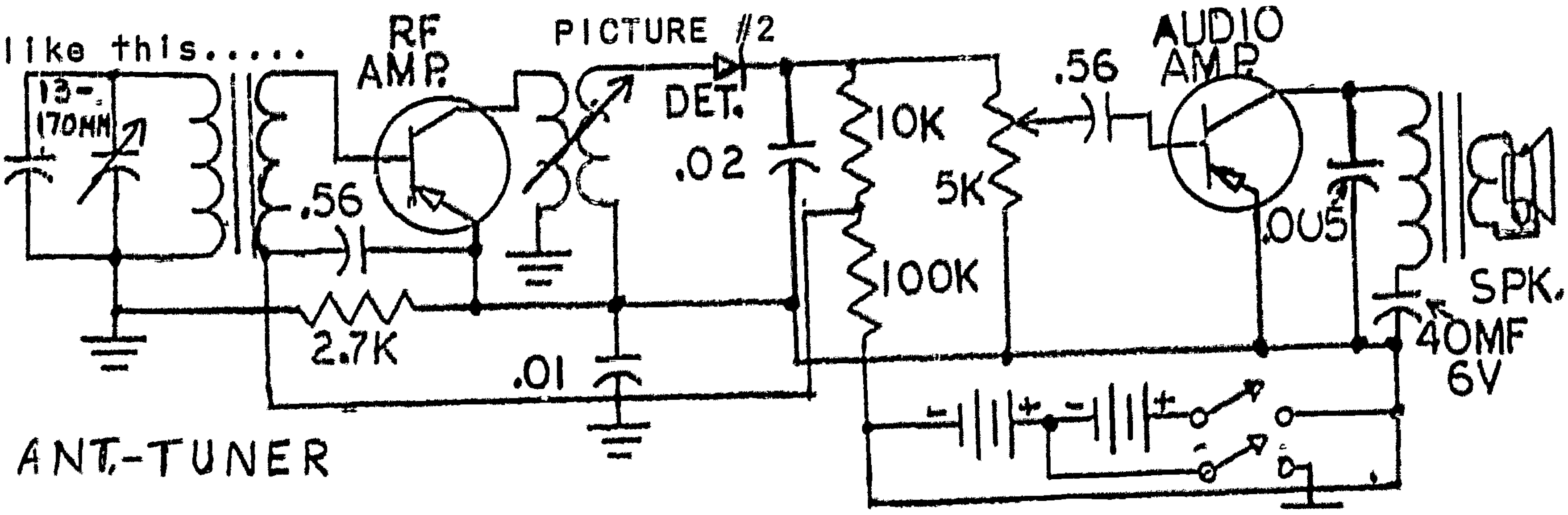
SCHEMATIC SYMBOLS AND COLOR CODES FOR ELECTRONIC PARTS

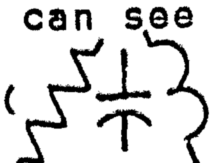
COMMON SCHEMATIC SYMBOLS

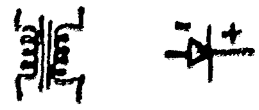
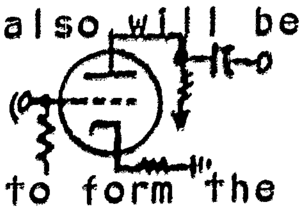
How many different types of electronic equipment have you used? Most people have a radio and usually a TV. Stereo phonographs and juke boxes also are used by many people. Did you know that all of these use very similar parts? Take a transistor radio, for example. When you take the cover off, it might look something like this.....



Probably you know already some of the names of the parts of a radio.....the speaker, the antenna, tubes, etc. In this booklet, you will be shown pictures of many basic parts of a radio, and you will learn the names for these parts. Now, did you know that a picture of a radio can be drawn to look like a diagram? The diagram for the above transistor radio might look like this.....

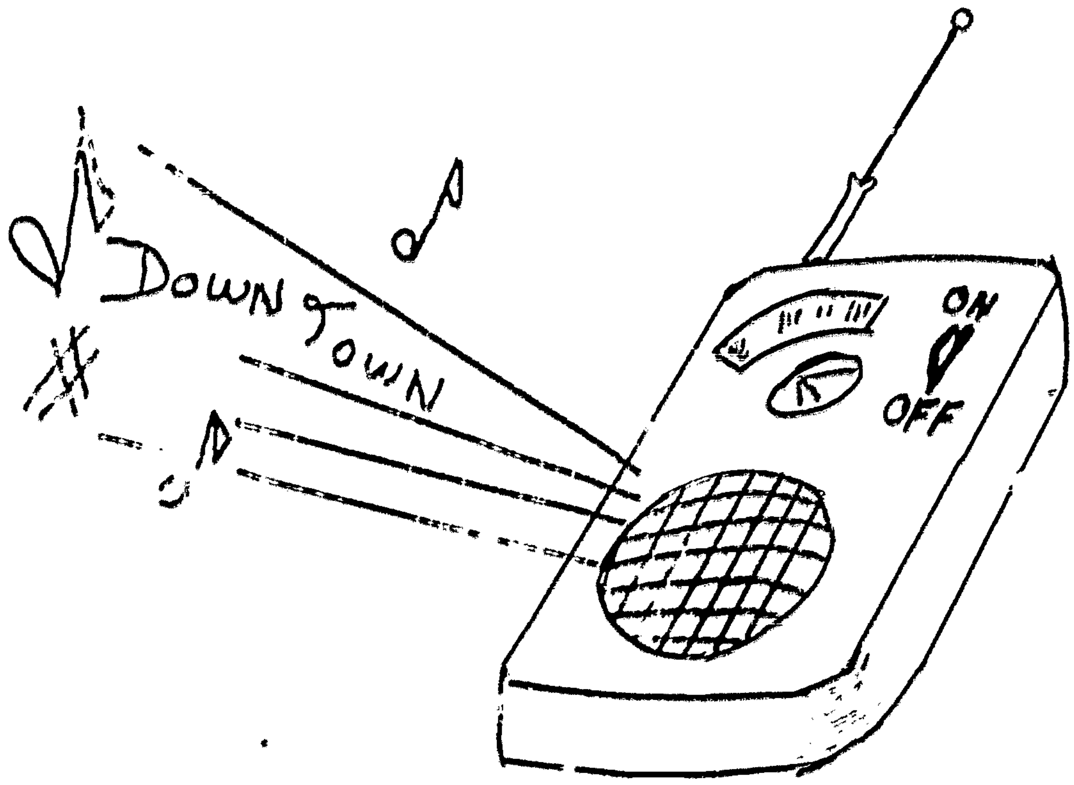


You can see that the diagram above is made up of lots of symbols () which are tied together by lines. All radio and TV repairmen must know how to read such diagrams. In this

booklet, you will be shown the symbols () for some of the basic parts that make a radio work. You also will be shown how these parts usually appear in a radio (). And, you will see how these parts are connected to form the diagram or schematic of a complete radio. This booklet will help you to look at a schematic diagram of a radio and understand it.

As you read along there will be questions on the material you read. To answer the questions you write in a word, circle a word or draw a symbol in the blank space. If you can answer a question from memory, you know you have learned the material well enough. If you do not know an answer, go back and review the material on that question. Be sure you can answer each question from memory before going to the new material.

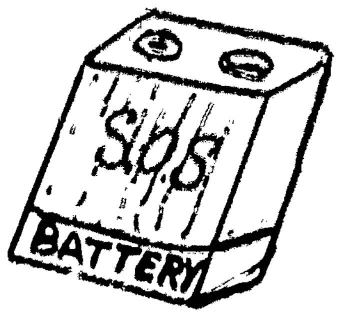
So now.....without rushing, turn the page and begin.



Batteries:

This transistor radio uses a battery.

OR



The symbol for this battery is

So battery =  = 

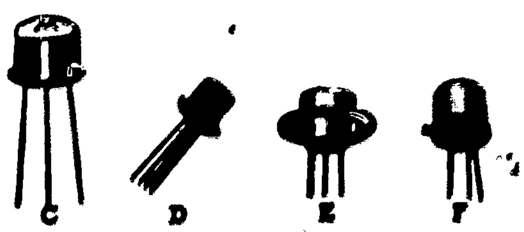
Write the name of this symbol

here ______________________________

Transistors:

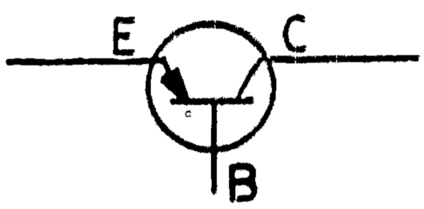
When you look inside a transistor radio, you see things like this:

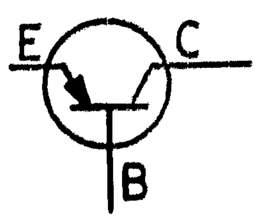
or like this



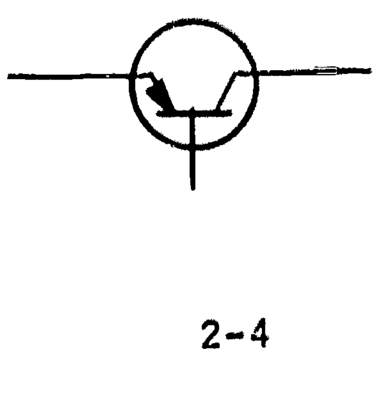
These are <u>transistors</u>.

The symbol for a transistor is:



 = Transistor = 

Write the name for this symbol:

 ______________.
word

Resistors:

Transistors ______________ are seldom connected directly
(a) symbol

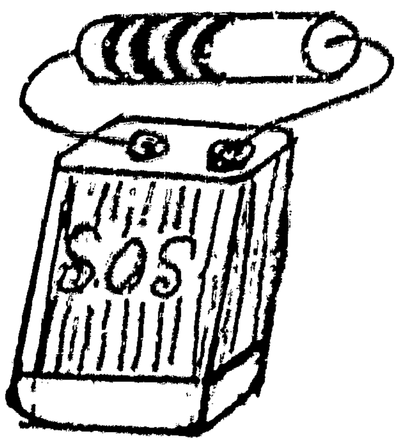
to each other. Rather, other types of electrical parts are connected between them. One such part is called a <u>resistor</u>. Resistors look like this..........

Sort of like a fire cracker.

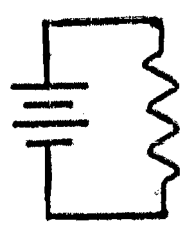
This symbol ( ) is used for a resistor.

A resistor (______________) and a battery (______________)
(b) symbol (c) symbol

connected together look like this.....



A schematic (symbol) diagram of a connected battery and resistor would be drawn like this......

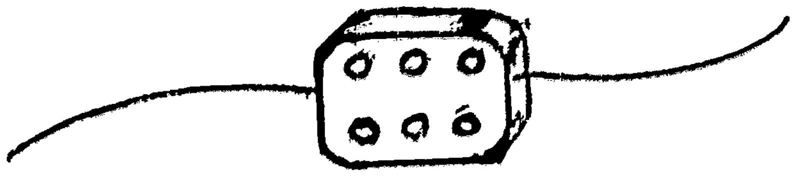


Capacitors:

Between two transistors, there may be one or more ________
(d)

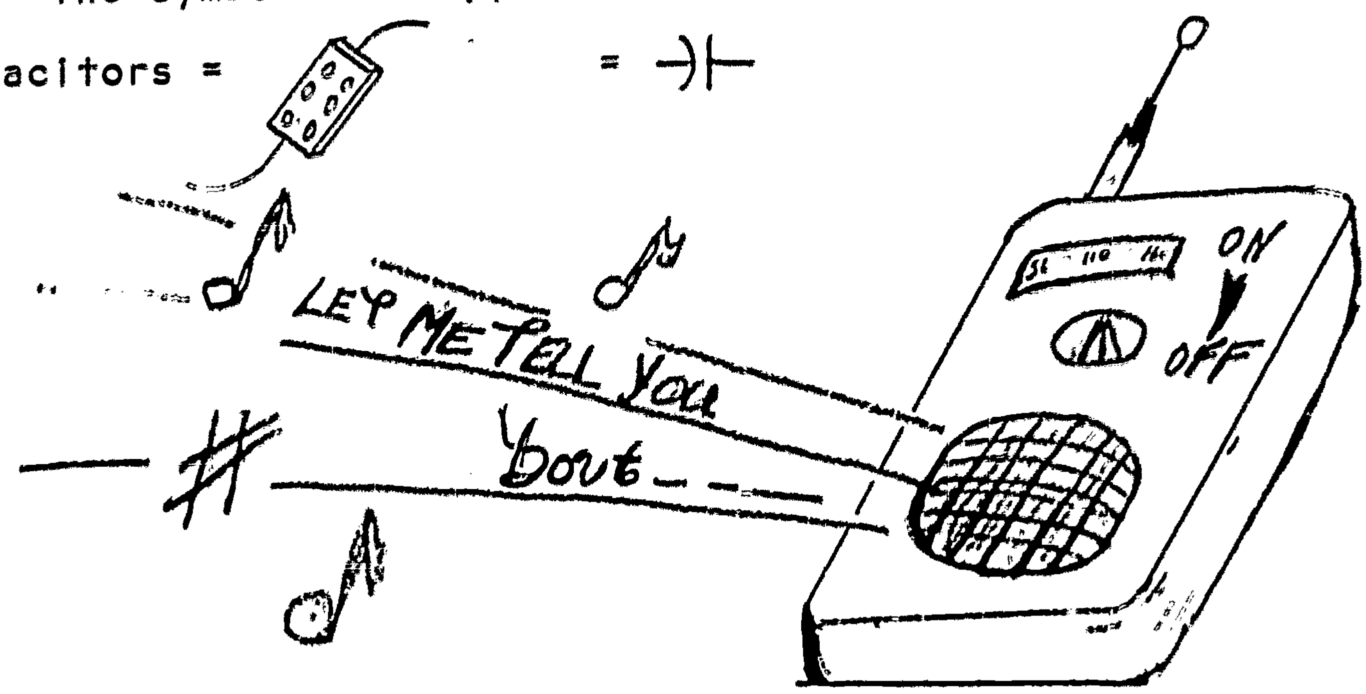
( ).
symbol

Also, between transistors, there can be electrical parts called <u>capacitors</u>. Capacitors look like this.



(Sort like a domino.)

The symbol —)|— is used for capacitors. So

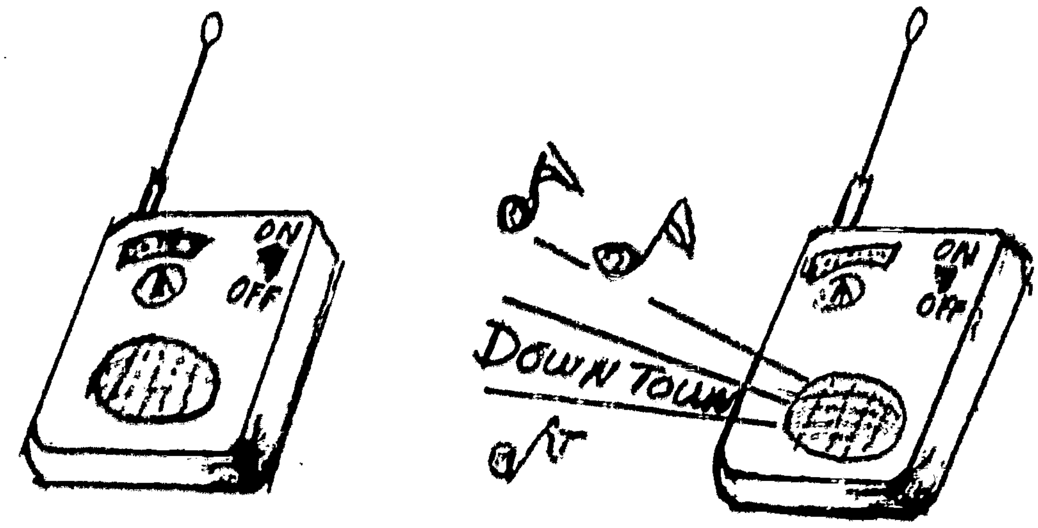
capacitors =  = —)|—

When all the parts of a radio are "good," the radio will play properly. The radio will not play properly if the battery (________ (a)) is bad. It will not play properly if any of the transistors (________ (b) symbol) or resistors (________ (c) symbol) or capacitors (________ (d) symbol) are bad. Later on, you will learn that when some radio parts go bad, the radio will not play at all. When other parts go bad, the radio will still play, but it doesn't sound right.

<u>Voltage and Current:</u>

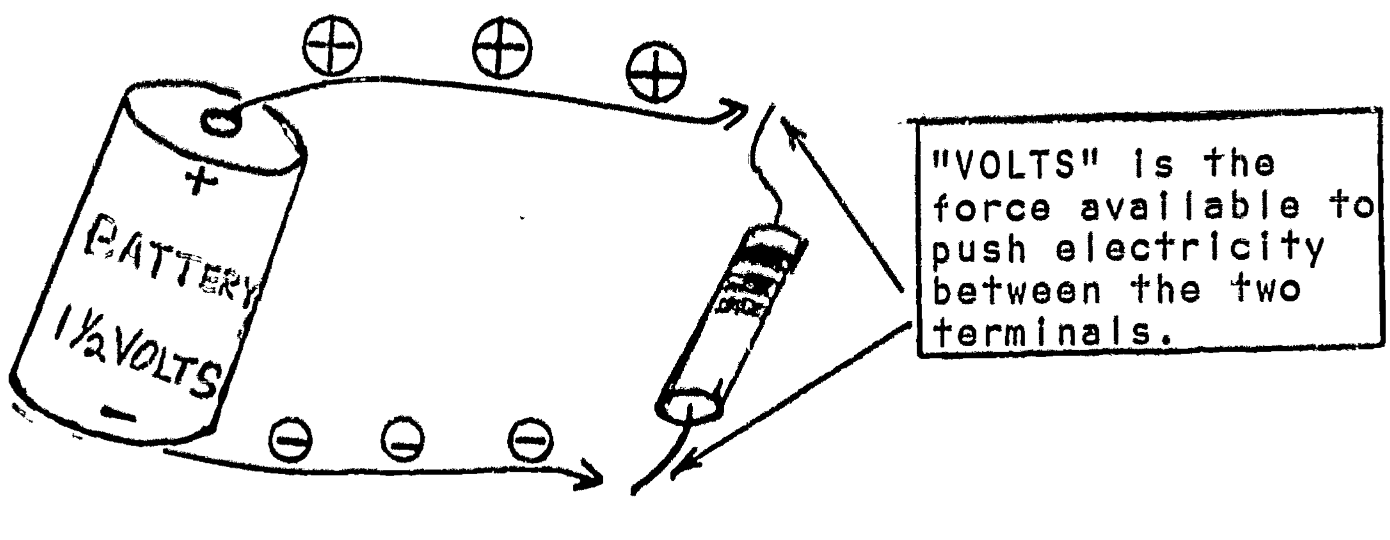
What makes a flashlight work? Where does the power come from that starts an automobile? Where does the electricity

come from that operates a portable TV or a transistor radio? That's right, in all these examples, the electricity or electrical power comes from batteries. Batteries supply the electrical power to operate transistor radios.



no battery - no beat battery good

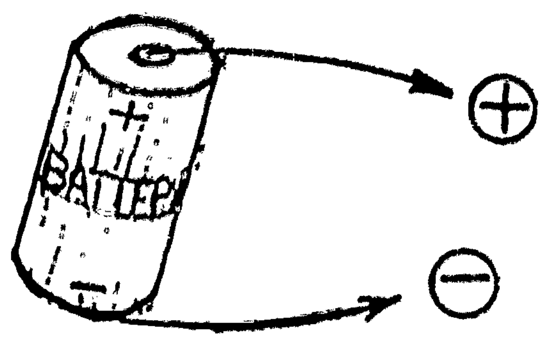
When you buy a new battery for your transistor radio, or for your automobile, or for a flashlight, you have to get the right size of battery. You buy a battery that will supply the right amount of electrical power. As you may know, the electrical size of a battery is expressed by the word "VOLTS". For example, automobiles may take 6 Volt or 12 Volt batteries. A flashlight uses 1 1/2 ______ (word) batteries. When you buy a new battery for your transistor radio, you must get one with the same "VOLTS" as the one you took out.



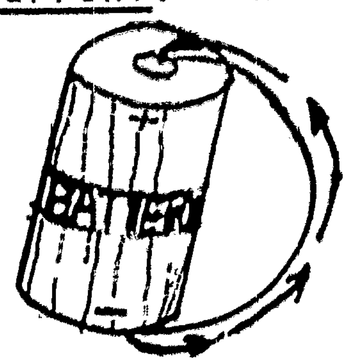
"VOLTS" is the force available to push electricity between the two terminals. The force is present if something is connected to the battery or not; electricity won't flow until something is connected between the terminals. In other words, a battery works something like a water fountain. A water fountain contains water, but the water doesn't come out until you turn on the fountain. A good battery contains electrical force but this force has to be "turned off". You "turn off" a battery by connecting something between the terminals of a battery.

Current:

When something is connected between the terminals of a battery, electricity will flow and we call this flow Current. Sometimes current is called electrical current. In any case.....



The force available to push current between the two battery terminals is called______________.
(a)



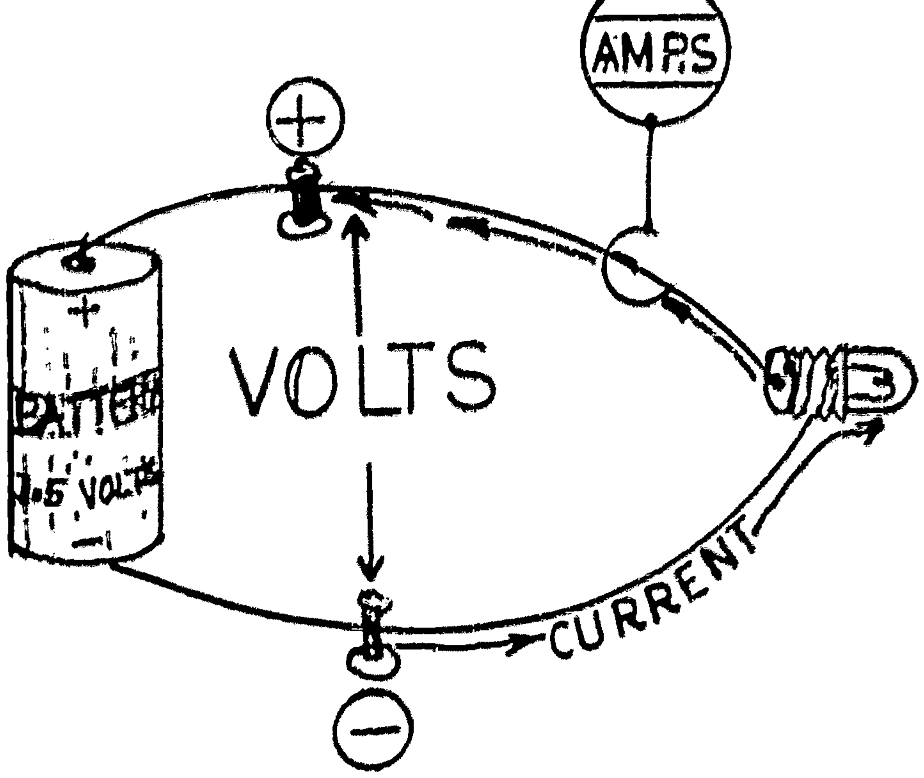
The electricity which flows between two connected battery terminals is called

______________________.
(b)

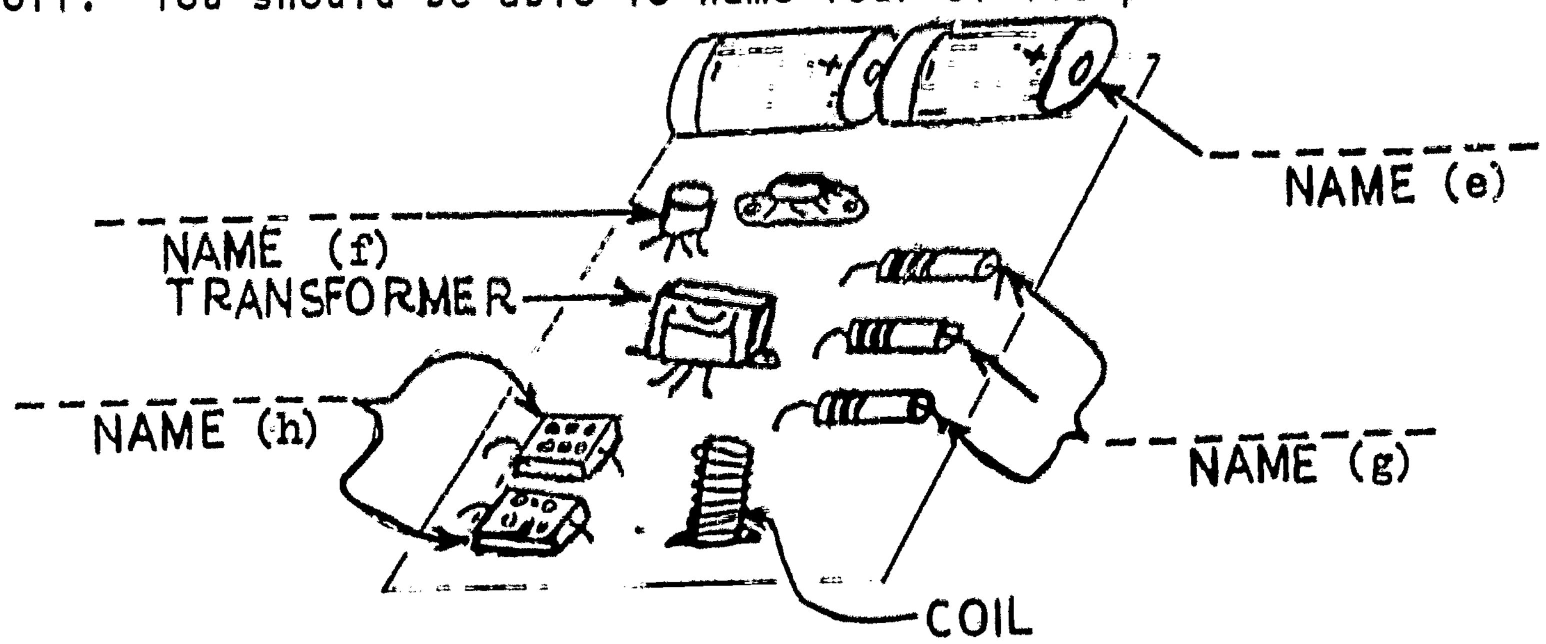
Amperes:

Current is the flow of electricity; the amount of current flowing is measured in amperes. Amperes is usually called AMPS. Just as your height is measured in feet and inches, and water flow is measured in pints, quarts, or gallons, electrical current is

measured in________. So........suppose someone asked you to tell
(a)
them how much current was flowing in the wire in the below diagram. You would measure the amount of electrical current flowing through the wire and then would describe this amount in terms of________.
(b)
Your answer might be 3 Amps, 5________, 15________or whatever
(c) (d)
number of Amperes was found to be flowing in the wire.



. Let's again look at a transistor radio with its back cover off. You should be able to name four of its parts.



Now try drawing the schematic symbols for these four parts:

Transistor

Battery

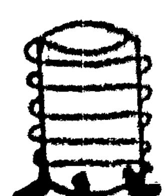
Resistor

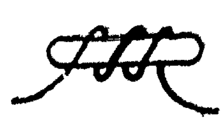
Capacitor

Notice that the previous picture contains two parts which we haven't talked about before. One part is called a COIL. The other part is called a TRANSFORMER.

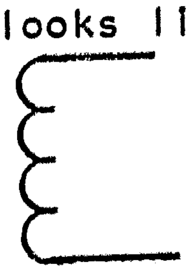
MORE SCHEMATIC SYMBOLS

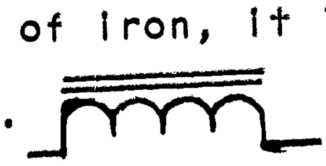
<u>Coils</u>:

Coils look like this ...  They look like a piece of coiled wire wrapped around a piece of cardboard. Sometimes the coil is wrapped around a piece of iron bar, like this ....



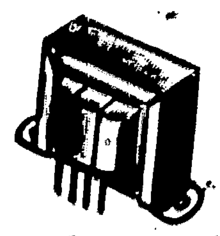
The symbol for a coil looks like a coil.



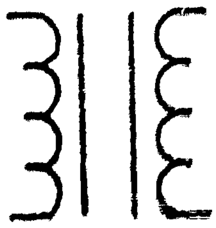
When the coil is wrapped around a piece of iron, it is drawn like this. The lines stand for the iron bar. 

Transformers:

The radio on the previous page contained a TRANSFORMER. They look like this........

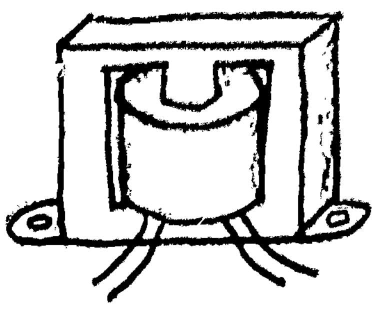


The symbol for a Transformer is drawn like this......

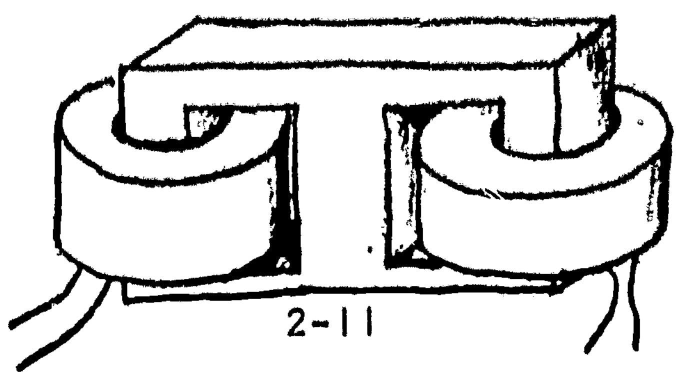


As with iron-core COILS, the lines between the coil symbols of a TRANSFORMER are the symbol for the iron-core of the transformer . Most transformers have iron cores.

All transformers have at least two separate coil windings. In many transformers, the two coil windings are wound one on top of the other, like this........



In other types of transformers, the two coils are separately wound on different parts of the transformer, like this........

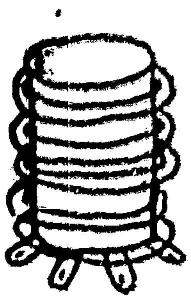


The pictured transformers are electrically the same. The same symbol would be used for either one. Draw what this symbol looks like.

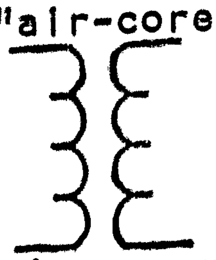
(a)

TRANSFORMER SYMBOL

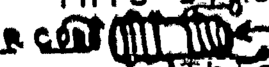
Sometimes a transformer must operate directly on radio waves. When this is so, the transformer may not have an iron core. Instead it will have an "air-core".



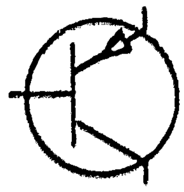
The symbol for this "air-core" transformer is:



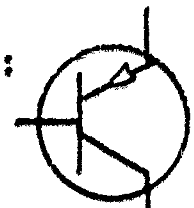
The double lines for iron core are just left out. The utmost in simplicity, isn't it?

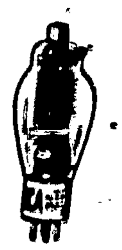
Now let's review a bit. This symbol  stands for a __________ (b) with an __________ (c) core. This 

is a picture of a __________ (d) whose schematic symbol looks like _______________ (e). The straight lines in this symbol  stand for an __________ (f). And lest you

forget, this symbol  stands for a ____________.
(a) Name

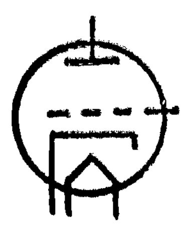
Vacuum Tubes:

Before  came into use, their job was done by vacuum tubes. Vacuum tubes are still used in many radios, TV, phonographs, etc. because they can do some things that a transistor cannot do. Vacuum________s come in many sizes and shapes. Two types of vacuum tubes are shown below.
(b)

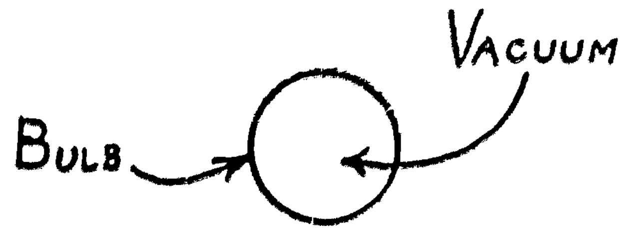


To work properly, vacuum tubes must have a vacuum. That is the purpose of the glass bulbs. It allows the air to be removed from inside the bulb

and then prevents air from getting back inside. Incidentally, vacuum tubes are usually called TUBES. There are many different types of TUBES, but all tube symbols usually look something like this........



Let's examine the symbol for a tube more closely. The circle stands for the bulb of the tube. (It's a lot easier to draw than a picture of a vacuum.)

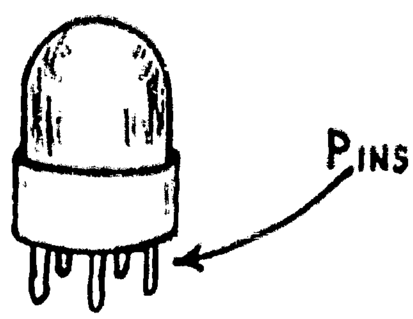


As a tube symbol suggests, there are a lot of things inside the bulb of a tube. We can't touch these parts. (It would be like killing the goose that laid the golden egg.) We can either have our vacuum tube or break it open and look inside.

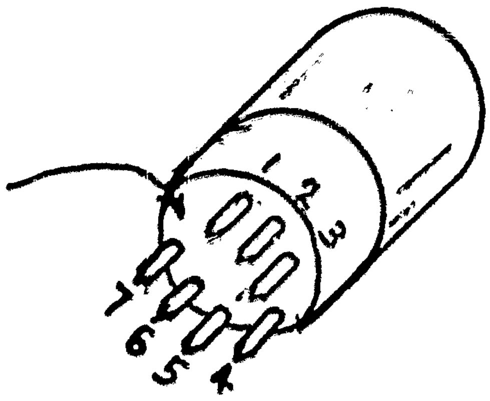
NUMBERING SYSTEM FOR TUBE PINS AND TUBES

Tube Pins:

We can use the things inside the tube only because they are attached to the pins which stick out of the bottom of the tube. There are the pins at the base of the tube....



The number of pins on a tube differ from tube to tube. But, no matter how many pins the tube has, there often will be a place which looks like a pin is missing.



This space between tube pins is very helpful because it tells you where to start counting the numbers assigned to each tube pin. That's right, all tube pins have a number ... 1, 2, 3, ... Tube pins are always numbered clockwise looking at the pins. And, (as shown in the above diagram) the first pin on the right, or clockwise from the space, is the number "1" pin. Pin number "2" is the second pin clockwise from the space.

As you look at radio and TV tubes, you will find that some tubes don't have any extra large space between two of their pins. Instead, they contain a center rod which has a hump on it. This hump is called a "key" and it points to the space in front of the number one pin. The bottom of such tubes look like this...

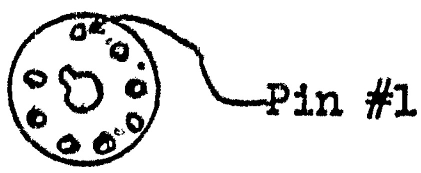


Diagram A

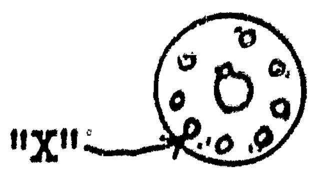


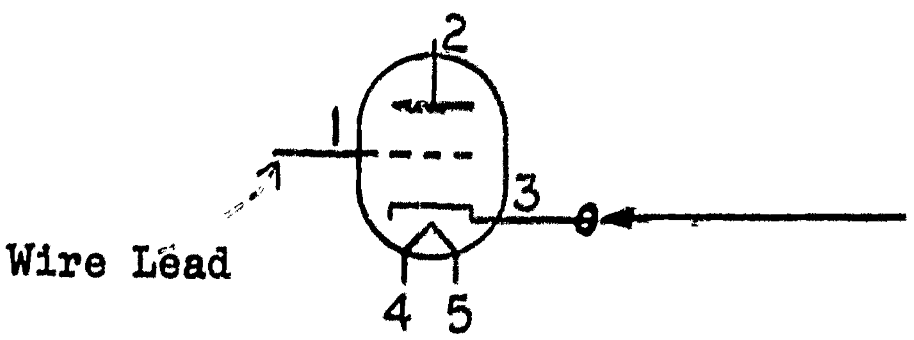
Diagram B

For these tubes, the number "1" pin is the first pin clockwise or to the right of the "key". OK then, what is the number of the pin marked "X" in Diagram "b" above? It is pin #__________ (fill in).

Perhaps you have noticed that a tube diagram or symbol seems to be drawn two different ways. The bottom of the tube is drawn like this........

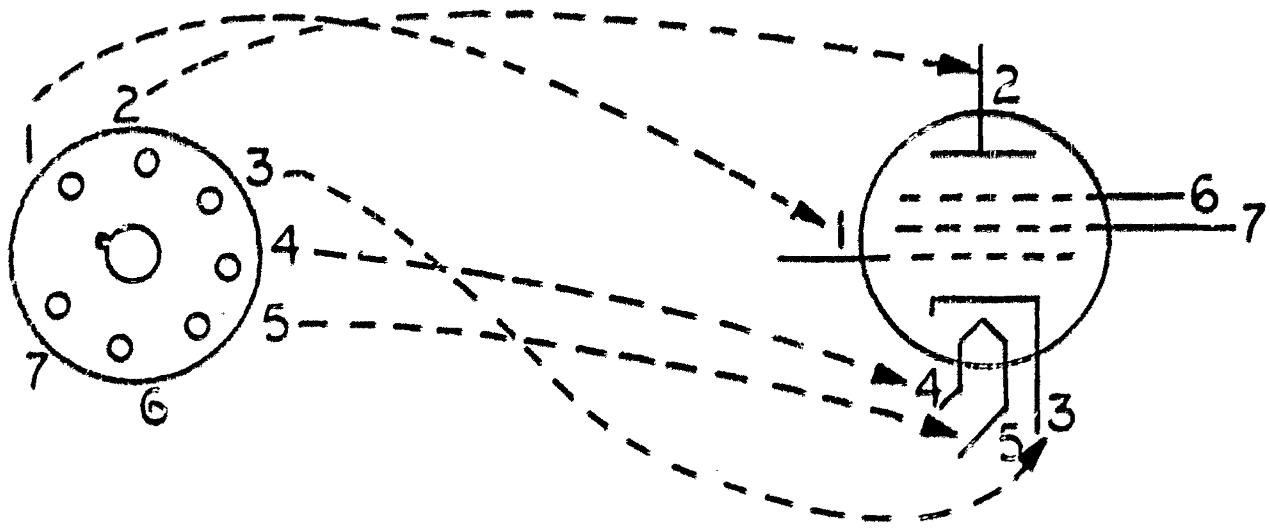
and the tube pins are numbered clockwise________or counter clockwise________from the space on the arrow. (check one) This type of diagram is called a "tube-pin" diagram.

The tube schematic or symbol which we first showed you looked like this.....



This type of tube symbol shows that parts are inside of the tube. The lines sticking out from the tube bulb represent wires that are attached to the things inside the tube. These wires are called "<u>wire-leads</u>" or "<u>leads</u>". You can't see these leads because they are inside the tube pins. Each wire lead can be numbered, but notice that they are not numbered in any particular order in the schematic.

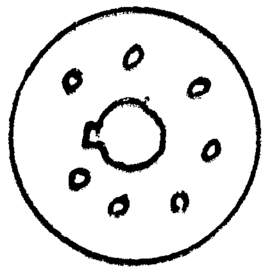
As you might guess, tube pins and wire leads are related in that wire lead #1 is attached to tube pin #1; wire lead #2 is attached to tube pin #2, and so on.



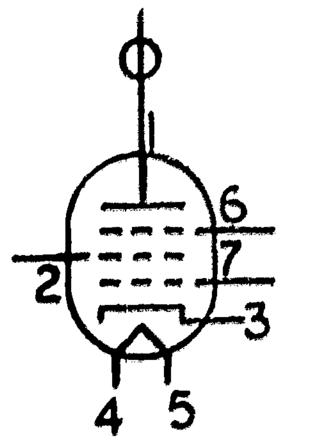
XVI
Tube-pin Diagram

VI
Tube Symbol

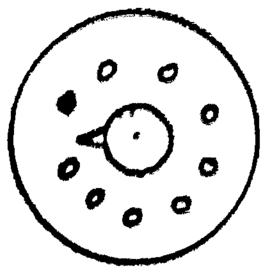
As we said before, there are many different types of tubes, and the symbol for each of these will be different in terms of the kinds of lines drawn inside the symbol. On the next page we have drawn the Tube-pin Diagrams and tube symbols for three types of tubes. The wire leads are numbered, and in each tube symbol one of the wire leads is circled. For each of these sets of diagrams, would you put an "I" over the tube pin that corresponds to the circled wire lead.



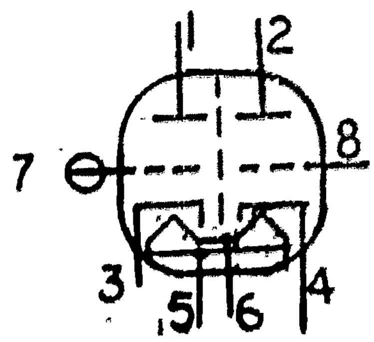
XV1



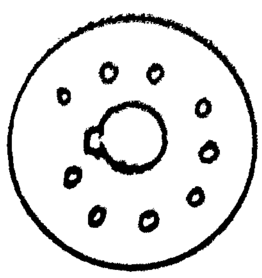
V1



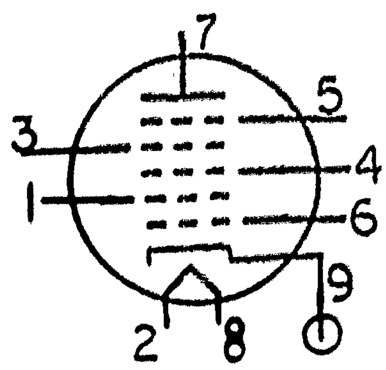
XV2



V2



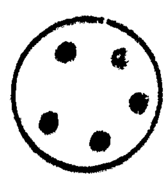
XV3



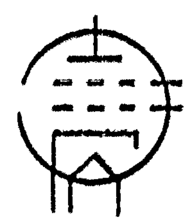
V3

Did you notice that on the previous diagrams the tube symbols were labeled V1, V2, and V3? Well, the tubes of a radio or TV are numbers from "1" onward. The letter "V" stands for "tube". Thus, "V3" means "tube number 3". Notice also, that it is only the schematic symbols of the tubes which are labeled with a "V". The other diagrams, the "pin diagrams" are labeled "XV". The "X" means "Tube bottom" and refers to the fact that "pin diagrams" show the bottom of tubes. OK then, in the below diagrams, which pin diagram goes with the tube symbol - Diagram A________, Diagram B________or Neither________?

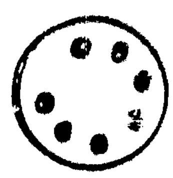
PIN DIAGRAM A



TUBE SYMBOL



PIN DIAGRAM B

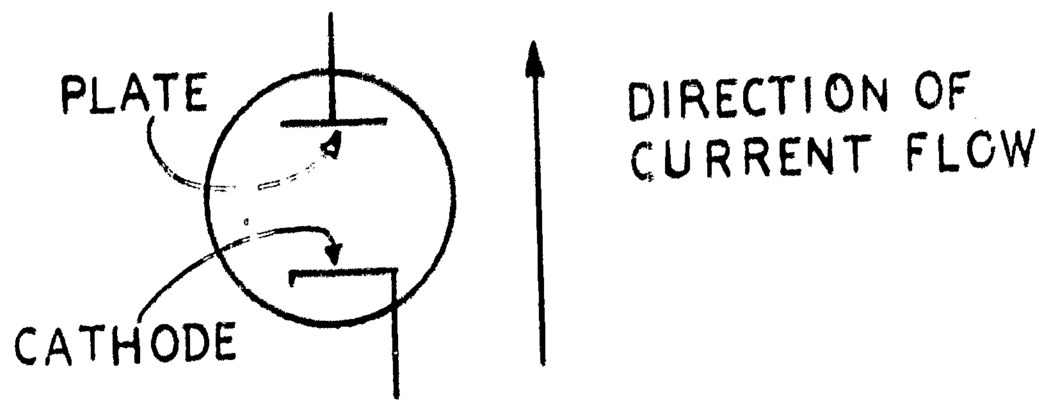


Some TV meters do not bother to use this "XV" label for the "tube bottom".

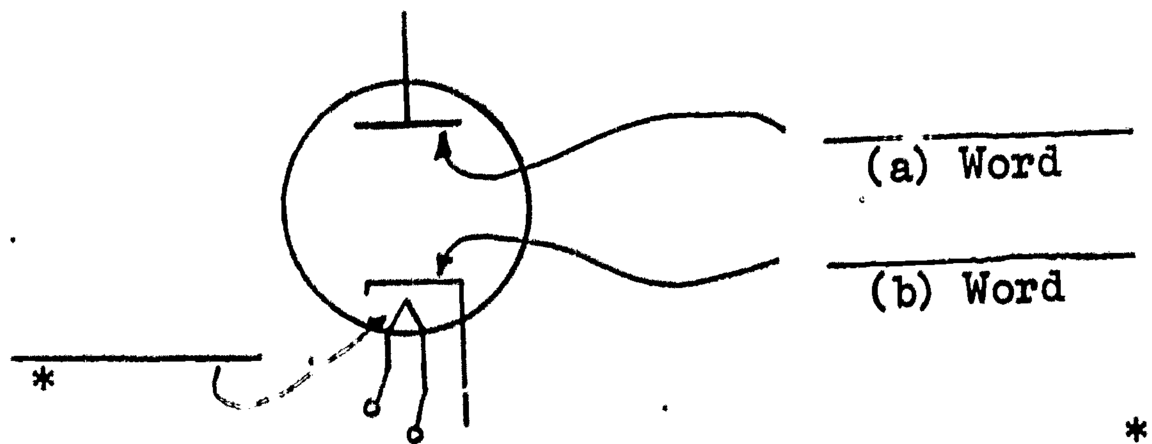
TUBE ELEMENTS

Plates, Cathodes, Heater:

Do you remember what we said about electrical current? We said that electrical current or electricity flows when the terminals of a battery are connected. Now, electrical current flows through electrical parts, and, in a vacuum tube the main electric flow is between two parts which are inside the tube. These parts are called the plate (or anode) and the cathode. As shown below, the symbol, the symbol for the "plate" looks like an upside-down "T"; and usually is drawn at the top of the tube; the symbol for the "Cathode" looks like an upside-down "L" and is usually drawn at the bottom of the tube.

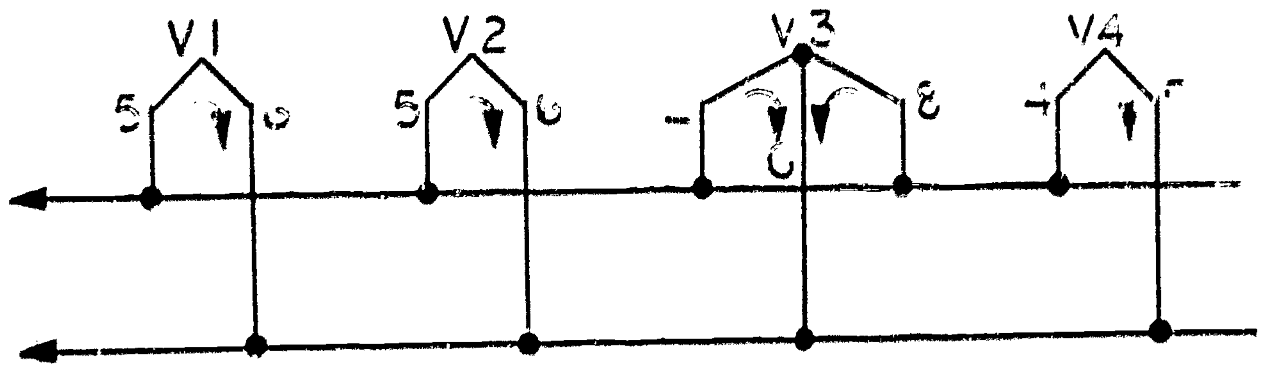


To keep current flowing through a tube, a continuous supply of heat is required. This heat is supplied by the "heater." The arrow below the cathode represents the "heater."

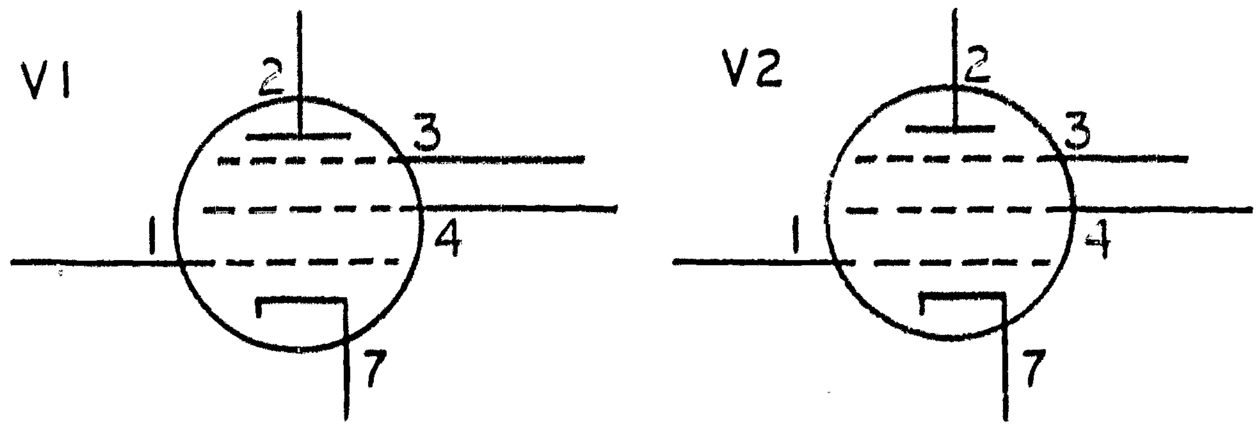


What are the other two leads or electrodes called?* (Answer on next page.)

Every vacuum tube must have a heater.* The heaters of all vacuum tubes must be supplied with electric power from an external source; such as a battery, or a wall outlet. Therefore, we often show all the vacuum tube heaters of a radio set, or what-have-you, together.



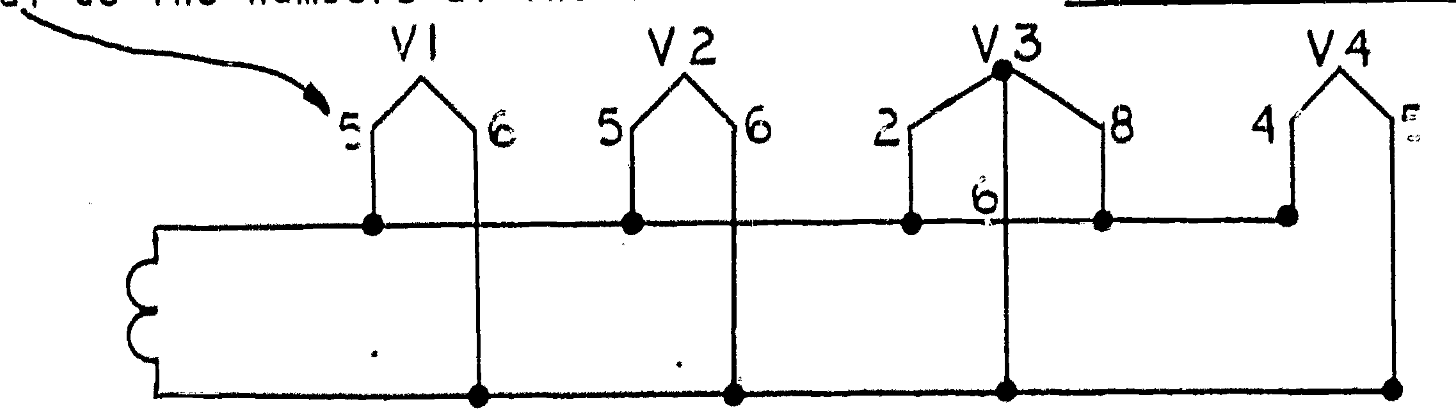
When this is done, the tube symbols are shown without their heaters.



and so on.

Notice that each tube end heater symbol is identified by a number V1, V2, V3, V4.

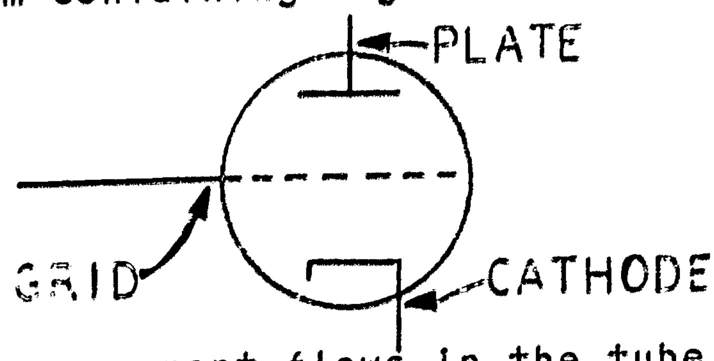
What do the numbers at the heater leads mean?________________



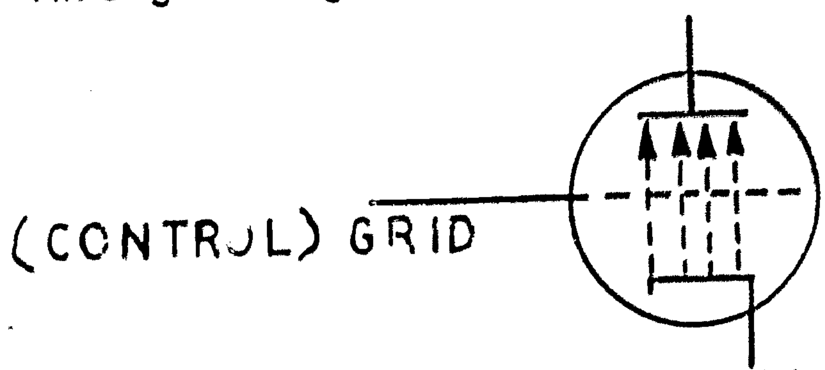
*There are a few exceptions.

Electrical Grids:

Between the plate ⊥ and the cathode ┐ of most tubes there is a wire mesh. It looks like a piece of screen. This is called a Grid. A tube diagram containing a grid looks like this......

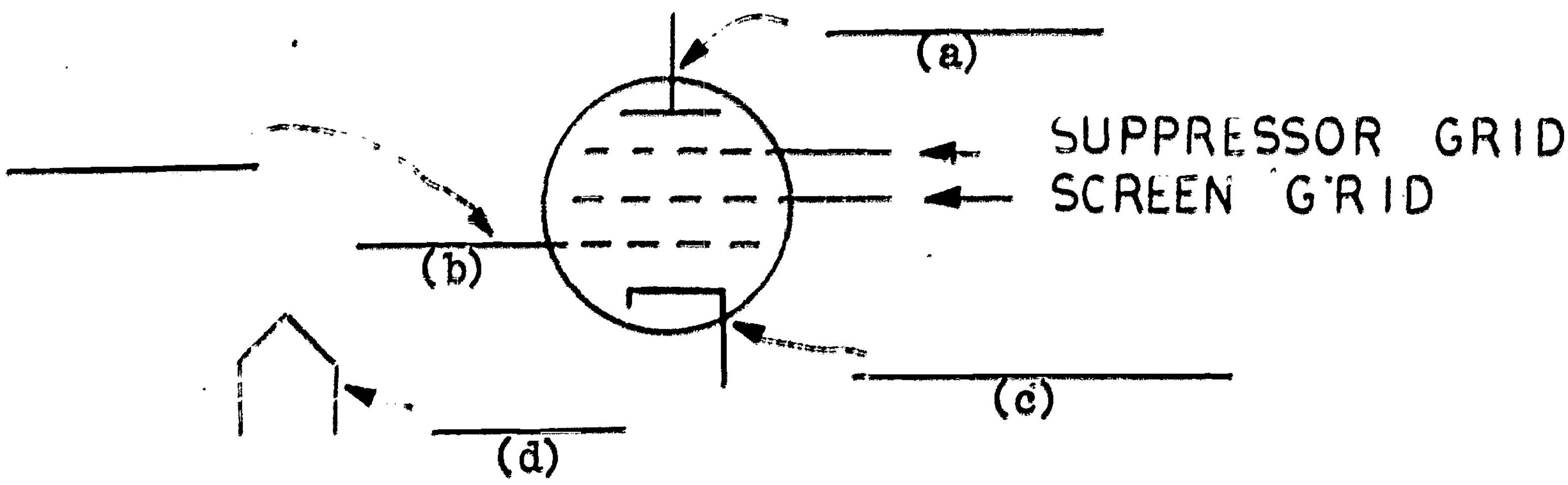


When electricity or current flows in the tube, the direction of this flow is from the cathode to the plate, and this current must flow through the grid, like this.



As electrical conditions on the grid are varied, the flow of cathode-to-plate electricity is varied. In other words, the grid can control the amount of current flowing through the tube. This is why a grid is sometimes called a control grid.

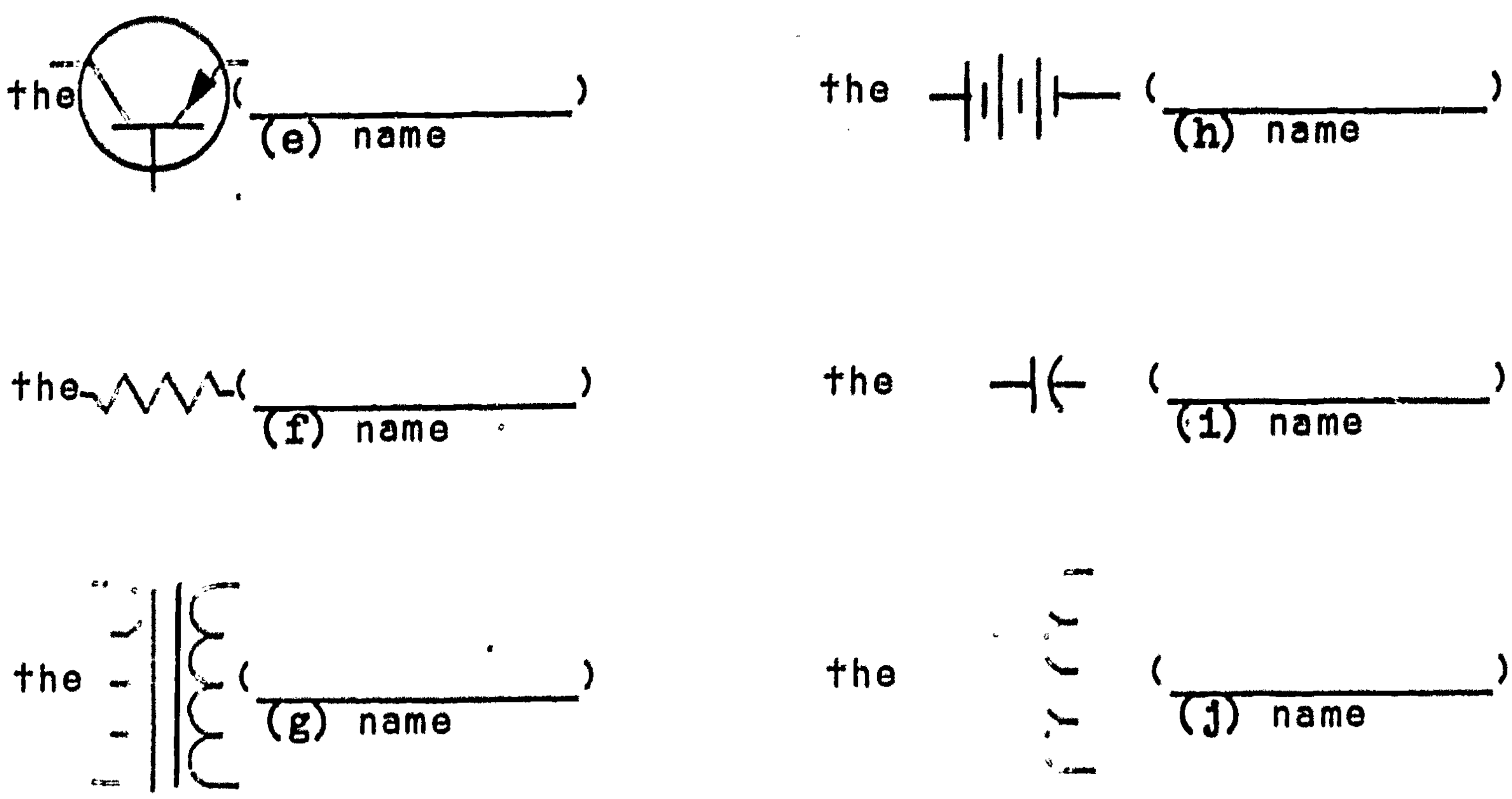
A tube may contain more than one grid depending on the purpose of the tube. Each of these other grids has a special name. For our purposes, we will call them suppressor grids and screen grids. Remember, though, that it is the control grid which is always located nearest to the cathode, and it exerts the most control over current flow in the tube.



Now, on the diagram above, enter the names of the element leads.

CONNECTIONS AND NODES

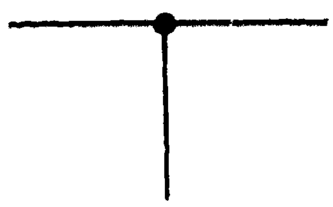
Let us return to the inside of a radio and find out how to draw the connections which exist between its parts. First though, let's review the symbols for these parts. They are



Electrical Connections:

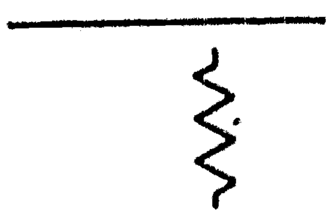
OK, that's fine. Now, for a radio, TV, or any other piece of electrical gear to work, its electrical parts must be connected. Parts are connected with wires, and the symbol for a wire is a line. That's all, just a line, like this..( ).

Do you remember what sticks out from most electrical parts? That's right, pieces of wire, which are called leads. (sometimes they are called pigtails). These wire leads are used to connect parts together or to connect parts to lengths of wire. And, when two pieces of wire are connected the connection is shown by a "dot," like this......

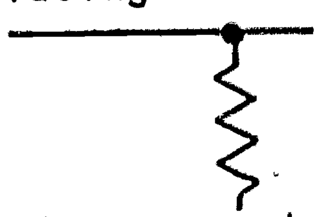


As an example, let us show by symbols how to draw a resistor and a capacitor connected to a piece of wire. First there is the wire symbol which is a straight line.

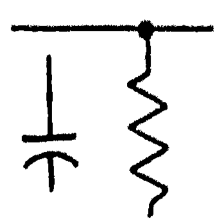
Then we add the resistor symbol with its wire leads sticking out of it.



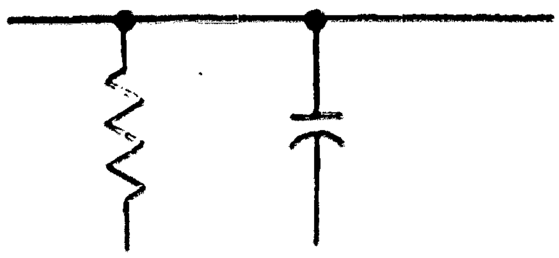
Now we connect the resistor and wire symbols and show that they are connected by placing a "dot" where they are drawn together.



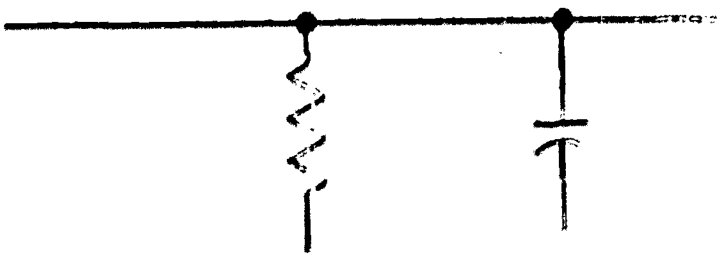
The capacitor symbol can now be added to the diagram.



As the last step, the capacitor symbol is connected to the wire symbol and a "dot" used to show the connection. Pretty easy, isn't it?

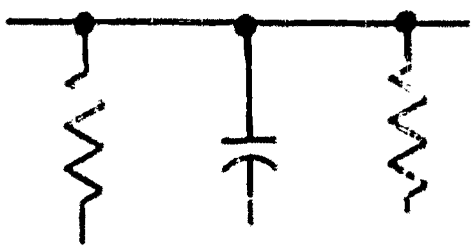


OK then, you try it. On the diagram below draw the symbol for a coil and show it as connected to the wire at Point X.

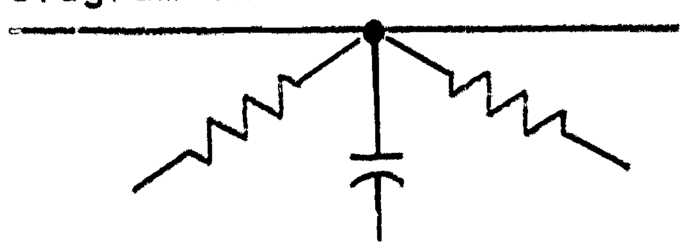


Electrical Nodes:

In the last two pages the diagrams showed each part as being separately connected to the wire, like this.....

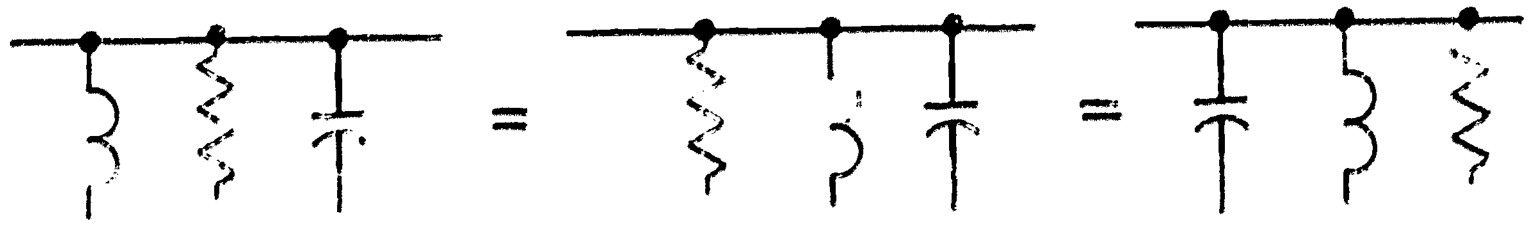


Now suppose we diagram these connections to look like this ....

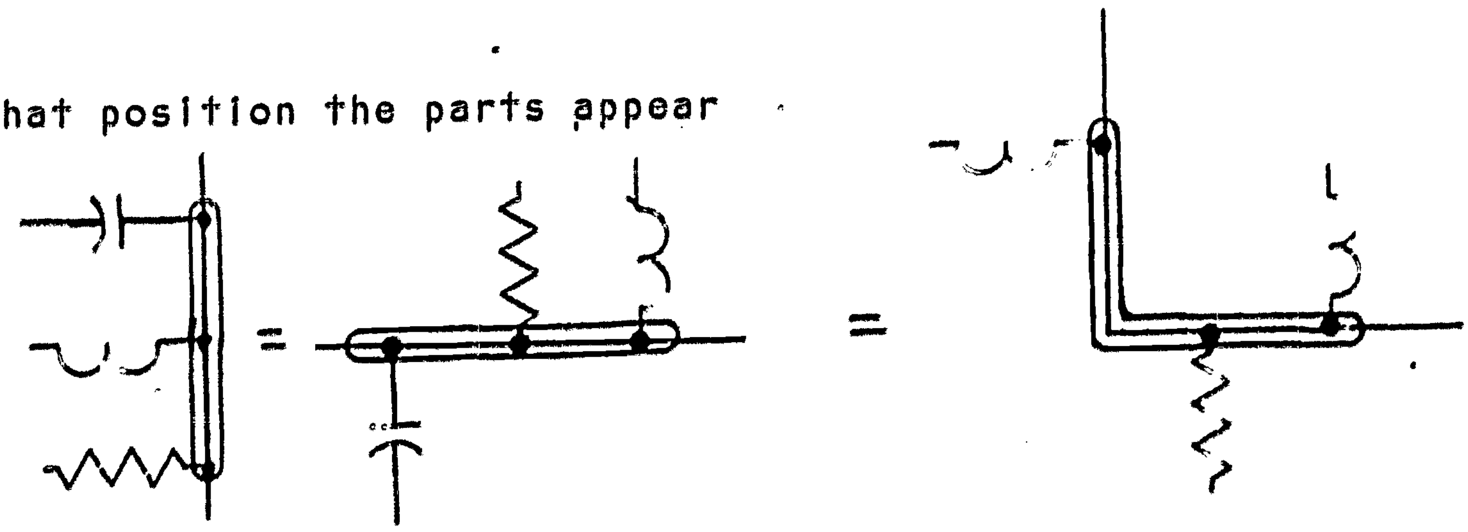


Now the parts are shown as being connected together at the same point. Does this make any difference? Is there an electrical difference between the two diagrams immediately above? No! There is not. The joining of the part wires to the common wire has the same effect electrically, as connecting all the wires to the same point.

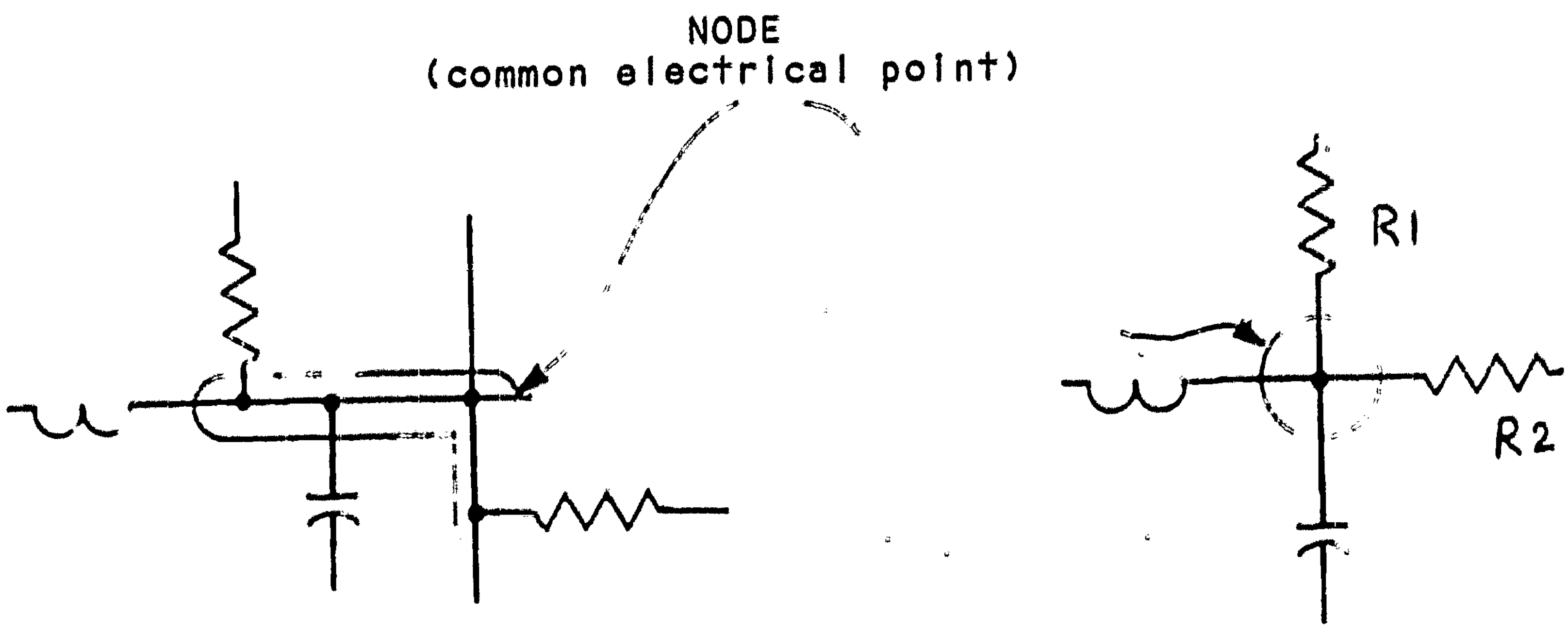
It does not matter in what order the parts are connected.



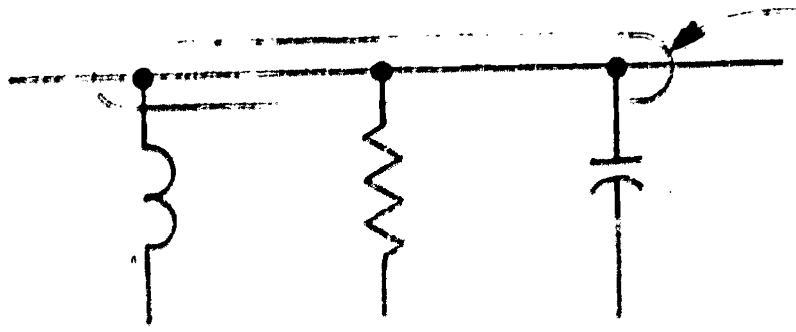
or in what position the parts appear



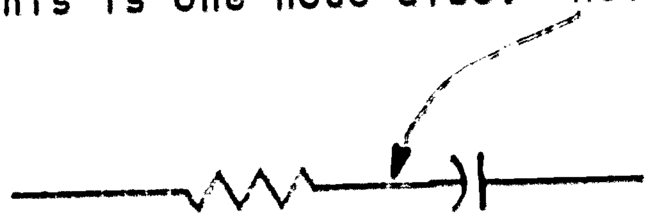
In other words, of the areas circled in the last three diagrams, each belongs to the same <u>electrical point</u>. A common electrical point is called a <u>node</u>.



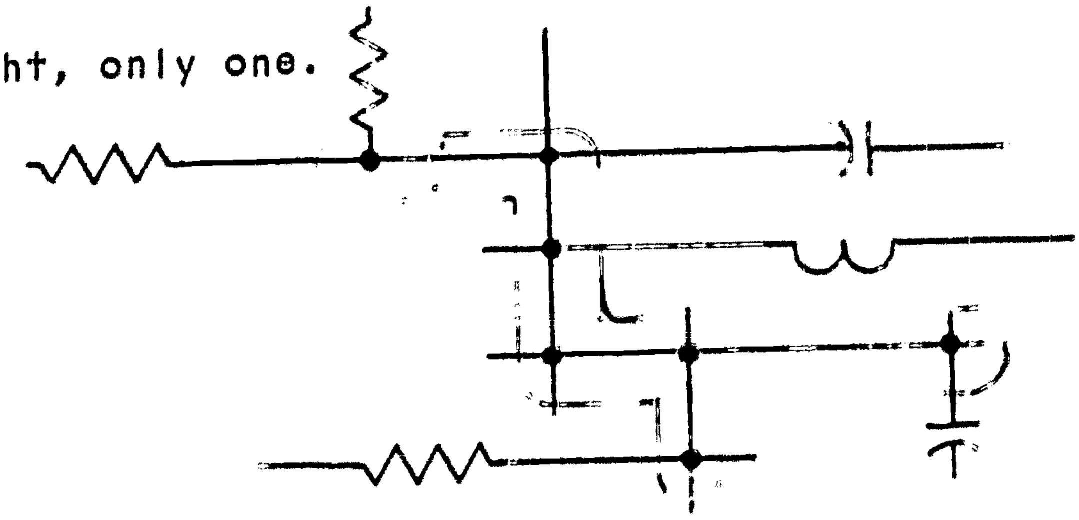
This is one node, even though there are three connections.



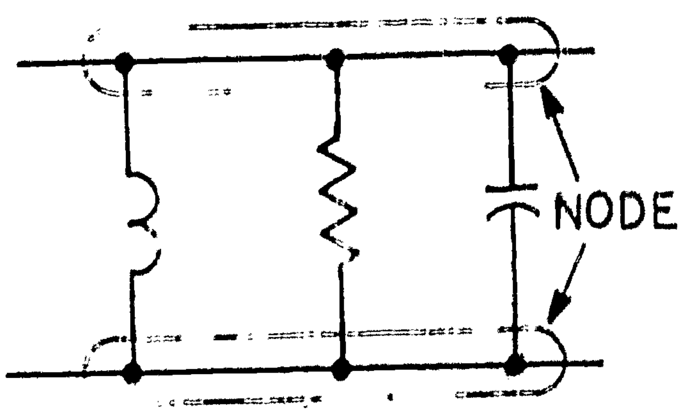
This is one node also. Notice that in this diagram a "dot" is not used to show that the two parts are connected. This often the case when parts are shown in line with each other on a schematic diagram.



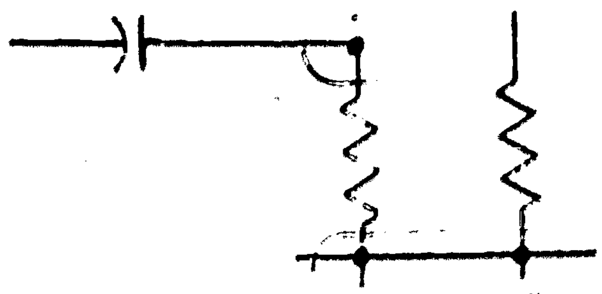
How many nodes are contained within the circled area in this diagram? That's right, only one.



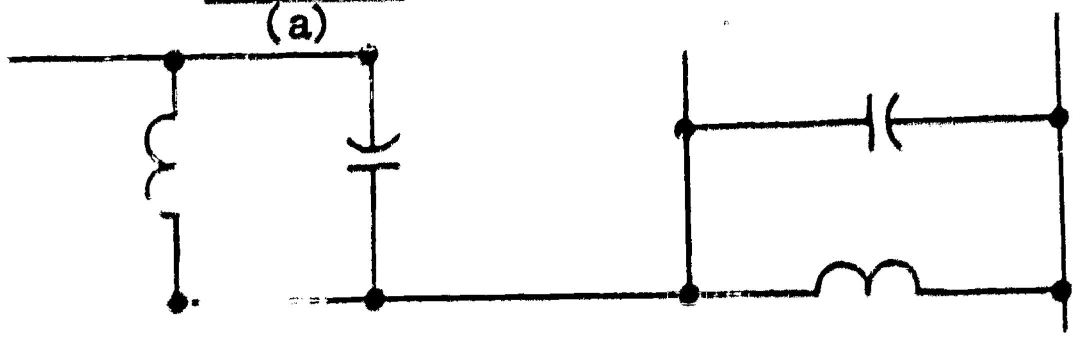
Now look at this diagram. It contains two nodes. Why is that? Because, there is no way for current to flow from the first node to the second node <u>without going through an electrical part</u>.



As you should have noticed, a circle drawn around a node contains only wire and connections. <u>It can not contain a part</u>.

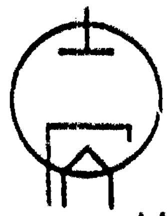


Let's see if you have learned to recognize nodes. In the diagram below, draw a line around each node. How many nodes in the total diagram? It has________nodes.
(a)

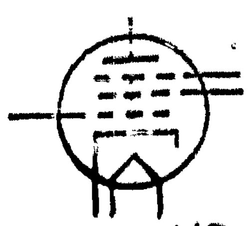


Vacuum tubes have nodes; in fact, they have quite a lot of them. For example, look at the following vacuum tube symbol. Are any of its leads connected to each other? No? This means that each lead or terminal of the tube is a node or is part of a node. In this figure there are a total of five (5) nodes.

In figure VI below, there are________nodes, and in figure V2,
(b)
there are________nodes.
(c)



VI

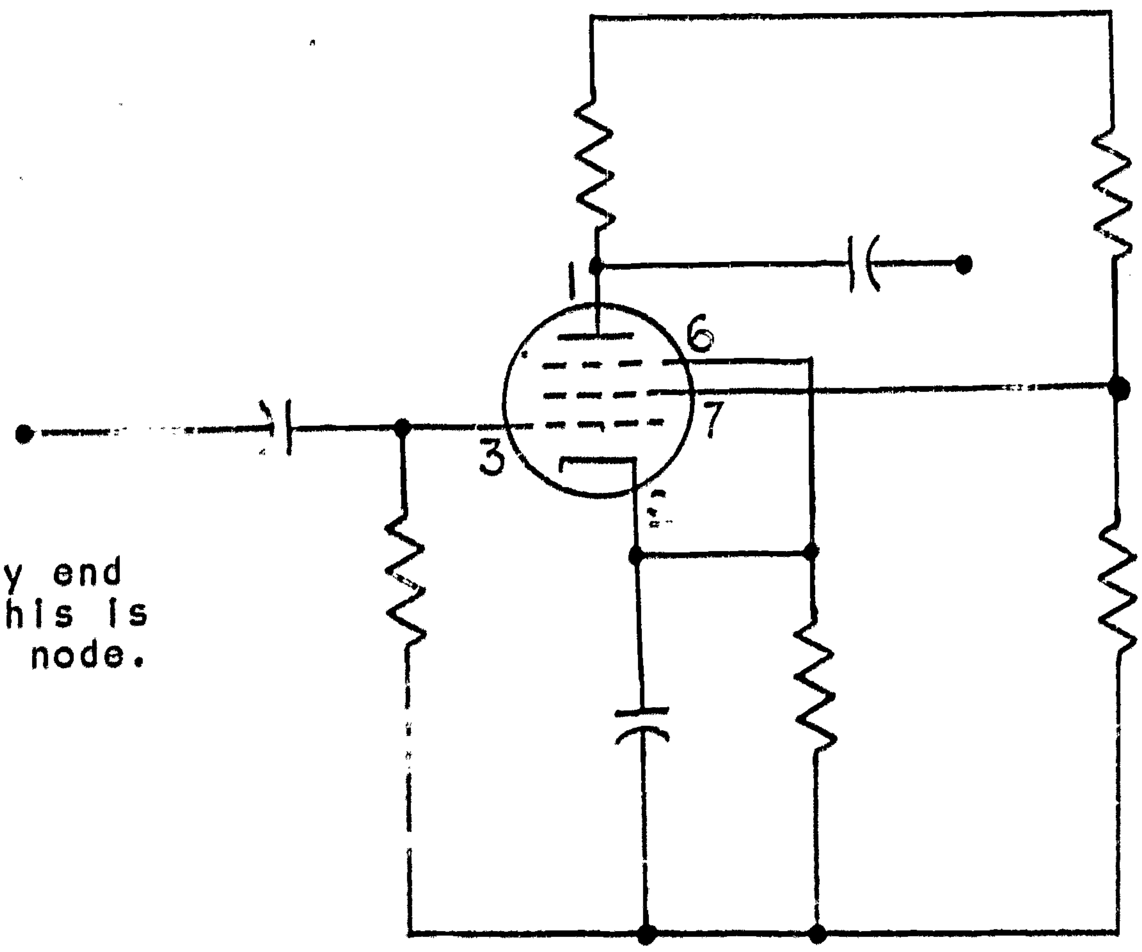


V2

OK, now for the big test. Look at figure V3 on the next page and

draw lines around the nodes of the circuit and count them. Record the number of nodes.

A stray end like this is also a node.



V3

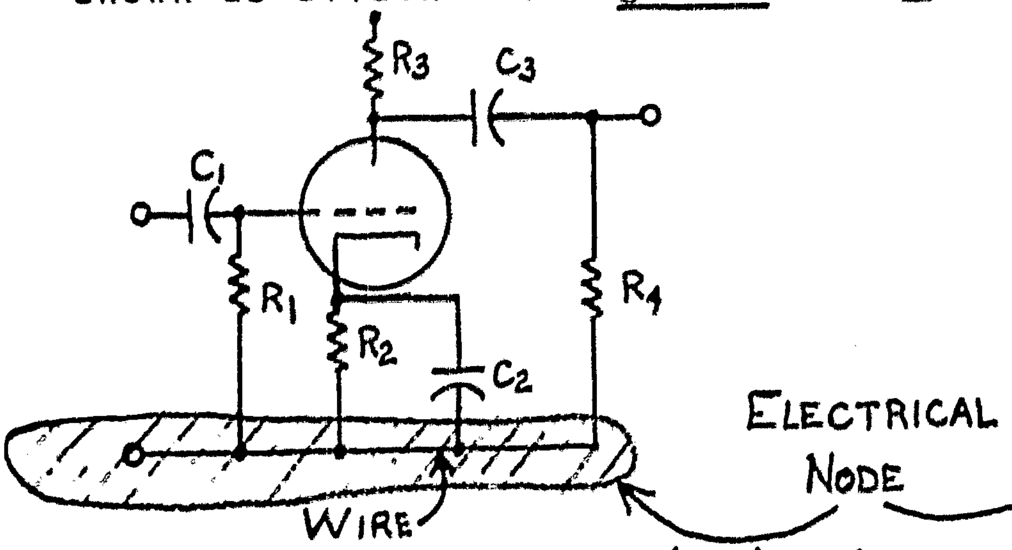
This diagram contains__________nodes.

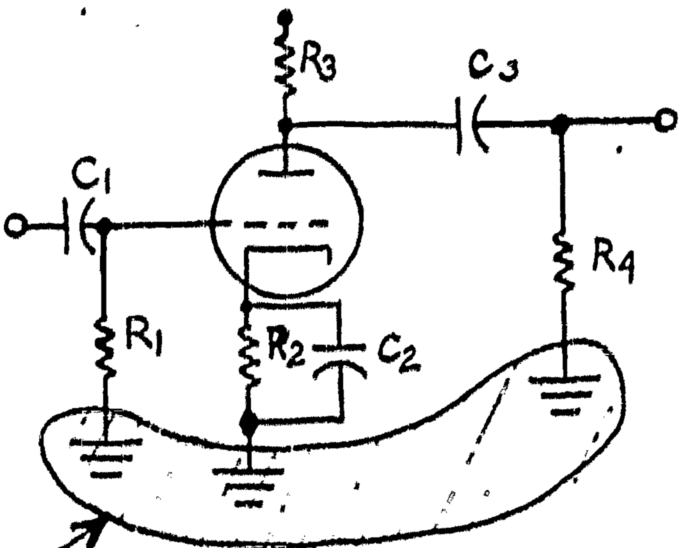
Remember ...... nodes stop when they get to parts. However, a node can come <u>up to</u> any number of parts.

Electrical "Ground":

Sometimes it is difficult to draw a schematic diagram which is not cluttered-up with lines which represent wires. One way of eliminating some of these lines is to see a "ground" symbol which looks like this ..

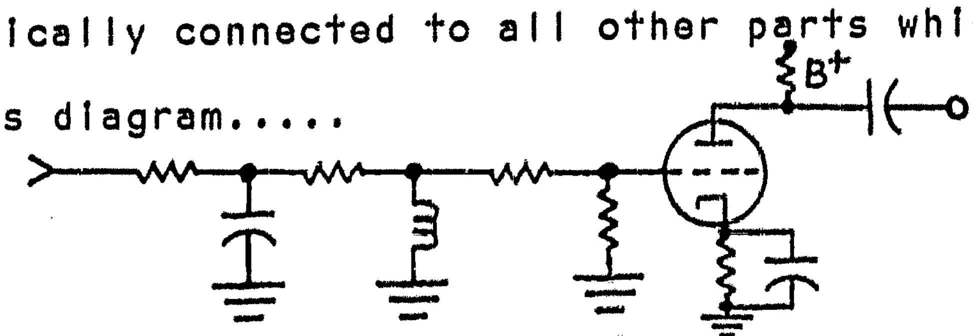
As an example, examine the two diagrams below. In the one on the left, the parts RI, R2, C2, and R4 are all connected to the same wire. You recognize, no doubt, that these four parts are all connected to the same electrical node. Now look at the right-hand diagram; the wire has been removed and the four parts are shown as attached to "ground".



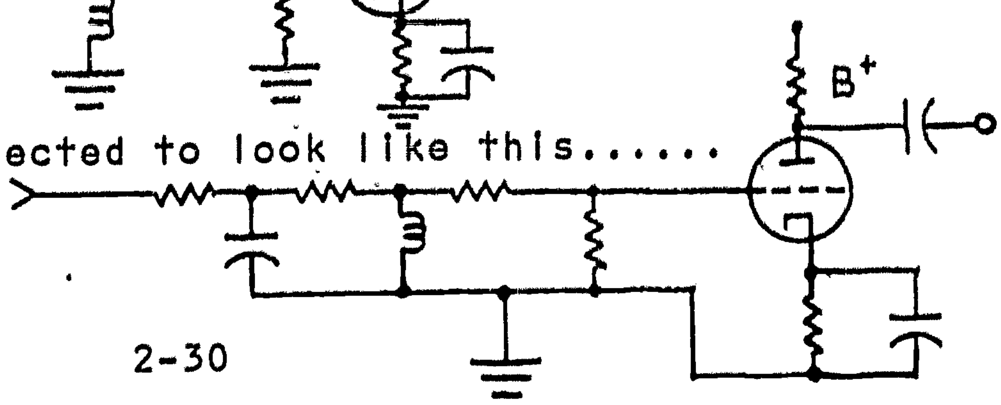


The ground symbol ( ) is used to simplify schematic drawings. The symbol is useful also because it indicates those points and parts which are connected to the same electrical node. That's right, every point or part connected to a ground symbol is electrically connected to all other parts which are "grounded."

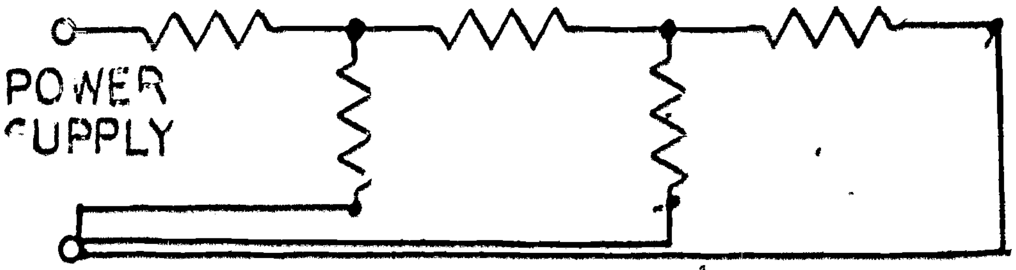
Thus, this diagram.....



might actually be connected to look like this......

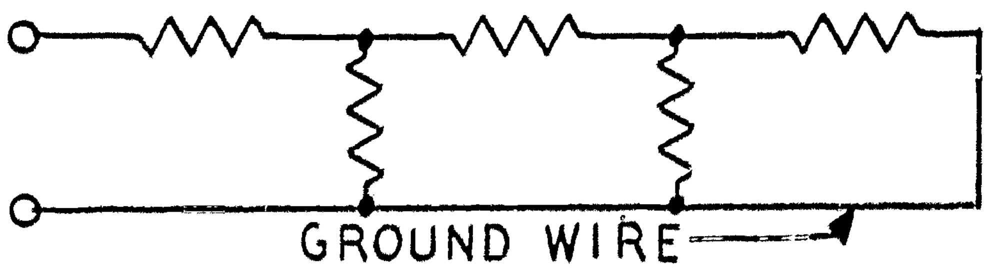


The ground is connected to one side (the "ground side") of the power source. This is convenient because there will be a number of parts which have to be electrically connected to this "ground side" of the power supply. If each of these parts were directly connected to the power supply, it would take a lot of wires.



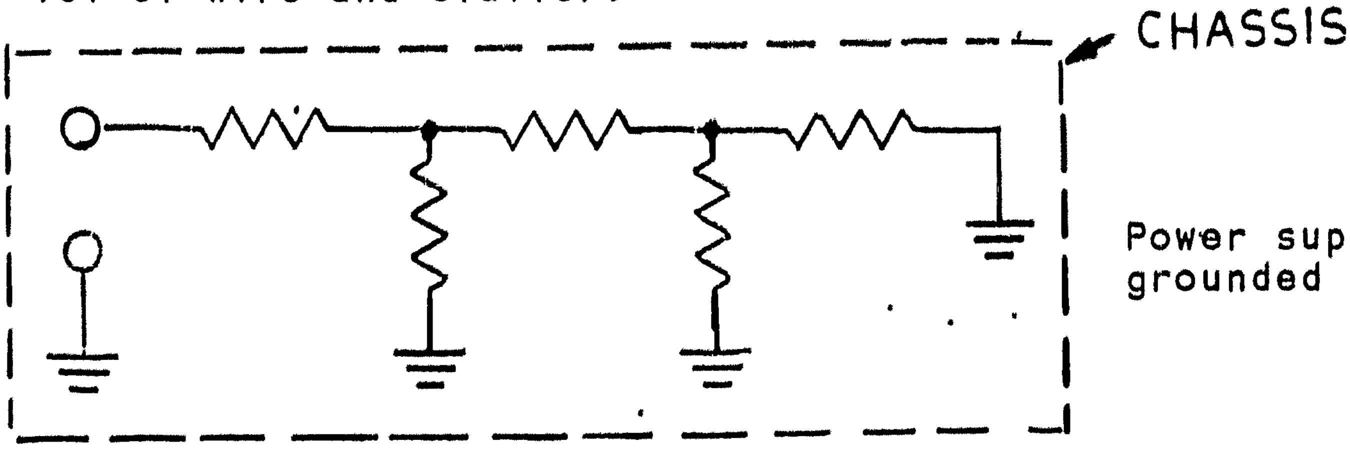
Separate wires connect parts to power supply

Instead of using a ground wire for each part which must be grounded, the parts can all be connected to a single "ground wire" which can then be connected to the power supply.



Parts connected to a common ground wire

Another way of doing the same thing is to attach the ground side of the power supply to the metal chassis of the radio or TV. This chassis becomes the "ground" and those parts which must be grounded (attached electrically to the ground side of the power source) can now be attached to the metal chassis. This saves a lot of wire and clutter.



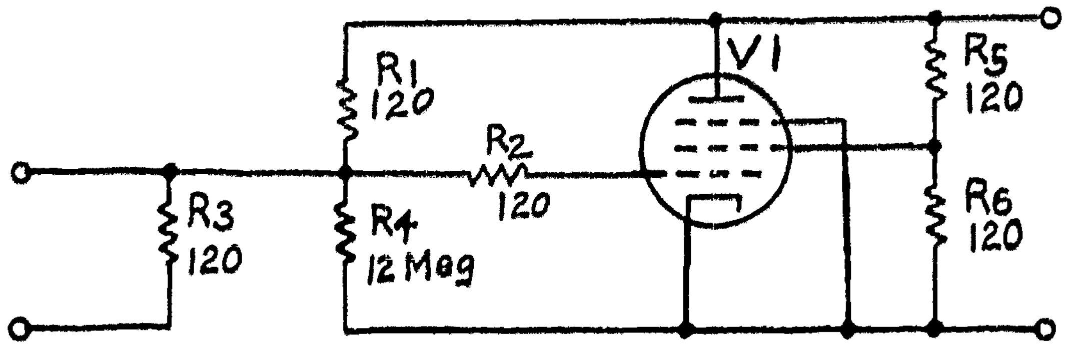
Power supply and parts grounded to chassis

READING SCHEMATIC DIAGRAMS

Labels and Numbers of Parts:

On most schematic diagrams there will appear a number of resistors, capacitors, coils, etc. There must be, therefore, some way to identify each particular part. In the diagram below, you will notice that there are a number of resistors. Each resistor has been given a number. In addition, the value in ohms of each resistor is indicated. This makes it easy to locate any particular resistor on the diagram.

NOTE:
All values in ohms unless noted otherwise



This system of numbering becomes very important as more and more parts are added to the schematic diagram.

You probably noticed that all the resistors are numbered with the prefix "R"...R1, R2, etc. This identifies the part as a __________. All the different part types have their own letter, and these letters are usually used when describing the way parts are connected, as, for example, "The other side of R28 is connected to C23." A list of part names and the letter symbols which represent them appears in Appendix B. For now, you need know only the following letters. As a review, draw the schematic symbols for the five parts listed below.

R = resistor = ______________
(a) symbol

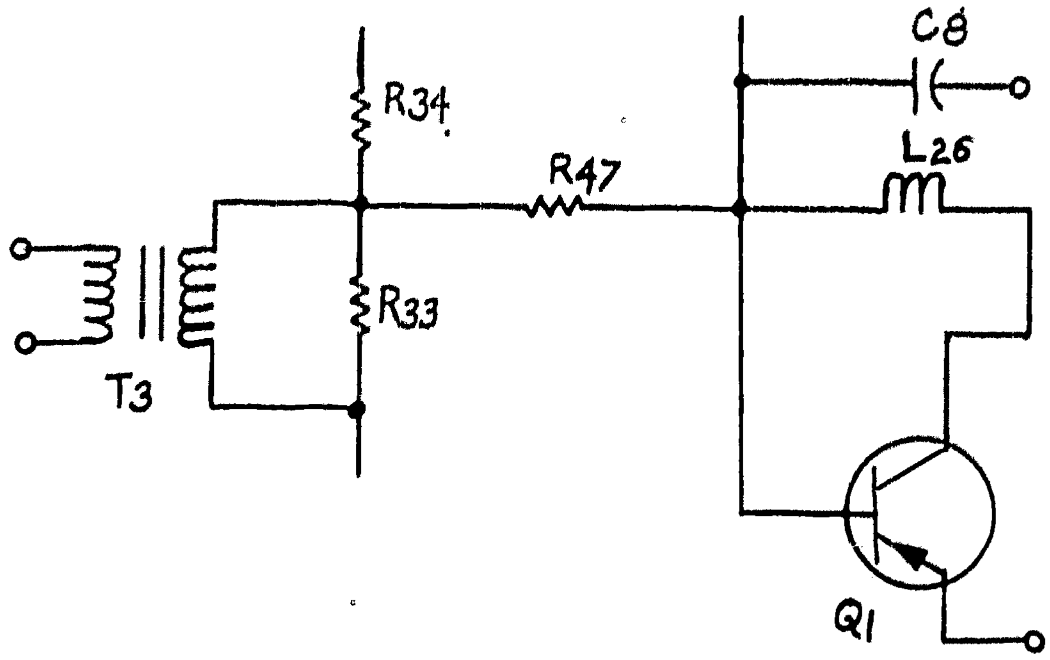
C = capacitor = ______________
(b) symbol

L = coil = ______________
(c) symbol

T = transformer = ______________
(d) symbol

V = (vacuum tube) = ______________
(e) symbol

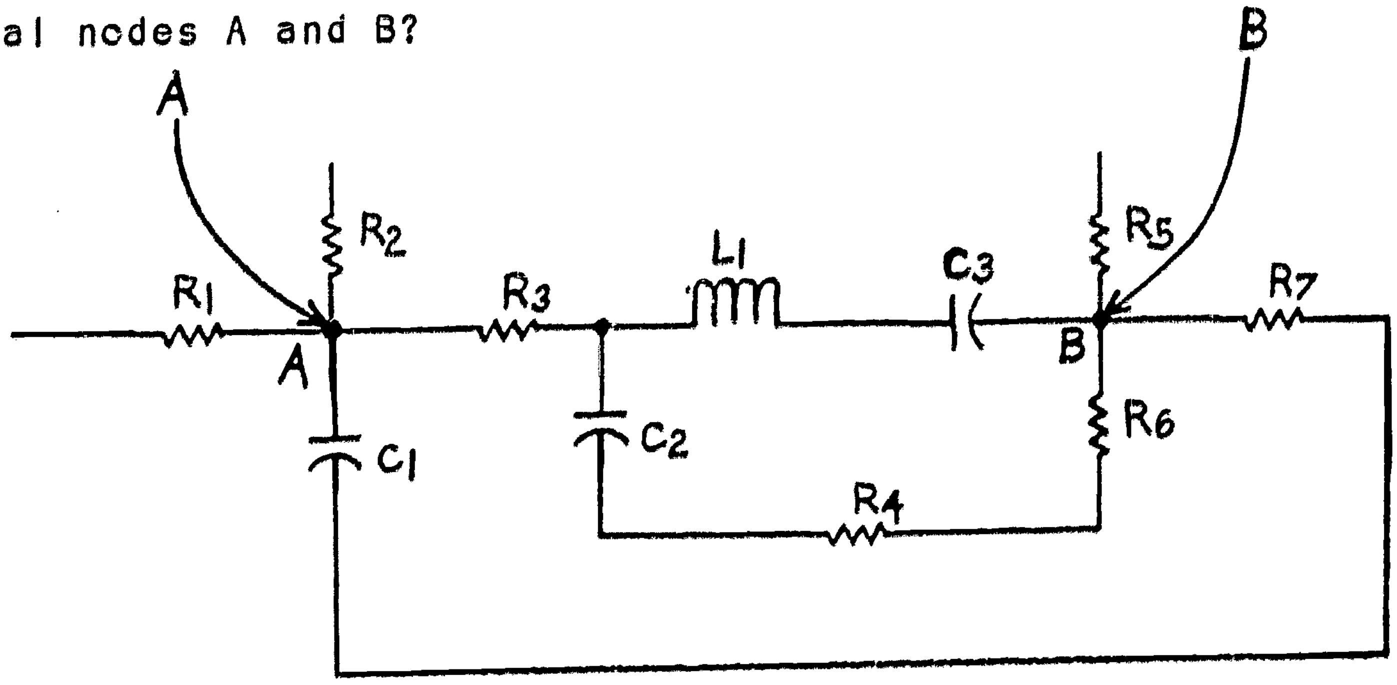
In previous diagrams shown in this booklet, we have drawn the connection of parts in a number of different ways. But, no matter how the diagram may be drawn, it is important to be able to recognize those parts which are connected to the same electrical node or which lie between two electrical nodes. So....... in the following diagram, a number of parts are connected (electrically) to R47. Would you list these parts in the blanks provided?



(f)

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
6. ______________

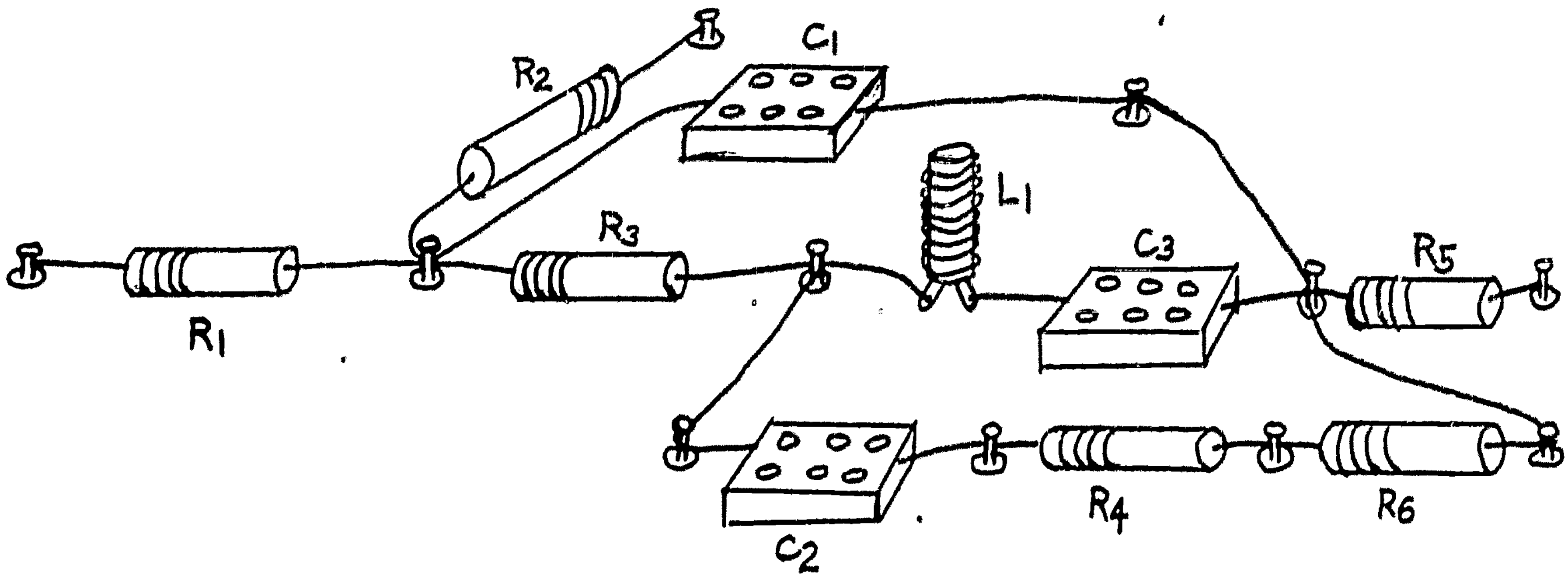
Now let's try another version of the same thing. In the following problem, would you list all the parts which lie between electrical nodes A and B?



1. ____________
2. ____________
3. ____________
4. ____________

5. ____________
6. ____________
7. ____________
8. ____________

As you probably know, the way in which parts and wires are arranged in a radio or TV will differ from that shown on schematic diagrams. What is different is the <u>physical</u> arrangements of the parts and wire; the <u>electrical</u> arrangement is the same. Thus, a repairman has to learn how to read schematic diagrams and then to locate specific parts and wires on the actual radio or TV. We call this <u>Chassis Navigation</u>. We are not going to teach you chassis navigation right now, but, just to give you an idea of what this is all about, here's an example. The following physical picture shows how the parts shown in the last schematic diagram might be physically arranged. But, we have drawn the picture, so that a part is missing. Can you tell what part has been left out, and what part or parts it should be connected to?

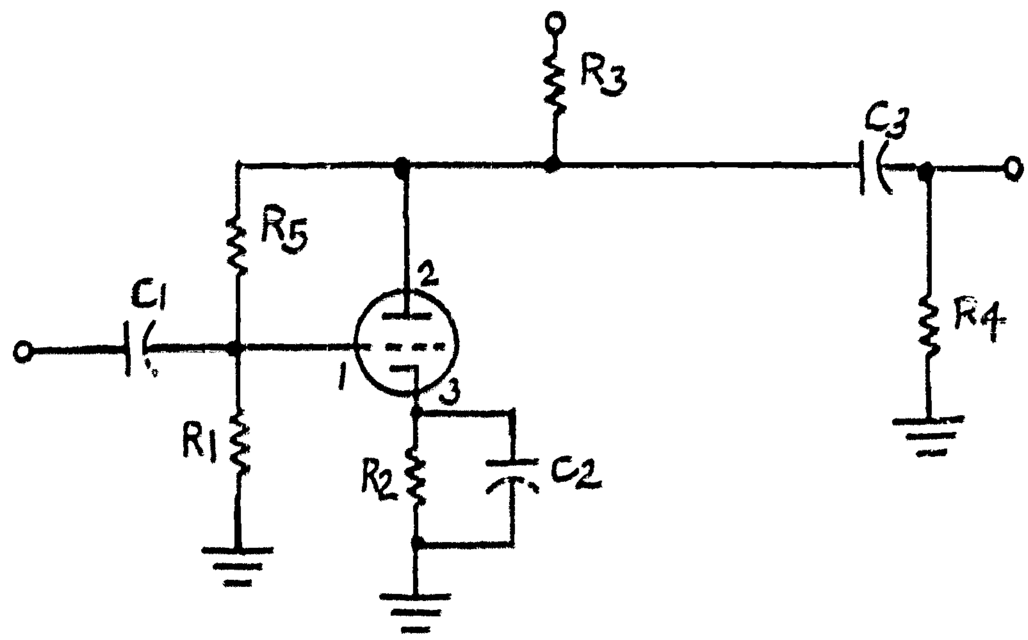


Part left out ____________
(a)

Part or parts connected to left out part ____________
(b)

Tracing the Electrical Path between Tube Pin and Ground:

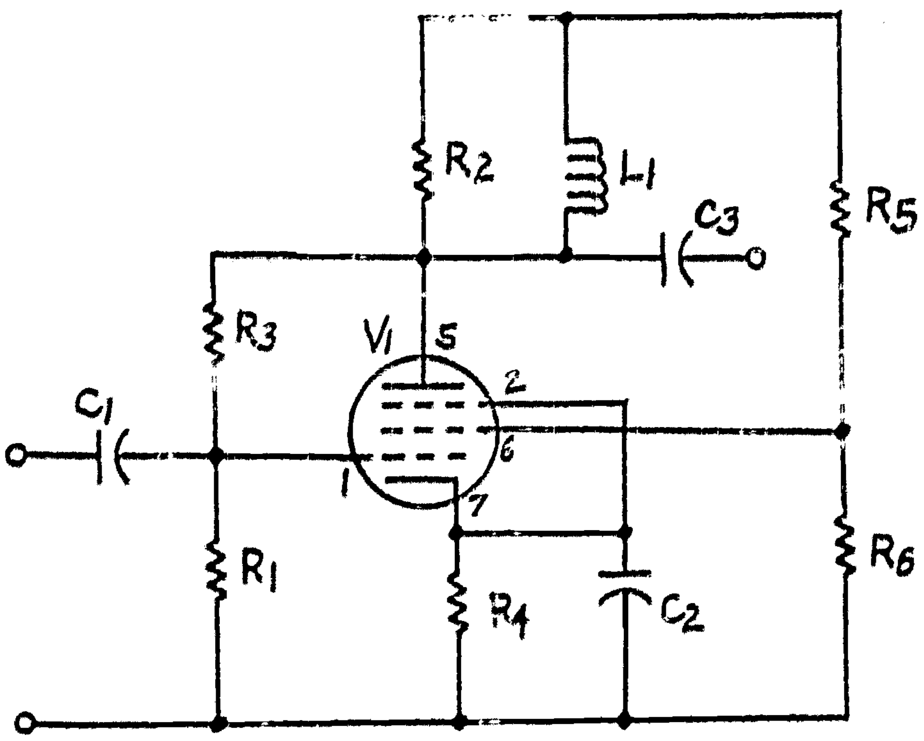
As you will learn shortly, it is very important to be able to look at a schematic diagram and recognize all those parts which are connected between a tube pin and ground. In the diagram below, for example, there are two parts, R2 and C2, which lie between pin 3 and ground. Would you list all the parts connected between pin 2 and ground? In these and similar problems, always assume that the tube has been removed.



1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________

Now try this problem......

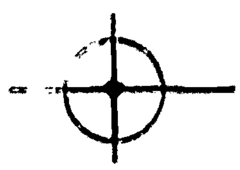
List all the parts that are connected between tube I pin 5 and the node common to RI and C2 with VI removed:

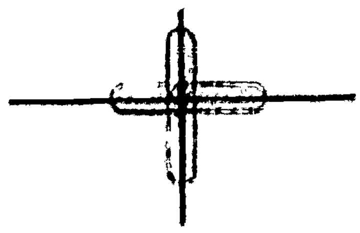


1. ______
2. ______
3. ______
4. ______
5. ______
6. ______

CONNECTED AND UNCONNECTED WIRES

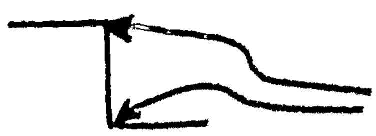
Oftentimes schematic diagrams are arranged in certain ways so as not to require a lot of space. When this is done, it often happens that two unconnected wires have to be drawn as crossing each other. In such cases the "dot" is omitted. Remember also, that when two wires are connected, one node is formed. If the wires are not connected, then there are <u>two</u> nodes involved.



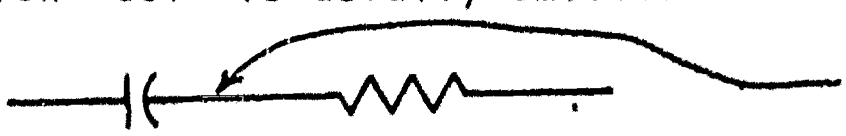


Connected wires	Not connected wires
The "dot" is present	The "dot" is not present
I node exists	2 nodes exist

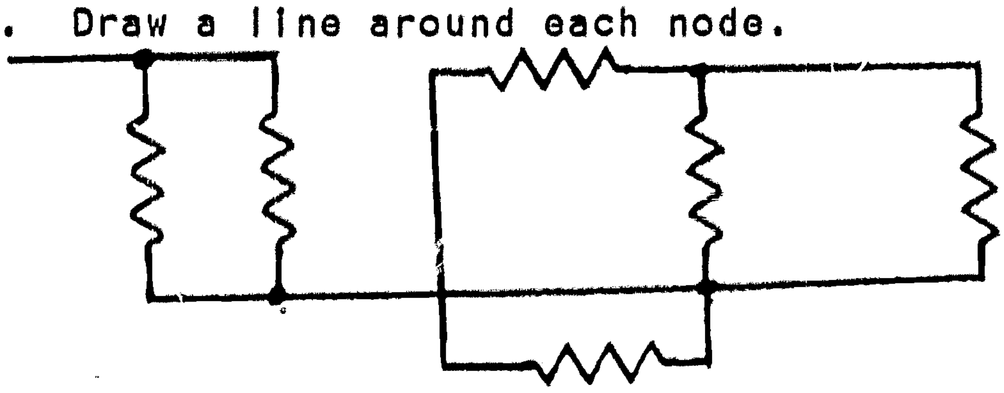
Oftentimes a wire is drawn as making a right angle. No "dot" is shown when a wire line makes a right angle bend only.


no "dot" necessary

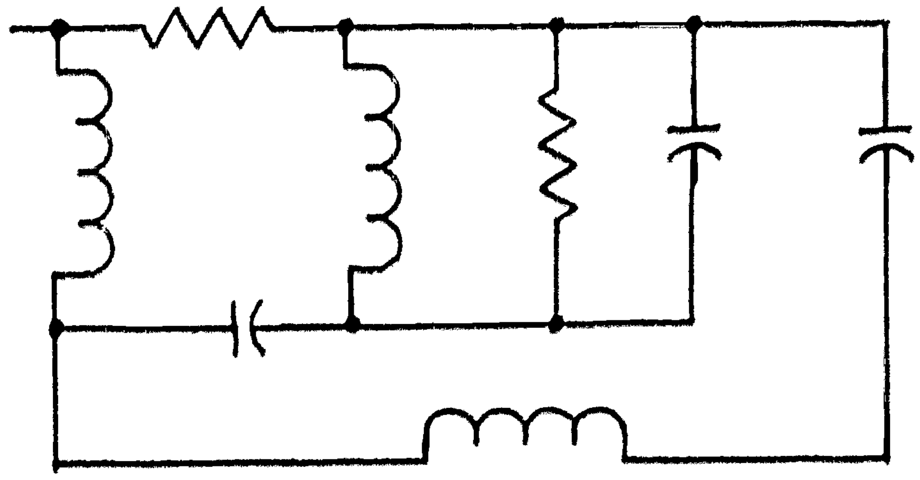
Remember also, that when two parts are directly connected, the connection "dot" is usually omitted.


no "dot" necessary

Now for a problem. The following circuit contains four nodes. Draw a line around each node.



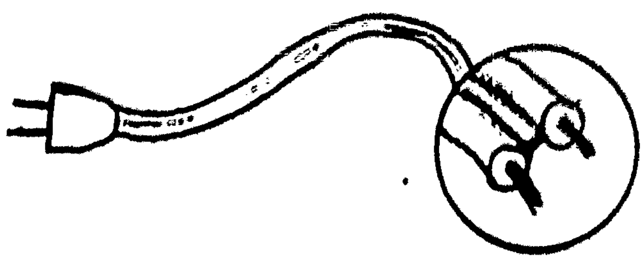
Now let's try one more problem dealing with nodes. The following diagram shows _______________ nodes. Draw lines around
number
each one of them.



CONDUCTORS AND INSULATORS

What are nodes made of? Nodes are made of wire conductors. The most common conductor is cooper. Aluminum and silver are also good conductors. Metals in general are conductors and so is dirty water. Electricity flows easily a conductor. Conductors do not <u>resist</u> or prevent electrical flow.

Wire conductors are contained inside of the flexible cable or cord which is attached to most lamps, radios, TVs, etc. An enlarged and cutaway view of such an electrical cord shows two conductors.

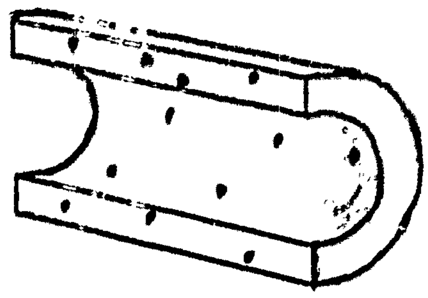


Now then, what material surrounds these conductors? It is usually rubber and may be plastic. But, the important thing is that this material "is an insulator." An insulator does not let electricity flow through it easily. It resists the flow

of electrical current.

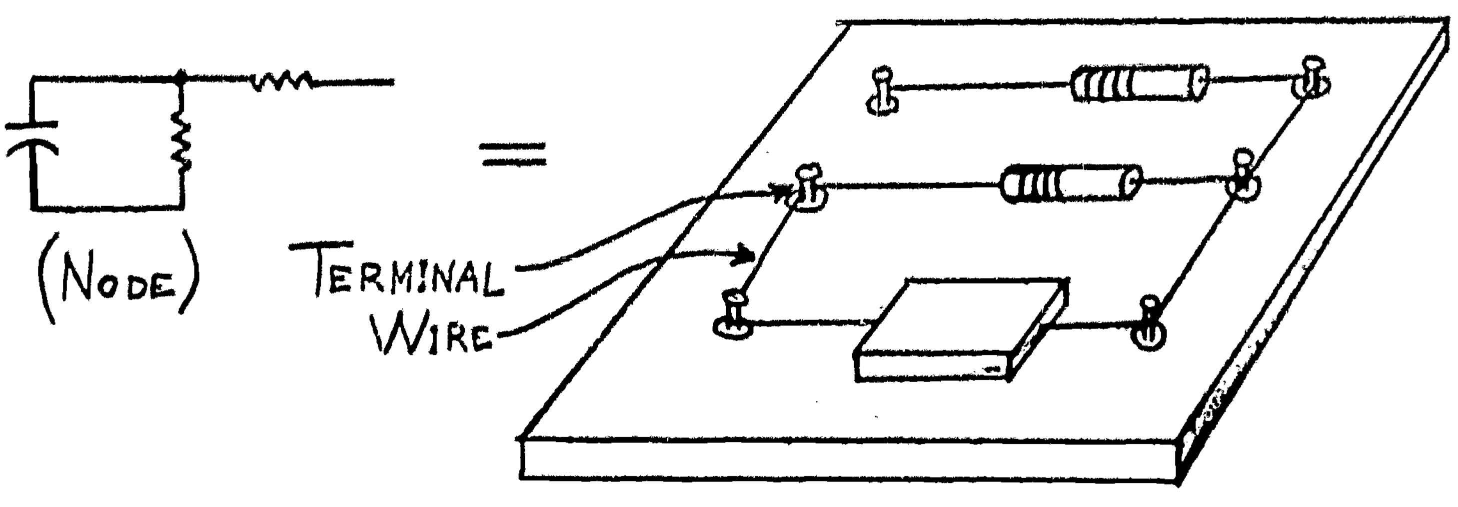
While electricity flows easily through a conductor

electricity has the toughest time getting through an insulator. Hardly any gets through.

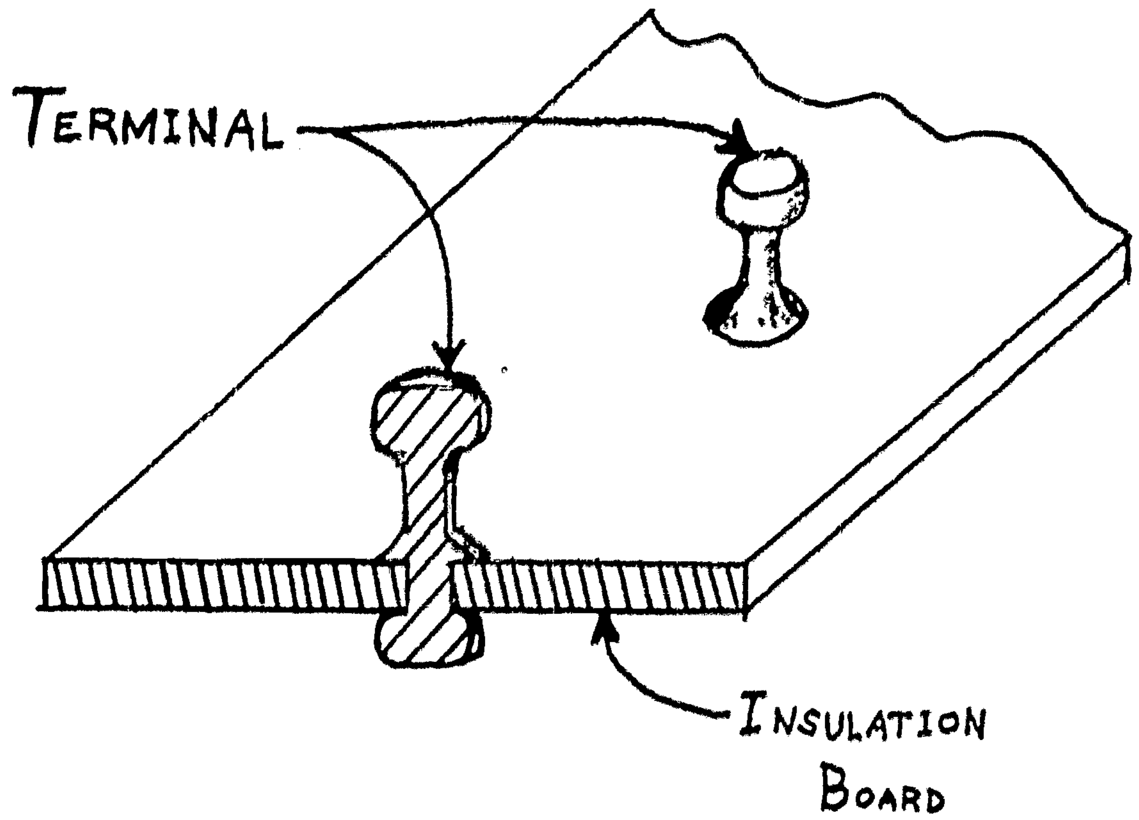


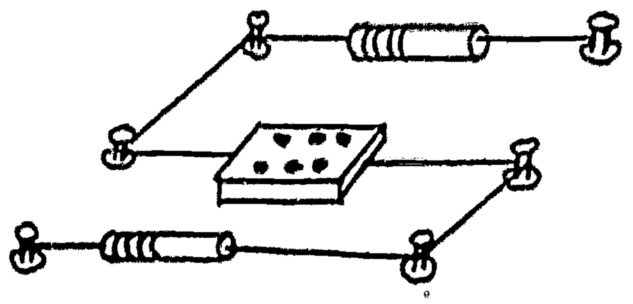
Insulators and insulation are a very important part of all electrical circuits. They are needed because electrical nodes must be kept electrically separated or "insulated" from each other.

An often-used way of insulating nodes and holding radio and TV parts in place is the use of terminals in a plastic board.



The parts and wires are attached to the terminals, and the terminals are attached to the board as shown by this cut away picture:





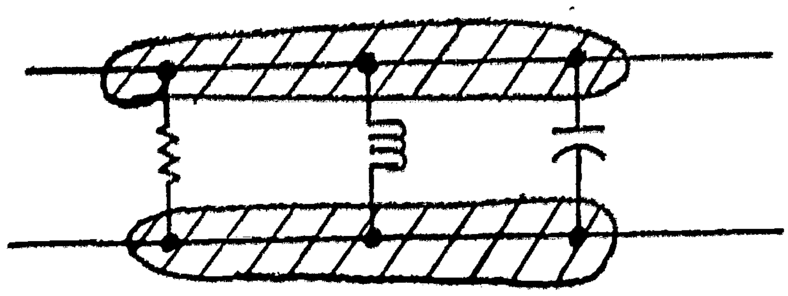
Draw the schematic or symbol diagram for the above wiring picture here.....

Now let us review a bit before we see of what use nodes are in electronic repair:

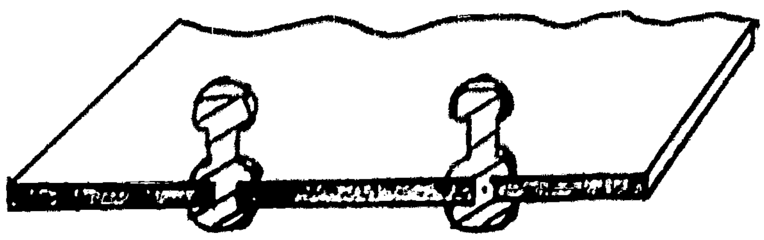
Nodes are made of ______________ and electricity flows
a word

easily through them.

Between the nodes are the electronic parts.



Nodes are held mechanically apart by



____
b word

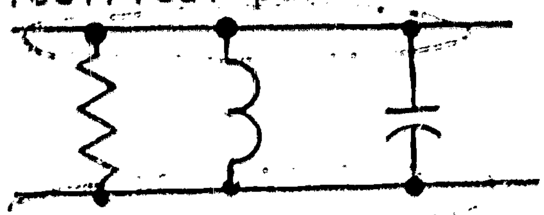
RESISTANCE OF ELECTRICAL PARTS

Conductors offer very little resistance to the flow of electricity, while insulators offer very much resistance to electricity flow. Therefore,

Conductors --- do not resist electrical flow

Insulators --- resist electrical flow

we say that conductors have a low resistance and that insulators Have a high resistance. The electrical parts which exist between electrical nodes



have a resistance to electrical flow that is between the low resistance of ______________s and the high resistance at
a name

______________s.
b name

The resistance of a particular part to the flow of electricity is a basic property or characteristic of that part. We call this the part's "resistance." The resistance of a part can be measured. This measurement indicates where the part lies on the resistance scale between conductors and insulators.

Conductors		Parts coils, resistors, capacitors		Insulators
Very low Resistance 0 ohms to 5 ohms		resistance depending on part		very high resistance 10,000,000 ohms to infinite resistance

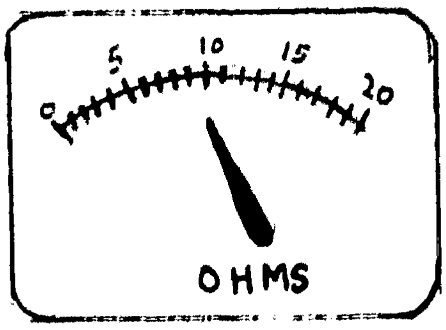
SCALE OF RESISTANCE

Ohms and Ohmmeters:

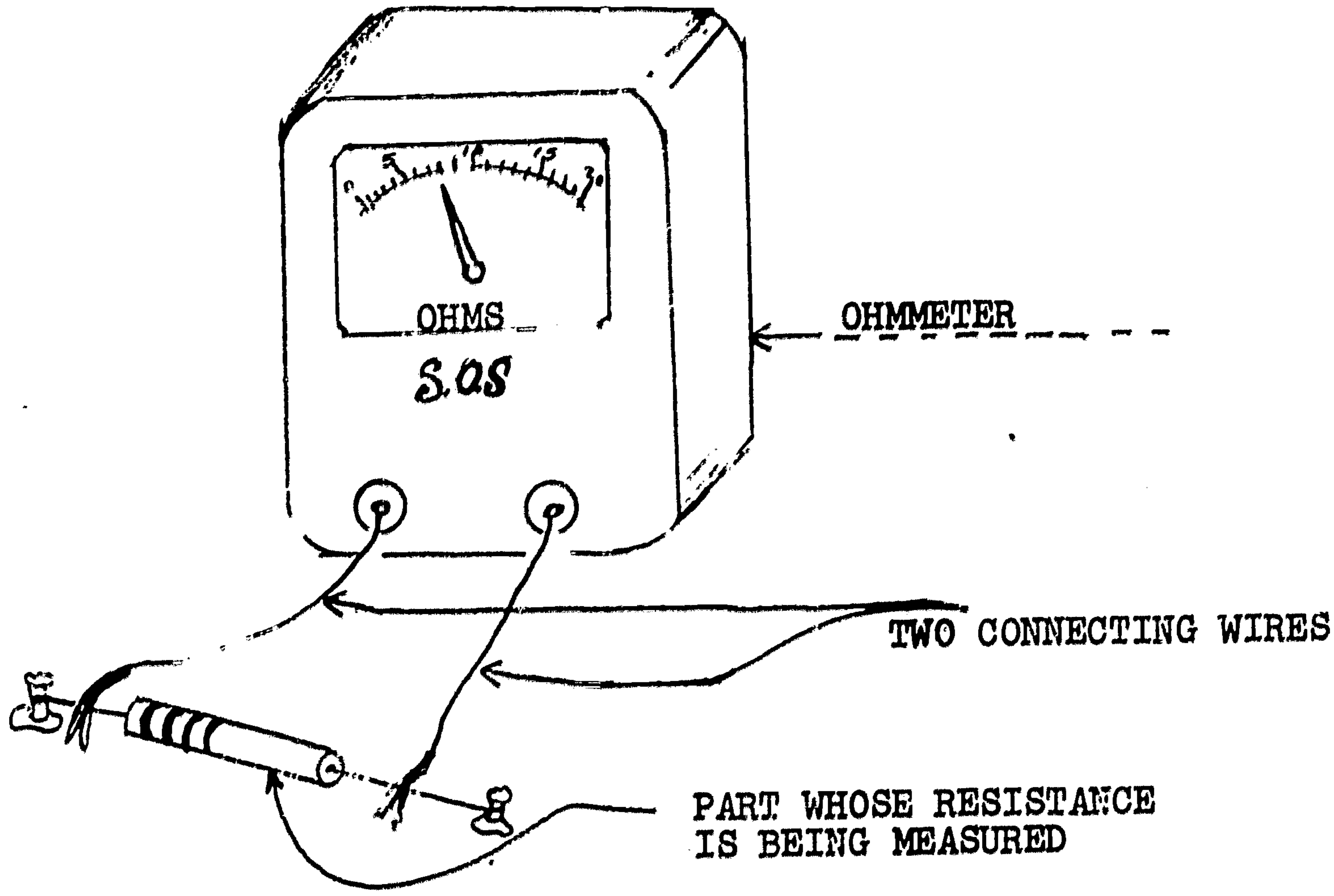
Resistance values are measured in units called Ohms. Ohms are a unit of measurement, just as are the measuring units of pounds, inches, and so forth. Differences in weight are measured and described in terms of tons, pounds, or ounces. Differences in resistances are measured and described in terms of ohms.

Just as we have scales to measure weight exactly, so we have ohmmeters to measure resistance exactly. You may not recognize the term "ohmmeter" but perhaps you have heard of multimeters. A multimeter is a very common electrical testing device which is really three testing devices. When a multimeter is set up in a certain way, it functions as an ohmmeter.

An ohmmeter is used to measure the resistance of electrical parts. An ohmmeter has a meter face and a pointer



which points to the numerical resistance value of the part across which the ohmmeter is connected.



More will be said later about ohmmeters:

The important thing to remember now is that the

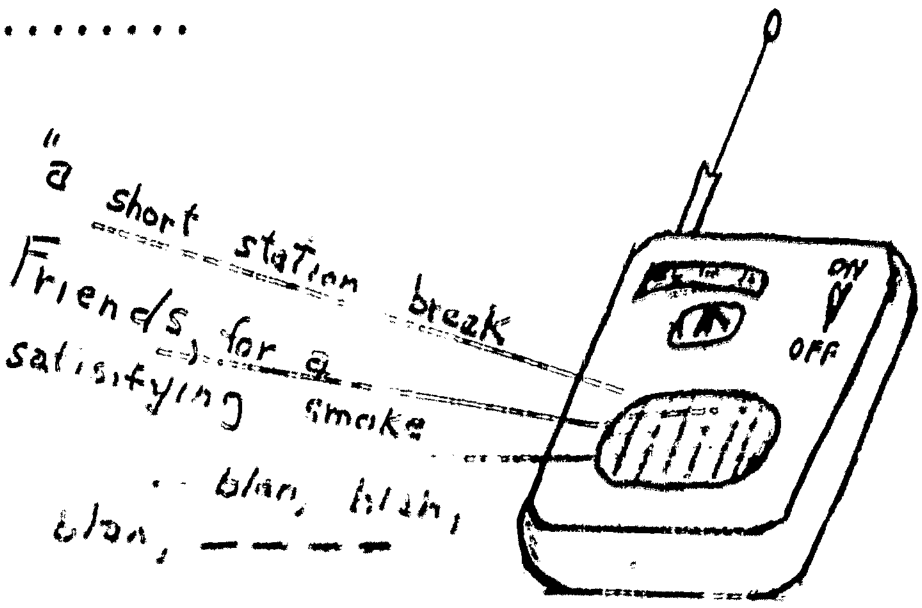
______________________ has two wires which were connected to
instrument's name

the opposite ends of the part being measured, and it has a scale and pointer which shows the value of the part resistance in ohms.

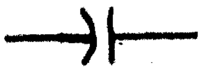
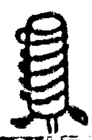
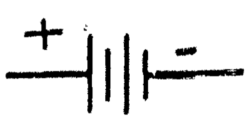
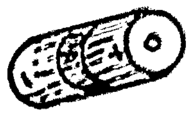
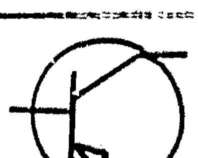
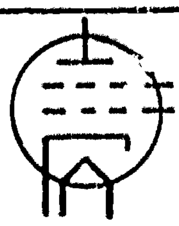
The resistance of an electrical part is a relatively fixed characteristic of the part. The resistance of a part will change slightly with temperature and with use, but the change is not very big. In addition, it is very difficult to make electrical parts which are identical twins. This means that the same types of electrical parts seldom will have the exact same resistance. Just as every adult foot will scale in at <u>about</u> one foot in length, so will every 250 ohms resistor scale in at <u>about</u> 250 ohms in resistance.

In order to repair electronic equipment, a repairman must know what resistance to expect from each part, and how to interpret error readings on the ohmmeter.

For this, let us review the basic parts of the transistor radio ....



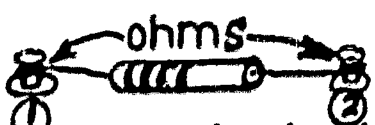
Fill in the words for the parts below:

Symbol	WORD	PICTURE
	(a)	
	(b)	
	(c) -----CORE	
	(d)	
	(e)	 
	(f)	

COLOR CODES

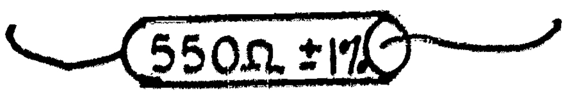
Electrical parts such as resistors, capacitors, and coils may have color codes. These codes describe the important electrical characteristics of the part. In this section, you will learn how to read these color codes.

Resistors:

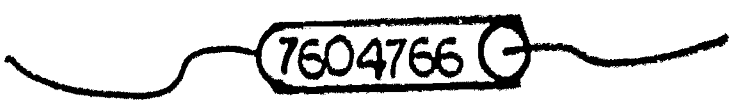
We will discuss resistors () first because its function is to have resistance. A resistor () is built to have a definite ohm value of resistance between its terminals (

).

The ohm value is indicated on the resistor, either in numbers



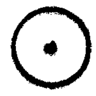
or hidden in a manufacturer's catalog number



or, as is usually the case, in a <u>color code.</u>

The ohm value of the resistor is coded in terms of four color rings on one end of the resistor. This permits us to read the value from any side of the resistor.

Resistor:

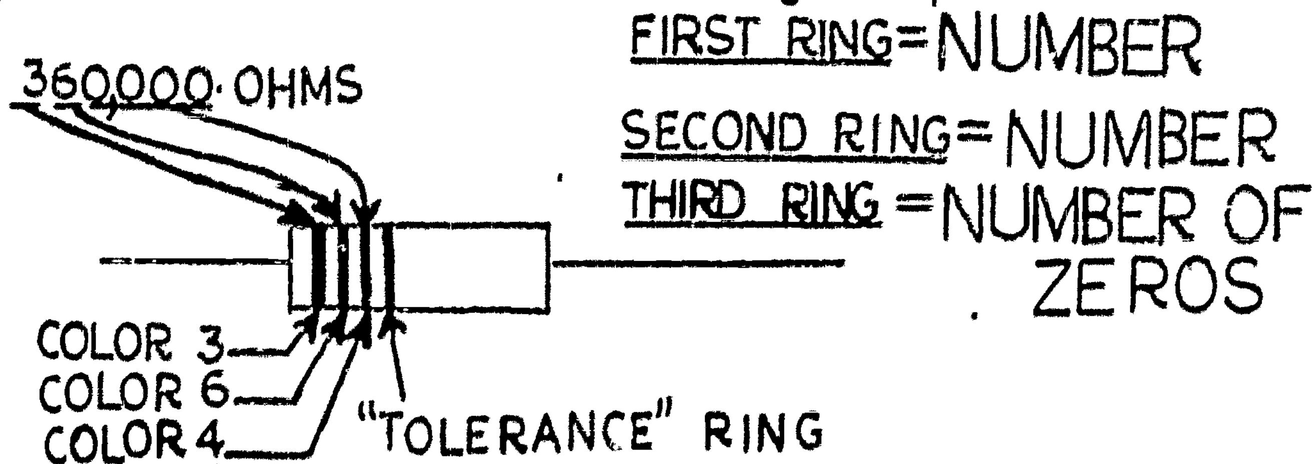


End view
no information

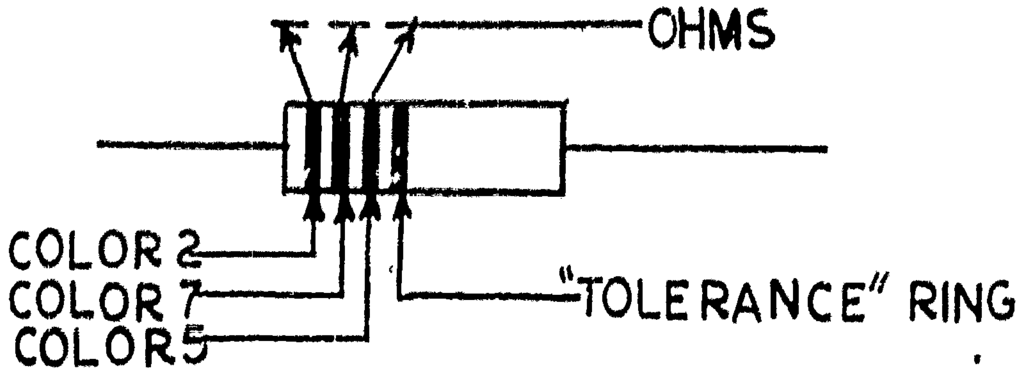
Resistor Side View

Resistor Bottom View

Ten different colors are used (standing for the numbers 0 to 9). The coding scheme is seen in the following example:



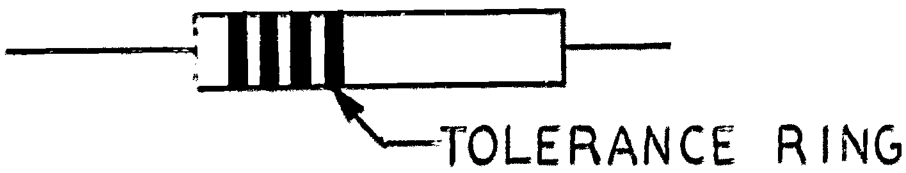
What is the ohm value of this resistor?



You will need to know what color stands for what number before you can use the code. This information is listed in Appendix B. Someday you may want to memorize Appendix B, but for the present, that isn't necessary.

Resistor Tolerance:

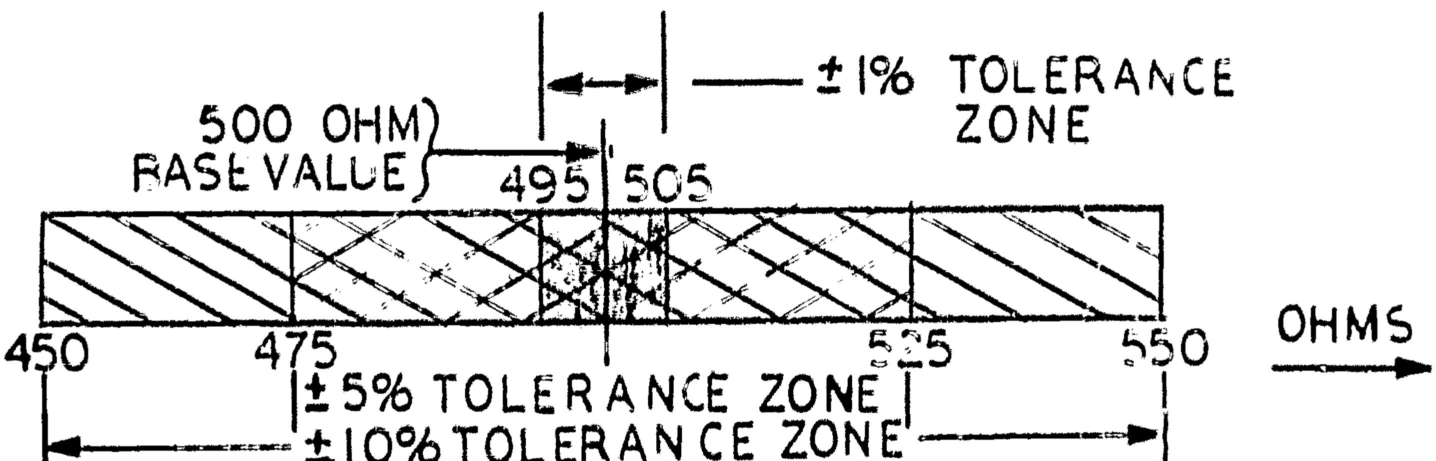
So far we have talked about the first three color bands on a resistor. Now let's talk about the fourth band. This band or ring is called the "tolerance ring. Let's find out what "resistor tolerance" is.



The resistor manufacturer has a hard time controlling the exact ohm value of his resistors. He may be trying to produce 500 ohm resistors, but when he measures his product he may get resistors of 490, 475, 480, 520, 505, and so on. These are grouped as 500 ohm resistors; but the fact that they are not exactly 500 ohms must be indicated. This is done by expressing the resistance with a tolerance or error zone added; as for example:

500 ohms $\pm$ 5%

The 500 ohms resistor may vary as much as 5 per cent from the value given. 5% of 500 ohms is 25 ohms. So, the resistance may be anywhere between 500 minus 25 = 475 ohms and 500 plus 25 = 525 ohms.



This tolerance or error zone is quite common and will occur with all parts. Notice that we can limit the values of the resistance closer and closer to the "base" value of 500 ohms by

decreasing the tolerance to 1% or even 1/2% (0.5%).

Questions:

1. A 400 ohms ± 1% resistor will vary between

   400 - ___ = ___ ohms

   and 400 + ___ = ___ ohms

2. A 300 ohm ± 5% resistor will vary between

   ___ - ___ = ___ ohms

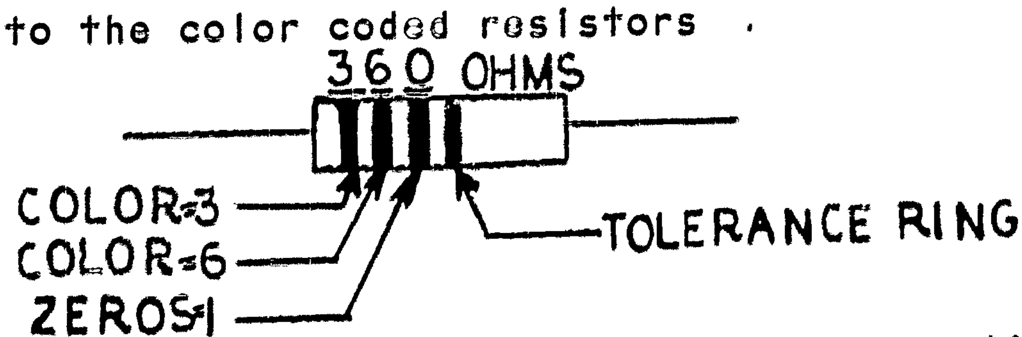
   and ___ + ___ = ___ ohms

3. A 900 ohm + 10% resistor will vary between

   ______________________ ohms

   and ______________________ ohms

On to the color coded resistors .



the 4th ring tells the tolerance or error limits as follows:

± 20% = no ring

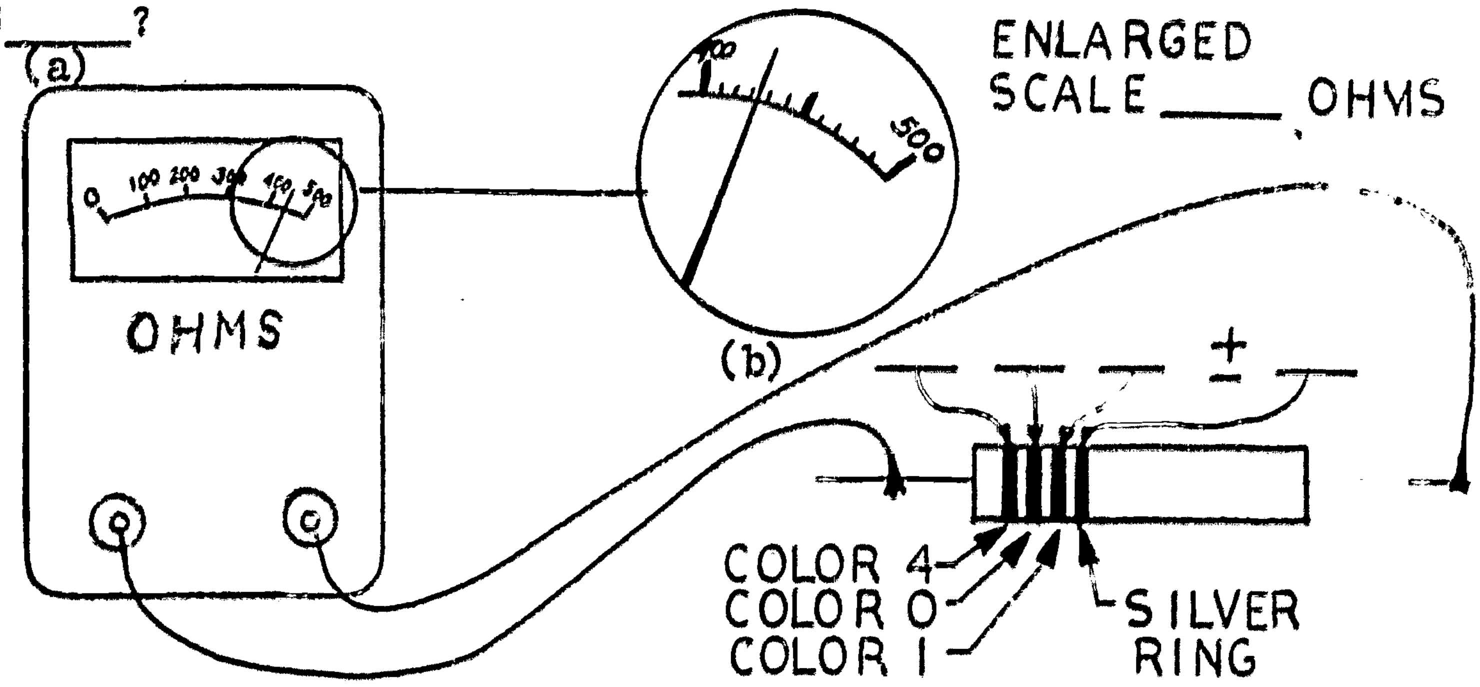
± 10% = silver ring

± 5% = gold ring

Gold is better than silver here. As an example, a 250 ohm resistor with a gold ring for the tolerance band should have a resistance value of no less than 237 ohms, or a resistance value no greater than __________ ohms.
(3) fill in

In measuring a part with an ohmeter you will have to take tolerance into account.

As a second example, is the following resistor good_____ or bad_____?
(a)



Now that we have pretty well beaten tolerance to death, let us look at other things.

Namely, you know the basic unit of resistance. What is it?_________________ Just as there are feet, yards, and miles; so
(c)
also ohms have their larger units. Instead of being named in groups of 12 (ft.) or 36 (yd.) or 5,420 (mi.) units as inches are, ohms are named in units of 1,000 ohms and 1,000,000 ohms.

The term "kilo" means one thousand, and the term "meg" means one million. (See Appendix A) Therefore, a thousand ohms is called one kilohm or "one K," and a million ohms would be called one megohms or "one meg." Thus ....

1,000 ohms = 1K = 1 kilohm

1,000,000 ohms = 1,000 K = 1 meghoms

You will find the prefixes "kil" (1,000) and "meg" (1,000,000) used again with other units. These and other prefixes that indicate multiples of 1,000 are in Appendix A.

Exercise

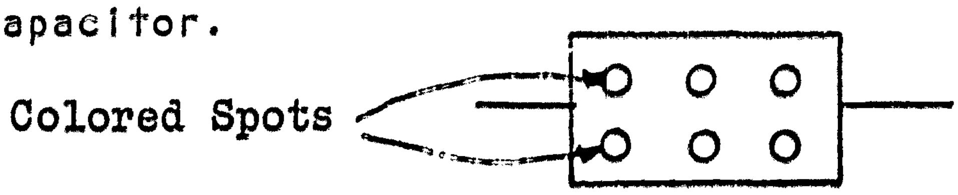
1. 240,000 ohms = ____________________K
2. 12 Megs = ____________________ohms
3. 3.6 meg = ____________________K
4. 1,200 ohms = ____________________K
5. 1,800,000 ohms= ____________________meg

Just as the plan for a house may contain the general note "All dimensions in feet unless otherwise noted," the diagram for an electronic circuit may contain the general note, " All resistance values in ohms unless otherwise noted."

Just as we use the abbreviation ft. or (') for feet, we use this strange symbol (Ω) for ohms.

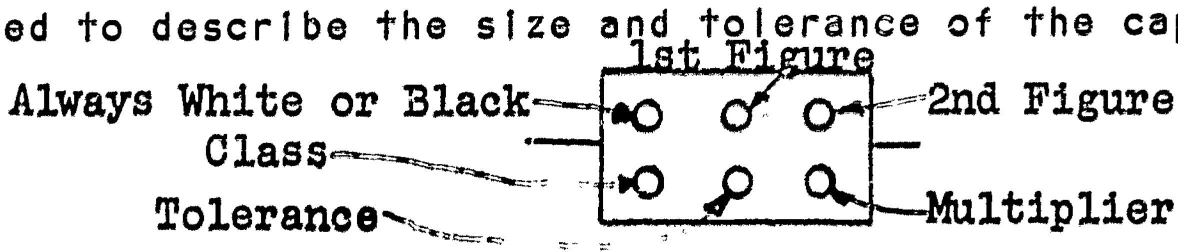
Capacitors:

You have just learned how to tell the value of a composition resistor by reading the color code. The colors are used not only for this type of resistor but for other types as well, and for certain types of capacitors. This is a drawing of a molded mica type capacitor.



Our old friend, the dominoe.

Those spots, however, are colored. The colored spots are used to describe the size and tolerance of the capacitor.



The color of the upper left hand dot depends upon whether the capacitor is a RETMA or MIL type. (RETMA is the type you will usually find in commercial electronic devises. It stands for Radio-Electronics-Television Manufacturers' Association. This association has produced a standard for marking electric parts.) It will be black for MIL and White for RETMA. The colors of the second and third dot from left to right on the upper row are the first and second figures of the value of the capacitor. For example, yellow-violet would mean 47. That's fine, but 47 what? The bottom right dot is the multiplier and it tells us what to multiply the 47 by (how many zeros to add) in order to find out "what." If the multiplier dot were red, it would mean to multiply the 47 by 100 (or add two zeros) so that the capacitance would be 4700. The unit of measure to use here is the <u>micromicrofarad</u>, or

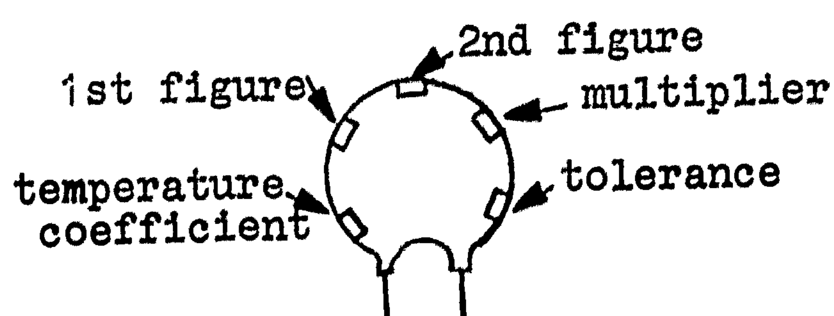
picofarad. The meaning of capacitor color codes is listed in Appendix B.

Like resistors, capacitors have their tolerances too. This is given by the second dot in the lower row. It will be either plus or minus 20, 10, 5, 2, or 1.

The class has to do with other properties of the capacitor, such as working voltage, insulation resistance, etc. You will not be concerned about such matters, as they are of principal value in design. In your repair work, you need only replace the part with its equivalent to be safe.

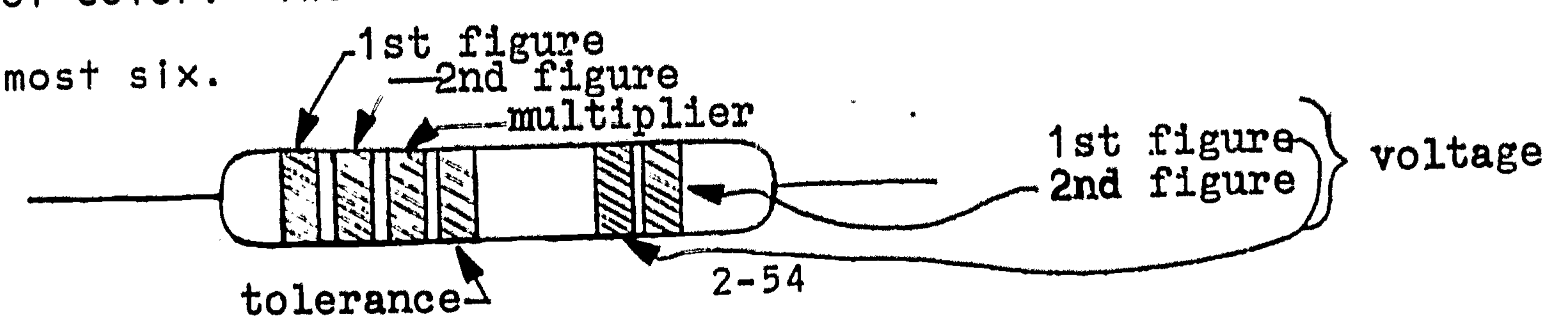
Have you noticed the arrow-like symbols along the upper row? They are molded into the case to tell you how to hold the capacitor when reading it. Always make sure the arrow points to the right.

Another type of capacitor you may see is the disc ceramic type. They look like this........



The dots are dabs of color, and stand for the numbers you have already come across.

Another type of capacitor is the molded paper capacitor. These are often tubular, and look something like a larger composition resistor. But notice that capacitors have more bands of color. The resistor has at most four, but the capacitor has at most six.



Some manufacturers print the value of the part right on the part, and in addition color code the part. But, you can't depend on finding every part so marked. Ease in using the color code will help you to identify a part without measuring it, and save you time.

SCHEMATIC SYMBOLS: NEWER PARTS

As you know, schematic symbols were invented because it is easier to represent an object with a symbol than to show a picture of it. In addition, the symbol is designed to show the most important thing about the object. The symbol for a resistor is  ______. Now, you can't tell from that symbol whether the resistor is rated at 1/2 watt, or 1/4 watt; it if is 10% or 20%; whether it's firecracker-shaped or any of a number of other things which would describe it more accurately. The symbol merely states that the part it represents is a resistor and not a capacitor or some other electrical part.

There are many more symbols used in schematic diagrams than you will come across in your studies here. As new devices are invented by engineers and scientists, new symbols are invented to represent them. Every day that passes seems to have its own quota. We shall be concerned only with those symbols that have to do with TV. You have already learned some of them. You are now going to learn some more.

Electrolytic Capacitors:

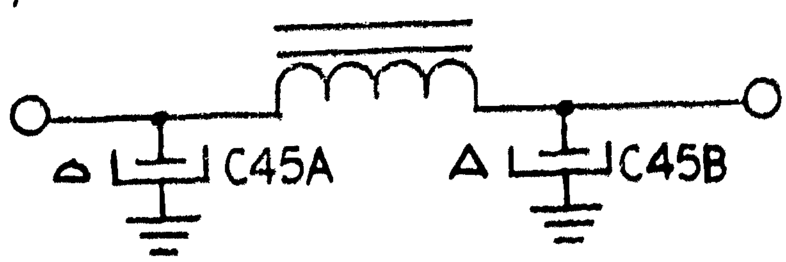
The symbol for a capacitor you have learned is ________________.

The fact that one side is curved means that this is the side to connect to the low voltage (or ground side).

Sometimes you will see or rather than .

In this case, the convention was not followed. Don't let it throw you. The symbol is still a capacitor.

When you see it means the capacitor has a special kind of construction which makes it capacitance value right. These are called "electrolytic" capacitors, and are normally found in power supplies. As a matter of fact, you will often see in power supply schematics a circuit that looks like this ......



Never mind the iron-core coil for now (called a choke) but notice the half moon and the triangle, and the C45A, C45B. As you have just learned, these are electrolytic capacitors. But what you probably don't know is that they are in the same "can." The half moon (⌓) and triangle (△) are actually punched out of a fiber card in the bottom of the can next to their terminals. The purpose is to identify which terminal belongs to C45A and which to C45B. Sometimes a square (□) is used. Be on the lookout for these symbols --- you may even find the sections of a capacitor in widely differing circuits.

You might also see a symbol like this .....

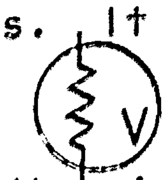
This symbol stands for two capacitors in one container. Are they electrolytics? If you said yes, compare the way the symbols are drawn. Notice that the electrolytics seem to have a U-shaped part.

Although there are standards for drawing the symbols, different manufacturers often draw their symbols differently. Anyway, you can always look up the part in his parts list to be sure.

<u>Thermistors:</u>

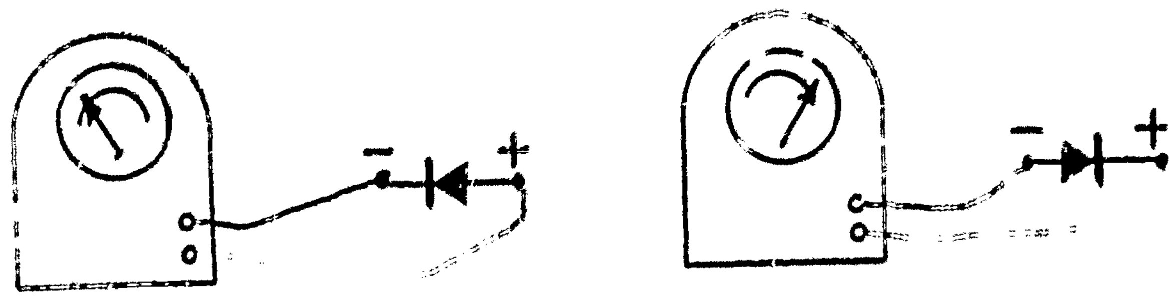
If you see a symbol like this  it stands for a resistor which changes its value according to its temperature. It is called a <u>thermistor</u>. They are used when other parts in a circuit change their resistance in an unwanted way. The thermistor will change its value in an opposite direction to compensate. The actual resistance of the thermistor at room temperature will depend upon the manufacturer and the type. The value of a thermistor can range from less than 100 ohms to the megohms. Their resistance <u>decreases</u> as they heat up. Their value decreases at a rate around 4% for each degree of temperature change. Since most metals (like copper) <u>increase</u> their resistance as the temperature rises, you can see that thermistors can be used for temperature compensation. .. that is to keep a circuit resistance constant.

Voltage Dependent Resistors:

There is another type of device now used in TV's. It is called a voltage dependent resistor. Its symbol is  . Symbolically the only difference between it and the thermistor is in the letter. The value of resistance which this device has depends upon the voltage applied to it, not the temperature.

Semiconductor Diodes:

Earlier, you learned the symbol for a transitor. A transitor is a semiconductor device. A semiconductor diode  belongs to the transitor family. It actually existed long before transitors did. When you measure the resistance of an ordinary composition resistor, it doesn't matter how you connect the ohmmeter to it, you still get the same resistance. When you try to measure the resistance of a semiconductor diode, you will find that the value you measure will depend upon which lead is placed at the bar-like end.



Low resistance High resistance

It is this property which makes the semiconductor diode useful for reactification of AC into DC. It is also useful as a detector. (A detector removes the high frequency as from a signal, and leaves a low frequency signal having the same shape as the high frequency did. You will learn more about such matters later.)

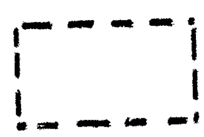
Dual Diode or Varistor:

When two semiconductor diodes are connected within one case, so that the points of the arrow heads meet, the combination is sometimes called a dual diode (because there are two of them). The  (______________________) is sometimes called a varistor.
name
Which name to apply to the symbol depnds upon its construction, and that depends upon how it is intended to be used.

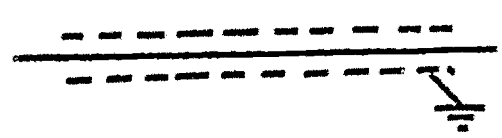
As you undoubtedly know, radio waves travel through space and through most solid objects, too. The material of which the object is made will determine how well the radio wave gets through it. There are circuits in most TV's and Radios which could be affected by unwanted radio waves. Engineers found that by enclosing these circuits in metal cans, or by surrounding wires with a braided metal tubing and grounding these to the chassis, they could pretty well eliminate interference.

Shielding:

The symbol generally used to represent such a type of mechanical construction is a series of dashes -------.



Shielded Can



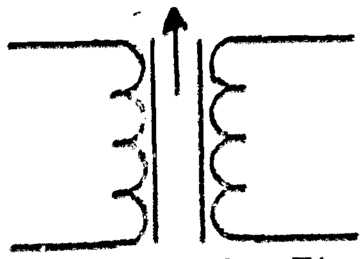
Shielded Wire

Sometimes a dashed line is used for showing a mechanical connection as between a knob and a shaft. But you will have no confusion, since it will be easy to tell what's meant by the way the drawing is made.

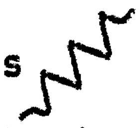
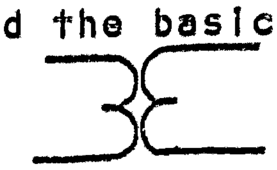
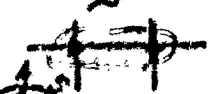
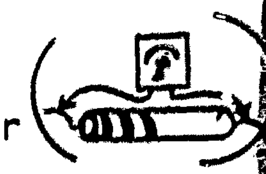
Tunable Transformers:

You have learned the symbol for a coil __________ (draw symbol)
(a)
for an iron-core coil __________ (draw symbol)
(b)
for a transformer __________ (draw symbol)
(c)
for an iron-core transformer ______ (draw symbol)
(d).

Here is a symbol which looks very much like an iron-core transformer....



Notice the difference? That arrow means that the core can be moved in and out of the transformer, usually by means of a screw. This symbol is likely to be used for IF transformers to indicate that they are tunable.

This completes this booklet. We have studied the basic electronic parts  and their symbols  . We have learned about electrical nodes,  about some electronic standards and conventions , and we have studied resistance which is what is measured with an ohmmeter . There are many more electronic symbols, some of which you will learn about in subsequent booklets in this series.

Before closing this booklet, look again at the Appendices. They contain very useful information, which a practicing repairman should memorize. Notice especially Appendix C which contains the symbols for many parts which we have not yet discussed. Notice also that each part in Appendix C has a letter (or letters) which is used to identify that part by its type. These letters are used on schematic diagrams and on parts lists, so you should learn to recognize them.

Appendix A

Prefix names for multiples of 1,000 used in unit value names.

10^{-12}	=	.000,000,000,001	pico	P
10^{-9}	=	.000,000,001	nano	n
10^{-6}	=	.000,001	micro	μ
10^{-3}	=	.001	milli	m
10^{0}	=	1.		
10^{3}	=	1,000.	kilo	K
10^{6}	=	1,000,000.	mega	M

Examples:

1,000 ohms	=	10^3 ohms	=	1K ohms
.000,001 farad	=	10^{-6} farad	=	1 μ farad
1,000 K ohms	=	10^3 K ohms	=	1 Meg ohms

Rotation remark:

10^0, 10^3, 10^6, 10^{-3}, etc. The number on top tells how many places to move the decimal point to the right (+) or left (-) from 1.0.

Appendix B

COLOR CODES — Resistors and Capacitors

Color	1st,2nd Figure	Decimal Multiplier	Tolerance percent	Voltage rating
Black	0	1	± 20	---
Brown	1	10	± 1	100
Red	2	100	± 2	200
Orange	3	1,000	± 3	300
Yellow	4	10,000	GMV	400
Green	5	100,000	± 5#	500
Blue	6	1,000,000	± 6	600
Violet	7	10,000,000	± 12.5	700
Gray	8	0.01*	± 30	800
White	9	0.1*	± 10 #	900
Gold	-	0.1	± 5	1000
Silver	-	0.01	± 10	2000
None	-	-	± 20	500

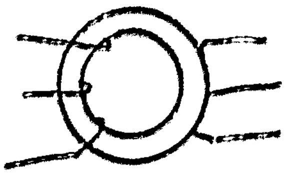
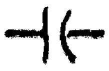
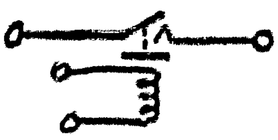
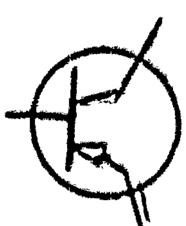
NOTE: *There are times when the metallic pigments, gold and silver are not used. In such cases, gray and white are used for indicating the decimal multipliers less than one.

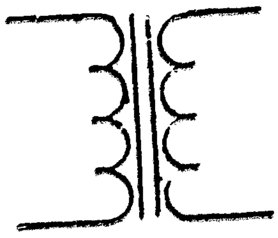
#For the same reasons the tolerances for 5 and 10 percent are also assigned colors. Most commonly gold and silver are used.

GMV stands for guaranteed Minimum value, and has the tolerance of -0 to +100%

Appendix C

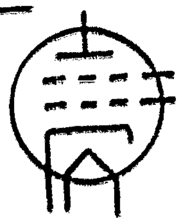
Letters used in calling out parts

	B	motor or generator
	BT	battery
	C	capacitor
	CR	crystal rectifier (crystal diode)
	DL	delay line
	E	terminal board
	F	fuse
	FL	filter
	I	(indicator) light
	J	Jack (convenience outlet)
	K	Relay
	L	inductor (coil or choke)
	M	meter
	P	Plug
	Q	transistor
	R	resistor
	S	switch



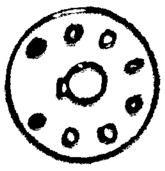
T transformer

TP Test point



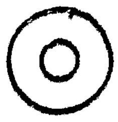
V (Vacuum) tube

VR varistor



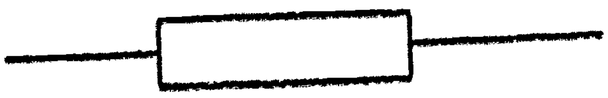
X socket prefix

Example: XV tube socket



XF fuse holder

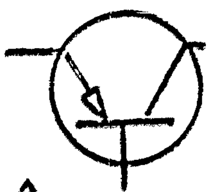
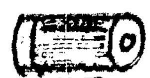
Y crystal

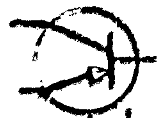
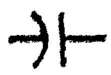
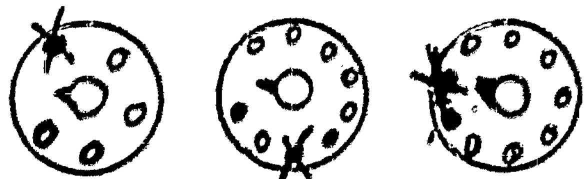


Z network

Form of symbols may vary, depending on the actual part.

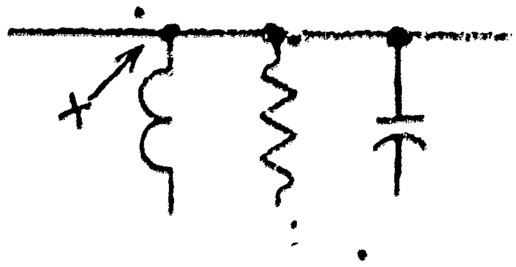
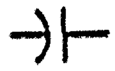
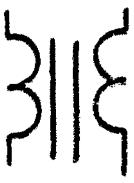
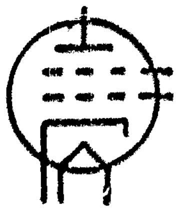
ANSWERS TO BOOK II PROBLEMS

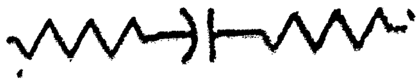
Page	Answer
2-3	Battery
2-4	Transistor
2-5 a	
2-5 b	
2-5 c	
2-5 d	Resistor
2-6 a	
2-6 b	
2-6 c	
2-6 d	
2-7	Volt
2-8 a	Voltage
2-8 b	Current
2-9 a	Amperes
2-9 b	Amps or Amperes
2-9 c	Amps
2-9 d	Amps
2-9 e	 = Battery
2-9 f	 = Transistor
2-9 g	 = Resistor
2-9 h	 = Capacitor

Page	Answer
2-10 a	 Transistor
2-10 b	 Battery
2-10 c	 Resistor
2-10 d	 Capacitor
2-12 a	
	b Coil, c Iron, d Transformer
	e , f Iron,
2-13 a	Transistor
2-13 b	Tube
2-15	6
2-16	Clockwise
2-18	 XV1 XV2 XV3
2-19	Neither
2-20 a	Plate
2-20 b	Cathode
2-21	They are pin numbers. They tell what tube pins the heater is attached to.
2-23 a	Plate
b	Control Grid
c	Cathode
d	Heater

e Transistor
f Resistor
g Transformer
h Batteries
i Capacitor
j Coil

ANSWER TO BOOK II PROBLEMS

Page	Answers
2-25	
2-28 a	4 nodes
2-28 b	V1 has 4 nodes
2-28 c	V2 has 7 nodes
2-29	7 nodes
2-32	Resistor
2-33 a	
2-33 b	
2-33 c	
2-33 d	
2-33 e	

Page	Answers
2-39	5 nodes
2-41	
2-42 a	Wire or Conductors
2-42 b	Insulator
2-43 a	Conductor
2-43 b	Insulator
2-45	Ohmmeter
2-46 a	Resistor
2-46 b	Capacitor
2-46 c	Air
2-46 d	Batteries
2-46 e	Transistor
2-46 f	Vacuum Tube
2-48	2.7 Meg or 2,700,000
2-50#1	-4 = 396 ohms
2-50	4 = 404 ohms
2-50#2	300 - 15 = 285 ohms
2-50	300 15 = 315 ohms
2-50#3	810 ohms
2-50	990 ohms
2-51 a	Good
2-51 b	400
2-51 c	Ohms

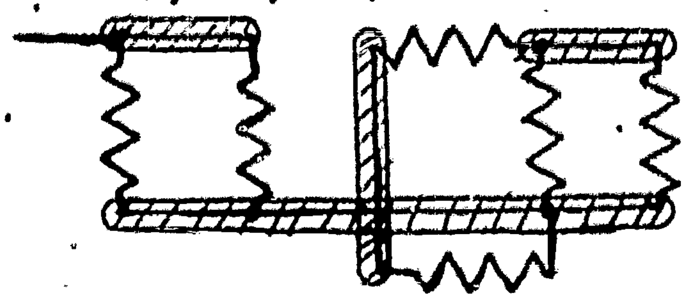
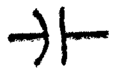
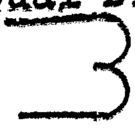
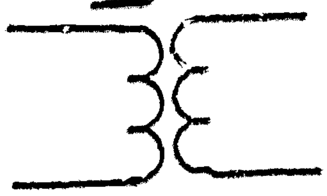
Page	Answers
2-33 f	R34, R33, T3, C8, L26, Z1
2-34	R3, L1, C3, C2, R4, R6, C1, R7
2-35 a	R7,
2-35 b	R5, C3, R6, C1
2-36	R5, R1, (R3 if you assumed that B was grounded and C3 blocks electrical path to ground.)
2-37	R3, R1, R2, L1, R5, R6
2-38	

Diagram contains 4 nodes

ANSWER TO BOOK II PROBLEMS

Page	Answer
2-52	1. 240 K 2. 12,000,000 ohms 3. 3,600 K 4. 1.2K 5. 1.8 Meg
2-56	
2-59	Dual Diode (or Varistor)
2-60 a	
b	
c	
d	

BOOK III

<u>RESISTANCE READINGS: THEIR CALCULATION AND INTERPRETATION</u>

BOOK III

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BOOK III

RESISTANCE VALUES: THEIR CALCULATION AND INTERPRETATION

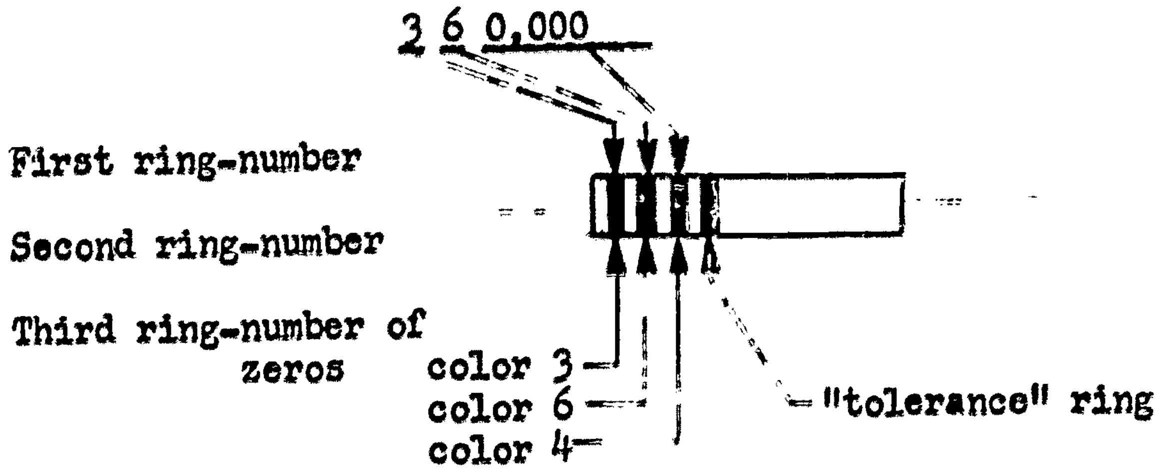
One of the big problems with all kinds of electrical equipment is that it won't work perfectly forever. Its parts wear out or go bad for some reason, and then the bad parts must be found and replaced. That's what troubleshooting is all about--to quickly find the bad parts and replace them.

When a tube goes bad, usually it isn't much of a job to find the bad tube and replace it. You can often find the bad tube by the way your TV picture looks. Sometimes this type of troubleshooting is referred to as "system" troubleshooting. But, what happens when a resistor, capacitor, etc., attached to a tube, goes bad? This type of trouble usually is harder to locate and to fix. This type of troubleshooting is sometimes called chassis troubleshooting, or piece-part troubleshooting. That's what we are going to talk about now ..... chassis or piece-part troubleshooting. More specifically, this book describes how to figure out the correct resistance value of individual parts and of combinations of parts. You will then be told how to use this information to locate faulty piece-parts.

Resistance Readings:

As you were told in Book II, all parts have resistance. Each part is made so that it has a particular amount of resistance, and, when the part goes bad, its resistance usually changes. Thus, we can use resistance measurements to help determine whether or not a single part, or a group of parts, contains a malfunction.

Let's review resistance values. You remember that a resistor contains up to four color bands. The first three bands describe the resistance value of the resistor. The fourth band is the "tolerance" band, and it describes the tolerance or error limits of the resistor.



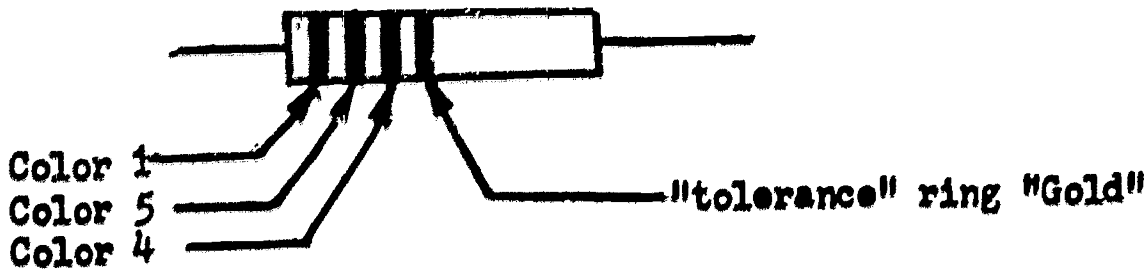
Resistor Color Coding System

± 20% = no color band

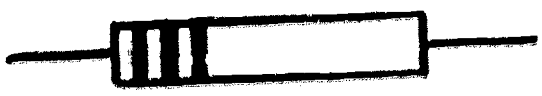
± 10% = Silver band

± 5% = Gold band

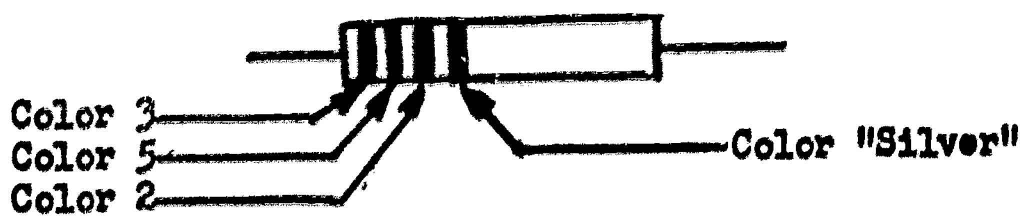
Interpretation of "Tolerance" band



What is the ohm value of the above resistor? ____________
answer



What is the tolerance value of the above resistor? ____________
answer



For the above resistor, which reading is correct?

3100 ohms ________

3500 ohms ________

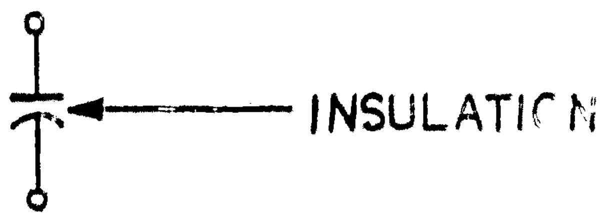
3900 ohms ________

A good resistor ( ) will show its correct ohms value within the tolerance band, when tested with an ohmeter. A resistor that does not measure within its tolerance band is no good.

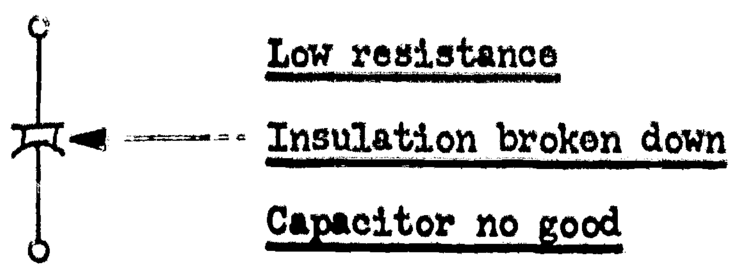
Telling if other parts ( ) are good by resistance (ohmeter) measurements is not so easy, because their main function is not just to offer resistance.

<u>Resistance of Capacitors</u>:

A capacitor, as its symbol crudely indicates, has no direct path between its terminals.



This is the hint for you; a good capacitor has a very high resistance. <u>If</u> the capacitor has a <u>low</u> resistance, something is wrong with the insulation and the capacitor is no good.

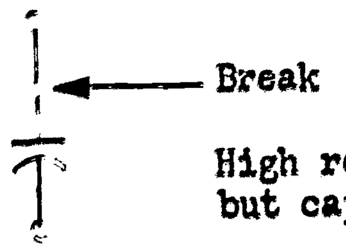


If a capacitor has high resistance, it is probably good ---

High resistance

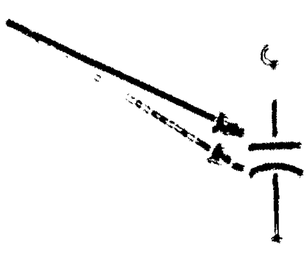
Good capacitor (Probably)

OR, one of the leads has broken open



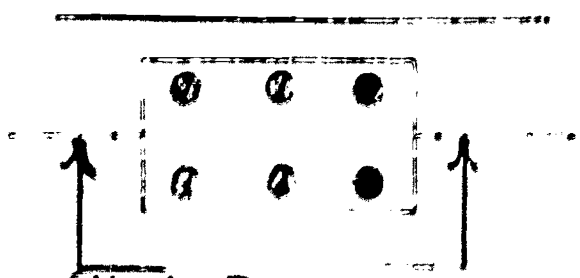
High resistance
but capacitor is still no good

This "open" capacitor is no good because the nodes must be connected to the plates.

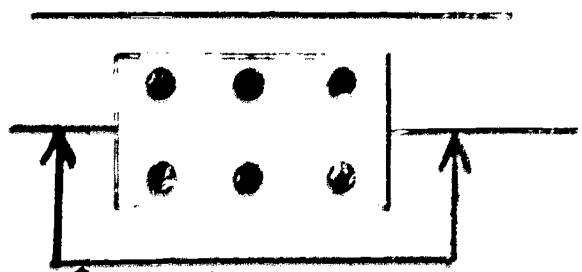


Open capacitors are rare and hard to detect. You can obtain the capacitance values by checking the part with a capacitor checker, but for the present we will only check for high resistance and therefore call high-resistance capacitors "good."

Which capacitor is good, and which is bad? (Draw the symbol).



High Resistance

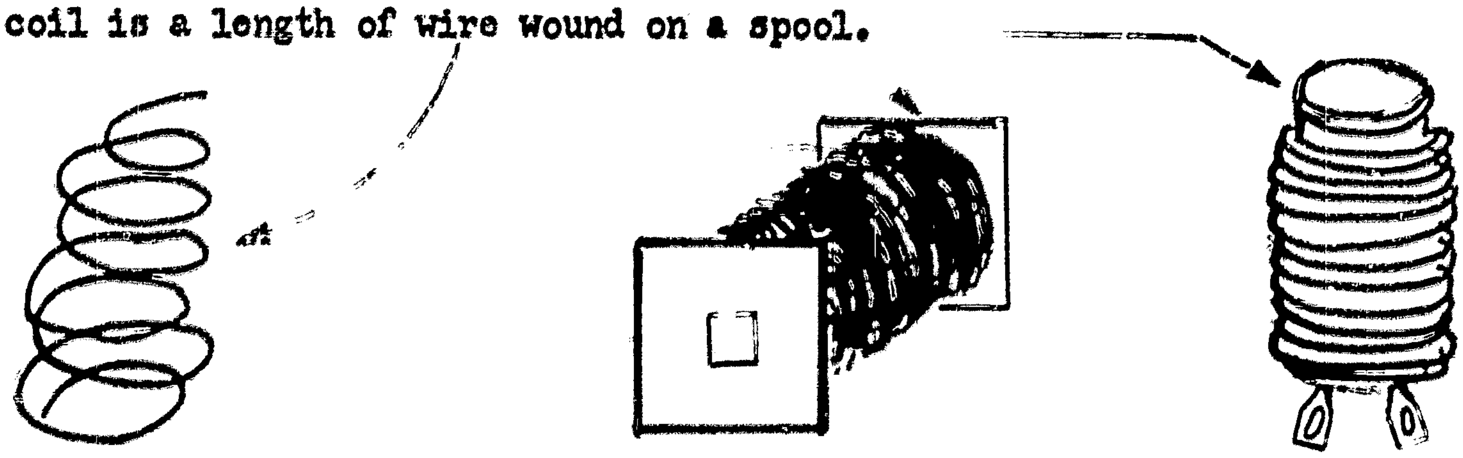


(Low Resistance)

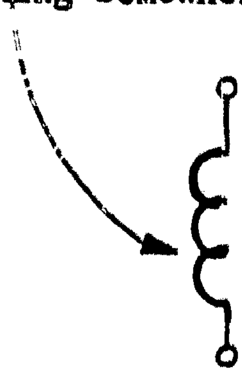
Resistance of Coils:

The clue to coil checking is again in the symbol. Coils are referred to by the symbol "L" and just as Capacitors are abbreviated as "C."

The coil is a length of wire wound on a spool.



A good coil has a low resistance. It has some resistance because even though the wire is a conductor, it is relatively long (it could reach across the street) and the wire does have a very small amount of resistance. A coil may give a reading of one to 10 ohms - as a general guide. If a coil has a high resistance between its terminals, there is an opening somewhere in the long wire of the coil, then the coil is no good.



A good coil has a __________ resistance.

The "companion" case to the <u>open coil</u> is the <u>shorted coil</u>. A shorted coil ( ) has a lower resistance than a good coil ( ).

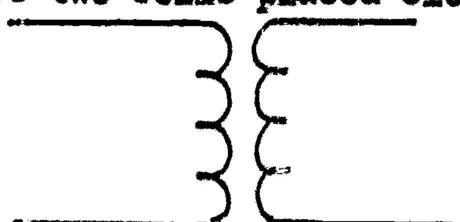
If only a few turns are shorted they are hard to detect and may or may not make a difference.

Now for some questions: mark the following parts "good" or "bad": (the symbol is the same in either case).

C1	High resistance	________
L1	High resistance	________
C2	Low resistance	________
L2	Low resistance	________

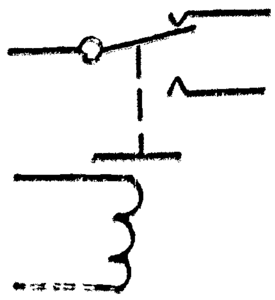
<u>Resistance of Windings:</u>

Transformers, which are two coils placed close together, can be tested

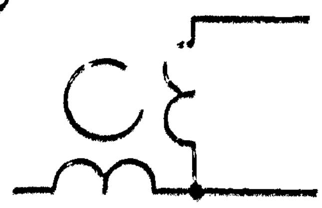


separately as two coils and <u>both</u> have to be checked.

Some other parts, such as relays



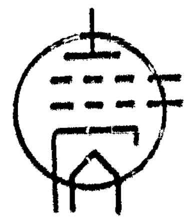
and motors,



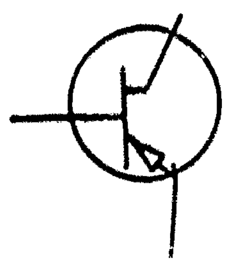
also contain coils () and coil resistance tests can be used on them also.

Resistance of Tubes and Transistors:

The things we look for in good tubes

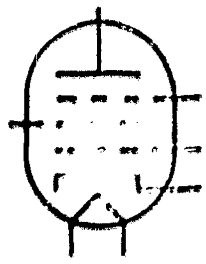


and good transistors

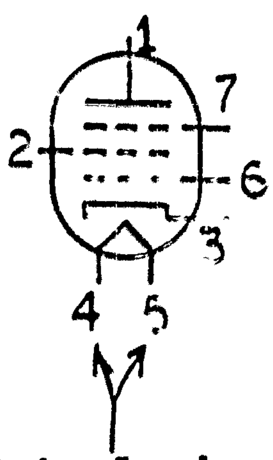


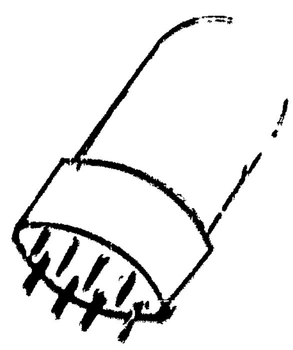
are not so easily checked by resistance readings. Therefore, these parts are taken out of the sockets which hold them and checked on a tube or transistor tester.

We should, however, see by the tube symbol (internal parts not touching) ---



that a high resistance should exist between every lead and every other lead (every pin and every other pin) <u>except between two pins</u>. Which two pins?





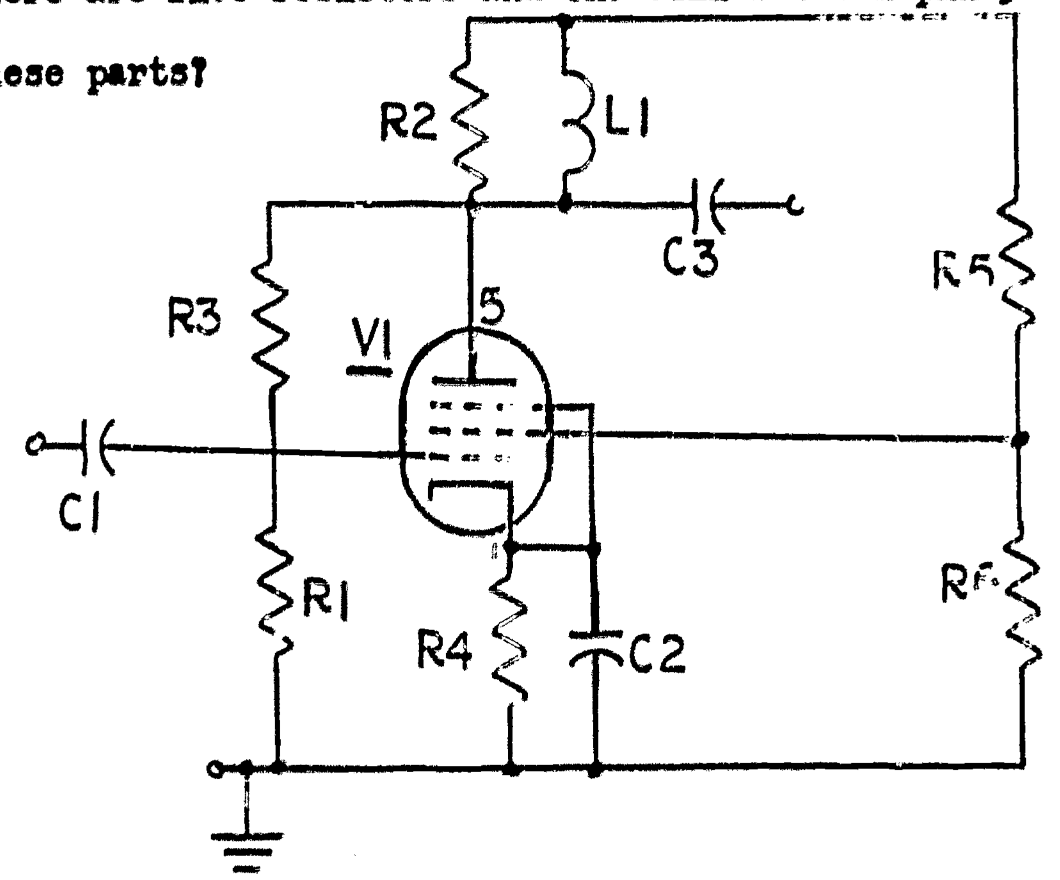
Obviously, because pins 4 and 5 are connected together to form the filaments of the tube.

The resistance of transistors is a tricky thing. Let's postpone that.

RESISTANCE OF RESISTOR COMBINATIONS: CALCULATION PROCEDURES

Typically, there are two or more parts attached to a tube pin or to a single terminal post. This means that when you obtain a resistance reading, that reading usually is the result of two or more parts.

In Book II, you learned to identify the parts between two electrical nodes or between a tube pin and ground. For example, in the diagram below, there are five resistors and one coil between pin 5 and ground. Can you identify these parts?

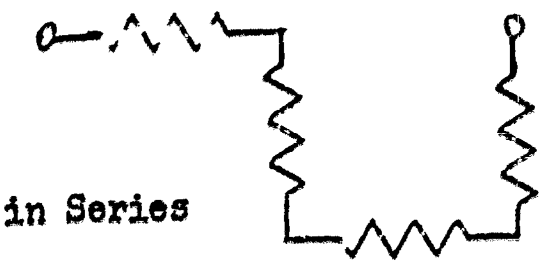


1. ________
2. ________
3. ________
4. ________
5. ________
6. ________

In this section, you will learn how to calculate the resistance value of resistor combinations.

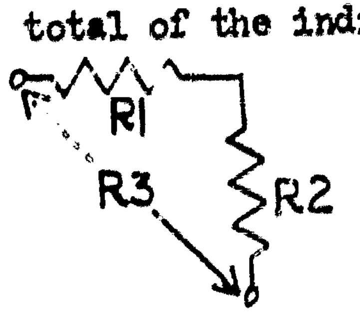
<u>Resistors in Series:</u>

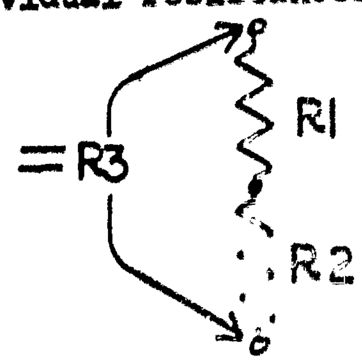
When two or more resistors are connected, one after the other, they are said to be connected in <u>Series</u>.

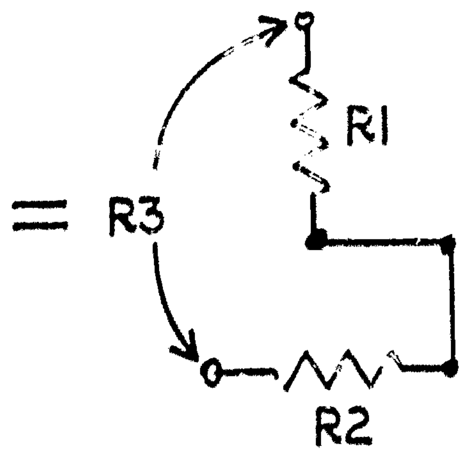


Resistors connected in Series

Furthermore, it doesn't matter how resistors are physically connected, so long as they are electrically connected one after the other. Moreover, when resistors are connected in series, the total resistance (R3) is the sum or total of the individual resistances.



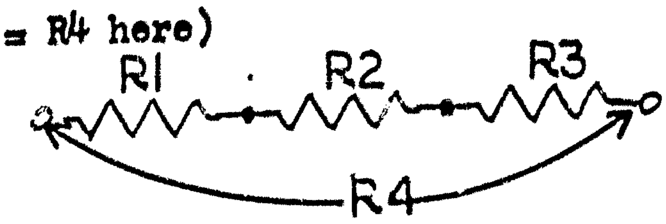




In other words:

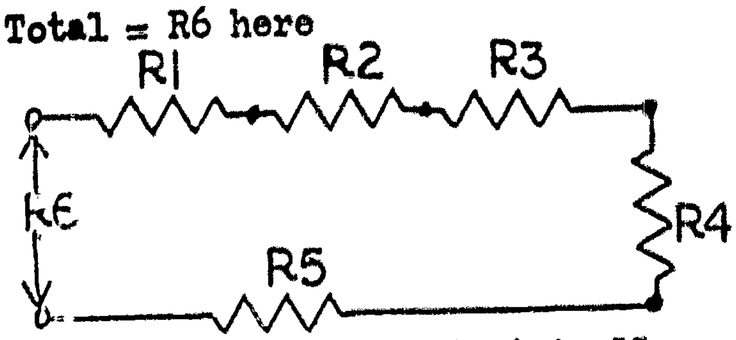
$R3 = R1 + R2$

(Total = R4 here)



$R4 = R1 + R2 + R3$

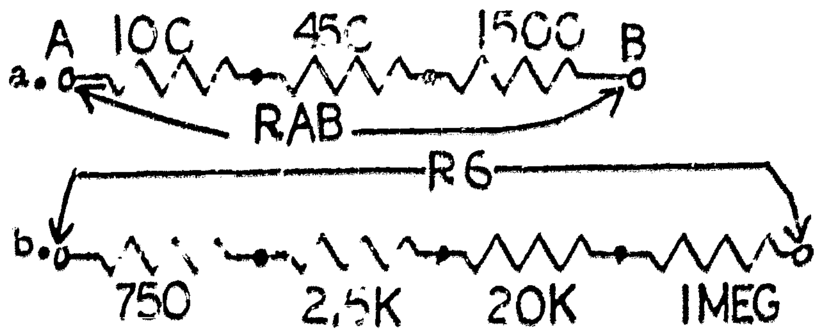
Total = R6 here



$R6 = R1 + R2 + R3 + R4 + R5$

Where resistors are electrically connected one after the other, they are connected in ______________.
(word)

Now, for a few problems ......



The value of R_{AB} is ____

The value of R_{AB} is ____

Now, watch out for this one. The value of a 500Ω, 1000Ω, and a 10K resistor is 15K____? or 9K____? The correct answer is 9K. Why is that? Because a resistor has a tolerance value, doesn't it? A resistor with a 20 per cent tolerance may be above or below its stated value by as much as 20 per cent. Thus, in the above example, if the resistors have a 10 per cent tolerance and were all off on the "low" side of their stated value, it would be quite possible to obtain a reading of 9,000 ohms and be within tolerance.

To make matters worse, unless otherwise stated, resistors usually have a 20 per cent tolerance. This means tha' a 10K resistor could be high or low by as much as 2000 ohms. In practice, this means that a resistance reading should be quite far off from its calculated value before you would think something was wrong with it.

Also, the tolerance of resistors means that when a large and small resistor is in a series, the value of the combination is equal to the value of the larger resistor alone. This is especially true when:

a. All resistors have a 20% tolerance, and the larger resistor is about 8 times bigger than the smaller.

b. All resistors have a 10% tolerance, and the larger resistor is about 10 times bigger than the smaller.

So......for the following problems, select the correct resistance reading.

More than one answer can be correct.

a. All resistors have a 10% tolerance;

There are four resistors in series with values of
1000 ohms, 10.2K,
5000 ohms & 20K

Combined resistance value could measure: 42.2K ______

33.0K ______

30.5K ______

b. All resistors have a 20% tolerance;

There are five resistors in series with values of
4500 ohms, 25.9 K, 2.5 meg,
8700 ohms, & 56.3K

Combined resistances could measure: 2.9 megs ______

3.5 megs ______

1.8 megs ______

c. All resistors have a 5% tolerance;

There are three resistors in series with values of
750 ohms, 1000 ohms, 500 ohms

Combined resistances could measure: 2075 ohms ______

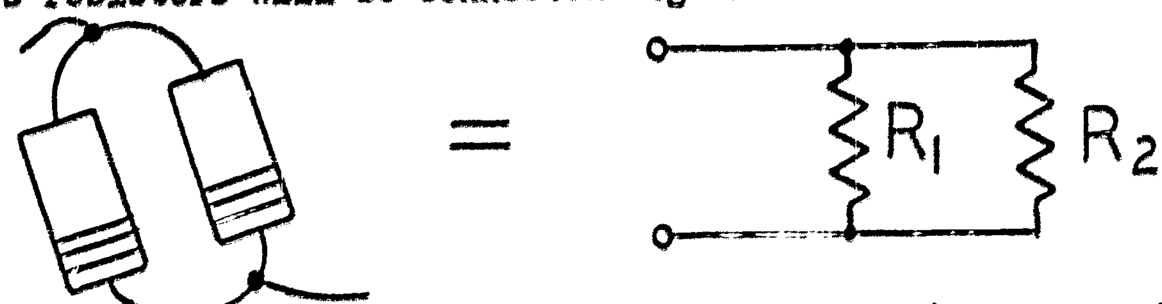
2300 ohms ______

2350 ohms ______

Remember: Resistance measurements will almost always be different from their calculated value. The amount that they can be off and still be considered "correct" depends on the tolerance limits of the resistors. Generally, these tolerance limits will be 20%, but they may be 10% or even 5%. On very rare occasions they may be as little as 1% or 2%. In such instances, you are dealing with "precision" resistors.

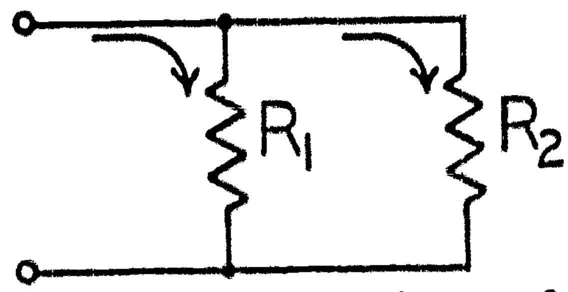
Resistors in Parallel:

Many times resistors will be connected together like this ......



Resistors connected like this are connected in "parallel" (also called "shunt", or R1 "across" R2). All parts are connected either in series or in parallel (or in series-parallel combinations). There is no other way in which they can be connected. In other words, if a circuit contains two resistors (R1 and R2) which are not connected in series, then they must be connected in ________.
(word)

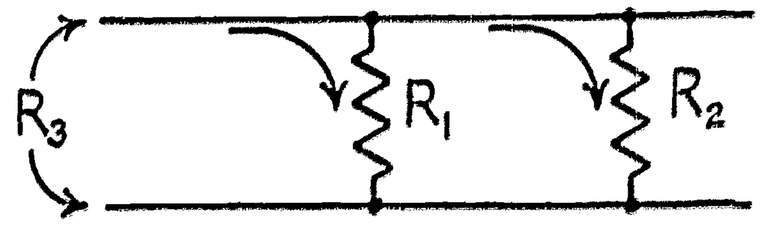
Now, let's examine a parallel circuit closely. In the below diagram, the electrical current is shown as flowing toward R1. Some of the current will flow through R1 only, and some of it will flow through R2 only. (In a series circuit, all the current must flow through first one part and then another).



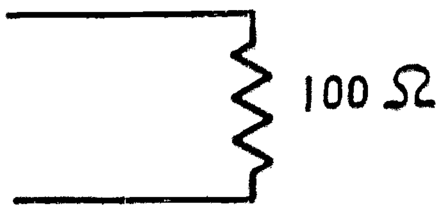
In a parallel circuit, the total resistance of the parts in parallel will be less than the resistance of the smallest part. So, if a 100 and a 200 ohm resistor are in parallel, the resistance of this combination must be less than 100 ohms. Now, let's discuss some specific examples.

<u>Equal-Value Resistors in Parallel:</u>

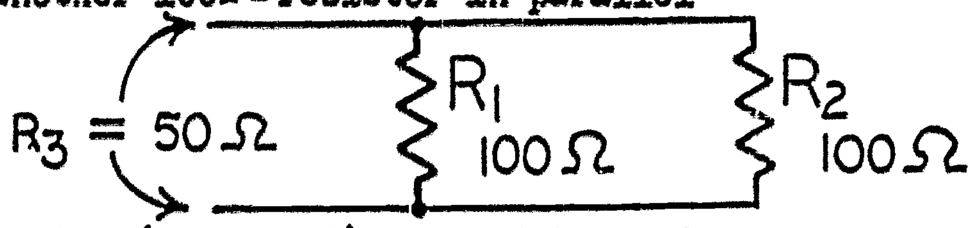
Let's first talk about a parallel circuit where R1 and R2 have the same resistance value.



In this circuit half the electricity flows through R1 and the other half flows through R2. The total or combined resistance of R1 and R2 is equal to <u>one half</u> of the resistance of either R1 or R2 by itself. That is, if a 100-Ω resistor is in a circuit by itself

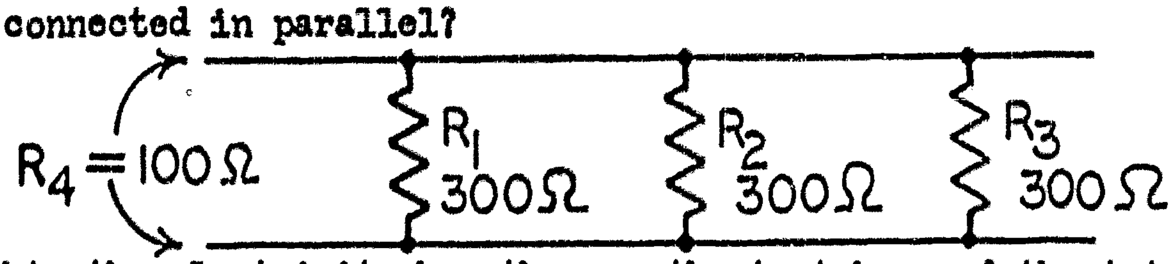


and to it is added another 100-Ω resistor in parallel



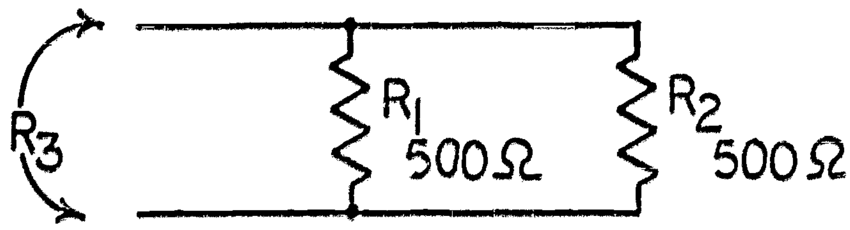
the resistance of the two (R1 and R2) is half that of either R1 or R2. In the example above, the combined resistance of R1 and R2 is 50 ohms.

What do you suppose the combined resistance would be of three equal resistors connected in parallel?

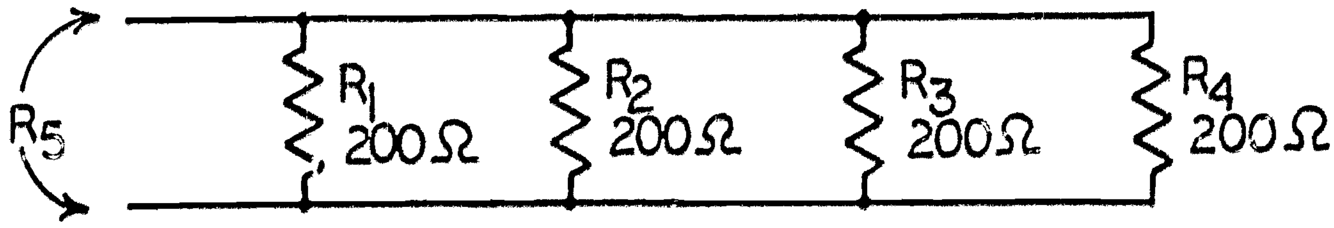


That's right, the electricity has three paths to take, and the total resistance would be one-third (1/3) of any one of them. If the resistors in the above diagram each had a value of 300-Ω, their combined resistance would be 100-Ω. When resistors in parallel have the same values, it is easy to figure their combined resistance value. Divide the value of an individual resistor by the total number of resistors in parallel.

In the following example, two 500 ohm resistors are connected in parallel. Their combined resistance (R3) equals 500 ÷ ½ or _____ ohms.



In the next diagram below, what is the value of R5, the combined resistance of the resistor Network? The value of R5 is _______.



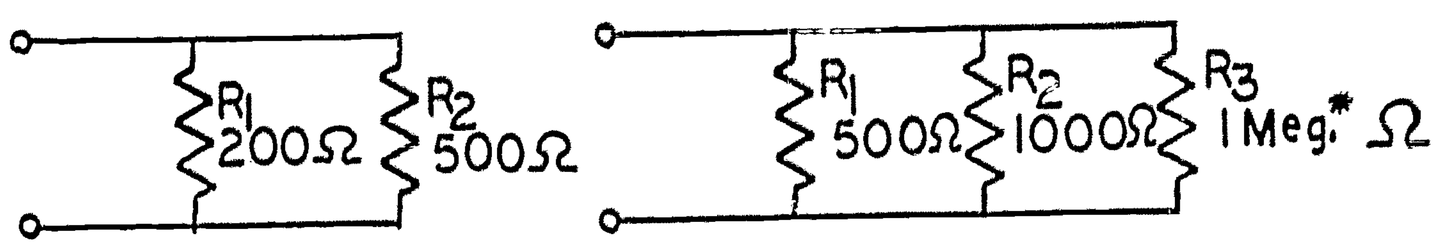
Now, let's try something slightly different. Suppose you have five 1000 ohms resistors in parallel. Assuming that they are 20% tolerance resistors, the combined resistance of these five resistors could be 250 ohms _____?, 240 ohms _____, or 150 ohms _____? (Check one)

OK, try one more. This time we have a parallel network of 10% tolerance resistors, each with a value of 600 ohms. There are three resistors in all. The combined resistance might be 300 ohms _____, 185 ohms _____, or 165 ohms _____. (Select one)

One last problem, and we'll go on. Suppose you had two 1000 ohm resistors in parallel, with one resistor having a 20% tolerance, and the second having a 10% tolerance. What might their combined value be? Well, this is a trick question because you do not expect to find resistors of unlike tolerances combined in the same network. It may happen on rare occasions, but generally all resistors in the same network will have the same tolerance.

Unequal-valued Resistors in Parallel:

For most combinations of resistors, you will find that the value of the resistors are unequal. This makes it more difficult to figure out the total resistance of the combination. However, it still isn't too difficult, once you know what you are trying to do and know a few tricks of the trade.



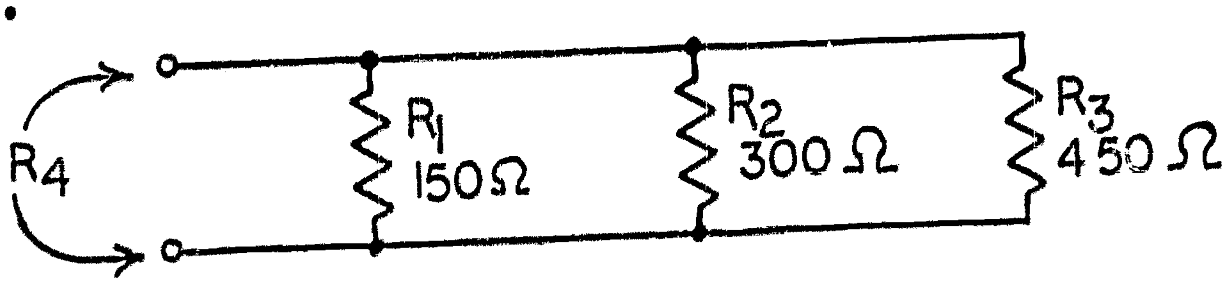
Typical resistor circuits containing unequal-valued resistors

*1 Meg = one million

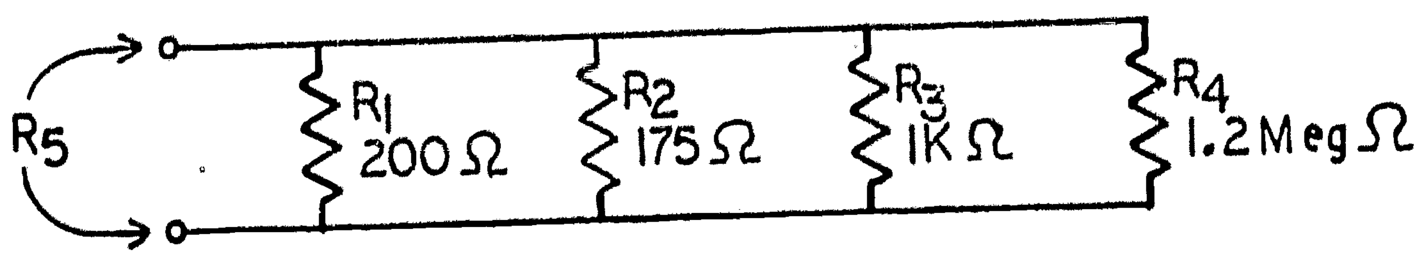
Let's begin by finding out how to rapidly estimate the largest and smallest values which a resistor combination might have. This puts your answer in the right ball park. The rule to follow is quite simple and goes like this ......

> For resistors in parallel, the combined value of the resistors <u>can be no larger</u> than the value of the smallest resistor, and, the combined value can be <u>no smaller</u> than the value of the smallest resistor divided by the total number of resistors in the circuit.

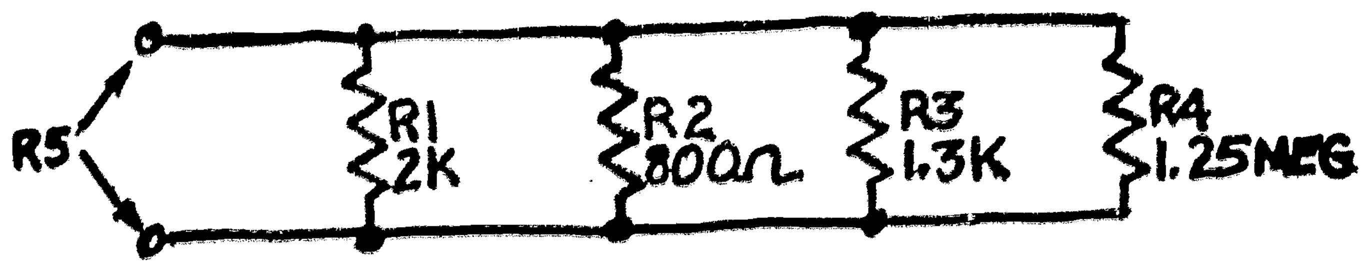
Now, let's see how to apply this rule. In the below circuit R4 can be no larger than 150, which is the value of R1, the smallest resistor in the circuit.



Also, in the above diagram R4 can be no smaller than 50 ohms, which is the value of R1 divided by 3. When you figure out your answer for R4, you know that it must be some value between 50 and 150 ohms. Now try another example. In the diagram below, R5 can be no larger than _____ ohms. R5 can be no smaller than _____ ohms.



In the diagram below, R5 can be no larger than _____ ohms.

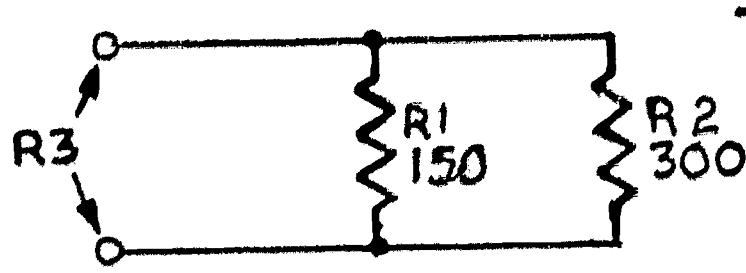


As you might expect, the actual resistance of parallel resistor combinations usually falls someplace between the ball-park estimates of their maximum and minimum resistances. For example, in the diagram above, the minimum resistance estimate is 800 (R2) divided by 4 or 200 ohms. Actually, the value of R5 is about 400Ω .

Now, let's learn how to calculate the approximate resistance of a resistor combination. First we will show you how to calculate, by formula, the value of the network. Then we will teach you how to estimate the value of the network.

For those of you who know algebra, or like to multiply and divide big numbers, or know how to use a slide rule, the following way of calculating resistance readings should be easy. For the rest of you, don't worry; we'll show you another way to do the same thing.

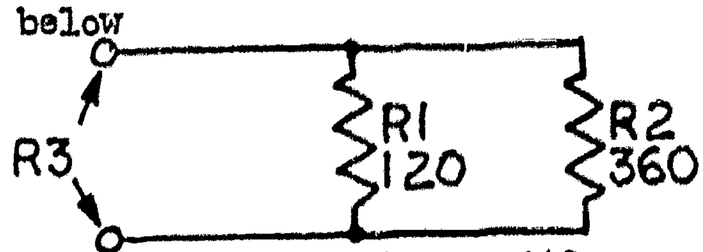
The formula for calculating resistances in parallel is $\frac{AB}{A + B}$. Applying this formula to resistance values, the formula becomes $\frac{R_1 \times R_2}{R_1 + R_2}$



Applying the formula to the above diagram,

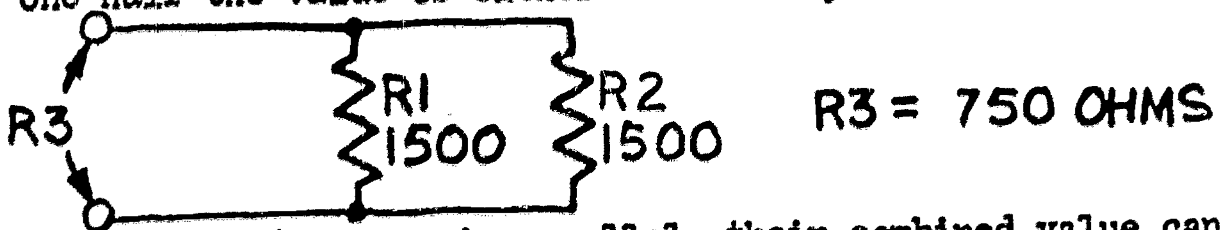
$$R3 = \frac{150 \times 300}{150 + 300} = \frac{45{,}000}{450} = 100 \text{ OHMS}$$

Now you try it. In the diagram below



The value of R3 is ______. That wasn't too hard, was it?

Now, let's learn how to estimate the value of resistor combinations. You remember that when two equal resistors are in parallel, the value of their combination is one half the value of either resistor by itself.



When two unequal resistors are in parallel, their combined value can be no smaller than one-half the value of the smaller resistor. Actually, the combined value is always somewhat larger than this. The problem is to find out how much larger it should be. So ...... when two resistors are in parallel, their combined value is one half the value of the smaller plus some additional value. By using the following chart, you can determine the additional value which should be added to one-half the value of the smaller resistor.

This chart will allow you to calculate resistance values for resistors having tolerances of 5% and up. (Actually, the Calculation Chart shows four slightly different ways of calculating resistor combinations).

Calculation Chart for Determining the Value of Two Resistors in Parallel

Relation of R2 to R1		Alternate Procedures for Calculating R1 and R2
R2 equals R1	.....	a. one-half R1 b. " c. "
R2 equals 2 R1	.....	a. one-half R1 plus 15% of R1, or b. R1 minus 35% of R1, or c. 2/3 of R1, or R1 minus 1/3 of R1
R2 equals 3 R1	.....	a. one-half R1 plus 25% of R1, or b. R1 minus 25% of R1, or c. 3/4 of R1, or, R1 minus 1/4 of R1
R2 equals 4 R1	.....	a. one-half R1 plus 30% of R1, or b. R1 minus 20% of R1, or c. 4/5 of R1, or R1 minus 1/5 of R1
R2 equals 5 R1	.....	a. one-half R1 plus 35% of R1, or b. R1 minus 15% of R1, or c. 5/6 of R1, or R1 minus 1/6 of R1
R2 equals 6 R1	.....	a. one-half R1 plus 35% of R1, or b. R1 minus 15% of R1, or c. 6/7 of R1, or R1 minus 1/7 of R1
R2 equals 7 R1	.....	a. one-half R1 plus 40% of R1, or b. R1 minus 10% of R1, or c. 7/8 of R1, or R1 minus 1/8 of R1
R2 equals 8 R1	.....	a. one-half R1 plus 40% of R1, or b. R1 minus 10% of R1, or c. 8/9 of R1, or R1 minus 1/9 of R1
R2 equals 9 R1	.....	a. one-half R1 plus 40% of R1, or b. R1 minus 10% of R1, or c. 9/10 of R1, or R1 minus 1/10 of R1
R2 equals 10 R1	.....	a. one-half R1 plus 40% of R1, or b. R1 minus 10% of R1, or c. 10/11 of R1, or R1 minus 1/11 of R1

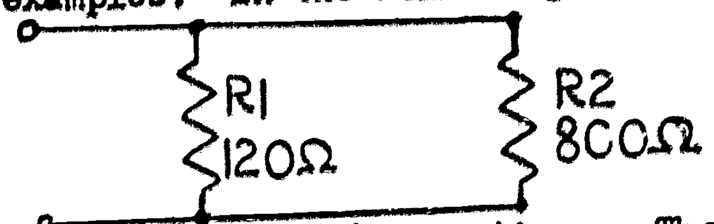
Notes:

1. Any of the above calculation procedures can be used with 10% and 20% tolerance resistors. For 5% tolerance resistors, use procedure c.

2. When dealing with 5% tolerance resistors, the above chart should be expanded as follows:

R2 = 11 to 14 R1	.....	R1 minus 10% of R1, or 14/15 R1
R2 = 15 to 30 R1	.....	R1 minus 5% of R1, or 19/20 R1
R2 = 30+ R1	.....	R1 only

Now, for some examples: In the following diagram,



R1 divides into R2 a total of 6 plus times. The actual number of times is closer to 7 than to 6, so round off to 7. According to the resistance Calculation Chart, the combined value of R1 and R2 equals one-half R1 plus 40% of R1. One-half R1 equals 60 ohms, and 40% of R1 equals 48 ohms. Thus, the combined value of R1 and R2 equals 108 ohms. OK, now try the following problems:

Problem A:

The combined value of a 500 ohms and a 800 ohms resistor in parallel equals ___________.

Problem B:

A 1.5K resistor and a 8.7K resistor are in parallel. Their combined resistance is ___________.

Problem C:

A 3.5K and a 1 Meg resistor are in parallel. Their combined resistance is ___________.

Problem D:

A 200,000 ohms resistor and a 1.2 Meg resistor are in parallel. Their combined resistance is ___________.

Resistance Networks With Three or More Resistors:

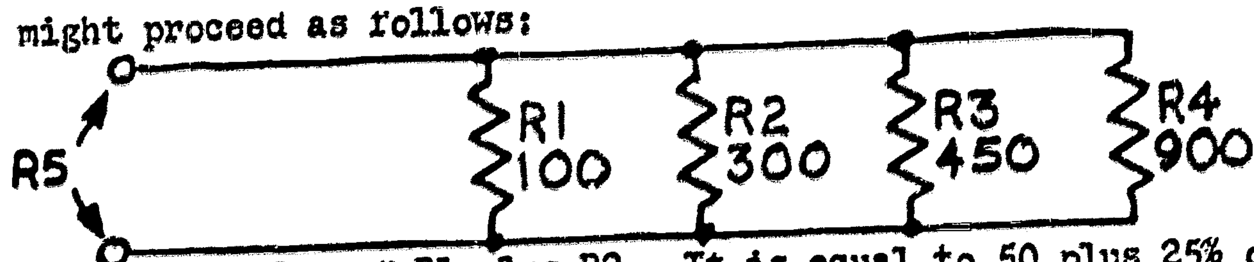
Resistor networks in parallel often contain three or more resistors. When all of these resistors are of equal value, it is easy to figure out their combined resistance; it is the value of any single resistor divided by : (select the correct answers).

a. The total number of resistors in the circuit ______.

b. The resistance value of any second resistor in the circuit ______.

c. The number of resistors in the circuit plus one ______.

When three or more unequal-valued resistors are in parallel, the value of the total combination must be worked out by dealing with two resistors at a time. It doesn't matter which pairs of resistors you begin working with, so pick pairs in which the smaller resistor can be easily divided into the larger resistor. Also, when possible, work with small resistances first. Thus, in the following example, you might proceed as follows:

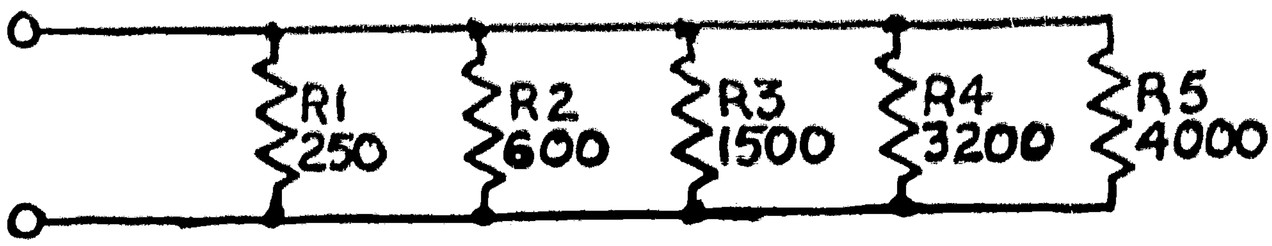


Step 1: Calculate the value of R1 plus R2. It is equal to 50 plus 25% of R1. Thus, R1 and 2 equals 75 ohms.

Step 2: Calculate the value of R3 plus R4. It is equal to 225 plus 15% of R3. Thus, R3 and 4 equals approximately 290 ohms.

Step 3: Calculate the combined value of R1 and 2 and R3 and 4 (75 & 290 ohms). This value equals 38 ohms plus 30% of R1 (which is about 22 ohms). The total value of the combination is about 60 ohms. (Notice that in these calculations it is permissible to round off to the nearest even number).

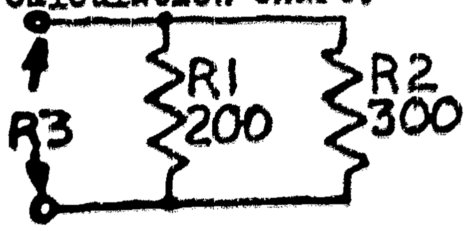
Now, you try it on the following problem. Remember that you can ignore any resistor which is more than ten times the value of any other resistor which it can be paired with.



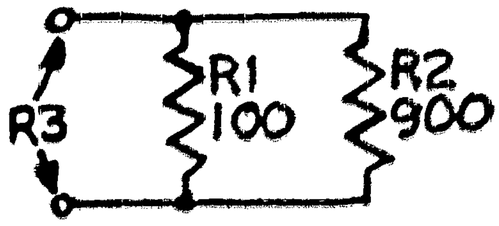
____
answer

Combining Large & Small Resistors:

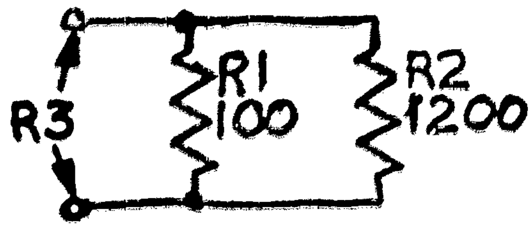
When the value of R2 is ten times or more than R1, then the bigger resistor doesn't have much of an influence on the total resistance of the parallel combination. This is shown in the three diagrams below and also on the Calculation Chart.



R3=120 OHMS



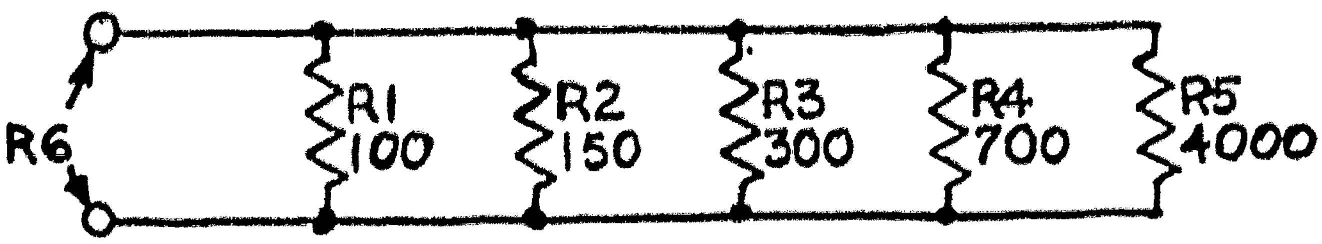
R3 =90 OHMS



R3 =92 OHMS

For practical purposes, then, you can ignore the presence of very large resistors because it can only effect the Combined value by 10% or less, and the values of most resistors can vary by at least this amount. So ...... the rule is that in parallel circuits, ignore all resistors which are ten times or more larger than the smallest resistor in the circuit.

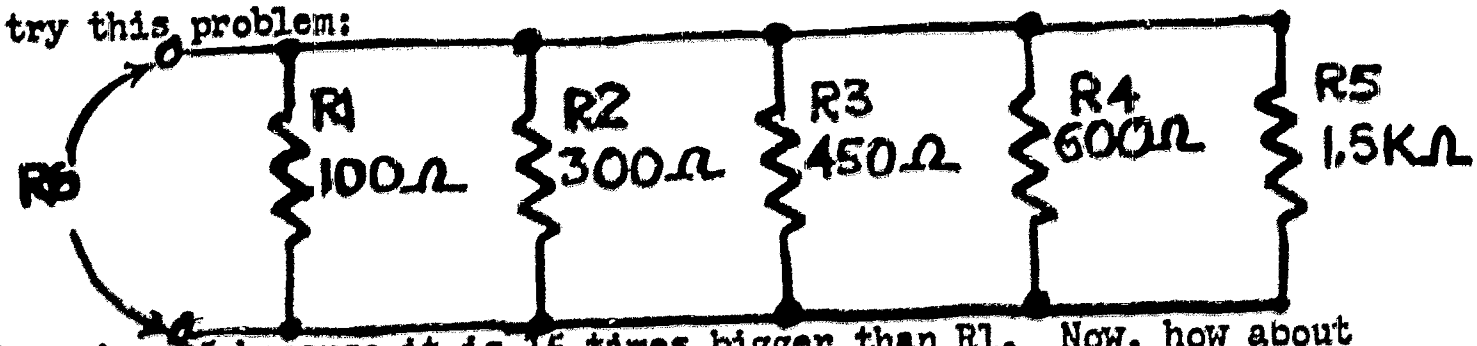
When you ignore any large resistors, and combine resistors of approximately equal value into pairs, you reduce the size of your resistance calculation problem. The only values you have left are those resistances which are less than ten times the value of the smaller resistor but are not equal to the smaller. And you know how to handle them ---- just take them two at a time and use the Calculation Chart to work out their value. Let's try another example, and this time let's use procedure "c" on your Resistance Calculation Chart ....



To begin, R5 (4000 Ω) is more than ten times R1 (100 Ω) so you can ignore R5. Next, pick an easy pair to work with. 150 and 300 look easy

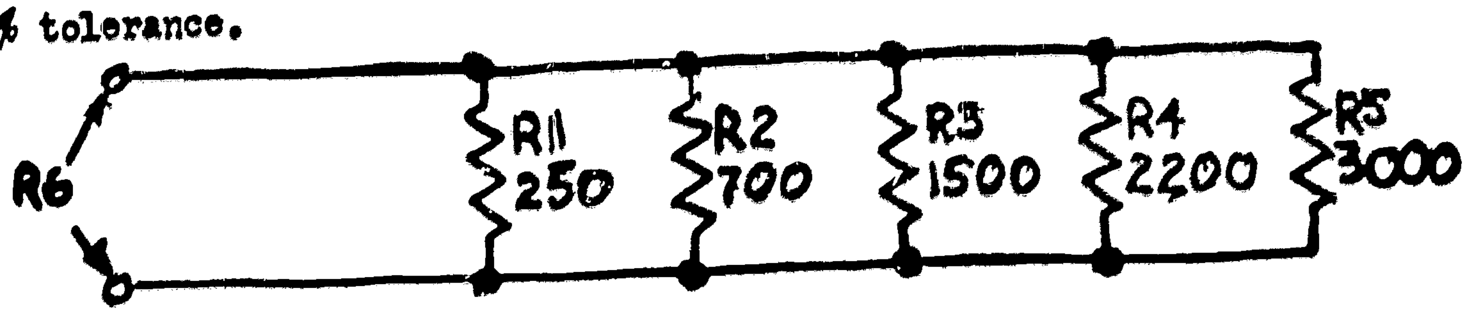
because 300 is twice 150. Look up in the Calculation Chart where it says "R2 equals 2 R1". Across from that and under "c" procedure, it says that R1 + R2 equals 2/3 of R1. In the example, R1 is 150 ohms and 2/3 of it is 100 ohms. Right? Now you can combine that 100 ohm value with R1, which is 100 Ohms, also. The result is 50 ohms. The only resistor you haven't worked with yet is R4, which is 700 ohms. This is more than 10 times the value of 50 ohms, so ignore R4. So......in this problem, the value of R6 is 50 ohms.

Now, try this problem:



Begin by ignoring R5 because it is 15 times bigger than R1. Now, how about working with R2 and R4 next. 600 is ______ times 300. According to the Calculation Chart, the combined value of 300 and 600 equals one-half 300 plus ______ per cent of 300. This equals ______ ohms. Now, combine this value with R1. According to the Calculation Chart, the result should equal "R1 minus 1/3" which is about 67 ohms. Now, what about R3? It's about 7 times larger than 67 ohms, so this reduced the 67 ohms by ______ ohms. Round off your result to the nearest "5" and you should get 60 ohms.

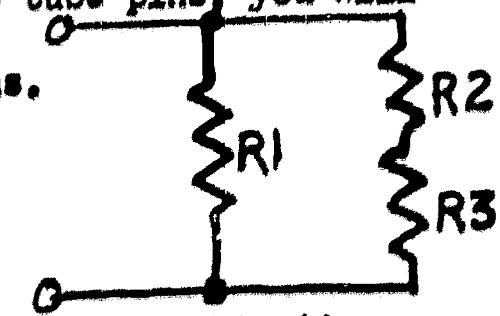
Now, work this problem completely by yourself. Assume that all resistors have a 20% tolerance.



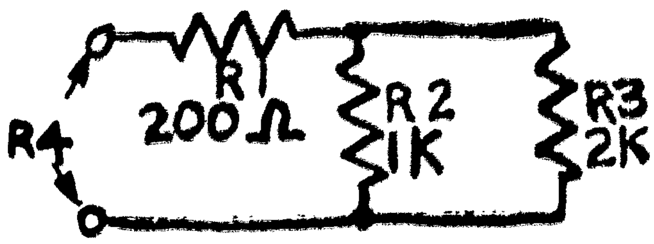
R6 equals ______.

Series-Parallel Resistor Combinations

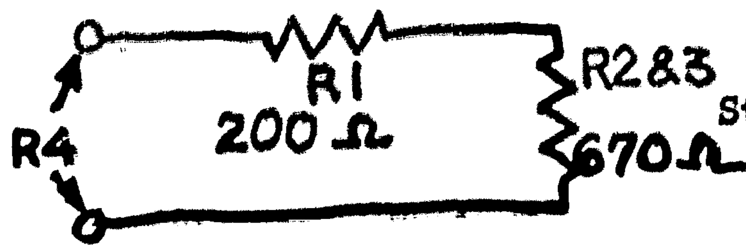
In most TV circuits, especially those connected to tube pins, you will find resistors connected in series-parallel combinations.



It isn't too hard to figure out the resistance value of these combinations. You work with two resistors at a time until you have converted the whole resistor network into a simple series or a simple parallel circuit. For example, in the diagram below, you can see that R1 is in series with the parallel combination of R2 and R3. Therefore, the first thing to do is to combine R2 and R3. This converts the circuit into a simple series circuit. Then add up the resistances to give R4.



Step 1. Combine R2 & R3

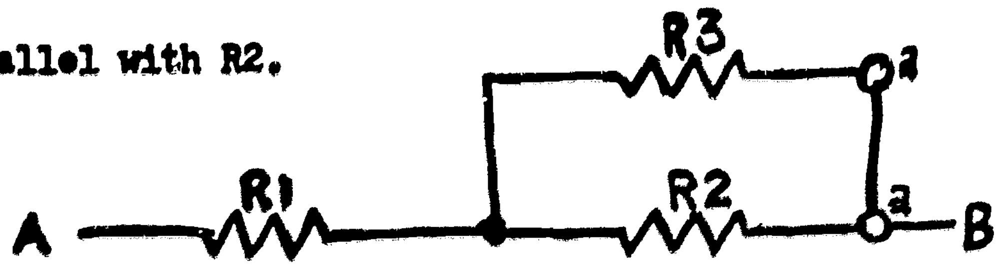


Step 2. Add R1 & R2 & 3

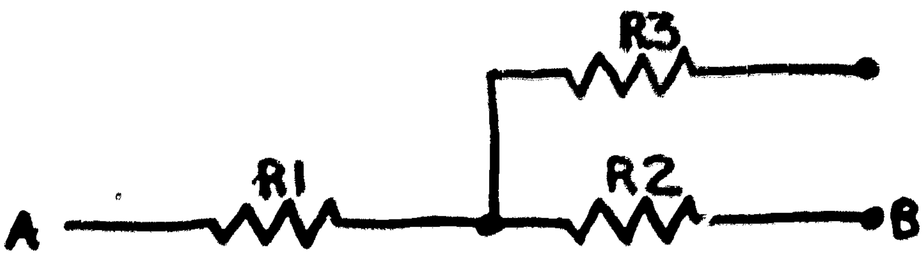
R4 = 870 Ω

Note carefully that in Step 1 we could not have combined R1 and R3, nor could we combine R1 and R2. This would have left the other resistor in parallel floating around without anything to combine it with.

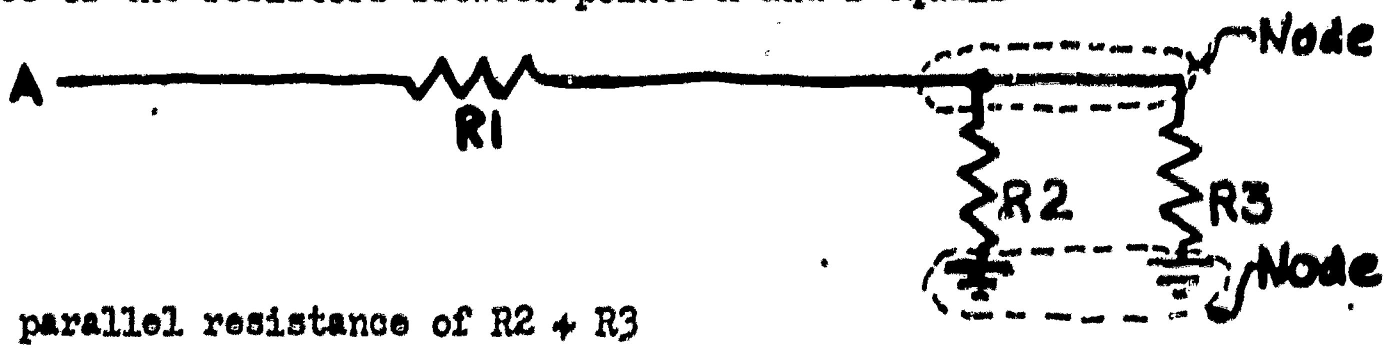
You can make a series addition only when nothing else is attached to the center node. Thus, in the diagram below, R1 and R2 cannot be directly combined because R3 is in parallel with R2.



In this next diagram you can combine R1 and R2 directly by adding them together. In other words, the resistance between points A and B = R1 plus R2. Can you see why? It's because R3 and R2 are parts of different circuits.... Electricity can flow through R2 to get to point B, but it cannot flow through R3 to get to point B.



Now, look at the diagram below. Do you recognize the ground symbols? What do they tell you? They tell you that R3 and R2 are both connected to ground, or to the same electrical node. Thus R2 and R3 are in parallel. The resistance of the resistors between points A and B equals ------



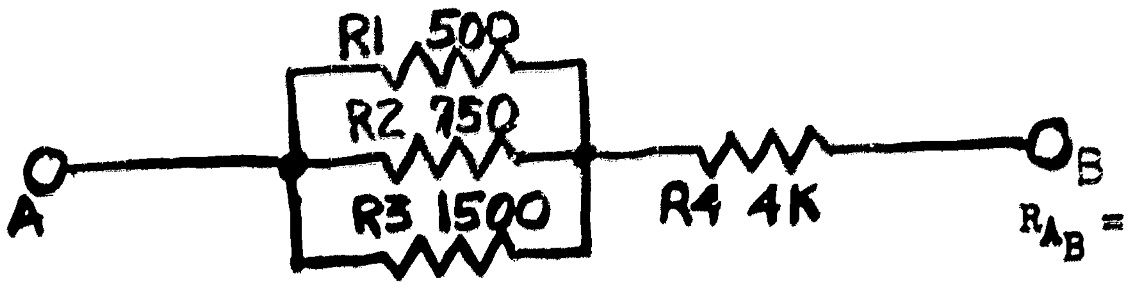
Step 1: the parallel resistance of R2 + R3

Step 2: the series resistance of R1 plus the value obtained in step 1.

Remember then, when two parts are connected to the same node, and the other side of these parts is connected to ground, then the two parts are in parallel.

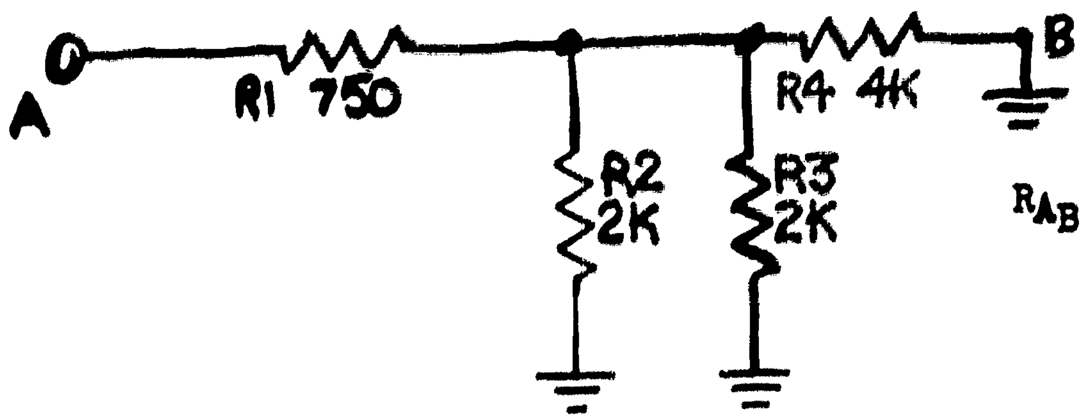
Now, for some problems. In the two examples below, determine the value of R_{A_B} which is the resistance between points A and B.

Problem A



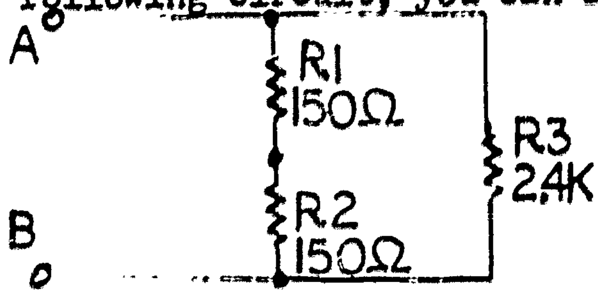
R_{A_B} = ________

Problem B



R_{A_B} = ________

Now, let's look at a slightly different arrangement of resistors. In the following circuit, you can see that R3 is in parallel with R1 + R2.

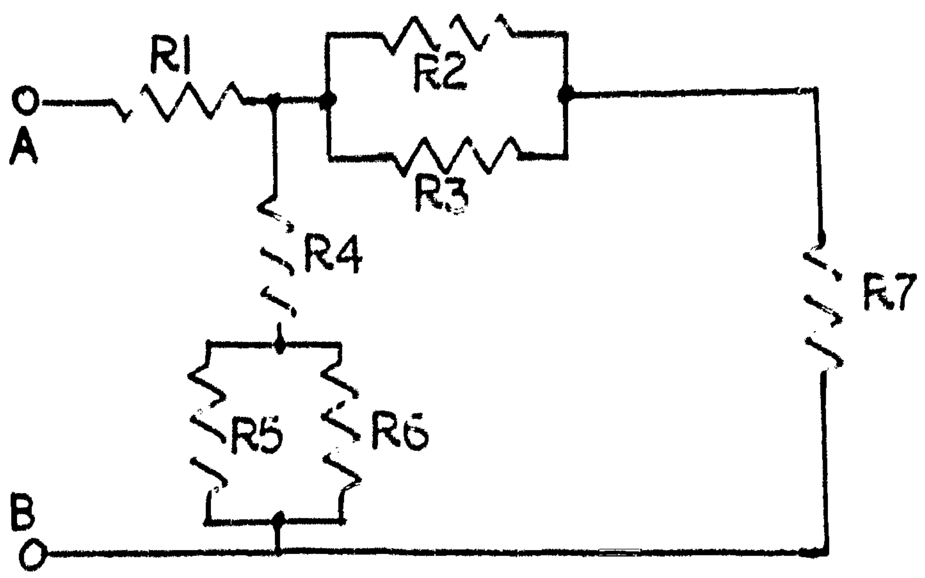


In this type of arrangement, you first have to combine the two resistors which are in series. Then in step 2, you will calculate the resistance of this combination in parallel with R3.

Step 1 R1 plus R2 = ______ R_{12} (fill in calculation)

Step 2 R3 and R1 plus R2 ______ R_{AB} (fill in calculation)

So....when calculating the resistance of a series-parallel combination, first calculate the value of the sub-sections. Keep doing this until you have converted the circuit into a simple series or parallel circuit. OK, now look at the following example carefully. After you have studied it a while, try the next problem.



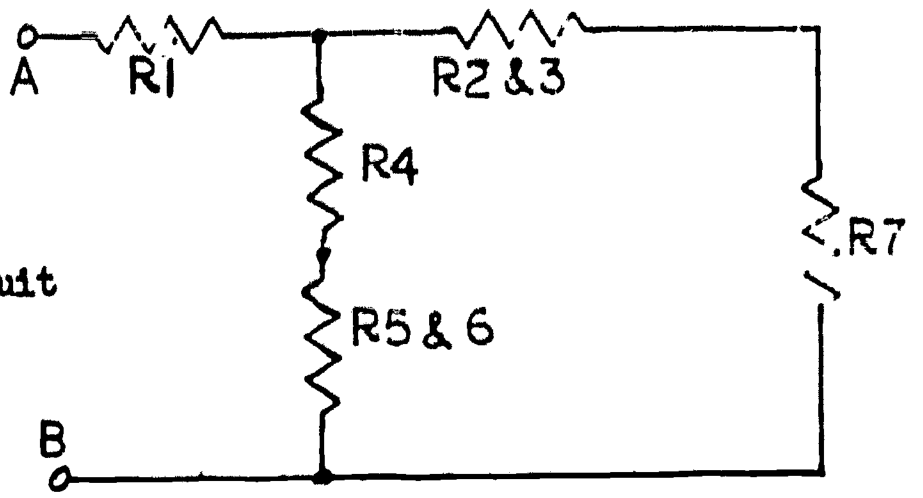
__Example:__

For the circuit on the right, the problem is to find the value or R_{AB}

Step 1: R_2 and R_3 = R_2 & 3

Step 2: R_5 and R_6 = R_5 and 6

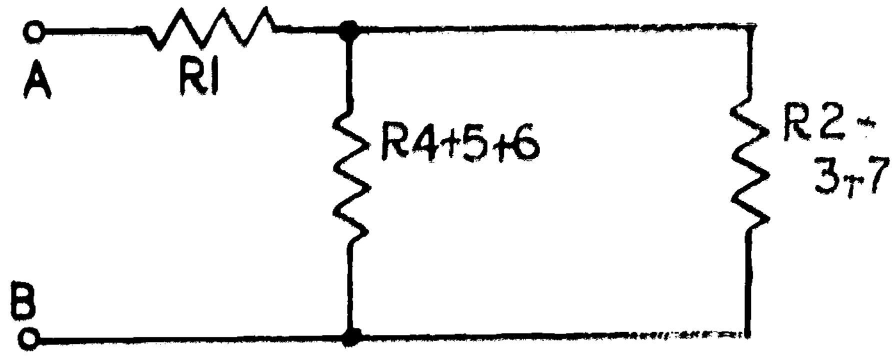
The problem has now been reduced to the circuit on the right.



Step 3: $R_{2+3} + R_7 = R_{2+3+7}$

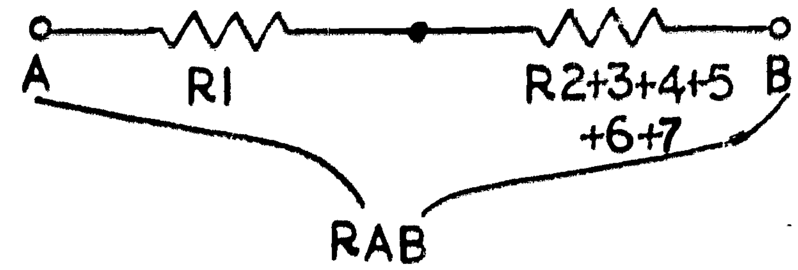
Step 4: $R_4 + R_{5+6} = R_{4+5+6}$

The problem has now been reduced to the circuit on the right



Step 5: $R_{4+5+6} + R_{2+3+7} = R_{2+3+4+5+6+7}$

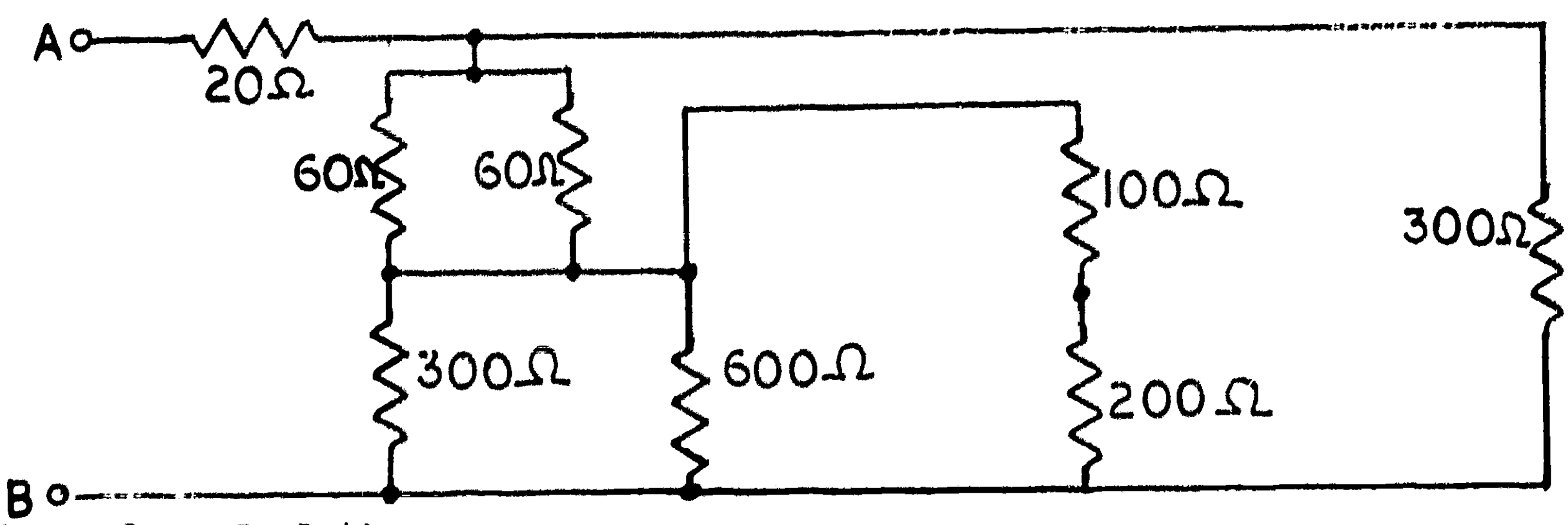
The problem has now been reduced to the circuit on the right



Step 6: $R_{AB} = R_1 + R_{2+3+4+5+6+7}$

Now you try it:

What is the resistance between A & B?

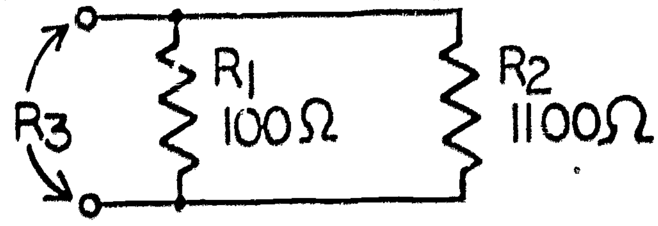


Space for calculation:

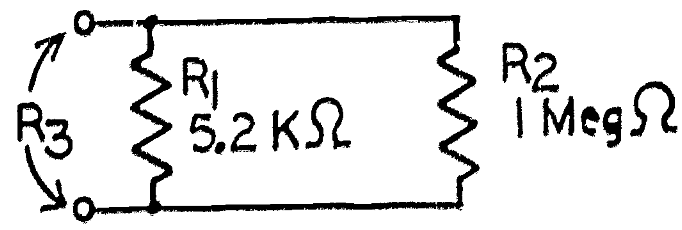
Answer _______ ohms

Hidden Resistors:

There are a number of instances where the resistance of a part will have no practical effect on the total resistance of the circuit. When this occurs, we say that this part is "hidden". We have talked already about one such instance .... when a resistor is in parallel with a second resistor which is ten times or more larger.

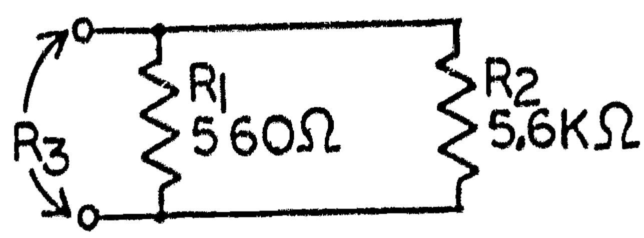


R_2 is "Hidden"



R_2 is "Hidden"

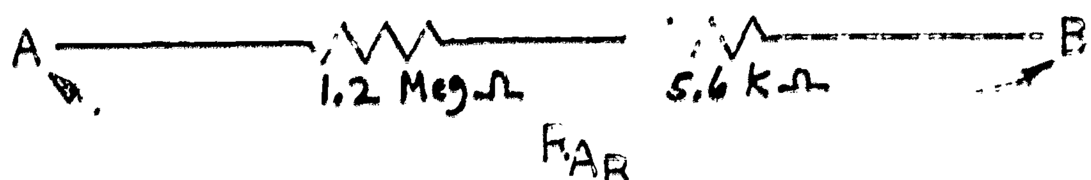
In both of the circuits above, R2 is 10 times or more larger than R1. Thus, the resistance of the R1 and R2 combination is less than 10 per cent smaller than the value of R1 itself. Usually, resistors have a tolerance of at least 10 per cent. So .... the value of R3 in the diagrams above is within the tolerance range of the value of R1 alone. Now look below. R1 has a tolerance of 10 per cent. The smallest value which R1 can have and still be considered within tolerance is ______.



OK. Now work out the value of R3. It is ______, and this value is within ______, outside of ______ the tolerance limits for R1. (Check one).

Thus, we can call R2 a "hidden" ______, "non-hidden" ______ resistor. (Check one).

Resistors connected in series can be "hidden" also. As an example, in the following example, what is the resistance of R_{AB} ______ ohms?



It adds up to be 1,205,600 ohms which is for practical purposes 1.2 megohms. This means that the big resistor is "hiding" the smaller resistor, R2. This is because with 10 per cent tolerance for the 1.2 Meg resistor, its value alone could be as high as 1,212,000 ohms.

What the above information means is that when combining resistance values, the following rules of thumb can be followed:

1. For parallel circuits, the combined value of a small and very large resistor is approximately the value of the small resistor.
2. For series circuits, the combined value of a small and very large resistor is approximately the value of the large resistor.

Finally, a good resistor will show its correct ohms value within its tolerance limits when tested with an ohmeter. A resistor that does not measure within its tolerance limits is no good, for most practical situations.

Now, by way of review, try the following problems. In these problems, assume that all resistors have a 20% tolerance.

Problem 1:

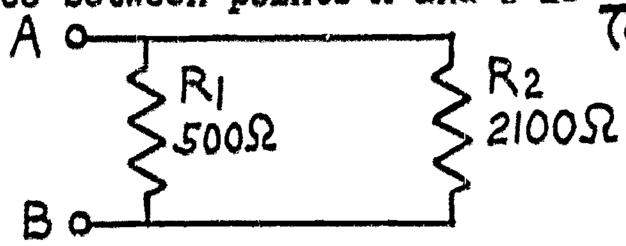
The resistance between points A and B is ____________ (calculate value)

Problem 2:

The resistance between points A and B could be 45.4K _____? 72.6K _____? 59.5K _____? (Select correct answer)

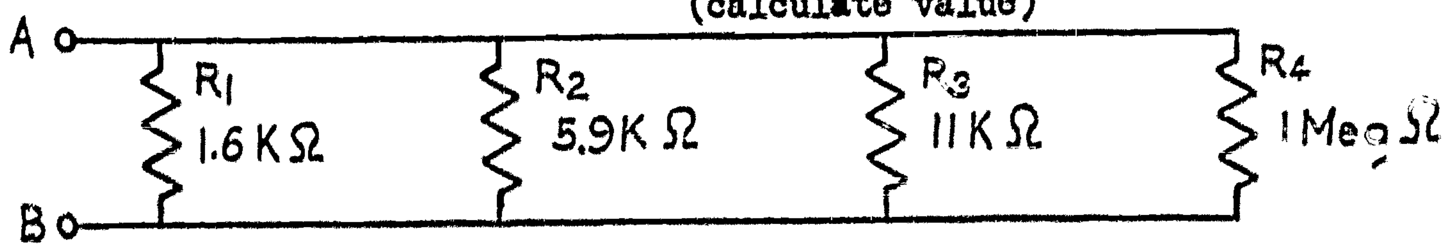
Problem 3:

The resistance between points A and B is ____________ (calculate value)



Problem 4:

The resistance between points A and B is ____________ (calculate value)



Problem 5:

If R1 & R2 are in parallel, and R2 is 6 times bigger than R1, then the combined value of R1 and R2 is: (Select correct answer)

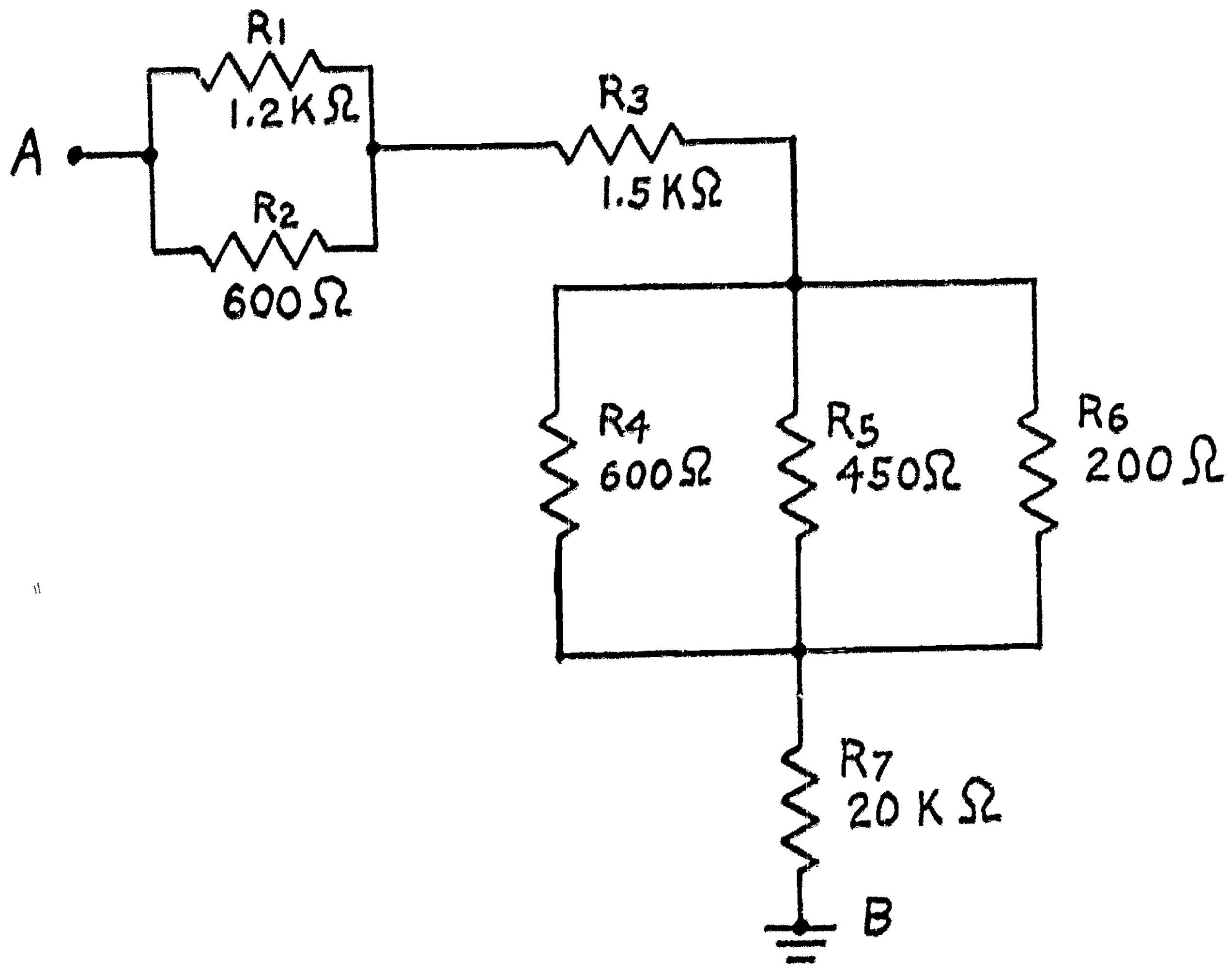
a. one-half the value of R1 _____

b. R1 value minus 15% of the R1 value _____

c. 5/6th of the value of R1 _____

Problem 6:

The resistance between points A and B is ______ (calculate value)



Tube Pin Resistance Chains:

Most piece-parts of a TV are connected together in series-parallel combinations. One side or end of these combinations is usually connected to ground or to a power supply. The other end of the combination usually is connected to a tube pin. It is important to know how to calculate and to interpret the DC resistance of these tube pin chains. Using this information, you can isolate TV or radio troubles down to a single part. Let's find out how this is done.

Resistance to Direct Current (DC):

Let us begin by reviewing the resistance characteristics of three common parts: resistors, capacitors and coils. The resistance of these parts is based on the ease with which DC current passes through them.

...... Resistors: their resistance value varies, depending on their stated value and tolerance of the resistor.

...... Coils (and all kinds of windings): their resistance usually is very low (5 - 10 ohms).

...... Capacitors: DC cannot pass through a capacitor. Therefore, a capacitor has an infinitely high resistance. (Actually, when a capacitor is checked, DC does charge it up by putting many more electrons on one side until the capacitor becomes fully charged. For large capacitors, this may take a second or two.)

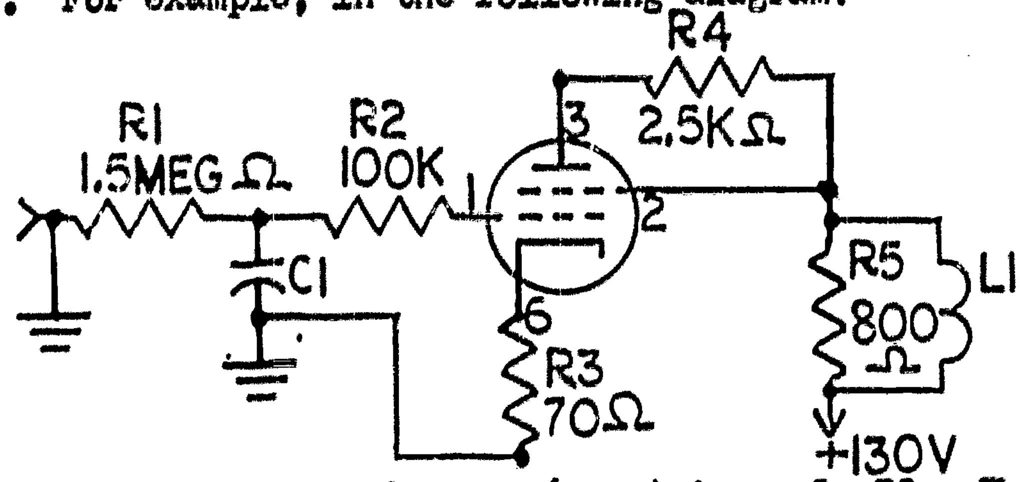
When you measure the DC resistance at a tube pin, you are measuring the combined resistance of all the parts which are on the DC path between that tube pin and ground. Sometimes this DC path (or tube-pin chain) is very obvious. Many times it is not obvious, and you will have to study your schematic diagram to figure out what the path is.

Before taking tube-pin resistance readings, there are two things which you should double-check. First, make sure that one side of your ohmeter or multimeter is grounded to the chassis. Second, make sure that you have grounded all of the power supplies. (You will be told how to do this in class.)

If you will look at your Zenith TV schematic, you will see that some tube-pin chains are grounded and some are not. Those that are not usually go to the power supply. By grounding all the power supplies, you ground all these pin chains.

DC Resistance Path Between Tube Pin and Ground:

When taking pin-readings, one of the biggest jobs is to figure out what parts you are measuring. In other words, you have to figure out the DC path between tube pin and ground. You need to study a schematic diagram to find this out. For example, in the following diagram:



...... The pin chain for pin 6 contains only R3. Therefore, the resistance reading at pin 6 should be ______ ohms. That's right, 70 ohms.

...... The pin chain for pin 2 contains R5 and L1 in parallel. Therefore, the resistance reading at pin 2 should be ______ ohms. Did you say 5-10 ohms, Fine!! The resistance of L1 is so small compared to R5 that R5 does not affect the pin reading.

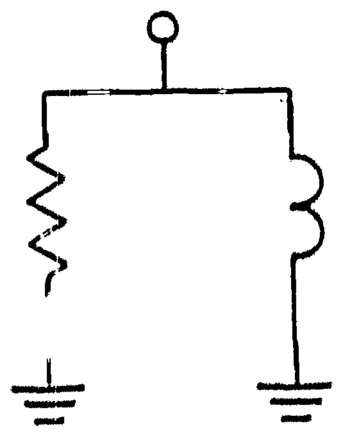
Notice that pins 2 and 3 are connected to a 130v power supply. You should have grounded this supply before taking the pin readings. This would ground the pin chains connected to pins 2 and 3.

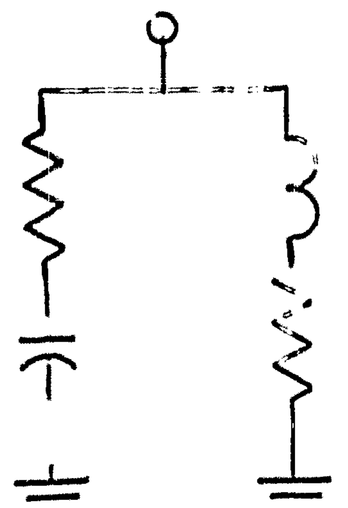
OK, now what about pin 1? The DC resistance path goes through R2. It can't go through capacitors, so it has to go through R1 and then to ground. So .... the resistance reading at R1 should be ______.

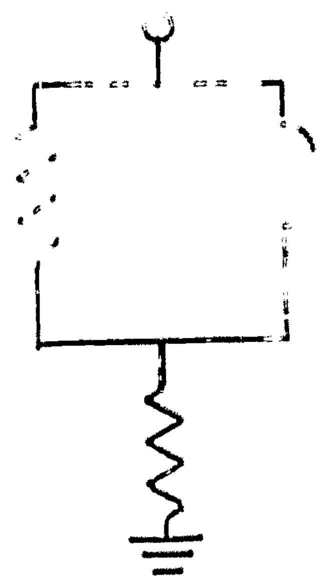
For this next set of problems, you will need the schematic of the Zenith TV set that has been furnished for class troubleshooting practice.

Sometimes it is easy to see what parts are in a pin resistance chain. For example, look at your Zenith schematic (Model N1250Y6)*and find V3 (1st IF stage, upper left of the schematic). What parts are attached to pin 2? ______. Right, only a 68 ohm resistor. (Notice that on this schematic, many resistors are unlabeled. That is, only their value is given. This is because these are common composition resistors which require no special description in the parts lists).

Now here's a harder problem. What is the resistance path from V3, pin 5 to ground. Is it like example A, B, or C? Answer ______


A


B

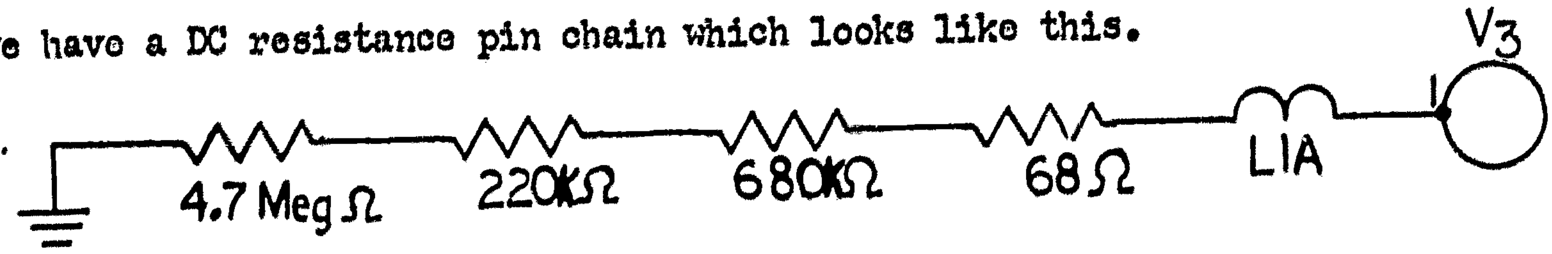

C

* 13N15 Chassis

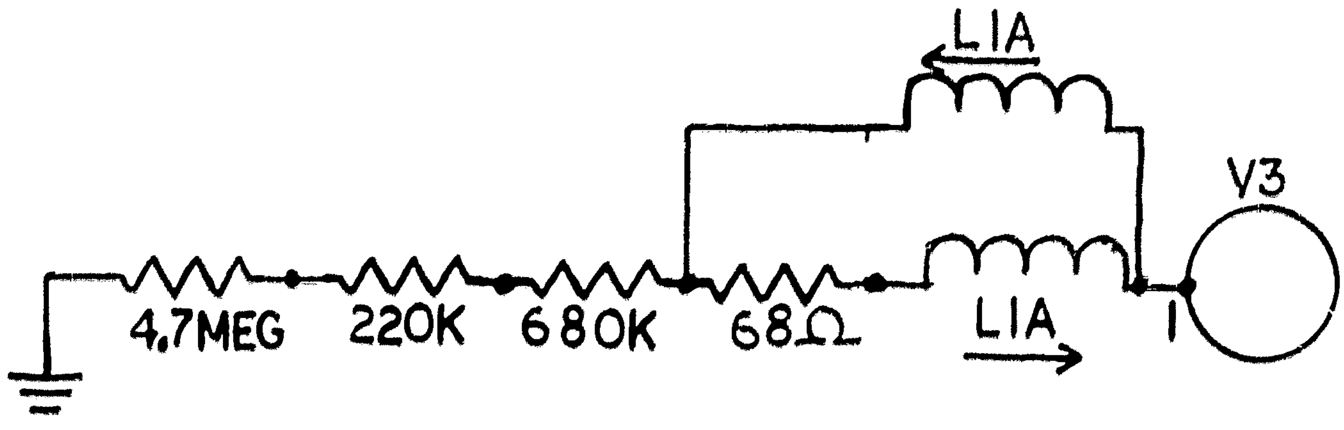
Reconstructing DC Resistance Circuits:

In the previous example, you were shown three possible "reconstructions" of the resistance path for V3, pin 5. It is useful for you to know how to reconstruct such circuits, so let's try a few.

On your Zenith schematic, let us reconstruct the DC resistance circuit for pin 1 of V3. Tracing backwards from pin 1, you come to a branching point with one path going to L1A and the other path through R1. Let's go through L1A first. After going through L1A, the path is blocked by C1 and C2. So we go off to the right and through a 68 ohm resistor. Then we come to a branch which goes off to the left, but this ends at C3, so that's blocked, too. Next we come to a point labeled E . Going off from this point to the left or to the right leads to a capacitor. So .... that's not a DC path. Going downward from point E , we go through a 680K resistor, then off to the left and through a 220K resistor, then down through a 4.7 Meg resistor to a grounded 130V power supply. So far, we have a DC resistance pin chain which looks like this.



Now, let's take another look at it. This time we go left from pin 1, down through R1, then over to the left and then down through the bottom half of L1A, then over to the right and down through the 680K resistor again. In other words, the complete DC path from pin 1 to ground looks like this ......



Now you should be able to figure out what the resistance reading at pin 1 should be. It could be 6 Meg [ ], 6.5 Meg [ ], or 7 Meg [ ]. (Select correct answer).

During much of your practical exercises on Chassis Navigation and on Chassis Troubleshooting, you will be trying to figure out what parts are attached to tube pins. So, try a couple more problems.

A .... Draw below a diagram of the DC resistance path between pin 3 and ground for tube V10B (on your Zenith schematic).

B .... For tube V6A, draw the DC resistance path between pin 7 and ground.

Often times there is a DC resistance path between two or more tube pins. Sometimes you can use these paths to check the resistance of individual parts. For example, on your Zenith schematic, locate V3, pin 5. Notice that there is a DC path from this pin to pin 6 of the same tube. By measuring the resistance between these two points, you actually are checking the resistance of one of the windings of the transformer T2.

Sometimes you may have to check the resistance between two tube pins because there is no other way to check the part. For example, on V12, R24 can be checked by measuring between pins 1 and 12. But you must be careful not to get shocked, as here the voltage is 13.5KV when the set is on, danger, turn off the power first!

Pin Resistance Charts:

For most TV sets, the schematics for these sets will contain a tube resistance chart. Such charts tell you what the correct DC resistance reading should be at each pin. But, be careful when using such a chart. First, be sure and read the chart to find out how the readings were obtained. Sometimes the readings were obtained without the power supplies being grounded. This makes the readings very difficult to use.

Unfortunately, the Zenith TV you are working with is so new that it doesn't contain a pin resistance chart. When you have to work with such sets, the best thing to do is figure out your own chart. This you can do by taking a TV which seems to be working OK. Disconnect it, ground the power supplies, then check and record the readings at each tube pin. If the set is quite new, these readings can serve as the "correct" readings, in most cases.

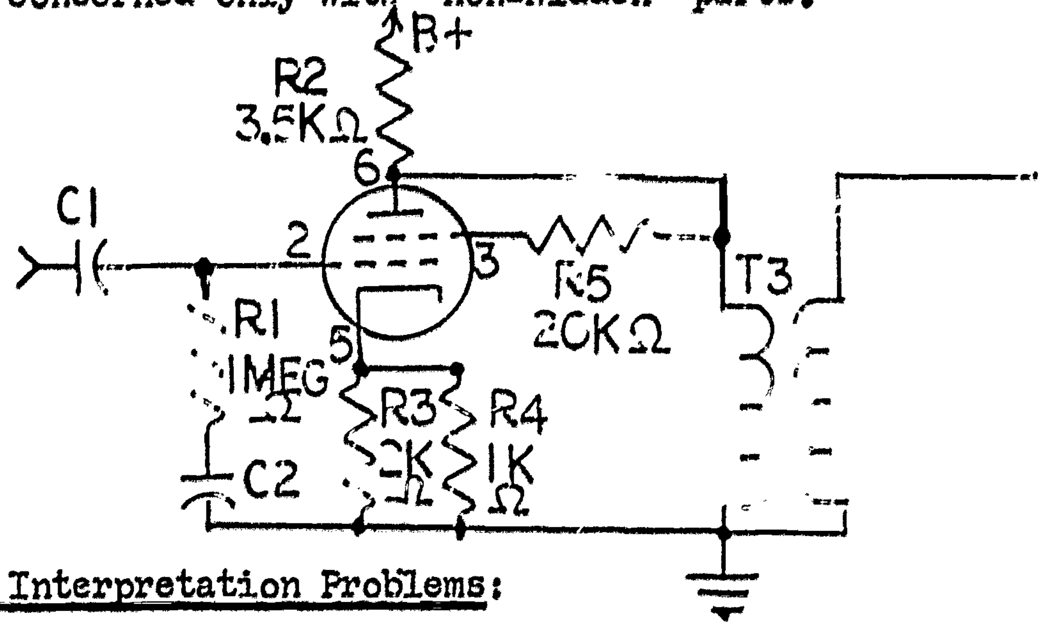
Interpretation of Pin Resistance Readings:

When troubleshooting a TV, you first use symptom and other information to isolate the trouble to one or more stages. You check the tubes for these stages. Suppose the tubes are OK. That's when you begin the chassis troubleshooting through the use of pin readings. It's important to remember, though, that you must try to use symptom information and your understanding of the TV Technical Story to isolate the trouble to one or two stages. In this way, you do not have too many individual parts to check.

Hidden vs. Non-hidden Parts:

As you should realize by now, most piece-parts are connected in some way to a tube pin. However, not all of these parts will affect the resistance reading at the tube pin. Those parts that do ~~not~~ affect the reading we will call "non-hidden" parts. They are non-hidden because if they go bad in a typical way, the effect of this will be to change the resistance reading at the tube pin.

There are certain parts, and certain arrangements of parts which lead to what we call "hidden" parts. These are parts which can go bad and still not affect the reading at the tube pin. An example which you are familiar with already is that of a very large resistor in parallel with a small resistor or with a coil. Later on, we will talk more about "hidden parts". In this section, we will be concerned only with "non-hidden" parts.



Resistance Interpretation Problems:

In the diagram above, the correct resistance readings at the tubes pins should be as follows:

pin 2	infinity
pin 3	20K
pin 5	670 ohms
pin 6	5 ohms

OK, now for some problems:

A..... the reading at pin 2 is 1 Meg. What is probably wrong? C1 is short?_____ or C2 is short?_____

That's right, C2 is probably short. Incidentally, capacitors typically go bad by shorting. This changes their resistance from infinity to about zero ohms.

B.....Next problem. The reading at pin 5 is 2K. What probably is wrong?

R4 is Shorted_____? or R4 is open_____?

Right! R4 probably is open. Resistors typically go bad by opening up. This changes their value from whatever it should be, to a value of "infinity" - maximum resistance.

C.....Suppose the reading at pin 3 is 23.5K. What is the trouble?

T3 is open_____? R2 is open_____? No trouble_____?

Can't tell_____?

This is a tough one. Possibly nothing is wrong because with 20% tolerance resistors, the correct reading could be 23.5K. On the other hand, T3 could be open or R2 could be open, and this would not greatly affect the reading at pin 3.

D.....Suppose the reading at pin 6 is 3500 ohms. What is probably wrong?

T3 is open_____? T3 is short_____? R2 is open_____?

T3 is probably open. Transformer windings can either short out or open up. When they short, they may short out only a few turns of the winding. When this happens, you can't detect this with resistance readings.

E.....One final problem. Suppose the resistance reading at pin 5 reads infinity. What would be wrong?

Not making a good connection with the multimeter probe_____?

Both R3 and R4 are open_____?

There is an open break in the line between pin 5 and ground_____?

All of the above_____?

Right! Any of the above could cause a reading of infinity. However, you don't usually expect two or more parts to go bad at one time, so probably both R3 and R4 are OK. Breaks in the line can occur; or parts and wires can come unsoldered. That's the thing to look for first in this case.

Let's conclude this lesson by interpreting a few readings from the Zenith TV you are working with. Again, you will have to use your schematic diagram for these problems:

A.....On V3, pin 7, the correct reading should be 0 ohms. The obtained reading is infinity. What probably is wrong?

a. broken multimeter_____

b. broken lead from pin 7_____

B.....On V3, pin 5, the correct reading should be 220 ohms. The obtained reading is 33K. What probably is wrong?

a. C6 is short_____?

b. T2 winding is open_____?

c. 130V is not grounded_____?

C.....On V7A, the obtained reading at pin 4 was .7 megs. Is this the correct reading? yes_____ no_____. If no, what part is probably bad?_________

D.....On V10A, the obtained reading at pin 9 was 149K. Is this the correct reading? yes_____ no_____. If no, what part is probably bad?_________.

This completes this lesson.

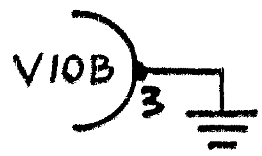
ANSWERS TO BOOK III PROBLEMS

Page		Page	
3- 3	150,000 ohms	27	2 times; 15%; 195 ohms;
3- 3	± 20%	27	7 or 8 ohms
3- 3	3500 ohms	28	about 160 ohms
3- 6	low resistance	31	Pr.A .. 4.25K
3- 7	good	31	Pr.B .. 1550 ohms
3- 7	bad	32	Step 1 .. 300 ohms
3- 7	bad	32	Step 2 .. 260 ohms
3- 7	good	33	120 ohms
3-10	R1, R2, R3, R5, R6, L1	34	about 500 ohms; about 505 ohms;
3-11	Series	34	"within"; "hidden"
3-12	2050 ohms; 1,023,250 ohms	35	1.205 megs
3-13	33.0K; 29 megs; 2300 ohms	36	Pr.1 .. 200 K or 2.004K
3-14	parallel	36	Pr.2 .. 59.5K
3-16	250 ohms; 50 ohms	36	Pr.3 .. about 400 ohms
3-17	240 ohms; 185 ohms	36	Pr.4 .. about 1100 ohms
3-18	175 ohms; 43, 44, or 45 ohms	36	Pr.5 .. choice "b"
3-19	800 ohms	37	Pr.6 .. about 22K
3-20	90 ohms	39	70 ohms; about 5 ohms
3-23	about 325 ohms; about 1275 ohms	40	1.6 megs; 68 ohm resistor;
3-23	about 2.65K; about 170,000 ohms	40	answer "c"
3-24	choice "a"	42	6 megs
3-25	about 165 ohms		

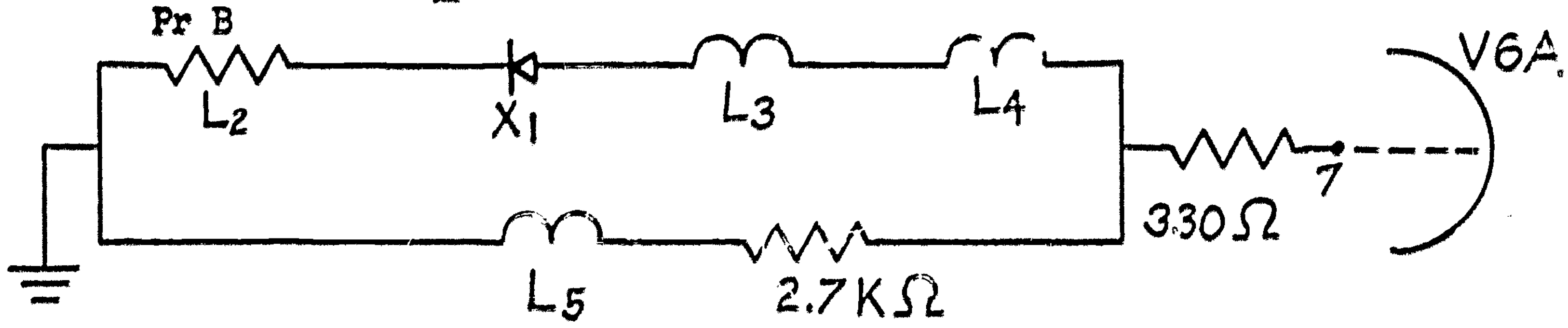
ANSWERS TO BOOK III PROBLEMS

Page

42 Pr A



45 Pr B



45 Pr.A ... C2 is short

46 Pr.B ... R4 is open

46 Pr.C ... Can't tell

46 Pr.D ... T3 probably is open

46 Pr.E ... All of the above

47 Pr.A ... choice "b" -- broken lead from pin 7

47 Pr.B ... choice "b" -- T2 is open

47 Pr.C ... reading is correct

47 Pr.D ... reading is incorrect; C52 is short

BOOK IV

WITHIN STAGE TROUBLESHOOTING

Directions

This book tells how to find bad parts in electronic chassis. It will give you practice by means of a set of problems.

Everything you will need to solve these problems is here in the booklet. This is a scrambled book. As you read through the booklet, you will notice at times you will be asked a question. Sometimes the questions are of the completion type. In the space left for you to complete the question, fill in the word or words you think best answers the question. You will be told to go to a page where you will find an answer to the question you have just answered. Some pages have answers to several questions on them. In order to keep questions and answers related, the answers are lettered as well as numbered. For example, you may be told to go to page 4-10b. Do not go to 4-10a or 4-10c since the answer will be on page 4-10b.

The next page gives the table of contents. Notice the location of the diagram. You will use it later on. Turn to page "1" and begin.

TABLE OF CONTENTS

Topic	Page
Within Stage Troubleshooting	4-1
Bug #1	4-29
Bug #2	4-30
Bug #3	4-32
Bug #4	4-14
Bug #5	4-15
Bug #6	4-39
Bug #7	4-35
Bug #8	4-34
Bug #9	4-37
TV Schematic Diagram	4-43

"WITHIN-STAGE TROUBLESHOOTING"

You start "Within-Stage Troubleshooting" after you have found a bad stage. Once you have named the bad stage, you know all of the parts which are connected to the tube in that stage. The tube and the parts connected to it are shown on the schematic diagram.

First you should check the tube in the bad stage. Second, you should "eyeball" the stage for charred resistors, bad solder joints, broken parts, etc. Third, if you can't find the trouble, you then begin using static checks. (Resistance measurements) You should use static checks at this point because the resistances of the parts don't depend on each other, and you want to have independent measures now rather than over-all measures. On the other hand, when the equipment is turned on you should use hot (voltage, oscilloscope) checks in measuring stage outputs because the parts act together as a whole to cause the overall stage output.

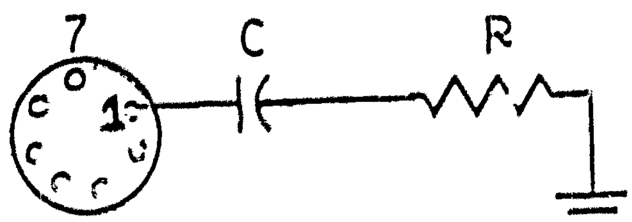
To find the exact part(s) causing the trouble, you measure resistance with the set <u>turned</u> <u>off</u>. You <u>must</u> <u>prepare</u> it for static resistance checks. You do this by grounding all power inputs. Why do you ground power inputs?--to make small networks of the parts between each tube pin and ground.

Each network will contain some combination of resistors, capacitors, inductors or other specific parts. You, as a repairman, must determine which parts in the stage belong in each net-

work. All networks are between tube pins and ground so you start at a tube pin to determine each network and trace it to ground. A bad part will usually change the resistance value of the network measured at the tube pin. The correct resistance values for each tube pin are easily figured out from examining the schematic.

The next Within-Stage Troubleshooting step is for you to measure the resistance value of each tube pin until the one is found which is bad. The network attached to that pin will contain the bad part. You then look at the network schematic to find out if you can measure smaller portions of it without unsoldering parts. Assuming you can, you continue measuring smaller portions until you have either found a single bad part or you must unsolder a connection to separate one part of the network from the remainder.

Sometime tube pin measurements fail to show bad resistance even though the stage is known to contain a bad part. In these cases, the trouble is a "hidden part." A hidden part is a faulty part which will not produce bad resistance readings at a pin because of the nature of the network it is in. There are only a few network circuit arrangements which produce hidden parts, they are:



(1) Capacitor in series.

The resistance at pin 1 in the circuit above will be infinite. This is the correct reading at pin 1.

From
4-2

To
4-3

Note, however, if the resistor is either open or short-circuited, the resistance pin 1 is still infinite. Therefore, the resistor could be badly damaged, or completely destroyed, and a resistance measurement at pin 1 would not show it. The resistor in this case is a "hidden part." This circuit is also an example of how a network can be split up so as to measure smaller portions of it. It is impossible to measure the resistor directly since one end connects to ground and the other to the capacitor. Thus, when possible, measure the resistance of individual parts in the chain. A resistance measurement of the resistor will show it to be good or bad.

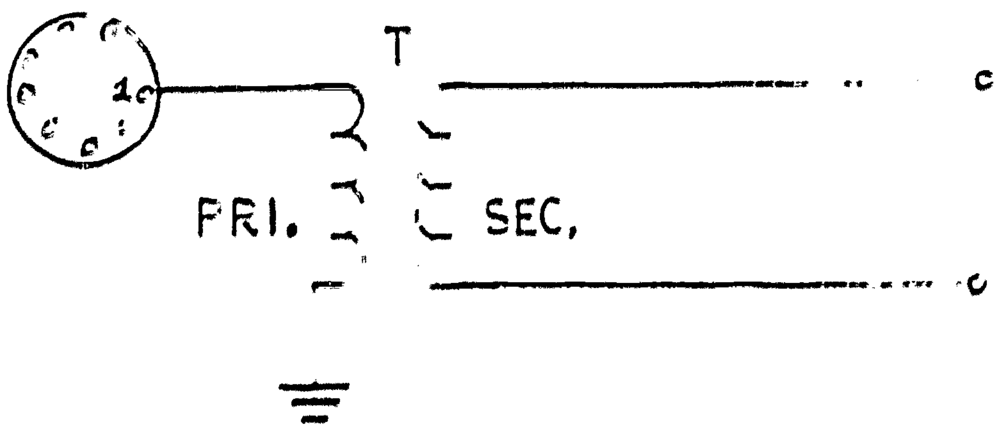
(2) Coil connected across part.

The resistance at pin 1 in the circuit above will be that of the coil. Coil resistances are usually very low (of the order of five or less ohms). Often the resistor connected across the coil has a resistance which is thousands of times greater than the coil. In these instances, the resistor could be open-circuited, and the measurement of resistance at pin 1 would still show the value of the coil, or in other words, a good reading. Therefore, a part connected across a coil may be either good or bad without having its condition revealed by a pin resistance measurement. The resistor in this case is the hidden part.

From
4-3

To
4-4

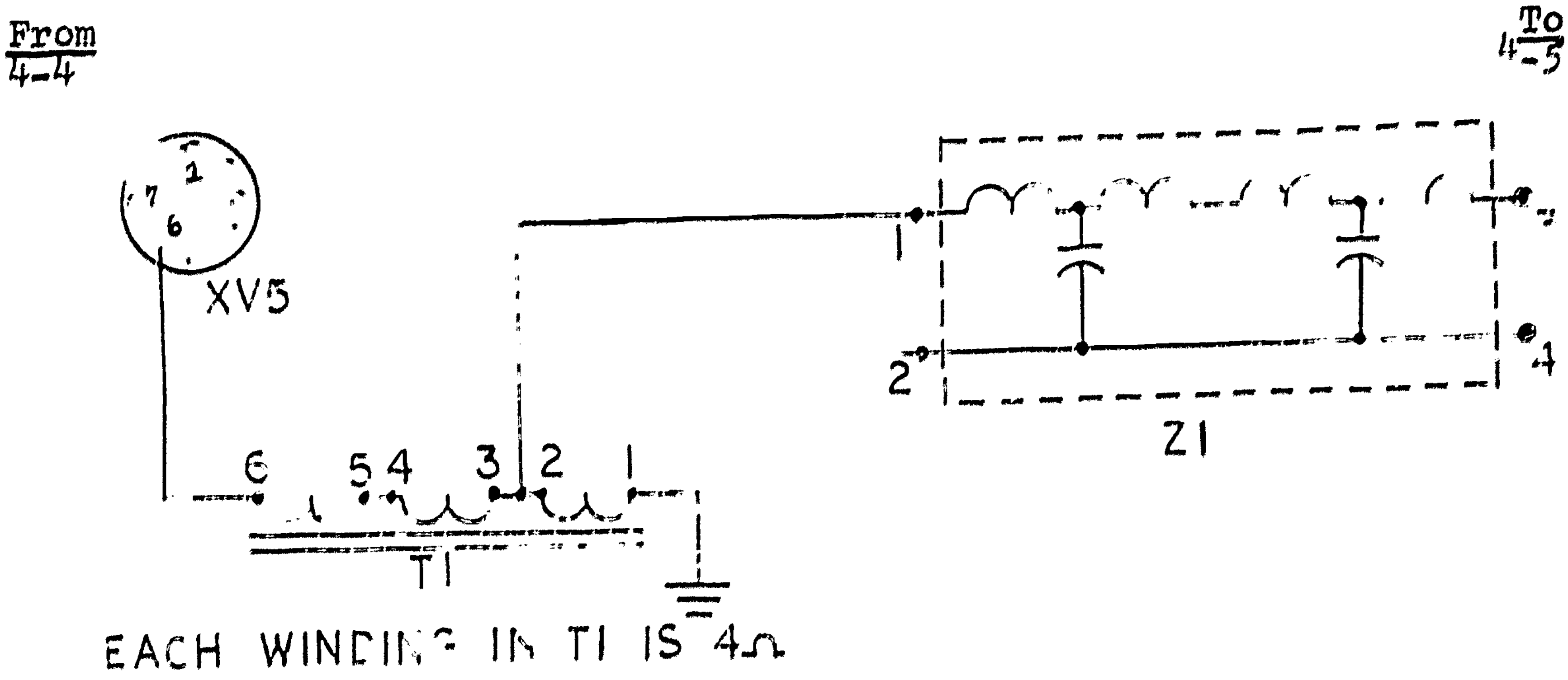
Remedy. This circuit is an example of when it is not possible to split up the circuit into smaller portions. In this case, you must actually detach one end of the part under test and measure the resistance of the individual parts. Such resistance measurements will show up the bad part. You will often have to unsolder one end of the part under test from other parts in the chain in order to isolate it. This is an important part of troubleshooting but should only be done when necessary.



(3) Transformer secondaries

The resistance at pin 1 in the circuit above is that of the primary winding of the transformer. A bad secondary winding would not affect the resistance measurement.

Remedy. You must note the presence of secondary windings and measure them separately by detaching other parts from at least one end of the winding under test. Do this to all windings of a transformer.



(4) Input-Output Connections.

The resistance measured at pin 6, V5 is 12 ohms as shown above. This resistance is the sum of the resistances of the windings numbered 1-2, 3-4, and 5-6. It has nothing to do with Z1, the delay network. Therefore, if the delay network contained the malfunction, pin resistance measurements would not show it.

When two stages are on different chassis, the output of one is often connected to the imput of the other by means of a "coaxial cable." When such a chassis is removed from the set in order to troubleshoot it, the coaxial termination, however, is left unconnected. Therefore, any part connected to the coaxial terminations will not be checked by means of the pin resistance measurements.

Remedy. Check the resistance of the parts individually, opening connections between them in the process. In the circuit above, a resistance measurement should be made between terminals 1 and 3 of the Z1 network. If the resistance is infinite, the trouble has been local-

From
4-5

To
4-6

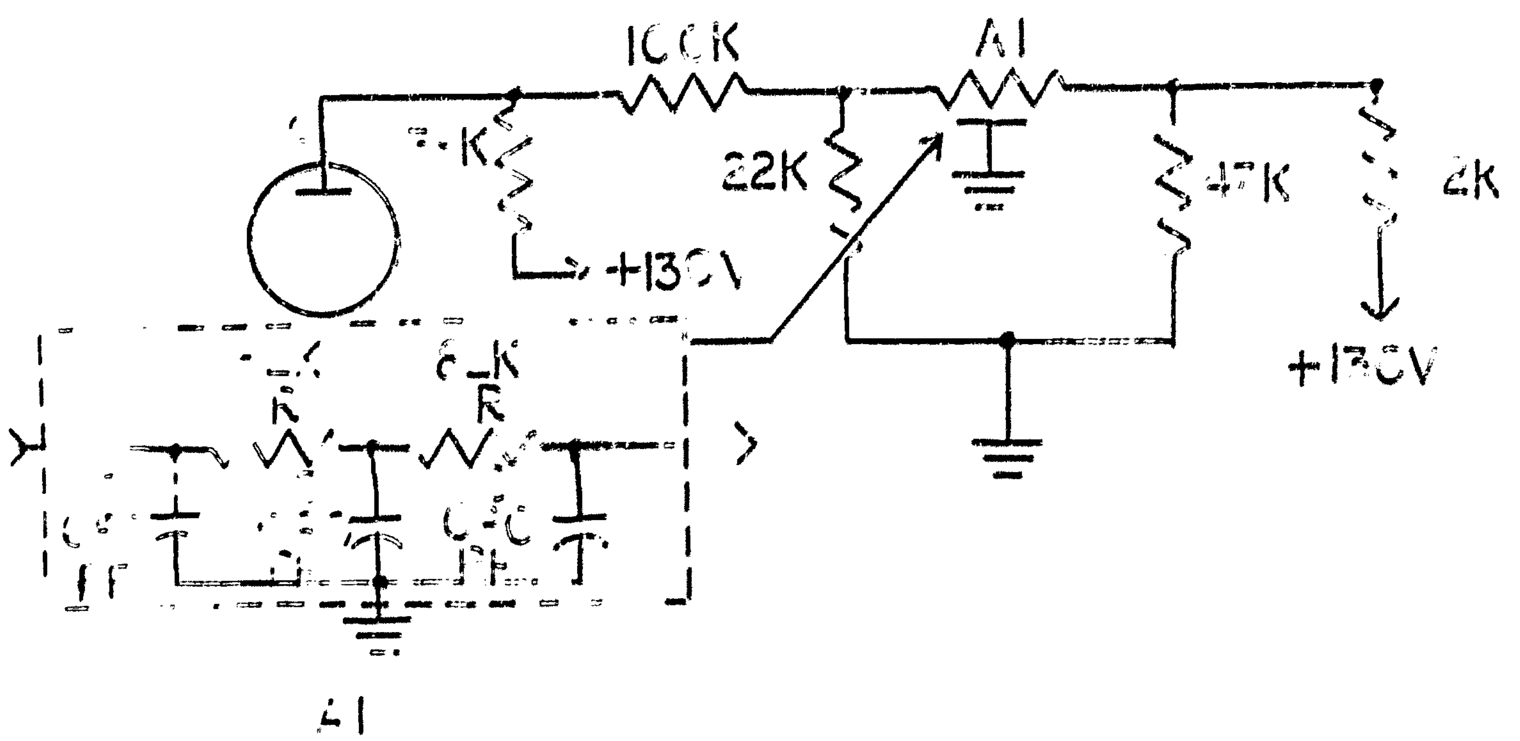
ized to the network, since the resistance between 1 and 3 should be that of a string of coils connected. It should be low, not infinite. If you have to continue to troubleshoot this component rather than to replace it, that is done by disconnecting terminal 1 of Z1 from T1 and checking the resistance between pins 1 and 2 of the network Z1. This resistance should be infinite; if it is not, the malfunction has been discovered. This is because the measurement includes capacitors.

We are now going to take a look at some examples.

It will be assumed you have used dynamic checks to isolate the trouble to a stage. Look at the schematic diagram in the back of the book. Your static troubleshooting begins with a visual check of the chassis. We assume you have done this and the chassis looks OK. You have also checked the tubes and they are good. Let's say you had an ohmmeter. Now you begin measuring the resistance of a chain of parts connected to the pins of <u>tube V8</u> by placing one probe of your ohmmeter on the pin in question, and the other at ground. But wait! What should you do before making resistance measurements at the tube pin? Right! OK, go to the next page.

You ground the power supply, of course!

Now, let's see what value we get. We start a pin 1 and note that the reading must be zero because its grounded. Next, pin 2 should measure 6.8K, since it is connected to +130V through R15 and we have grounded the 130 volt line. Next let's find the resistance at pin 8. The parts of interest are shown below:



A1 has a circuit equal to that shown dotted.

The A1 circuit completes another path through 82K resistance near the picture tube which is grounded.

Compute the resistance*reading which you should get at pin 8 and go to page 3-21a for verification of your answer.

* Add up the resistance involved and write the sum in the space, then go to page 4-21a.

From
4-42a

To
4-8

D. Right. In circuits of this sort, your best choice is to measure the individual parts. Go ahead. 4-82

In cases of this sort, the strategy of repair will depend on how the parts are actually physically wired into the circuit. If it is possible to do it, it is probably worthwhile grouping the parts in two sections, and measuring each section separately.

This is, of course, applying the old "split-half" technique, which will probably save you some time and effort if you have no special reason for measuring at any particular place. If you do this, you will find that C29 has shorted. You replace it and measure your pins again to find they are OK.

Notice that C30 is within a dotted line representing a can. It might be difficult to replace C30 were it shorted out; therefore, the whole assembly might have to be replaced.

You have just completed a series of problems designed to give you practice in troubleshooting within a chassis. You have learned how dc resistance checks can be used to help find a failed part, how to interpret pin resistance readings, what to do if all checks are good (hidden part troubles) and how to make simple deductions based on the circuit and the values of your measurements.

Practice of this sort will help prepare you to do your job.

This concludes the booklet.

From
4-21b

To
4-9

B. Right! Since A1 could have opened up without changing the value of the pin reading at pin 8. Moreover, the 47K or 82K resistor attached to the right side of A1 should be opened.

Grounding the power supply created a parallel path that didn't exist before. So, you are probably wondering why should you ground the power supply if it is only going to make your job harder? You will find, however, that it generally makes your job easier. Let's see why!

Suppose you didn't ground the power supply and measured at pin 8 of V8. What now would be the circuit and the resistance reading? Whatever the +130V tie point is joined to will appear in series with the 39K resistor and in parallel with the remainder of the network. Take a look at the schematic and find out where the circuit goes after it leaves 39K through the +130V line. We will assume that capacitors will block the DC current of the ohmmeter and will look like open circuits.

The +130 line can be found at many places in the diagram. Notice that every branch of this circuit is blocked by a capacitor or a tube (which in a deenergized chassis blocks current like a capacitor), except one which goes through the brightness control (located above V9B on your schematic). Because of this, the reading should be 39K+ 250K in parallel with about 120K or about 85K.

From
4-9

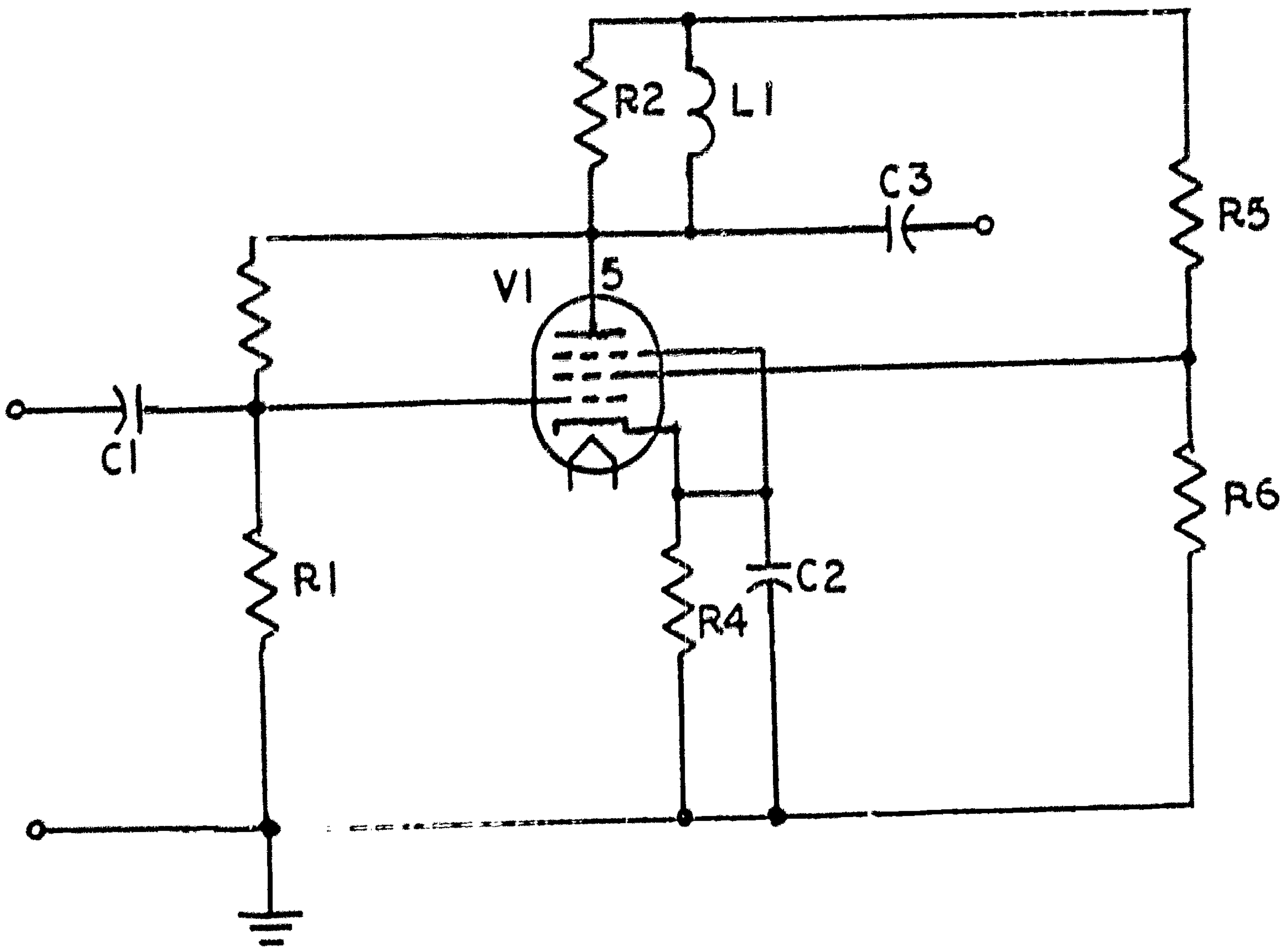
To
4-10

Why then, do we ground the power supply?

A. Because in most instances, it helps restrict the number and location of parts to measure. Go to 4-16b.

B. Because you might burn out the set if you didn't. Go to 4-13b.

Extra Problem #1: Draw the equivalent circuit for the following schematic:



From
4-20b

To
4-11

C. You measure 405K at one extreme of R11, and 11.5K at the other. This is because C34 has shorted through and explains why the pin reading was so low. That is, since C34 has shorted, the ohmmeter was actually measuring 680K in parallel with the 1 Meg part, R11. (The other resistors are so small they can be ignored.)

Go ahead. 4-11a

Now you have found two bad parts. Do you think you have them all? 4-11b

A. Yes. Go to 4-22c.

B. No. Go to 4-18c.

A. This could happen but it is probable that you would have noticed it when you were handling C19 before. Try again. Go to 4-33b. 4-11c

---

A. We said opened not shorted. Try again. Go to 4-35d. 4-11d

A. If you did this, you would still have the short circuit. Try again. Go to 4-42a. 4-11e

From | To 4-12

B. This would certainly give you the answer, but the accuracy of the capacitance checker is not needed. And besides, you don't have one in the shop. Try again. Go to 4-24d.

You can use this space for figuring or drawing cartoons or schematics or equivalent circuits.

4-16b C. Right! After studying the schematic, you will find that there is a capacitor which could produce this result, if it shorted. This is C17B. Go to 26a, a

---

A. Not at all. You must always disconnect the TV from the wall outlet before working on the parts inside of it. Try again. Go to 4-10a. b

---

4-28b B. You will have time enough for this. You'd better act now. Try again. Go to 4-29a. c

---

4-32a L1A, R1, C2, C1, 68Ω, 470Ω, 22 Meg, R2

Go ahead. d

The parts in the network of T1 are so interconnected that a variety of alternate paths exist which result in relatively little change, regardless of how the parts go bad. This is because they all connect through the 680K, 220K and 4.7 Meg resistor to the grounded supply, and these parts dominate the resistance reading. e

R2 is hidden with respect to pin 5 because it is across the primary of T2, a low resistance.

True______ Go to 4-17c.

False______ Go to 4-22a.

From

To
4-14

Bug #4

You have isolated the trouble to V7. You have made the following measurements:

Correct		Measured	
Pin	Ohms	Pin	Ohms
1	Fil	1	Fil
2	1K	2	1K
3	180Ω	3	180Ω
4	687K	4	406K
5	5Ω	5	5Ω
6	10K	6	10K
7	~2Ω	7	~2Ω
8	350Ω	8	350Ω
9	1600Ω	9	1600Ω
11	500KVar	11	350KVar
12	Fil	12	Fil

Q-1 As your next step you would:

C. Measure at pin 11 and rotate the volume control to extremes. Go to 4-20a.

A. Replace the tube socket since there must be a short in it. Go to 4-15a.

B. Examine the 680K resistor connecting pin 4 through 680 resistor to the B+ boast since it must have changed its value out of tolerance. Go to 4-18a.

a

From		To
		4-14a
4-38b	1. If it opened you'd have infinity. If it shorted you'd have zero ohms. Try again.	b
4-37c	Three, go ahead. Of the types of parts connected to the tube at that pin, which do you think most likely to short? A. Resistor. Go to 4-33d B. Capacitor. Go to 4-36b. C. Transformer. Go to 4-24g.	c d

From
4-14a

To
4-15

B. The socket might have a short in it but your measurements so far should not have suggested this to you. There's a better choice. Try again. Go to 14a.

Bug #5

4-22d You've got the trouble narrowed down to V5 and its parts. Your check of the pins' resistance shows you the following:

Measured Pin	Measured Ohms	Correct Pin	Correct Ohms
1	2	1	2
2	0	2	100
3,4	Fil	3,4	Fil
5	220	5	220
6	220	6	220

You have checked the tube and it's good. You have examined the vicinity of the tube for obvious signs of failure and found none.

Clearly the trouble has to do with pin 2. Which part appears to have changed its value? __________?

(Turn to page 4-24c).

From 4-17c | To 4-16

A. You said yes. And you are right because pin 6 actually connects directly to the other side of T2 primary at the junction of C6 and the 220 ohm resistor.

Go ahead to page 4-14a. 4-16a

4-10a B. Right. Since the +130V line is now open, the brightness control is in the circuit.

We ground the power supply to make little circuits out of bigger ones, so that you can more easily spot the source of an incorrect reading. 4-16b

Let's look at an example where thepower supply has not been grounded. Such an example can show the problems you get into if you don't ground the power supply.

Let's suppose that without grounding the power supplies, you measured at pin 8 of V8 and got a reading of 30K. That's what the reading is supposed to be when the power supplies are grounded. That should make you suspicious. You get a "correct" reading without making the measurement correctly. That suggests that something is wrong someplace. In fact, it suggests that the +130V power supply is grounded, even though you didn't do it. So.... your job now is to find out what could go wrong that would ground the +130V PS.

Q-3 As your next step you would:

A. Measure the 39K resistor circuitry directly. Go to 4-25a.

B. Measure the 100K and 22K resistors by measuring between pins 8 and ground. Go to 4-23a.

C. Study the schematic diagrams to see what might be wrong and still give a 30K reading. Go to 4-13a.

From
4-21d

To
4-17

Pins 2 (which should have been 1K) and 9 (which should have been 1600). Go ahead.

You have found the pins with the bad reading. Looking at the schematic diagram, you can see that one of the resistances you should have read would have been due to the series combination of the resistance of two parts. Since you measured, in fact, infinite resistance for both pins, you could deduce that one part had:

A. Opened up. Go to 4-19a.

B. Shorted out. Go to 4-24a.

4-13e B. You said True. Good. You know that coils usually have low resistances and that this 33K resistor is in parallel with it. Go ahead.

Would it be hidden with respect to pin 6?

A. Yes (page 4-16a)

B. No (page 4-25d)

From
4-14a

To
4-18

D. It's possible that R26 changed its value, but notice that there are resistance measurements which are wrong. You'd better think a little about why and try an easier way first. Return to 4-14a. a

---

4-20b C. Well you could do that, but it's grasping for straws. Remember you've got two bad readings. Try again with 4-20b b

---

4-11b B. You probably do have them. The tube V7 was bad and you found that by making a routine check. Go ahead to page 4-22d. c

---

4-35b A. You said "yes." No! You've already checked the tube and it's OK. Go to page 4-37a. d

---

B. It's possible that this was the trouble but there's a better answer. Try again. 4-42a. e

From
4-17b

To
4-19

A. Right. It would have been very unlikely that both parts would have opened up to produce exactly the same resistance of infinity. So it is probable that only one part opened up. Go ahead. a

Take another look at the resistance values listed for your measurements at V7.

Pins	Measured Resistance	Correct Resistance
1-12	Fil	Fil
2	∞	1K
3	180	180
4	687K	687K
5	5 Ω	5 Ω
6	10K	10K
7	5 Ω	5 Ω
8	500	500
9	∞	1600
11	.5 Meg Vari	.5 Meg Vari

Notice there are two incorrect pin readings. The resistance at pin 2 is made up of R12 to ground. Whereas pin 9 has R12 and the primary of the output transformer T8.

Which part do you think opened?

A. Primary? Try 4-23c.

B. R12? Try 4-30a. b

From
4-14a

To
4-20

A. This is a good "next" step. Since R11 is in one pin chain which had a bad resistance reading, you would be interested to see if it might be the source of trouble. Your measurements at the extremes give you 1K and 405K. a

Go ahead.

Allright, you think you have found a bad part, but remember you had two readings which were wrong. Pin 11 and pin 4.

Q-2 Your next step is to:

A. Measure R11 by putting the probes directly across it. Go to 4-24b.

B. Replace R11 with a good volume control. Try 4-22b.

C. Measure between pin 11 and pin 4. Back to 4-11a.

D. Check for shorts in shielding. Back to 4-18b. b

4-38b 2. Right. If shorted, it would put the 33K resistor in parallel with R22, providing 23.5K ohms. Go to 4-34c.

4-20c

About 30K. Go ahead. a

If you measure 30K at pin 8 does this mean all the parts are good?

A. Yes. Go to 4-25b.

B. No. Back to 4-9a. b

4-29a

A. Good choice. You can profitably spend a few minutes doing this. If you find a damaged part or parts, looking at your schematic diagram will help you decide which parts to check Go ahead. c

Q. Unfortunately, you didn't find the bad part by looking at the chassis. You've checked the tube and it's OK. Now you decide to measure the pin resistance readings at V7. You ground the power supply and begin measuring. This is what you find. d

Pins	Measured Resistance	Correct Resistance
1-12	Fil	Fil
2	∞	1K
3	180Ω	180Ω
4	687K	687K
5	5Ω	5Ω
6	10K	10K
7	<5Ω	<5Ω
8	500Ω	500Ω
9	∞	1600Ω
11	.5 Meg Vari	.5 Meg Vari

Note: (<)means "less than" and (>) means "greater than."
Which pin or pins have bad resistance readings? ______

Go back to page 4-17a to check your answer.

From 4-13e

To 4-22

A. You said False. If you will trace the path from pin 5 of V3, you will find that R2 is connected to T2 at one end and to pin 6 at the other end of T2. So R2 is actually across the transformer primary. Since the resistance of this winding is low, R2 could open and not be noticed. Go back to 4-17c. a

---

B. You just cost the boss another $5.00 because the new one acts the way the old one did. Try again. Back to 4-20b. b

---

4-11b

A. Yes. You seem to have them all, because being a good troubleshooter, you have already checked the tube V7 and found it bad. Go ahead. c

You won't really be certain you've got them all until you have replaced the parts you have found to be defective, and checked out the resistance readings before energizing. Then, after you have energized the set, you can measure the stage outputs and find out if they are OK. d

In this particular problem, you found all the bad parts. What happened was that C34 shorted. This put a high voltage on pin 11 of V7. Such a high positive voltage drew grid current which saturated the tube, thus producing an excessive plate current which damaged the tube. The set owner turned the set off fast enough to prevent any additional damage from occurring. But sometimes other parts can fail, too.

So the failure of one part can cause other parts to fail. As a consequence, you have to be ready to detect and replace all bad parts.

Let's go on to the next problem, which is found on page 4-156.

From			To 4-23
4-16b	B.	You measure between pins 8 and ground and find the same result--30K. You can't readily measure this combination without unsoldering some parts. Go to 4-26a.	23a
4-29	D.	No. While it's true the tube pin resistance measurement will not show this resistor to be bad, it's far too early to begin measuring individual parts, even if they are hidden. Try again. Go to 4-29a.	b
4-19b	A.	No, the primary is alright. But you should have known this because the reading at pin 2 was also bad. If the primary had opened, pin 2 would have read 1K ohms as before rather than ∞. R12 is open, go ahead to page 4-30a.	c
4-24d	C.	Yes. You find the capacitor has a very high resistance so it is not shorted out. Go ahead to page 4-33b.	d
	C.	R22 opened, not the 33K resistor. Try again on page 4-35d.	23e

From			To 4-24
4-17b	B.	You said "shorted out." If one branch had shorted out, the resistance at pin 2 would have been zero and not that of the other branch. Try again. Return to 4-17b.	a
4-20b	A.	You measure 405K ohms. You haven't got much more information than before. There's a better choice, try again on 4-20b.	24b
4-15b		C9 appears to have shorted.	c

Q. You could be sure about that only by:

A. Pulling the tube and measuring across the capacitor. Try 4-33a.

B. Disconnecting it from the circuit and measuring on a capacitance checker. (A capacitance checker is used to measure capacitance very accurately.) Try 4-12b. d

C. Disconnecting one end and measuring its resistance. Back one page to 4-23d.

D. Asking your boss. Go to 4-34a.

4-38b	4.	The resistance measurement would be unaffected by it. Try again with 4-38b.	24e
4-42a	C.	C29 has a smaller value; it's true, but that doesn't mean it will go bad first. Try again on page 4-42a.	24f
	C.	Transformers can go bad by shorting out. When they do, they can short between turns, short from one winding to another or short to ground. But they are not so likely as are capacitors. Go ahead to page 4-42a.	24g

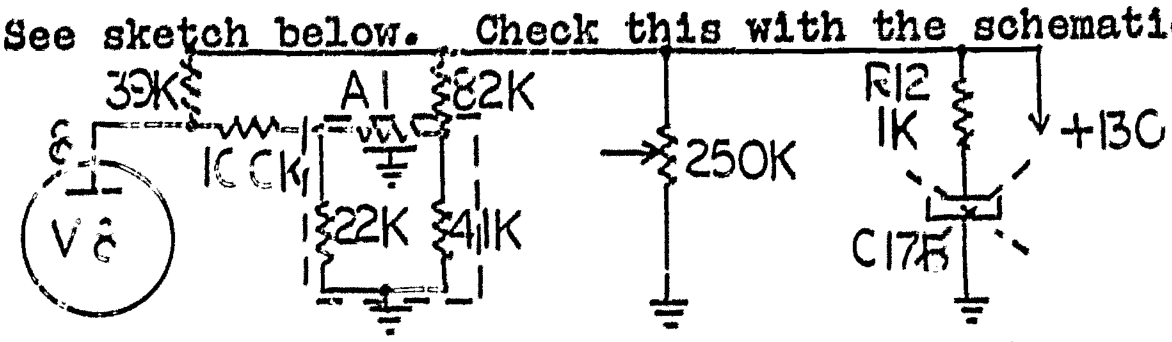
From 4-16b			To 4-25
	A.	You could do this accurately only by opening one end. If you do, you find it's OK. Go to page 4-26a.	25a
4-21b	A.	You said "yes." You are wrong. The A1 network could have opened up, and you would not have known it because the effect of these parts is so small on the total resistance measured. Try again--back to 4-21b.	b
4-29a	C.	Since you have been told the very stage where the trouble has occurred, you need not go to specialized equipment since it's primary uses are in calibration, and in measuring electrical parameters of the operating chassis. Try again on 4-29a.	c
4-17c	B.	You said no. But you should have said yes since pin 6 is actually connected directly to the other end of T2 primary at the junction of C6 and the 220 resistor. Go ahead to page 4-14a.	d

From
4-13a

To
4-26

If you chose to measure 39K directly, you learned that it was good. Of course you can always measure directly resistance of a part which has one end connected to a tube pin. This measurement is made between the tube pin and the other side of the part. Also, if you measure between the tube pin and ground, its OK where no other parts are in the pin chain; otherwise, you may have to unsolder one part in order to measure it individually.

Suppose you decided to measure the combination of 100K and 22K singly. Were you surprised by the results? They were due to the fact that the 39K was still connected in parallel. If you said you were going to study the schematic, it's possible that you would have come across the part which could have produced this trouble; namely C17B. Notice that it is functionally unrelated to the circuit of V8 when the system is energized, yet if C17B should fail by shorting, the 1K resistor associated with it would be connected into the measuring circuit through the +130V supply and ground. Let's assume C17B shorted and note what parts would be measured at V8 pin8. See sketch below. Check this with the schematic.



<u>If the +130V point had been grounded, we would never have had to look beyond that point</u>; all the parts that could affect pin measurements would be confined to a small, easily-examined region of the diagram. You might think that if C17B had shorted and we had

From
4-26

To
4-26a

grounded +130V, we would not have been able to find the trouble. This is not true, because if C17B had shorted, and that were the reason for checking this chassis, we would not be measuring the pins of V8. Rather, our dynamic checks would have isolated the trouble to the sound output stage (of which V7 pin 2 is a part instead of to the Sync Clipper). (Go to page 4-27.)

We would therefore be measuring the values at tube V7 instead of at V8. And of course, if power supplies were grounded, +130V would be connected to ground and pin 2 of V7 would read zero because of C8 being shorted.

In this example, we have tried to show that there is a distinct advantatage to grounding the power supply. We shall assume this in the troubleshooting exercises which follow.

(5) Crystal Diodes

Special attention must be paid to pin measurements which include the resistance of crystal (semi-conductor) diodes. If you don't measure the correct resistance, reverse the ohmmeter leads and check again. If it's still wrong, then you've found a chain containing a malfunctioning part. This is because crystals (or semi-conductor diodes) have a resistance which depends upon the direction of current through them. Sometimes they are in circuits which place them in parallel with resistors. The combined resistance of such a combination will depend upon which ohmmeter probe is grounded. Rather than specify each time which lead goes to ground, we simply note that if the value is incorrect, you are to reverse leads and remeasure.

Since an ohmmeter actually supplies a voltage to the unit being measured, there is a danger that an ohmmeter might ruin the diode. Use the low range X1, X10 for measuring them. Go to page 4-28.

There is the story of a man who was told to check out a shipment of 10 microampere fuses. He rejected the shipment, saying that he had not found one good fuse in the lot. His supervisor thought that this was unlikely and asked him how he checked the shipment. The man replied, "With an ohmmeter, of course!" Unfortunately, the ohmmeter burnt out each fuse measured!

You should not expect to be able to reliably measure the resistance of a semiconductor diode since the actual value depends upon the voltage applied and the temperature at which the measurement is made. For troubleshooting purposes, it is sufficient if you can measure within the tolerance specified for the tube pin resistance you can calculate.

(7) Variable Resistors

Occasionally you will find a variable resistor connected to a circuit at a tube pin. The variable resistors are used, so that a certain amount of adjustment can be made for changes in the operation of the chassis. Since the pin resistance reading will depend upon the setting of the variable resistor, you may find, on measurement, what appears to be an out-of-tolerance reading. If you do, record somewhere the value you have measured and then adjust the resistor through its range of values to see if you can obtain the required value. 4-28b

(Go to page 4-29)

From
4-28

To
4-29

If you are able to obtain the required resistance value, you may still find that the reading on the pin does not vary as it should when the variable resistor is turned. This is a clue for you to measure the values of other parts in the circuit. If you find that there is ample range of adjustment available, then return the adjustment to the pin reading you recorded and continue with your checks. If not, replace the part(s) to make it possible to adjust the variable resistor to the proper resistance value for the pin.

Now that you know some of the tricks of troubleshooting within a chassis, you are going to have a chance to practice them.

Let us begin with the first "bug."--don't swat it, solve it!

Bug #1

You've been handed the TV set. You are told that the trouble has been narrowed down to V7 by symptoms and by dynamic checks. Your job is to find the bad parts or part.

Q. Your first step is to:

A. Eye ball the chassis for obviously damaged parts. Try back on page 4-21c.

B. Study the schematic diagram. Try again with 4-13c.

C. Get the sweep generator ready. Take a crack at 4-25c.

D. Measure the value of the 10K resistor connected to C34 near the volume control. Go for 4-23b.

From
4-19b

To
4-30

A. Correct. You, of course, recognized that if the primary had opened, you would have had a good reading at pin 2, which you did not. Go ahead.

You have just worked through a sample exercise. The ones which follow may not include so much help as this one, nor will they be so easy. Now, let us try the second "bug."

Bug #2

This problem is intended to give you some practice in spotting "hidden parts" which, as you recall, can change their resistance without showing any effect on tube pin resistance measurements. Turn to the schematic diagram again. Look at V6. List below all the parts which could go bad in this stage and not affect the pin resistance measurements:

1.
2.
3.
4.
5.
6.
7.
8.

When finished, go to page 4-31a.

From
4-30

To
4-31

The following are true:

Pin

2 Secondary of L6 is T5.

3 Secondary of T6, C31.

7 39K tied to C15, L5, C11

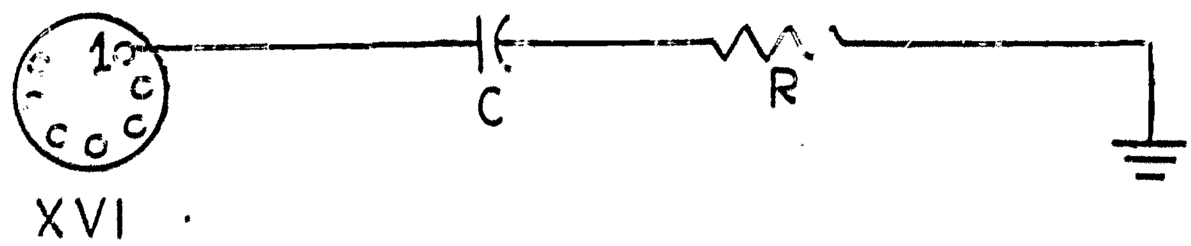
9 22K, 100K resistors near C21, C18, C21.

C31 and Secondary of T6 are isolated from pin 2 of V6 by C26. It could go bad by shorting or by opening and their condition wouldn't be noted. L6 is blocked by C20. a

Likewise, the condition of the 39K resistor wouldn't be noticed because there is no path to ground through it. Both the 100K and 22K resistors joining the sync clipper to the video amp are isolated by C37. (Go to page 4-42b.)

Sometimes, when you have a circuit like this: b

4-42b



you can tell if the resistor is conducting and if the capacitor will block when you touch the ohmmeter probe to Pin 1. The d.c. voltage source in the ohmmeter will "charge" (that is, store electric energy) on the capacitor. The ohmmeter pointer will indicate the charging current. In such cases, you may notice the ohmmeter pointer swing from maximum resistance (infinity) to some lower value and start back toward infinity. If the pointer moves at all, you know at least that the resistor hasn't opened. If the pointer returns to infinity,

From

To
4-31a

you know that the capacitor hasn't shorted. Go to page 4-32.

You can use this method only part of the time.

If the capacitor is too small, it will draw so little current that the meter will not register it. Also, if the resistance is too small, the capacitor will chrge before the pointer has a chance to move. The meter will continue to read infinity. This is no reason to think that the resistor or capacitor has opened. a

If the capacitor and resistor both are of a high value, the charging current may last for a minute or two, while slowly decreasing as the capacitor becomes fed-up (charged). During this time, the meter will indicate a low resistance, but this is no reason to think the capacitor has shorted.

Let us now continue with the exercise. Come on students, try to solve this third problem!

Bug #3

Find and list all the hidden parts in the circuit of V3. Assume that all cables have been disconnected from the chassis and that only the power supply has been grounded.

1. ____________ 5. ____________
2. ____________ 6. ____________
3. ____________ 7. ____________
4. ____________ 8. ____________

Go to page 4-13d to find the answers.

From
4-24d

To
4-33

A. Since you've checked the tube, you would not need to pull it out. And besides, C9 is connected across the R100 ohm resistor. You still measure zero. This leads you to disconnect one end of the capacitor and measure its value. What do you know! You find that is not shorted! Go ahead.

a

Q. You have discovered that C9 is good when disconnected from the circuit and apparently bad when connected. What can you make of that?

b

A. C9 has an intermittent short which appears only when held in the circuit. 4-11c.

B. When soldered into the circuit, something is shorting C9. 4-35a.

---

3. Whether open, or shorted, could not be determined with resistance measurements at pins. It's a hidden part. Try again. Go to page 4-38b.

4-33c

4-14d

A. Composition resistors can change their values sufficiently, that for all practical purposes they have shorted. You can sometimes find them in chassis which have been de-energized before the resistor burns out. But, in general, the capacitor is more likely to short. Go ahead to page 4-42a.

4-33d

D. What are you being paid for? Work a little!

Try again. 24d. a

D. No, just make some calculations using the information on the schematic and try again. 4-35d. 4-34b

---

This was a little exercise in making an educated guess about the possible site of a malfunction and then checking to see if you were right. Go on to the next problem. 4-34c

Bug #8

"Here's a TV Set," Mr. Joiner, your boss, says to you. He says, "I figure the trouble's in the V8 stage, fix it up." The boss lights a butt and leaves you to your job.

OK, you look at the schematic, ground the power supplies (the tube's OK); you measure:

Pin	Resistance(ohms)
1	0
2	6.8K
3	4.9 Meg
4,5	Fil
6	1.04 Meg
7	50 Meg
8	29.6K
9	10 Meg

You gaze at the schematic for a while, comparing the measured values with what you figure you should get. Then, you decide that either the 3.3K connected to R13 off pin 7, or R4 off V6 pin 8 could have failed and you wouldn't know it. Turn to page 4-37 for verification. d

From
4-33b

To
4-35

B. That's right. Even though the schematic doesn't show it, something is providing a parallel path at pin 2. Go ahead. a

Q. Could it be a grid cathode short in the tube?

A. Yes. 4-18d.

B. No. 4-37a. b

Bug #7

4-41 You've been measuring the resistance of the pins on V10. You measure at pin 6, 23.5K ohms. You are to decide which part is most likely bad by considering the pin resistance readings resulting from the failure of specific parts. For example, supposing R22 opened, what would the resulting resistance at pin 6 be? c

A. 0 Ohms. 4-11d

B. Infinite ohms. 4-38a

C. 82K ohms. 4-23e

D. Impossible to tell. 4-34b d

From | To 4-36

6. We said pin 6, not pin 2. Try again. 40b | 4-36a

B. Right. Although composition resistors can change their values sufficiently to be called shorted (especially if they are in chassis which have been de-energized prior to the resistor opening), they are less likely to short than capacitors. Go ahead to page 4-42a. | 4-36b

---

4-37a The 100 ohm shorted out. But if you disconnect one end from the tube pin and measure it, you find it measures 100 ohms. Therefore, the only possibility left is ______________. (Go to 4-39a after you have made your conclusion.) | 4-36c

From
4-35b

To
4-37

B. You said no. Right -- You checked the tube. Go ahead. 4-37a

You disconnect one lead of C9 from the tube socket again. But this time you measure at the tube pin and find zero. Since it should be 100Ω (the value of the resistor) you conclude that______.

Go to page 4-36c when done.

4-34d
Right! Such low resistances are completely masked by the higher 50 Meg R13. R13, incidentally is a voltage sensitive resistor. With the set off, the resistance measures about 50 Megohms. With it 4-37 on, it will measure something different because of the voltage applied to it. The schematic doesn't show the value of this part and you'll have to measure known good ones or ask for manufacturer's data on it to be able to calculate the resistance.

Now, let's try one more problem:

Bug #9

You've got problems! It's V6. You don't have a list of correct resistance measurements. Your pin measurements are below:

Pin	Resistance (ohms)
1	zero
2	100K
3	zero
4	Fil
5	Fil
6	15
7	500
8	68K
9	4.7K

By calculating the values yourself, you are easily able to say 4-37 that pin---has the incorrect reading. Turn to page 4-14c for verification of your answer.

From
4-35d

To
4-38

B. Right. Go ahead

Now that you've got the idea, figure out which part, being bad, would give 23.5K ohms at pin 6 and select an answer below. 4-38b

1. R22. Go to page 4-14b.
2. C54. Go to page 4-20c.
3. 33K. Go to page 4-33c.
4. C53. Go to page 4-24e.
5. C51. Go to page 4-36a.

From
4-37a

To
4-39

Pin 2 is shorted to pin 1 in the socket, placing R17 in the circuit of pin 1 in parallel with C9 and its resistor. Actually, pin 1 measures two ohms but you changed meter ranges to measure pin 2, and then thought that you were measuring "0" when it was "2".

Fortunately, this sort of thing doesn't happen very often, but you should be prepared for it when it does. Go on to the next problem.

Here it is!

Bug #6

You have been told that there is trouble in the V10 stage. You have checked V10, examined the chassis for obvious signs of failures, and found nothing wrong. In addition, you have measured all the pins of the tube and the resistance is good. (Grounded supplies)

List all the parts which, if bad, could result in such a condition:

1. __________
2. __________
3. __________
4. __________
5. __________
6. __________
7. __________
8. __________
9. __________
10. __________
11. __________
12. __________

When you are finished turn to page 4-40a.

From
4-39

To
4-40

All those parts, which could have caused such a condition are as follows:

Pin	Part	
2	C49	It is always shorted by the relatively low value of the Horizontal Hold coil.
6	33K	This is a classic hidden part, whose value could never be measured directly from pin 6 since the capacitor C54 blocks the DC measurement.
9	150K	This resistor, connected to pin 9 is connected through C52 to ground. Regardless of how it fails, the resistance measurement would not show the effect.
9	330K	These resistors, which are part of the network forming the horizontal sync circuit, are interesting because they become hidden parts, depending on how the pin resistance measurement is made. Since the dual selenium diode is connected, so that each half is across a 330K resistor, if the polarity of the ohmmeter is plus at the pin and minus to ground, the upper 330K resistor hides, and vice versa for reversed polarity.

Go to page 4-41a.

From
4-40a

To
4-41

So this means that you must pay very close attention to circuits that contain semi-conductors, like diodes, since the resistances you measure depend on polarity of the measurement.

You will recall that resistors are rarely at their "nominal" value. Ten per cent resistors are actually in a band which ranges from either 5-10% low or 5-10% higher. So that a 1 Megohm resistor actually, when purchased, might lie in a range either from 900K to 950K or from 1100K to 1050K, but never at 1 Meg. This is due to the way resistors are sorted by their maker. The result of all this is that you must be prepared to measure a value off of the rated value. Besides, your ohmmeter is probably in error by between 3-5%.

So you see, "exact" measurements are not required. It's when you get very large errors, 30% to 100%, that you can confidently expect something to be wrong.

(Sure, you didn't list parts in the Low Voltage Power Supply as it is grounded!)

Go ahead to the next problem on page 4-35c.

From
4-36B

To
4-42

This being the case, as your next step in repairing this chassis, you would: 4-42a

A. Replace R8. Go to 4-11e

B. Replace C30. Go to 4-18e

C. Replace C29 because it's smaller and more likely to go bad. Go to 4-24f

D. Measure each part separately. Go to 4-8a

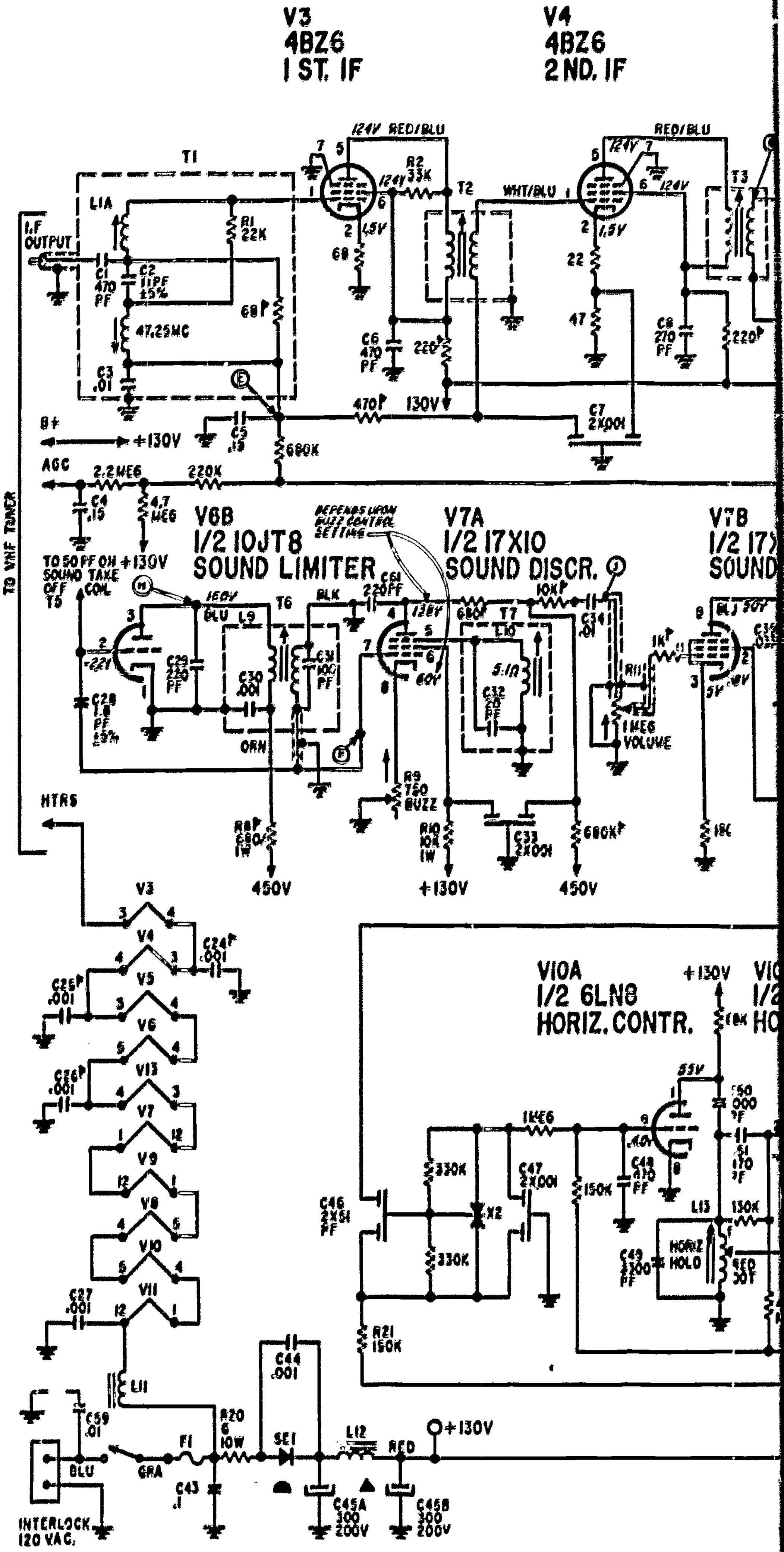
4-31a 4-42b

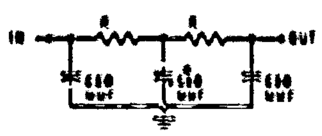
C12 and C13, within T4 are not properly classified as hidden parts, since if they short, they can be detected by making use of your knowledge of the way diodes behave. Remember that the back resistance is much higher than the forward. (So to check on the goodness of those capacitors--at least if you suspect they are shorted--you would expect the resistance at pin 7 to be around 500 to 1000 ohms, if you connect the ohmmeter up right.)
But if you get the same reading, regardless of how you connect the meter up, the capacitor C12 or C13 is shorted, or the diode is shorted.

The 100K resistor in T5 is not a hidden part because it can be measured from pin 2 of V6.

Go ahead to 4-31b.

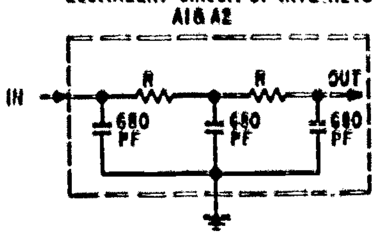
ITEM NO.	PART NO.	DESCRIPTION	
C1	22-3217	470 PF DISC 20%	500V
C2	22-3856	11 PF DISC CAP 5%	500V
C3	22-4617	.01 MFD DISC	500V
C4	22-5107	15 MFD DISC 20%	100V
C5	22-5107	.15 MFD DISC 20%	100V
C6	22-3363	470 PF DISC 10%	500V
C7	22-21	2 X .001 MFD DISC 10%	500V
C8	22-3140	270 PF DISC 10%	500V
C9	22-16	470 PF DISC 10%	500V
C10	22-17	.001 MFD DISC 10%	1000V
C11	22-3221	5.5 PF DISC 5%	500V
C12	22-1516	4.7 PF GIMMICK 20%	500V
C13	22-1516	4.7 PF GIMMICK 20%	500V
C14	22-4100	.022 MFD MOLDED 10%	400V
C15	22-4617	.01 MFD DISC	500V
C16	22-3163	.01 MFD MOLDED 10%	200V
C17A	22-4586	4 MFD ELECTROLYTIC	200V
C17B		50 MFD ELECTROLYTIC	200V
C18	22-2497	47 PF DISC 5%	500V
C19	22-2343	3.3 PF GIMMICK 20%	500V
C20	22-3515	50 PF DISC 20%	500V
C21	22-6	470 PF DISC 20%	1000V
C22	22-2460	50 PF GIMMICK 20%	500V
C23	22-4115	.1 MFD MOLDED 20%	200V
C24	22-7	.001 MFD DISC 20%	500V
C25	22-7	.001 MFD DISC 20%	500V
C26	22-17	.001 MFD DISC 20%	1000V
C27	22-7	.001 MFD DISC 20%	500V
C28	22-4515	1.0 PF GIMMICK 5%	500V
C29	22-2926	220 PF MICA 10%	500V
C30	22-3748	.001 MFD DISC 10%	1000V
C31	22-365	100 PF MICA 10%	500V
C32	22-3139	20 PF DISC 10%	500V
C33	22-21	2 X .001 MFD DISC 10%	500V
C34	22-4617	.01 MFD DISC	500V
C35	22-1779	.01 MFD 20%	600V
C36	22-4617	.01 MFD DISC	500V
C37	22-11	.0033 MFD DISC 20%	500V
C38	22-5077	.033 MFD DISC 10%	400V
C39	22-2577	.1 MFD MOLDED 20%	600V
C40	22-3714	.018 MFD MOLDED 10%	400V
C41	22-2996	.0082 MFD MOLDED 10%	200V
C42	22-5035	.015 MFD MOLDED 10%	600V
C43	22-4147	.1 MFD MOLDED 20%	400V
C44	22-7	.001 MFD DISC 20%	500V
C45A	22-5405	300 MFD ELECTROLYTIC	200V
C45B		300 MFD ELECTROLYTIC	200V
C46	22-35	2 X 51 PF DISC 15%	500V
C47	22-21	2 X .001 MFD DISC 10%	500V
C48	22-6	470 PF DISC 20%	1000V
C49	22-3471	3300 PF MOLDED 10%	400V
C50	22-4635	1000 PF MOLDED 10%	400V
C51	22-5133	470 PF DISC 20%	500V
C52	22-4121	.047 MFD MOLDED 20%	200V
C53	22-12	.0015 MFD DISC 10%	500V
C54	22-18	.0022 MFD DISC 10%	500V
C55	22-7	.001 MFD DISC 20%	500V
C56	22-4161	.15 MFD MOLDED 20%	600V
C57	22-4602	270 PF DISC 10%	3KV
C58	22-4114	.033 MFD MOLDED 10%	600V
C59	22-4601	.01 MFD DISC 10%	1000V
C60	22-14	.0047 MFD DISC	500V
C61	22-2	220 PF DISC	500V
C62	22-7	.001 MFD DISC 20%	500V
R1	63-2848	22K OHM A.B. ONLY	1/2W
R2	63-4008	33K OHM A.B. ONLY	1/2W
R3	63-5381	3.3K OHM A.B. ONLY	1/2W
R4	63-6105	6.8K OHM	1W
R5	63-3675	4.7K OHM	4W
R6	63-5421	30K OHM CONTRAST CONTR.	
R7	63-5419	250K OHM BRIGHT. CONTR.	
R8	63-6188	680K OHM 20%	1W
R9	63-3284	150 OHM BUZZ CONTROL	
R10	63-6112	10K OHM	1W
R11	63-5037	1 MEGOHM VOLUME CONTR.	
R12	63-5670	1000 OHM	2W
R13	63-5472	VOLT. DEP. RESISTOR	
R14	63-5470	500K OHM A.G.C. CONTR.	
R15	63-6105	6.8K OHM	1W
R16	63-4505	1.8 MEGOHM A.B. ONLY	
R17	63-6328	3.4 MEGOHM VERT. SIZE CONTR.	
R18	63-6329	1 MEGOHM VERT. HOLD CONTR.	
R19	63-6330	500K OHM VERT. LIN. CONTR.	
R20	63-4450	6 OHM	10W
R21	63-4844	150K OHM I.R.C. ONLY	1/2W
R22	63-5750	82K OHM	2W
R23	63-5670	1K OHM	2W
R24	63-1551	4.7 OHM W.W.	1/2W
R25	63-6331	THERMISTOR	
R26	63-5058	VOLT. DEP. RESISTOR	
L1A	8-57621	1ST I.F. & TRAP COIL ASSEM.	
L1B			
L2	8-55140	4TH I.F. ASSEMBLY	
L3	20-2013	DETECTOR SERIES PEAK. COIL	
L4	20-2004	CHOKE COIL	
L5	20-2014	DET. SHUNT PEAK. COIL	
L6	8-58348	SOUND TAKE-OFF ASSEMBLY	
L7	20-2512	VIDEO SERIES PEAK. COIL	
L8	20-2001	VIDEO SHUNT PEAKING COIL	
L9	8-66705	INTERCARRIER COIL ASSEMBLY	
L10	8-45229	QUADRATURE COIL ASSEMBLY	
L11	20-1260	CHOKE COIL	
L12	05-2244	FILTER CHOKE	
L13	8-56875	HORIZ. OSC. COIL	
L14	20-2005	SPOOK COIL	
T1	8-66851	1ST I.F. & TRAP COIL	
T2	8-66852	2ND I.F. TRANSFORMER	
T3	8-66853	3RD I.F. TRANSFORMER	
T4	8-66854	4TH I.F. TRANSFORMER	
T5	8-66849	SOUND TAKE-OFF COIL	
T6	8-68765	INTERCARRIER COIL	
T7	8-58377	QUADRATURE COIL	
T8	05-2243	SOUND OUTPUT TRANSFORMER	
T9	05-2297	VERT. OUTPUT TRANSFORMER	
T10	05-2242	YOKE	
T11	8-66845	HORIZ. SWEEP TRANSFORMER	
A1	87-8	INTEGRATOR R/C NETWORK	
A2	87-7	INTEGRATOR R/C NETWORK	
A3	105-70	R.C. NETWORK	
F1	136-62	FUSE 1.7 AMP	
SE1	212-27	SILICON RECTIFIER	
SP1	49-1052	SPEAKER	
X1	103-23	DIODE CRYSTAL	
X2	103-20	DUAL SELENIUM DIODE	



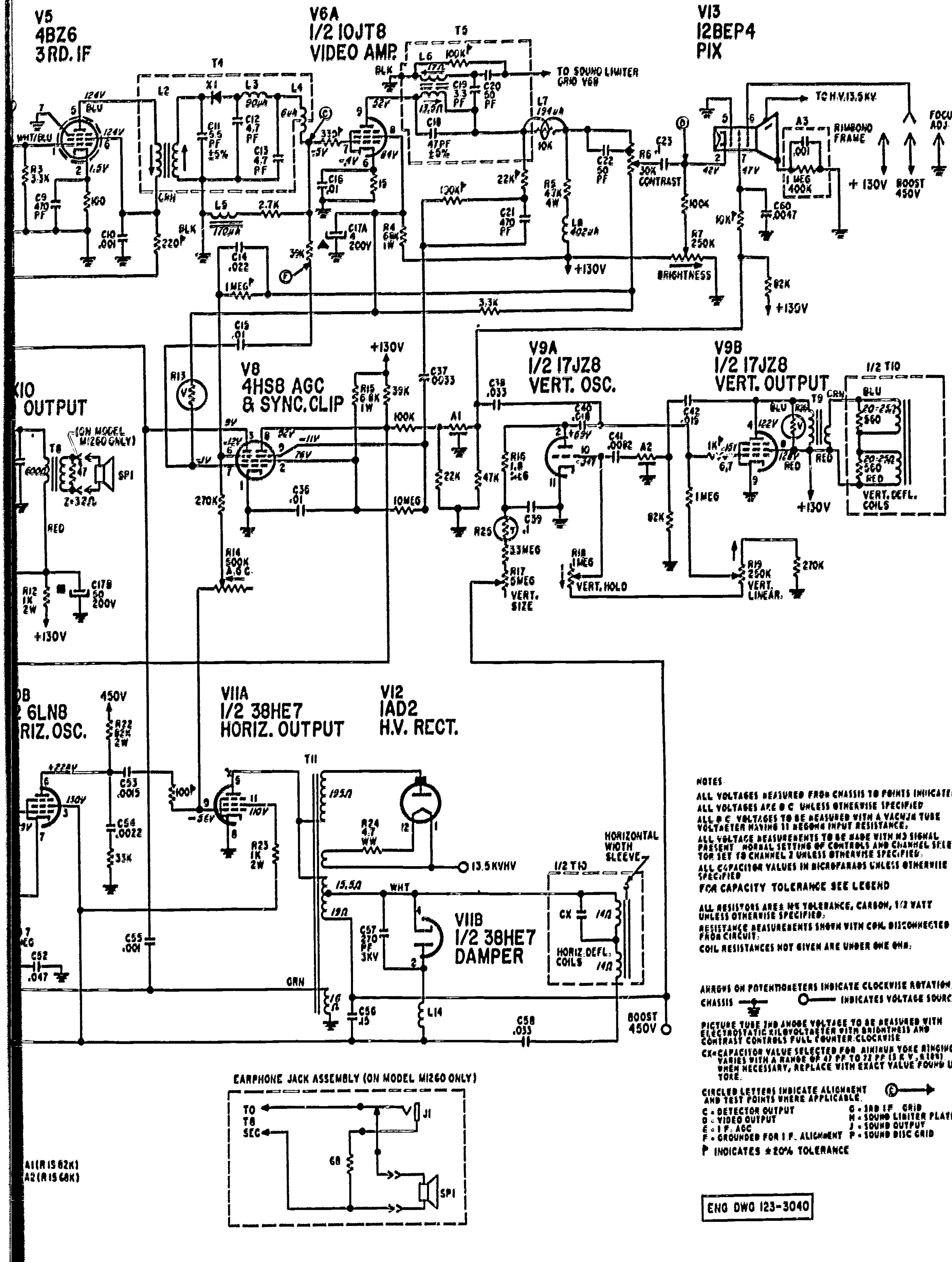


EQUIVALENT CIRCUIT
A-1 and A-2 INTEGRATORS

EQUIVALENT CIRCUIT OF INTEGRATORS A1 & A2



87-7 R is 68K
87-8 R is 82K



NOTES:

ALL VOLTAGES MEASURED FROM CHASSIS TO POINTS INDICATED.

ALL VOLTAGES ARE D C UNLESS OTHERWISE SPECIFIED.

ALL D C VOLTAGES TO BE MEASURED WITH A VACUUM TUBE VOLTMETER HAVING 11 MEGOHM INPUT RESISTANCE.

ALL VOLTAGE MEASUREMENTS TO BE MADE WITH NO SIGNAL PRESENT, NORMAL SETTING OF CONTROLS AND CHANNEL SELECTOR SET TO CHANNEL 2 UNLESS OTHERWISE SPECIFIED.

ALL CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

FOR CAPACITY TOLERANCE SEE LEGEND

ALL RESISTORS ARE ± 10% TOLERANCE, CARBON, 1/2 WATT UNLESS OTHERWISE SPECIFIED.

RESISTANCE MEASUREMENTS SHOWN WITH COIL DISCONNECTED FROM CIRCUIT.

COIL RESISTANCES NOT GIVEN ARE UNDER ONE OHM.

ARROWS ON POTENTIOMETERS INDICATE CLOCKWISE ROTATION.

CHASSIS — INDICATES VOLTAGE SOURCE

PICTURE TUBE 2ND ANODE VOLTAGE TO BE MEASURED WITH ELECTROSTATIC KILOVOLTMETER WITH BRIGHTNESS AND CONTRAST CONTROLS FULL COUNTER-CLOCKWISE

CX = CAPACITOR VALUE SELECTED FOR MINIMUM YOKE RINGING VARIES WITH A RANGE OF 47 PF TO 72 PF (3 K V, ± 10%). WHEN NECESSARY, REPLACE WITH EXACT VALUE FOUND IN YOKE.

CIRCLED LETTERS INDICATE ALIGNMENT AND TEST POINTS WHERE APPLICABLE.

C = DETECTOR OUTPUT
D = VIDEO OUTPUT
E = I F. AGC
F = GROUNDED FOR I.F. ALIGNMENT
G = 3RD I F. GRID
H = SOUND LIMITER PLATE
J = SOUND OUTPUT
P = SOUND DISC GRID

P INDICATES ± 20% TOLERANCE

ENG DWG 123-3040

Schematic of the 13M15 & 13M15X chassis.