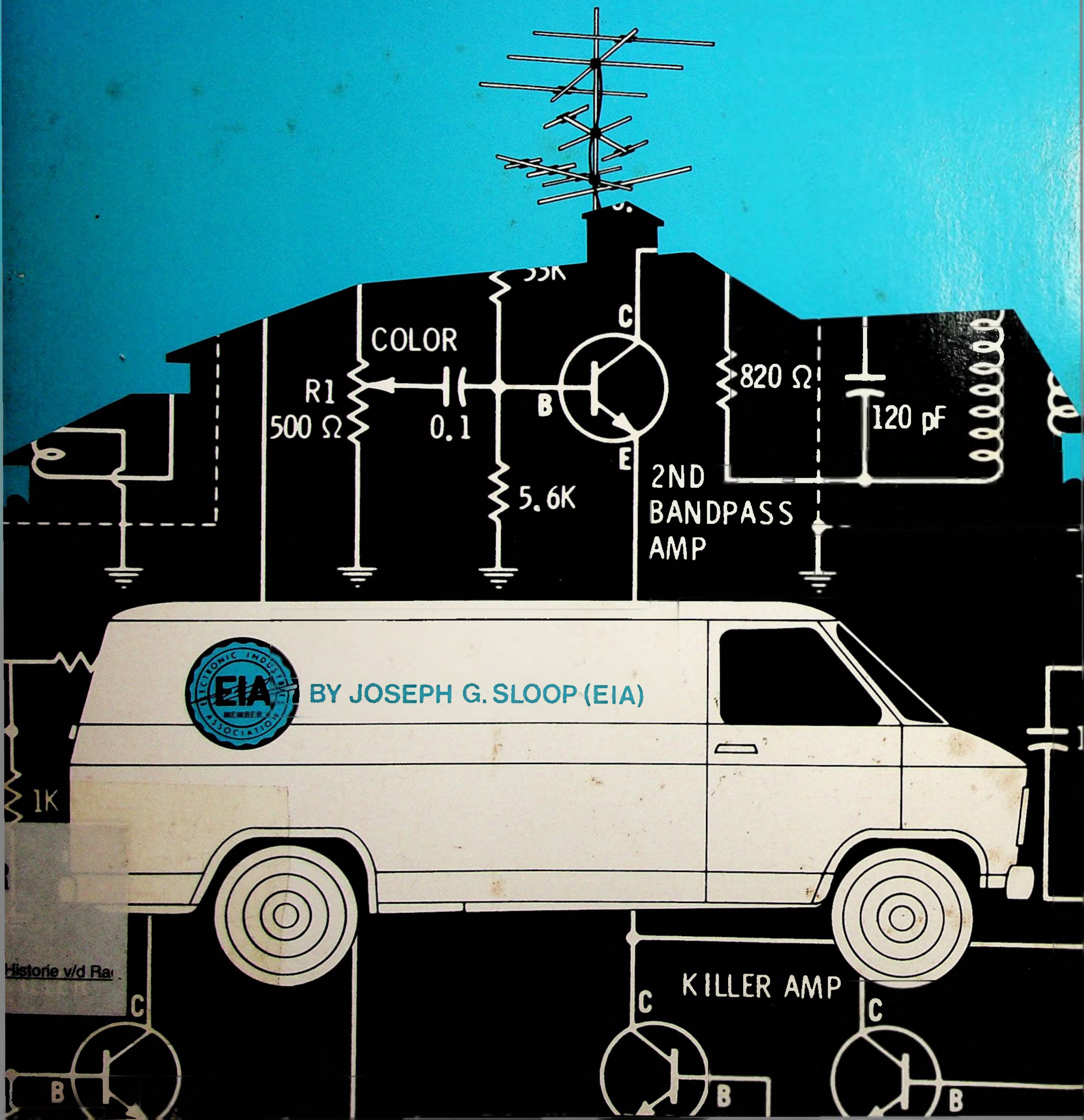
TELEVISION SERVICING WITH BASIC ELECTRONICS



BY JOSEPH G. SLOOP (EIA)

Television Servicing—With Basic Electronics

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Television Servicing—With Basic Electronics

by

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Series Preface

Electronics is the core for a wide variety of specialized technologies that have developed in the past several decades. Faced with the need for increasing numbers of technicians and challenged by a rapidly expanding technology, the Consumer Electronics Group Product Service Committee of the Electronic Industries Association (EIA) has long been active in developing and constantly revising educational materials to meet these challenges.

In recent years, the rapid introduction of large numbers of new consumer electronic products and the growing complexity of traditional radios and television, plus the pressing need for training programs to permit students of various backgrounds and abilities to enter this growing industry, has induced EIA to sponsor the preparation of an expanding range of materials. Three different categories in two specific formats have been developed. The following paragraphs explain these aids to education and suggest proper use to achieve the desired results.

The laboratory text manuals in the Basic Electricity Electronics Series provide in-depth, detailed, completely up-to-date technical material, combining a closely coordinated program of experiments, each preceded by a comprehensive discussion of the objectives, theory, and underlying principles. *Electricity Electronics Fundamentals* provides an introductory course especially suitable for the preparation of service technicians or for other broad-based courses; *Basic Electricity* and *Basic Electronics* are planned as 270-hour courses, one to follow the other, providing a more thorough background for all levels of technician training. A related instructor's guide is available.

The Basic Electricity-Electronics Series

Title	Author	Publisher
Electricity-Electronics Fundamentals	Zbar/Sloop	Gregg/McGraw-Hill Book Co.
Basic Electricity	Zbar	Gregg/McGraw-Hill Book Co.
Basic Electronics	Zbar	Gregg/McGraw-Hill Book Co.

The Radio-Television Servicing Series

Title	Author	Publisher
Television Symptom Diagnosis—An Entry into TV Servicing	Tinnell	Howard W. Sams & Co., Inc.
Television Symptom Diagnosis (33 film loops or sets of slides)	Tinnell	Howard W. Sams & Co., Inc.
Television Servicing—With Basic Electronics	Sloop	Howard W. Sams & Co., Inc.
Advanced Color Television Servicing	Sloop	Howard W. Sams & Co., Inc.
Audio Servicing	Wells	Gregg/McGraw-Hill Book Co.
Basic Radio: Theory and Servicing	Zbar	Gregg/McGraw-Hill Book Co.
Basic Television: Theory and Servicing	Zbar and Orne	Gregg/McGraw-Hill Book Co.

The Radio-Television Servicing Series includes materials in two categories: those designed to prepare apprentice technicians for performing in-home servicing and other apprenticeship functions, and those designed to prepare technicians for performing more sophisticated and complicated servicing, such as bench-type servicing in the shop.

The apprenticeship servicing course includes *Television Diagnosis—An Entry into TV Servicing* (Text, student workbook, instructor's guide) and *Television Symptom Diagnosis*, a series of 33 film loops. The first is a set consisting of profusely illustrated text, student response manual, and instructor's guide designed to train persons with no previous electronics training in job-entry troubleshooting skills for servicing in the home and shop. The text utilizes the "cue response" concept of diagnosis, concentrates on identifying abnormal circuit operation and symptom analysis, and develops skills in troubleshooting. In the response manual, students are exposed to hundreds of television trouble symptoms through the use of color photos and illustrated problems. The instructor's guide is a complete and essential professional course of study that also contains the answers for the text and lab manual.

Television Symptom Diagnosis consists of a series of color-sound motion picture film loops or slides, a student workbook, and an instructor's guide. These audiovisual materials function as an integrated learning system to teach color-television adjustment and setup procedures, trouble symptom diagnosis, and the ability to isolate troubles to a given stage in the receiver, concentrating on the requirements for servicing in the customer's home. But these audiovisual materials can also be used to supplement all levels of television courses. This medium is especially suitable for students who may have reading and, in turn, learning difficulties.

Since only a minimum of electronics theory is presented in the two courses described above, it is expected that apprentices completing these programs will be motivated to progress to the more comprehensive programs provided by the following courses in order to deepen their understanding of electronics and what makes the radio and television receiver work, and to obtain adequate proficiency for the servicing of all consumer electronics entertainment items.

The intermediate *Television Servicing—with Basic Electronics* (text, student workbook, instructor's guide) goes beyond the basics and expands on the math and use of test equipment introduced in the beginning text. The book continues the diagnostic troubleshooting method.

Advanced "bench-type" diagnosis servicing techniques are covered in *Advanced Color Television Servicing* (text, student workbook, instructor's guide). Written primarily for color television servicing courses in schools and industry, this book follows the logical diagnosis troubleshooting approach consistent with the manufacturers' approach to bench servicing.

Audio Servicing (text/resources, text/lab manual, and instructor's guide) covers each component of a modern home stereo with an easy-to-follow block diagram, diagnosis approach, consistent with the latest industry techniques.

The "bench-type" service technician courses consist of *Basic Radio: Theory and Servicing* and *Basic Television: Theory and Servicing*. These books provide a series of experiments, with preparatory theory, designed to provide the in-depth, detailed training necessary to produce skilled radio-television service technicians for both home and bench servicing of all types of radio and television. A related instructor's guide for these books is also available.

The Industrial Electronics Series

Title	Author	Publisher
Industrial Electronics	Zbar	McGraw-Hill Book Co.
Electronic Instruments and Measurements	Zbar	McGraw-Hill Book Co.

Basic laboratory courses in industrial control and computer circuits and laboratory standard measuring equipment are provided by the Industrial Electronics Series and their related instructor's guides. *Industrial Electronics* is concerned with the fundamental building blocks in industrial electronics technology, giving the student an understanding of the basic circuits and their applications. *Electronic Instruments and Measurements* fills the need for basic training in the complex field of industrial instrumentation. Prerequisites for both courses are *Basic Electricity* and *Basic Electronics*.

The forward to the first edition of the EIA co-sponsored basic series said: "The aim of this basic instructional series is to supply schools with a well-integrated, standardized training program, fashioned to produce a technician tailored to industry's needs." This statement is still the objective of the varied training program that has been developed through joint industry educator-publisher cooperation.

PETER MCCLOSKEY, President
Electronic Industries Association

Preface

This text and its associated Student Activities Manual were written as a part of the EIA Consumer Electronics Technician training series. As a second semester text, *Television Servicing—With Basic Electronics* follows the first semester text, *Television Symptom Diagnosis—an Entry into TV Servicing* by Richard Tinnell. As an individual textbook, it is written to stand alone for those who wish to learn monochrome television circuitry and troubleshooting.

Though written as a second semester text, it is suitable as a beginning text and presents monochrome television theory and circuitry along with basic electronic theory. Electronic theory has been injected into the text where it is needed for an understanding of television principles and theory. By doing the exercises in the Student Activities Manual, in conjunction with each chapter of television theory, a knowledge of components, test equipment, and circuits is gained as the need to know it arises.

The text is arranged in an industry approved "servicing sequence." The industry approved sequence pursued in repairing a monochome television is as follows:

1. To cause the set to display a raster—which requires the following:
   A. An operating power supply (Chapter 3).
   B. An operating horizontal circuit (Chapter 4).
   C. An operating high voltage supply (Chapter 5).
   D. An operating vertical system (Chapter 6).
2. To cause the set to display a picture—which requires the following:
   A. An operating tuner (Chapter 7).
   B. An operating if amplifier system (Chapter 8).
   C. An operating video circuit (Chapter 9).
   D. An operating agc system (Chapter 10).
3. To cause audio to be produced (Chapter 11).

By arranging the text in this sequence the student studies the television in the same order that should be used to service the receiver.

The general order of parts failure and troubleshooting logic is stressed in the troubleshooting portions of the book. This means that the student, upon completion of a course using this text and its companion Student Activities Manual, will have acquired the necessary tv theory, electronic theory, test equipment usage, in circuit fault analysis, and diagnostic techniques necessary to be employed as an entry level bench technician.

The author wishes to thank the following members of the EIA Textbook Review Committee for their invaluable time and assistance in bringing this book to print.

Jack Berquist, *GTE Sylvania*
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Andy Murnick, *Rockwell International/Admiral*
Irv Rebeschini, *Simpson Electric Co.*
Jerry Surprise, *General Electric Co.*

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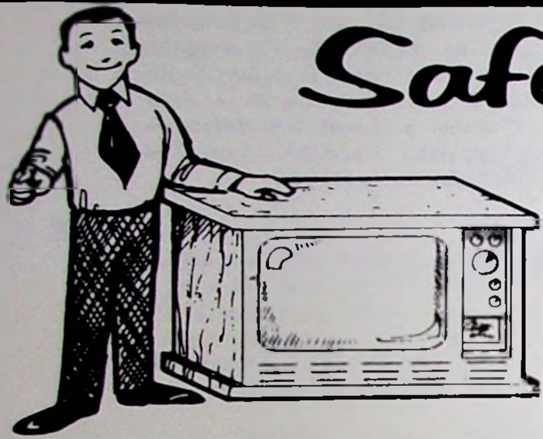


YOU SHOULD KNOW

FOR YOUR SAFETY

A Fire condition and Hazardous Shock condition may extist in your television set, or any item of home electronic equipment, if any of the following conditions occur:

1. Objects are poked or dropped into set through cabinet.

2. Equipment has been dropped.

3. Equipment has been damaged.

4. Liquid has been spilled into set.

5. Extension cords are overloaded.

6. Furniture is sitting on electrical wires.

7. The back of a TV set is removed.

8. Normal ventilation of set is obstructed.

9. Set is operating where you can become a conductor. such as near pools, sinks, bath tubs, damp earth, etc.

10. Set is placed near a heater vent or fireplace.

11. Set is located in an improperly ventilated enclosure.

12. Set is not turned off before cleaning the screen or face.

13. Set is left plugged in during electrical storm OR when set is left unattended for an extended period, (long weekends and vacations)

WHEN INDOUBT----PULL THE PLUG & CALL FOR ADVICE

Chapter 1

Safety

TECHNICIAN SAFETY

Safety can never be overemphasized. Regardless of the level—manufacturer, technician, or consumer—the product must be made, serviced, and used with safety in mind. Television manufacturers expend a great deal of time and money to make their products as safe as possible for the service technician and consumer.

As a rule, technicians are aware of the safety hazards of their occupation and are careful to use safe procedures in their work. However, the customer is often unaware of the hidden dangers posed by electricity or electrical appliances. This makes it essential for the technician to always eliminate faults in the television receiver that could cause consumer injury. The technician must *not* defeat in any way the built-in safety features because of carelessness, ignorance, or use of improper parts. If the technician fails to thoroughly safety check each set he repairs, he/she may be held liable for any injury occurring as a result of his/her actions or inactions. The technician must, therefore, make a complete check of the entire receiver to see if faults exist that could cause injury, and check his/her own work for compliance with appropriate safety procedures.

Manufacturers include many special components to make the television as safe as possible. These special components are usually indicated on schematics and parts lists by some notation, such as shading as shown in Fig. 1-1. If any component needing replacement is indicated to be a safety-related part, it must be replaced by the *exact* or factory-approved part. Safety warnings and cautions given in service literature or on the receiver chassis must be followed *exactly*. An example of some of these are shown here as taken from a Howard W. Sams PHOTOFACT®.

SAFETY CHECKS

Once the original service fault has been corrected, a thorough visual check should be made. The following is a list of visual checks as suggested by the Electronics Industries Association in CONSUMER ELECTRONICS SERVICE TECHNICIAN SAFETY GUIDELINES:

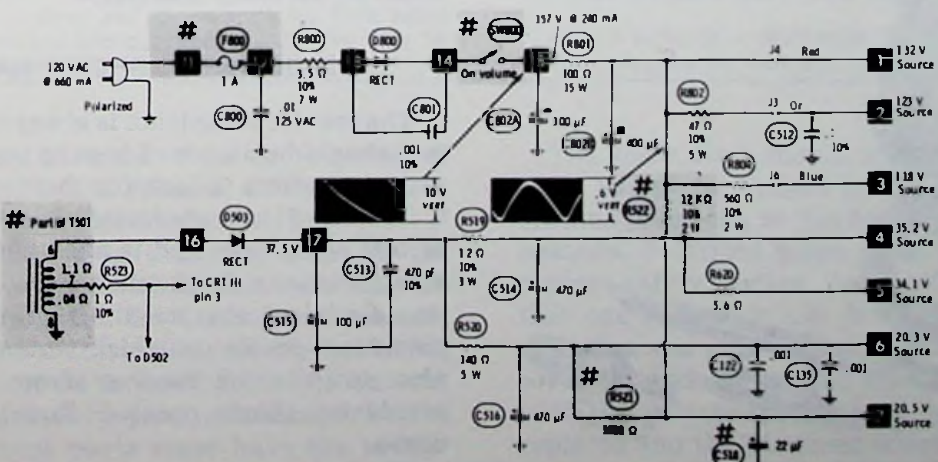


Fig. 1-1. Shaded components must be replaced with exact replacement types.

1. No insulated lead or component should touch a receiving tube or a resistor rated at more than 1 watt. Lead tension around protruding metal objects must be avoided. All insulating or isolation materials, as well as strain relief devices originally used, must be in place.
2. Soldering must be inspected to uncover possible cold solder joints, frayed leads, damaged insulation, solder splashes or sharp solder points. Be certain to remove all loose foreign particles.
3. Never release a repaired receiver unless all covers, clips, cans, screws, bolts, ground straps, shields, and other hardware have been reinstalled as per the original design.
4. Incorrect parts, tubes, and transistors must be removed and replaced with factory approved replacements.
5. Parts or components showing physical evidence of damage or deterioration must be replaced, following original layout, lead length, and dress.

After the visual inspection has been made and the set replaced in the cabinet, a check for *leakage current* must be made. Even a small amount of current through a person's body might cause an involuntary reaction, such as a sudden jump or jerk. If the person happens to be near to, or is holding a sharp object or something hot or breakable when he/she makes contact with the electrical charge, he/she may hurt himself/herself, someone nearby, or cause property damage.

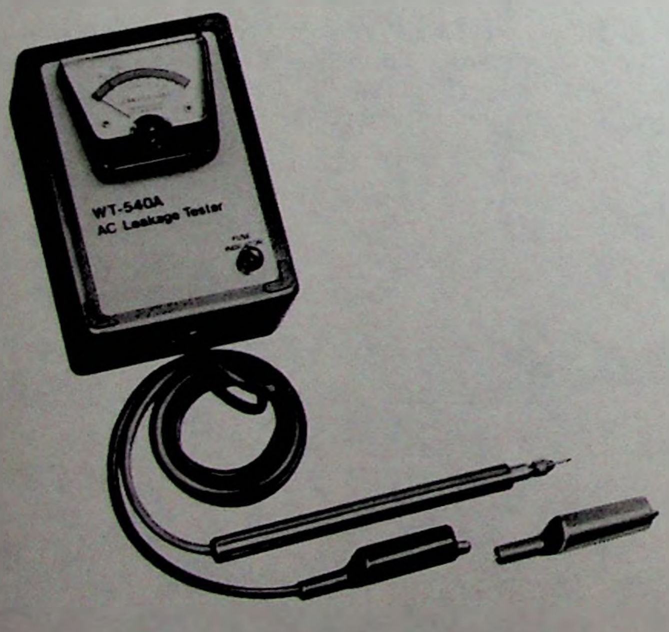


Fig. 1-2. Commercial leakage tester. (Courtesy Viz Manufacturing Co.)

To check for leakage current, leakage testers, such as the one shown in Fig. 1-2, are available commercially, or the technician may use the circuit shown in Fig. 1-3. Plug the set into a 120-V ac receptacle. Using two clip leads connect a 1500-ohm 10-watt resistor paralleled by a 0.15-μF capacitor in series with all exposed metal cabinet parts and a *known* earth ground. Use a vtvm or a vom with a sensitivity of at least 1000 ohms-per-volt and place it across the resistor-capacitor combination. With the ungrounded test lead, touch exposed metal parts which might have a return path to the chassis (antenna, screw heads, knobs, control shafts, etc.) and on the meter note the ac voltage drop across the resistor.

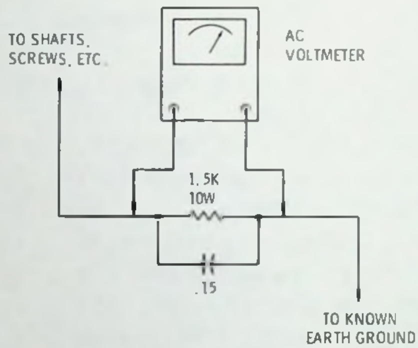


Fig. 1-3. Technician made leakage tester circuit.

Any reading of 7.5 volts rms on a set manufactured before 1973 or 0.75 volt rms on a set manufactured after January 1, 1973 is excessive and indicates a possible shock hazard. This hazard must be removed before the set is released to the customer.

Reverse the ac plug in the receptacle and repeat the above test. *Do not use an isolation transformer when performing this test.*

ELECTRICAL SHOCK HAZARDS

The service technician is always subject to shock and should be aware of how to test for shock hazards and where to look for them.

The isolation transformer is an important piece of test equipment and is used almost entirely for safety reasons. It should be used when servicing *any* electrical equipment. It protects the technician from accidents which would cause shock. It also protects the receiver from damage due to accidental shorts created during service procedures.

The ac line can cause fatal shocks if it becomes accessible to the technician or consumer. Line-

SAFETY PRECAUTIONS

CAUTION: NO WORK SHOULD BE ATTEMPTED ON AN EXPOSED TELEVISION CHASSIS BY ANYONE NOT FAMILIAR WITH SERVICING PROCEDURES AND PRECAUTIONS.

1. SAFETY PROCEDURES should be developed by habit so that when the technician is rushed with repair work, he automatically takes precautions.

2. A GOOD PRACTICE, when working on a receiver, is to use only one hand when testing circuitry. This will avoid the possibility of carelessly putting one hand on chassis or ground and the other on an electrical connection which could cause a severe electrical shock.

3. Extreme care should be used in HANDLING THE PICTURE TUBE. Rough handling may cause it to implode due to atmospheric pressure (14.7 lbs. per sq. in.). Do not nick or scratch glass or subject it to any undue pressure in removal or installation. When handling, use safety goggles and heavy gloves for protection. Discharge picture tube by shorting the anode connection to chassis ground (not cabinet or other mounting parts). When discharging . . . go from ground to anode with a well insulated piece of wire.

Avoid prolonged exposure at close range to unshielded areas of the cathode ray tube. Possible danger of personal injury from unnecessary exposure to X-ray radiation may result.

4. The TEST PICTURE TUBE used for servicing the chassis at the bench should incorporate a safety glass and magnetic shield. The safety glass affords shielding from the tube viewing area against X-ray radiation as well as implosion protection. The magnetic shield limits X-ray radiation around the bell of the picture tube in addition to restricting magnetic effects.

5. If the HIGH VOLTAGE is adjustable, it should always be ADJUSTED to the level recommended by the manufacturer. If the voltage is increased above the normal setting, exposure to unnecessary X-ray radiation could result. High voltage can be measured with an accurate high voltage meter connected from the anode connection to chassis.

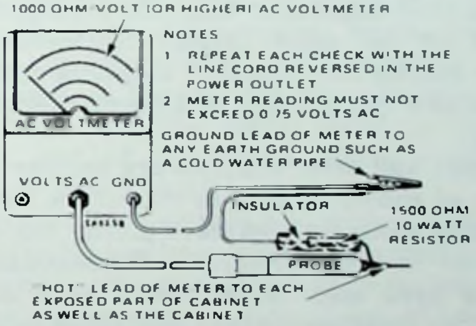
6. An ISOLATION TRANSFORMER should always be used during the servicing of a receiver whose chassis is common to the AC power line. Use a transformer of adequate power rating as this protects the serviceman from accidents resulting in personal injury from electrical shocks. It will also protect the receiver and its components from being damaged by accidental shorts of the circuitry that may be inadvertently introduced during the service operation.

7. Always REPLACE PROTECTIVE DEVICES, such as fishpaper, isolation resistors and capacitors and shields after working on the receiver. Use only manufacturers recommended rating for fuses, circuit breakers, etc.

8. BEFORE RETURNING A SERVICED RECEIVER (of any type) TO THE OWNER, the service technician must thoroughly test the unit to be certain that it is completely safe to operate without danger of electrical shock. DO NOT USE A LINE ISOLATION TRANSFORMER WHEN MAKING THIS TEST.

The following test, is related to the minimum safety requirements of the Underwriters Laboratories. It should be performed after the receiver is serviced and before it is returned to the owner.

A 1000 ohm per volt AC voltmeter is prepared by shunting it with a 1500 ohm, 10 watt resistor. The safety test is made by contacting one meter probe to any portion of the receiver exposed to the consumer or operator such as the cabinet trim, hardware, controls, knobs, etc., while the other probe is in contact with a good "earth" ground such as a cold water pipe.



Voltmeter hookup for safety check.

The AC voltage indicated by the meter may not exceed 0.75 volts. A reading exceeding 0.75 volts indicates that a potentially dangerous leakage path exists between the exposed portion of the receiver and "earth" ground. Such a receiver represents a potentially serious shock hazard to the operator. The fault must first be located and corrected.

Repeat the above test with the receiver power plug reversed.

NEVER RETURN A RECEIVER TO THE CUSTOMER which does not pass the manufacturers safety test.

Courtesy Quasar

operated receivers have one of the ac power wires attached directly to the chassis. Of course, this should be the ground side of the line. However, if for any reason the plug becomes reversed, the chassis assumes a potential of 120 volts ac with respect to earth ground. In this case, the chassis is said to be *hot*. For this reason all exposed metal cabinet parts must be isolated from the chassis. This is accomplished by plastic bushings, knobs, etc. So replacement parts *must* have the proper insulation. Any broken or missing insulators must be replaced.

The technician should also closely check line cords and plugs. Frayed or cracked line cords and cracked plugs can be fire hazards as well as shock hazards. Polarized plugs (Fig. 1-4) are also important safety devices. People often do not realize that one receptacle slot is wider than the other, and when the plug cannot be plugged in they discover the wide prong and trim it to fit. Any plug with the polarization feature defeated should be replaced and the customer educated as to its purpose.

In the shop, strip-line outlets (Fig. 1-5) could

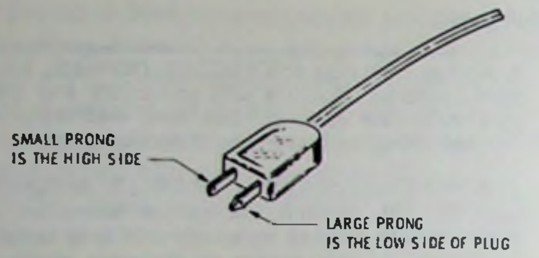


Fig. 1-4. Polarized plug.

be hazardous because they allow reversal of polarized plugs. Other types of unpolarized outlets present similar threats.

Inside the chassis, often directly across the line cord input, a so-called "line" capacitor is found. The purpose of this capacitor is to prevent any rf present in the receiver from entering the power line. These capacitors are special ac types and are designed to safely dissipate damaging power surges caused by lightning and power line excesses. It is important that this capacitor be replaced by the *exact* factory replacement type. When used in this function, a specific type of capacitor is a requirement of Underwriters Laboratories.

Tuners and other controls are another possible source of shock. In fact, to reduce the shock hazard many controls even have plastic shafts. Tuners used in transformerless (line-operated) receivers have split tuner shafts, with a plastic insert for isolation (Fig. 1-6). Those sets manufactured after July 1, 1977 must have their tuners *double* insulated.

Other isolation is placed between the chassis and the antenna leads. This is performed by capacitors and resistors as shown in Fig. 1-7. Because this isolation is necessary for protection against shock, exact replacement-type tuners must be used. *Do not* make replacements based on appearance since many tuners look similar but have totally different isolation characteristics.

Tuners used in transformer-type chassis are grounded to the chassis through a center tap or through one leg of the antenna coil. This system is usually considered safe. However, contact with

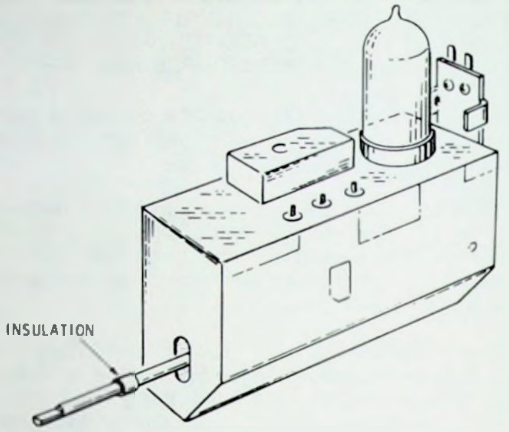


Fig. 1-6. Vhf tuner with isolation.

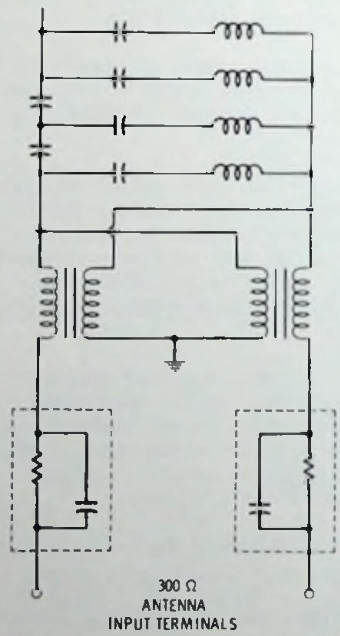


Fig. 1-7. RC antenna isolation network.

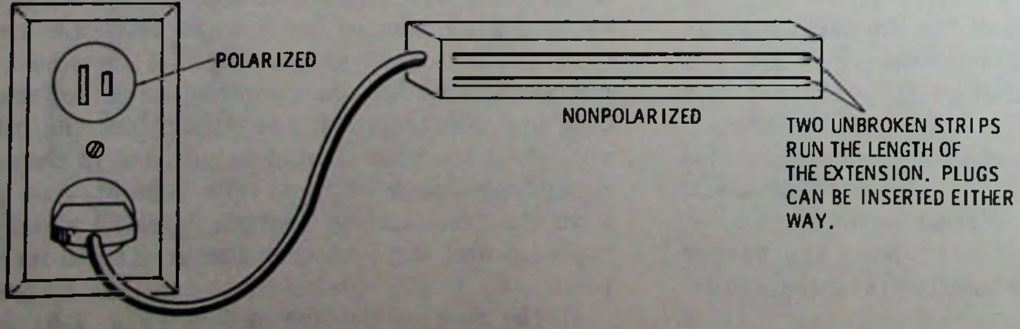


Fig. 1-5. Nonpolarized extension.

an ac power source inside or outside the building can cause the antenna to become a dangerous 120-volt source—a severe shock hazard. Do not neglect the antenna terminals when performing the leakage tests as explained earlier in this chapter.

In transformer-operated sets the secondary of the power transformer isolates the television power supply from the power line and earth ground. The transformer is a very reliable component and rarely has defects which cause shock hazards. However, the possibility of such hazards must not be overlooked.

Leakage from the primary winding to the chassis or from the primary to secondary windings can cause the chassis to be *hot*. Leakage from primary to secondary can cause a varying degree of potential to appear on the chassis. Other hazards are possible and are sometimes caused by shorts due to bare wiring being close to the chassis, by leads pinched between cabinet and chassis or by chassis components. Checks for shorts of the primary to ground or primary to secondary can be made with an ohmmeter. Such tests should be routinely made while bench servicing any television receiver.

It is also a good practice for the technician to check polarized ac outlets. It is not too uncommon to find such outlets incorrectly wired. To determine which slot of the receptacle is really grounded, a tester can be constructed as illustrated in Fig. 1-8. The additional 5-megohm resistor provides sufficient isolation to prevent shock in the case of accidental grounding of the body while making the test. To complete the test, connect one end of the tester to a known earth ground and insert the other lead of the tester in turn into each receptacle slot. The lamp will glow when the lead is inserted into the hot terminal. It will not glow when touched to the grounded terminal. On properly wired outlets, the wide slot will be grounded.

Most shocks to the technician come from the B+ or high voltage power supplies. Usually, injury to the technician is caused by involuntary reaction to the surprise of an unexpected shock. Reflex movement away from the shock hazard causes bruises and cuts of the hands and arms as they are dragged over edges and corners of the receiver chassis or cabinet. Other parts of the body are also susceptible to injury if the technician is near any object that he/she may strike as he/she jerks away from the shock.

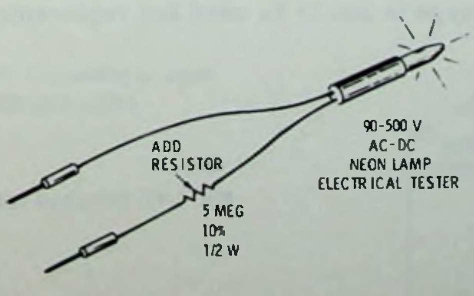


Fig. 1-8. Neon-lamp tester.

The technician should sit or stand on an insulating surface, away from any other objects (such as tables, counters with sharp corners, etc.) which could be struck. The technician should follow the old electrical safety standard of working with one hand in his/her pocket whenever possible. This prevents him/her from holding onto something which may be grounded as he/she probes with the other hand and thus prevents any shocks. The technician should *never* wear jewelry when working near an open set.

If the interlock and back cover of the receiver are in place as they should be, the user is not exposed to dangerous voltages. So, these must be replaced in their original positions by the technician. Also, any RC networks connecting any part of the chassis to the cabinet must be properly installed to prevent the charge build-up on any "floating" part of the cabinet. Such a charge build-up can pose a shock hazard.

The extreme high voltage and power levels involved in the high voltage circuits make the components and leads susceptible to deterioration. This deterioration may be in the form of lead insulation cracking, or the overheating of components, such as the flyback transformer. Arcing is the common result of these conditions. It is hazardous to work near, and can be a fire hazard as well. The technician should carefully inspect such areas and replace any leads that have cracked insulation, or transformers which show definite signs of deterioration, such as excessive wax "puddles" or cracked insulation jackets.

Replacement of any high voltage components must be done with care.

1. Use only approved replacement parts.
2. Solder connections should be ball-shaped and never sharp or pointed.
3. Leave no loose strands of wire. Loose wire strands and pointed solder joints can cause corona (a high voltage arc).
4. Dress all leads as nearly like the original dress as possible. These precautions apply to any high voltage components, including the focus and damper components.

Technicians for years have checked for the presence of high-voltage rf by drawing an arc from

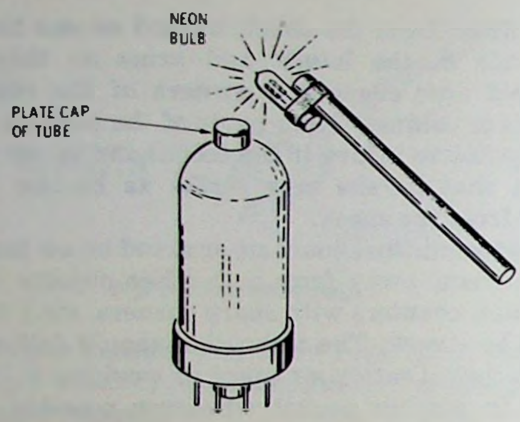


Fig. 1-9. Neon bulb high-voltage rf tester.

the plate cap of the high-voltage rectifier. It should be pointed out that this practice "carbonizes" the plastic plate cap, reducing its insulating properties. Corona can sometimes be seen about such a plate cap, which must be replaced when such corona appears. More important is the fact that arcing is not recommended at all in solid-state receivers. Arcing can cause destruction of solid-state devices throughout the receiver. A simple test jig for the indication of a high-voltage rf is illustrated in Fig. 1-9. It consists of an NE-2 neon bulb with the leads *cut off*. The bulb is taped to the end of a nonconducting rod (plastic or wood). When held near a high-voltage rf, the lamp will light.

Another point where the high voltage is most likely to arc is at the anode button on the picture tube. Continued arcing here may eventually penetrate the glass and destroy the vacuum. The anode should be checked for crumbling and cracking. If any deterioration is apparent, the picture tube should be replaced.

Because of the possibility of static charge build-up in certain areas of the television, a component called a "spark gap" is used. Before the voltage build-up is great enough to cause any damage, it is allowed to arc to ground across the spark gap. Some spark-gap capacitors perform two functions: one is that of the capacitor itself, and the other is that of a spark gap. The most common of these is shown in Fig. 1-10. Other spark

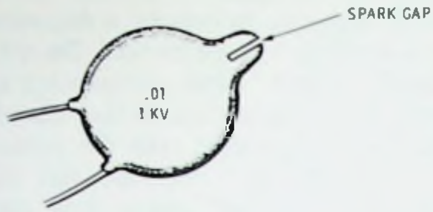


Fig. 1-10. A combination capacitor-spark gap.

gaps are just that and perform no other function (Fig. 1-11). These devices must never be defeated and must be replaced with the exact type that was removed.

FIRE HAZARD

Fire hazard is a major problem in any electrical appliance, and especially in those repaired with incorrect parts. The technician must be careful to replace any parts with the exact replacement types. This is necessary so the components used will be made of self-extinguishing materials, i.e., materials that will not sustain a flame.

The circuits where high-power components are used are the low- and high-voltage power supplies, and the output circuits for the video, vertical, audio, and horizontal stages. In these circuits or any circuit in which components may become hot, lead dress is an extremely important consideration. Wires or other flammable materials should be kept away from tube envelopes, power resistors, and output transistors.

Proper overload protection of a system is essential. The fuse or circuit breaker is a safety device selected for maximum protection. It should never be replaced with anything except the exact replacement type. To do so and to have the receiver cause a fire leaves the technician legally liable for damages. Do not jump fuses with wire, and do not "over-fuse"—that is, use a fuse device of a higher rating than the original.

A fusible resistor is a combination fuse and resistor. It is a special device and a standard resistor of any type is not to be used for replacement.

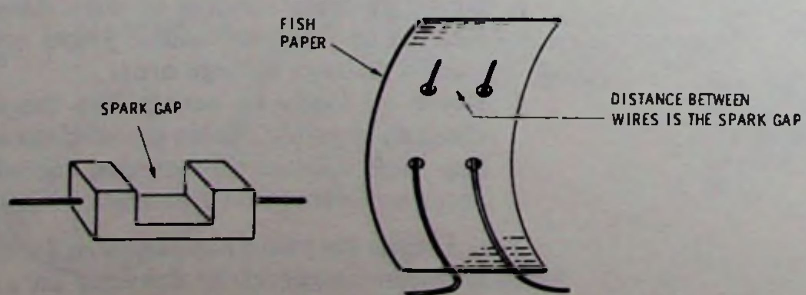


Fig. 1-11. Common spark gaps.

PICTURE TUBE INSTALLATION

The picture tube is a source of danger because of the possibility of shock or implosion. The inner and outer graphite coatings of the picture tube form an excellent capacitor that will hold a charge for days. Before removing a picture tube or working near the high voltage, the anode connection (anode button) should be discharged. This connection should not be shorted directly to ground. To do so, as is often done with a long screwdriver, can cause damage to the anode button because of the high energy arc. It also does not always remove all the charge from the tube.

The high voltage stored on the picture tube should be discharged slowly through a high-value resistor (for example, 10 megohm) to ground. To do this connect the resistor to two clip leads. Connect one lead to ground first. Then connect the other clip lead to the blade of a well-insulated screwdriver and touch the screwdriver blade to the anode button. It should be left in contact with the anode button for several seconds. If the tube is not fully discharged, it is possible for the technician as he handles the tube to receive a shock and drop the tube. Implosion could then occur and cause serious injury.

Implosion results as a violent reaction of the inward rush of air to fill the tube vacuum when the vacuum seal is broken by cracking the glass envelope. Implosion can be caused by careless handling, production flaws, or stresses caused by deep scratches on the surface of the picture tube envelope.

When replacing a picture tube the working area should be cleared of other people, and the technician should wear safety glasses and gloves. The picture tube should always remain in the carton until it is time to actually place it into the cabinet. Defective picture tubes (duds) should not be left with the customer. Explain the danger, pack it in the empty carton, and remove it from the customer's home.

The following list is given by the Electronics Industries Association as details of picture tube installation that deserve particular attention with respect to safety.

1. Remove the picture tube from the carton and check the part number stamped on the tube. Picture-tube cartons are rarely, if ever, mismarked, but a few seconds of your time eliminates any possibility of a wrong picture-tube installation.
2. The picture-tube mounting hardware should be tightened evenly and securely. An uneven or overtight installation may cause uneven pressures on the glass, which can in turn cause the picture tube to crack.
3. Proper grounding of the picture tube and surrounding shield is of extreme importance. Static charges can develop on the mask which can reach anode voltage potential and cause a shock hazard as well as damage chassis circuitry. The original grounding method and hardware should be restored.

Some picture tubes have a "glass-allowance" or "dud" value which makes it worthwhile to return them to the supplier. These tubes should be placed in the carton as soon as they are removed from the set, and should not be scratched or broken. Tubes with no glass allowance value should be disposed of immediately by placing them face down in the carton, closing the carton flaps around the neck, and gently tapping off the glass tip as shown in Fig. 1-12. This should never be

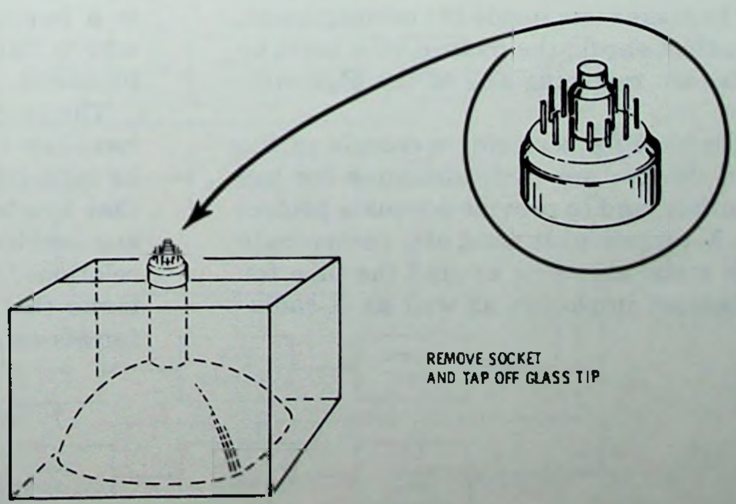


Fig. 1-12. Disposing of used picture tubes.

done on customer property. Once this is done the tube cannot be used for any purpose, nor does it have a dud value.

X-RADIATION

In recent years, attention has been given to the possibility of X-radiation caused by faults which result in excessive high voltage. The principal offenders in monochrome televisions are the picture tube and the high voltage rectifier.

Special glass and shielding is used in the more recent receivers to prevent X-radiation that may exceed levels established by the US Department of Health and Human Services. Tubes in these circuits must be replaced by an approved type and all shields must be properly replaced in order to prevent exceeding radiation level standards. In the case where a receiver comes in for repair without the shield, it should be replaced as a standard servicing procedure. In sets manufactured in more recent years, solid-state high voltage rectifiers have been used, eliminating that circuit as an X-radiation hazard. Thus, in most sets in use today the radiation hazard is confined to the picture tube.

X-radiation, of course, is the result of excessive high voltage. It is, therefore, essential that the technician check the high voltage of each set serviced. High voltage must be maintained at the design level for best picture quality and to maintain X-radiation safety levels. A high voltage probe is easily used, inexpensive, and usually accurate; however, the accuracy should be checked against another meter periodically.

When troubleshooting sets that have excessive high voltage, the set should be operated only long enough to make the necessary tests. The high-voltage compartments must be closed except when it is necessary to make tests inside the compartment. To ensure against shock, the picture tube must be discharged before replacing any of the high-voltage tubes.

Any test jig used for servicing a chassis on the bench should use picture tubes designed for use at high potentials, and to provide adequate protection against X-radiation. It must also incorporate all necessary metal shielding around the tube for protection against implosion as well as X-radiation.

Any picture tube used as a test tube must be designed for operation at a voltage greater than that of the chassis under test. Follow the test-jig manufacturer's instructions. Dealing blindly with high potentials can be very dangerous.

CUSTOMER SAFETY

Ensuring customer safety has become an increasingly more important aspect of equipment manufacturing and servicing. The manufacturer takes the utmost in precautions when the set is designed and produced so that no normal safety hazard exists. Yet, the customer in many cases will defeat the design of the set or create a safety hazard by misusing the set. It is a good customer relations technique to thoroughly explain to the customer how some of these more common misuses can cause safety hazards. This could be done when the customer purchases the set or when it is repaired, especially if the repair was necessitated by misuse.

Many manufacturers pack a brochure with each set that points out the misuses of a television receiver that can cause a safety hazard. That brochure, prepared by the Electronic Industries Association (EIA), is reprinted here.

It should be explained to the customer that although the manufacturer takes all the precautions necessary to be sure the customer gets the safest possible product, you, the technician, have also safety checked the set. And caution him to observe all the safe users' practices as have been illustrated here. Thus the customer has been educated concerning the safe and efficient operation of his set and assured that you are looking after his best interests. The result is a happy, assured, safety minded customer who is likely to return when his set does have problems.

The proper manner to safety check a receiver has been thoroughly explained and so will not be repeated. It should be emphasized, however, that a safety check should be a routine part of any service procedure. And, for good customer relations, it should be pointed out to the customer that such safety check has been provided for *his safety*.

Chapter 2

Monochrome Television Block Diagram Analysis (by Function)

The television receiver is a system requiring two inputs and supplying two outputs as shown in Fig. 2-1. In order to convert these two inputs into intelligent outputs several operations are required of the receiver. It must be capable of producing a lighted screen (raster), putting a picture on the screen, adding sound, and having control over all functions to allow individual viewer adjustment.

This chapter is concerned with an in-depth description of the television receiving system by its functions. The reader with a background in block diagram "symptom diagnosis" should feel at home. Those with no background in symptom diagnosis may find the chapter to be a little difficult. It should not be felt that everything in this chapter must be totally understood, for throughout the book these concepts will be expanded and explained. However, if possible, the reader should read *Television Symptom Diagnosis—an entry into TV servicing* by Richard W. Tinnell, which is an excellent review that will prepare the reader for this text and is available from Howard W. Sams & Co., Inc. In symptom diagnostic training a block diagram as seen in Fig. 2-2 is used as the foundation for further television service training.

A look at each function of the receiver should show what part each stage plays in developing picture and sound. The first functions to be discussed are those necessary to produce a lighted screen. *The order in which these functions are presented is the same order in which the receiver should be repaired.* That is, first the set should

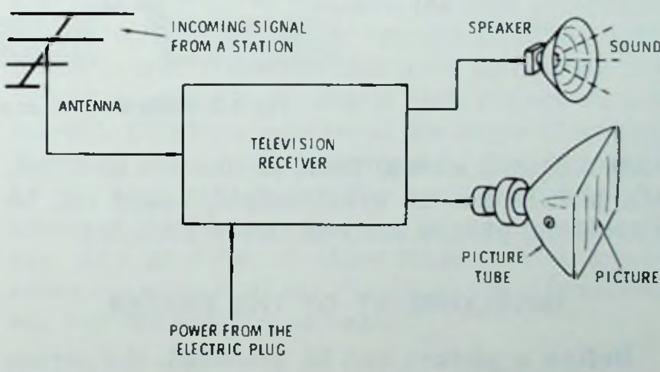
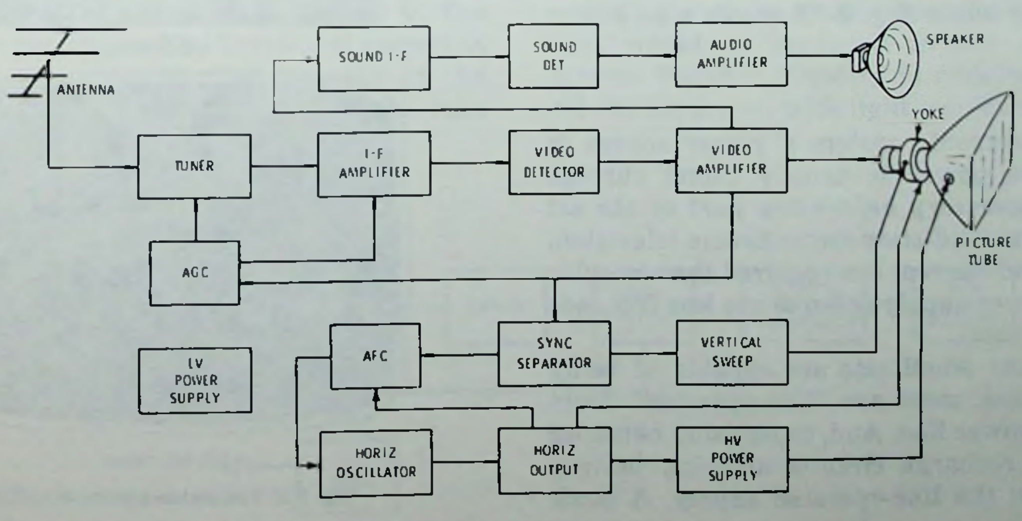


Fig. 2-1. Block diagram showing inputs and outputs.



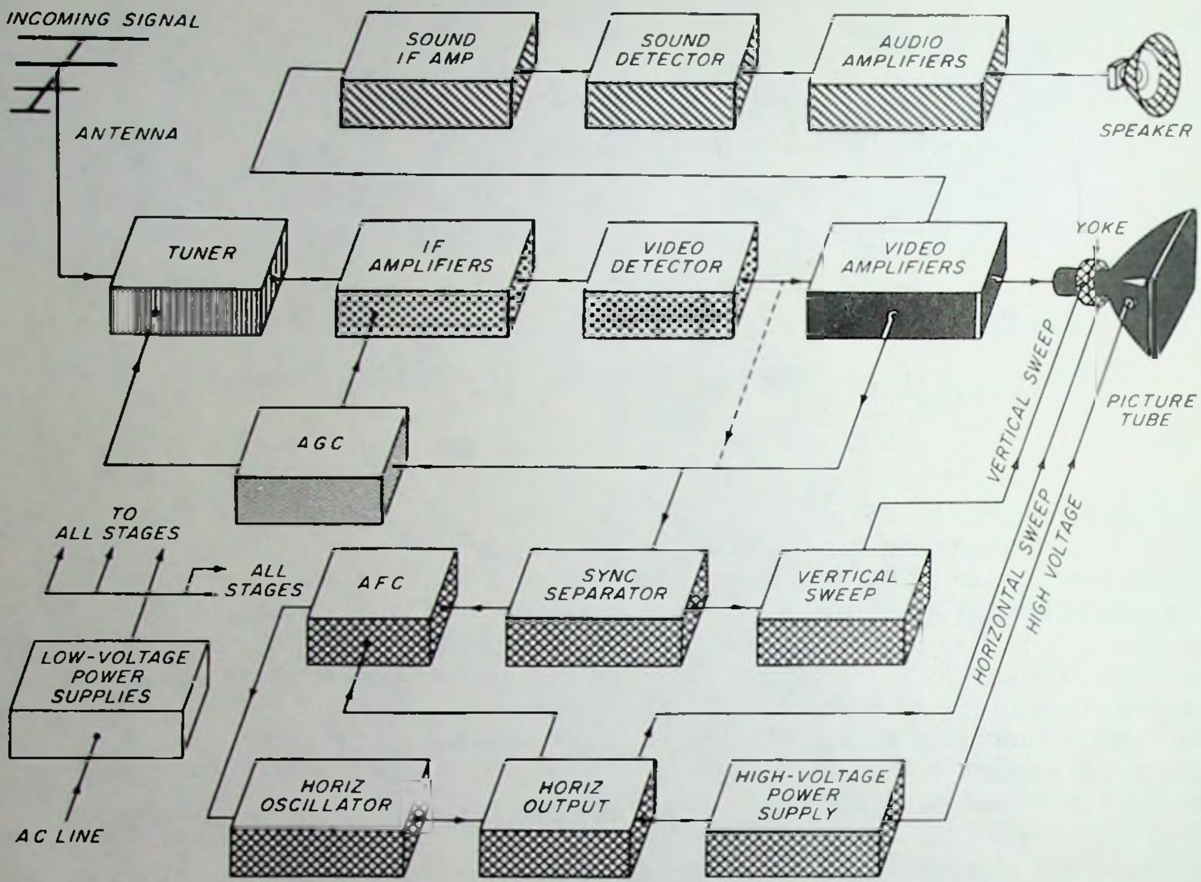


Fig. 2-2. Block diagram of a typical black-and-white receiver.

have a lighted screen. Then, picture can be added, the picture can be synchronized, sound can be added, and picture controls can be adjusted.

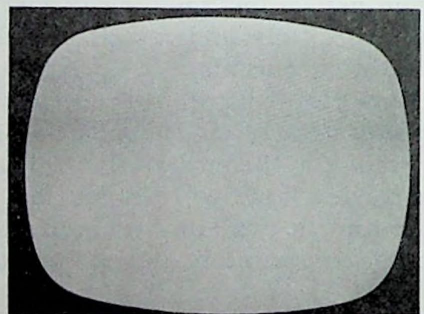
DEVELOPMENT OF THE RASTER

Before a picture can be produced, the screen must be lighted. This light is called *raster* and hereafter will be referred to as such. Fig. 2-3A shows a raster while Fig. 2-3B shows a no raster condition.

Low Voltage

For any electronic system a power source is required. This power is usually direct current (dc) and is *necessary before any part of the set can operate.* In solid-state monochrome television, less voltage and current are required than in color sets. Thus, power supply failures are less frequent than in color sets.

Though many small sets are capable of being battery powered, most are "line-operated" from the 120-V ac power line. And, those using batteries usually have recharge circuits allowing battery recharge from the line-operated supply. A block



(A) Raster.

(B) No raster.

Fig. 2-3. Television screen condition.

(A) Block diagram.

(B) Schematic diagram.

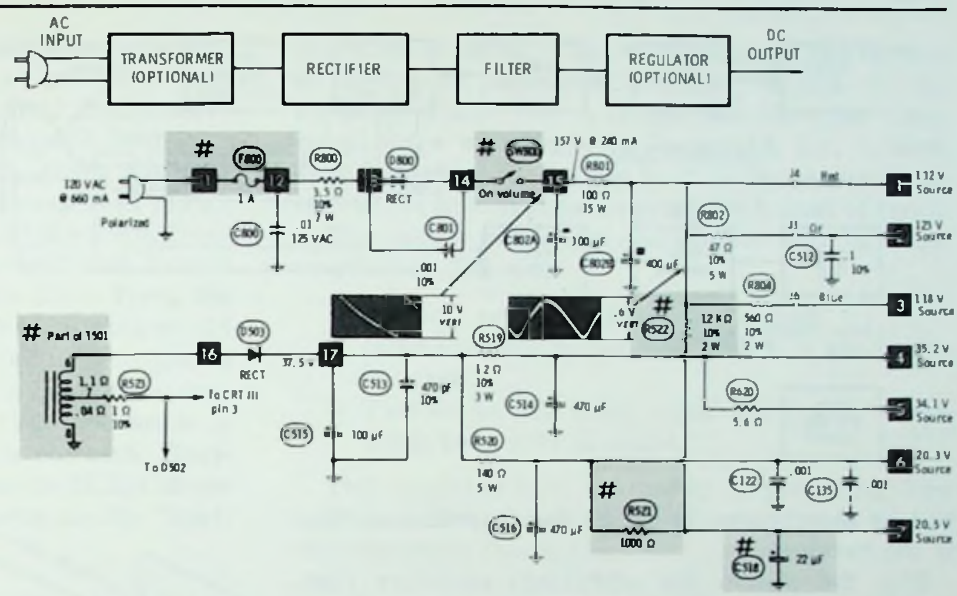


Fig. 2-4. A typical line operated power supply.

diagram of a typical line-operated supply is illustrated in Fig. 2-4A. The schematic of this supply is shown in Fig. 2-4B.

High Voltage

Operation of the low voltage power supply does not in itself assure that the screen will light. Fig. 2-5 shows the stages that are required in order to produce a light on the screen. These stages provide a high voltage which is applied to the second anode of the picture tube. This is an accelerating voltage used to attract an electron beam from the electron gun in the neck of the tube to its screen. *Without this high voltage the screen will not light.*

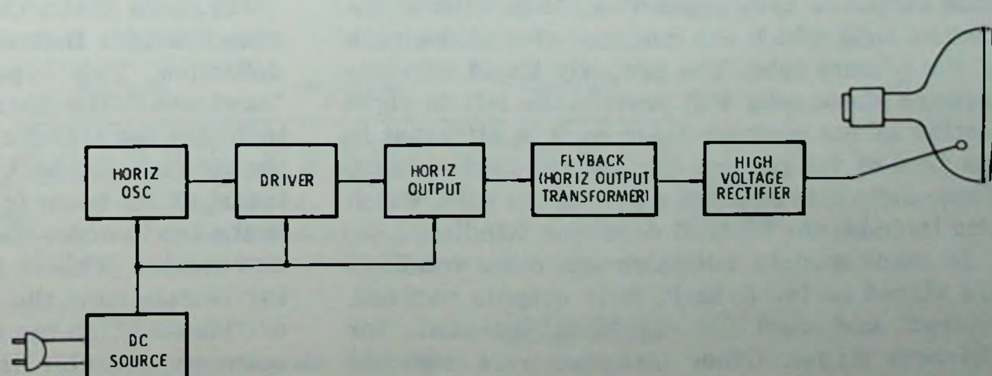
Referring to Fig. 2-5, the purpose of the horizontal oscillator is to take dc voltage from the low voltage power supply and change it to a 15,734 Hz horizontal pulse. This pulse is then fed to the driver stage which is responsible for increasing its power level after which it is applied to the horizontal output stage. The horizontal output is an important stage for the development of the high voltage required to light the picture tube screen. It must supply a large amount of current for the flyback (horizontal output) transformer in order to produce the high voltage output. This means that much heat is created. The horizontal output transistor is thus usually mounted on a heat sink in order to dissipate the heat generated.

The 15,734 Hz pulses of current from the horizontal output transistor are used to operate the flyback in order to develop a high voltage at low current. This high voltage, on the order of several thousand volts, is then changed to direct current by the high voltage rectifier and applied to the anode of the picture tube for its operating voltage. *Any problems in these stages which would cause one or more of the circuits to cease functioning will cause a loss of raster.*

SCANNING THE RASTER

With the circuitry just described only a bright spot would be produced in the center of the screen. Further circuitry is required in order to fill out the screen with light—create a raster. This

Fig. 2-5. Stages required to place a "light" on the picture tube screen.



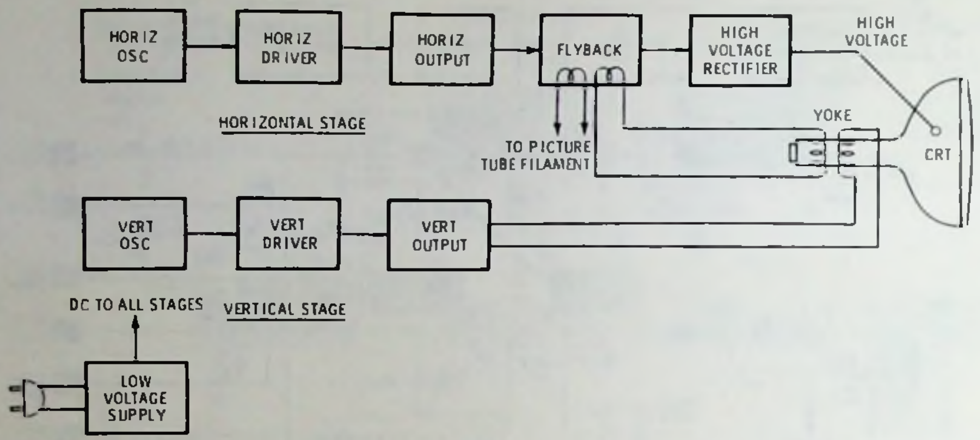


Fig. 2-6. Circuitry necessary to create a completely "lighted" screen (raster).

will be the responsibility of the scanning section of the receiver.

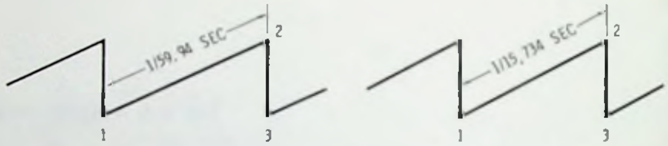
Fig. 2-6 shows the additional circuitry that must be added in order to produce complete deflection of the electron beam both horizontally and vertically on the crt screen. Notice that many of the same stages which were used for the developing of high voltage are also used for deflecting the beam horizontally. Remember though, that if the high voltage is absent, there is no raster; therefore, scanning cannot be seen even though it may be occurring.

As Fig. 2-6 shows, two different stages are required in order to accomplish scanning of the picture tube. One action will be in the horizontal direction, left to right; the other will be in the vertical direction, top to bottom.

Horizontal Scanning

Horizontal scanning must begin at the horizontal oscillator stage where the basic scanning frequency of 15,734 Hz is developed. The horizontal oscillator output is applied to the driver stage, to the output stage, and then to the output transformer. So far these are the same circuits that are required in the development of high voltage. Normally, a voltage is tapped off the transformer by coupling a secondary winding to it. This output is then applied to the horizontal deflection coils which are mounted around the neck of the picture tube. The properly timed currents through these coils will provide the left to right motion of the electron beam as it is attracted to the face of the picture tube by the high voltage. These deflection coils are a part of the *yoke*, which also includes the vertical deflection windings.

In many modern television sets other windings are placed on the flyback, their outputs rectified, filtered, and used for operating potentials for different stages. Other manufacturers will add still another winding to the transformer and use the produced voltage to heat the picture tube filaments. These two items indicate the importance of being able to read schematic diagrams in order to localize problems to their individual stages for efficient and rapid troubleshooting.



(A) Vertical sawtooth. (B) Horizontal sawtooth.

Fig. 2-7. Deflection current waveforms.

Vertical Scanning

Vertical deflection starts with the vertical oscillator which takes dc from the power supply and changes it to a 59.94 Hz pulse. The oscillator output is then fed to the vertical driver stage, increased in level, and then used to operate the output stage. The output circuit will supply the proper current to the vertical deflection yoke in order to cause the beam to move from the top of the screen to the bottom.

Scan Currents

Fig. 2-7A shows the shape of the vertical scanning currents that are required to cause proper deflection. This type of waveform is called a "sawtooth." The distance between points 1 and 2 indicates the travel of the beam from the top of the screen to the bottom. Points 2 to 3 indicate the travel of the beam from the bottom of the screen to the top in order that the process of screen scan be repeated. This is termed "retrace" time. During retrace time the beam must be extinguished, or "blanked," so the retracing electron beam will not cause a visible line on the screen. This action must take place 59.94 times per second; therefore, 59.94 vertical scans or "fields" are produced each second. This is termed the "vertical frequency."

In Fig. 2-7B the horizontal sawtooth is shown. For every one vertical sawtooth, there are 262 horizontal sawtooths. The distance between points 1 and 2 indicates the travel time of the beam from the left side of the screen to the right side. Points 2 and 3 indicate the travel of the beam from the right side of the screen to the left side. This would then be trace and retrace times for the horizontal scan. As in the vertical circuit, horizontal retrace must occur during the period when the beam is blanked so the "retrace lines" are not seen. Horizontal trace and retrace must occur 15,734 times per second and this becomes known as the "horizontal frequency."

Interlace Scanning

It should be evident that in order to have proper scanning action, horizontal and vertical deflection must occur simultaneously. One force pulls the beam left to right, while the other force moves the beam from top to bottom of the screen.

If the screen of a television receiver is closely observed, it can be seen that the picture is made up of individual lines. These lines, when put together, cause the entire screen to light.

In the United States system of television broadcast, standards have been set with which receivers must comply. Five hundred and twenty-five lines are used in order to make one picture which is termed a frame (complete picture). If all of the lines were counted, 483 would probably be the most that would be seen. This is because some lines are lost during vertical retrace time as the beam is retracing from the bottom of the screen to the top.

Another US broadcast standard requires the use of a 2 to 1 interlace. This simply means that two fields, or two vertical scans, are used to form one complete picture on the screen.

This interlace is accomplished by having the beam first scan the odd lines, i.e., first, third, fifth, etc., until the 262½ line is scanned. At this point the beam is blanked and retraced from the bottom to the top of the screen. Once at the top, the remaining ½ line will be traced and the even numbered lines will begin to be traced, i.e., second, fourth, sixth, etc. A close look at the top and bottom of the screen should reveal the ½ lines of trace.

The entire scanning mechanism can be summarized as follows:

1. A 2 to 1 scanning interlace is used.
2. 262½ lines equal one field which is one vertical scan.
3. Two fields, 525 lines, equal one frame which takes two vertical scans.

This explains how the raster is produced. The next function of the television receiver is to put the picture on the raster.

THE COMPOSITE VIDEO SIGNAL

In putting a picture on the screen, the receiver is a slave of the broadcast station. All of the commands for the receiver to follow are broadcast from the television station. As far as monochrome is concerned, the television station will be sending two signals, the composite video, and audio. A composite video signal is illustrated in Fig. 2-8—it is made up of the following:

1. Video signal
2. Horizontal blanking pulse
3. Horizontal synchronizing pulse
4. Vertical blanking pulse
5. Vertical synchronizing pulse
6. Equalizing pulses

Video Signal

This signal will supply the picture tube with the proper information for displaying a picture on the screen. Video is made up of frequencies that start at about 30 hertz and extend to 4.2 MHz. Low frequencies will display the large picture area information, while high frequencies produce fine picture detail.

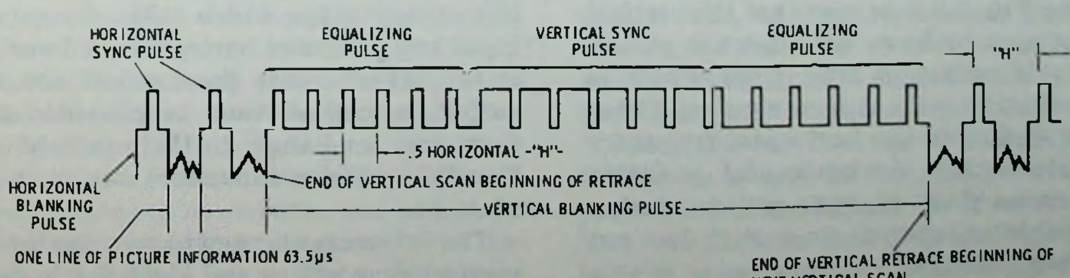


Fig. 2-8. Composite video signal.

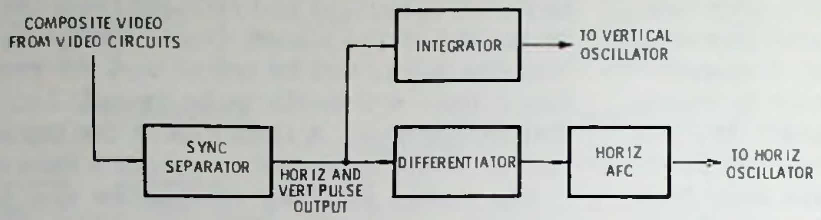


Fig. 2-9. Sync circuits.

Horizontal Blanking Pulse

The horizontal blanking pulse will tell the receiver to blank out the electron beam in order that horizontal retrace can occur without being seen imposed on the picture. It will give a pulse repetition rate of 15,734 Hz and is utilized by the crt.

Horizontal Synchronizing Pulse

This pulse is applied during the time that the horizontal blanking pulse shuts off the electron beam. The horizontal synchronizing pulse is used to keep the horizontal oscillator in step with the horizontal frequency at the transmitter. This is necessary to ensure that the picture is properly framed in the horizontal direction. The horizontal synchronizing frequency is the same as the horizontal blanking frequency—15,734 Hz. The difference in the sync and blanking pulses is the pulse widths as seen in Fig. 2-8.

Vertical Blanking Pulse

The vertical blanking pulse is used to blank the picture tube prior to the application of the vertical synchronizing pulse. It has a pulse repetition rate of 59.94 Hz.

Vertical Synchronizing Pulse

The vertical synchronizing pulse keeps the vertical oscillator timed to the broadcast station vertical pulse so the picture will be properly framed in the vertical direction. In addition it gives the proper time for the start of vertical retrace. It has a pulse repetition rate of 59.94 Hz, the same as the vertical blanking pulse. The difference is in the pulse widths.

In examining Fig. 2-8 it is seen that the vertical sync pulse appears to have six separate pulses. Actually there is only one sync pulse which is serrated or broken into six separate pulses. These serrations are at double the horizontal frequency and function to supply the horizontal oscillator with a continuous flow of sync pulses, during the vertical blanking interval, so that it does not go off frequency. The vertical sync pulse is at a 59.94 Hz rate, and the serrations are at a 31,500 Hz rate. Every other pulse is used to synchronize the horizontal oscillator.

Equalizing Pulses

As seen in Fig. 2-8 equalizing pulses precede and follow the vertical sync pulse. Their frequency is 31,500 Hz and they are used for two purposes.

(1) Maintain half line differences between fields so scan lines do not overlap.
(2) Discharge the integrator capacitor prior to the application of the vertical sync pulse.

To this point, lighting the screen has been discussed in two parts:

(1) Producing a light on the screen.
(2) Scanning this pin-point of light up, down, and across the screen in such a manner as to produce a totally lighted screen.

Now picture information must be received from the broadcast station and caused to produce an identical picture on the television screen.

SYNCHRONIZING THE PICTURE

As discussed previously, tv scanning oscillators must be synchronized to the broadcast signal. Therefore, the sync signal portions of the composite video signal must be channeled to the correct stages (Fig. 2-9).

The sync signal pulses take the same path as the video and audio signals through most of the receiver. After the video detector, the composite video signal is applied to the sync separator circuit. This circuit is used to separate the horizontal and vertical synchronizing pulses from the video —just as its name implies. The sync separator is a clipper stage which takes a composite video input and produces horizontal and vertical pulses at the output. Since these pulses share the same output, a method must be provided to separate them and send them to their individual circuits. Two RC (resistor-capacitor) circuits perform this function.

The *integrator* is used to pass the low frequency vertical sync pulses and block the high frequency horizontal pulses. The vertical sync pulses then

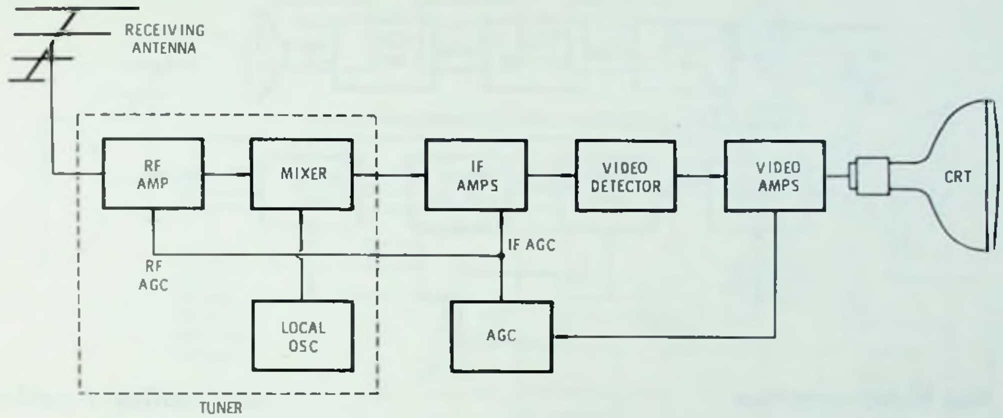


Fig. 2-10. Picture production requires these circuits.

trigger the vertical oscillator and hold it to the frequency of the transmitter.

The *differentiator* passes the high frequency horizontal pulses on to the horizontal stages but blocks the low frequency vertical pulses. Prior to the horizontal oscillator stage is a stage called the horizontal automatic frequency control (afc) circuit. A sample of the horizontal oscillator frequency is taken from the horizontal output (flyback) transformer and applied to the afc circuit along with the incoming sync pulses. If they are of different frequencies, a control voltage is created. This control voltage is applied to the horizontal oscillator causing it to correct its output frequency. In this manner, the horizontal oscillator in the receiver is synchronized with the transmitted signal and proper "framing" results.

PRODUCING A PICTURE

Several circuits are required to receive, amplify, and reproduce video information. A block diagram of these circuits is shown in Fig. 2-10.

The Tuner

The tuner is used for two purposes: (1) selecting a channel, and (2) developing an "intermediate frequency" (if) to carry the intelligence. By the proper selection of "tuned" circuits, the tuner is able to select the desired transmitted channel of frequencies. The if is developed by action occurring in the mixer stage.

The tuner itself is made up of a radio frequency amplifier, local oscillator, and mixer stages. The purpose of the rf amplifier is to increase the level of the signal as it comes in from the antenna, provide a good signal to noise ratio, and to isolate the oscillator from the antenna to ensure that the antenna does not radiate the oscillator frequency and cause interference to other receivers.

The purpose of the local oscillator is to generate a carrier wave which is used to heterodyne or "beat" with the incoming rf signal in the mixer to develop the if.

The mixer is a nonlinear amplifier which beats the two frequencies together. Four frequencies are the product of this heterodyning action. One of these frequencies is the difference between the incoming channel frequency and the local oscillator frequency, thus giving rise to the term intermediate frequency. This if is selected by tuned circuits at the output of the mixer and in the if stages. It should be remembered that the conversion from the rf modulated wave to the if modulated wave in no way affects the information that is obtained in the wave. It is simply a change in the frequency that is used to carry the information.

The Intermediate Frequency Amplifier

The prime responsibility of the if amplifiers is to provide proper gain and selectivity. The amplifiers will provide the gain, and the tuned circuits will supply the selectivity. The amplifiers will operate Class A in order to preserve fidelity of the modulated wave.

The Video Detector Stage

Prior to application of the video signal to the picture tube, we must separate it from the carrier. This is the function of the video detector stage which is made up of a signal diode rectifier, a load resistance, and a bypass capacitor.

The diode rectifies the if modulated wave and applies its output to the load resistance. The capacitor is used to bypass the if *carrier* around the load resistance so that only the video signal (and not the if carrier) is amplified by the following stage.

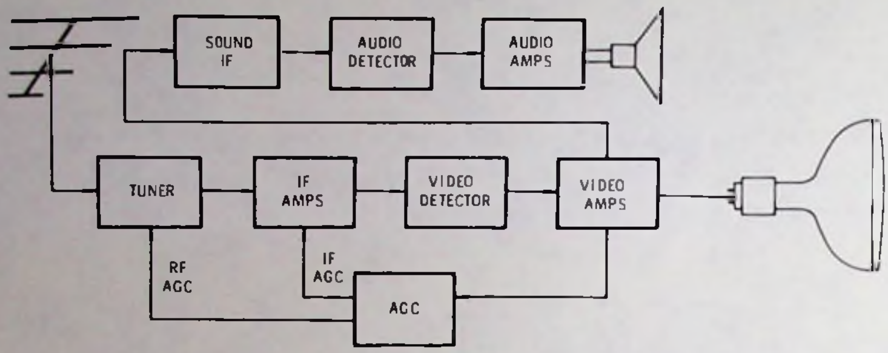


Fig. 2-11. These circuits are necessary to receive and reproduce sound.

The Video Amplifier

The video amplifier stage is a wideband amplifier operating Class A in order to preserve fidelity. Its output is fed to the picture tube causing the electron beam, being accelerated to the crt screen by the high voltage, to be modulated. The beam is thus made to turn on and off creating light and dark spots as it scans across the screen. A picture is now formed on the face of the picture tube.

Automatic Gain Control

In order to eliminate the fluttering of picture due to differences of signal level, a special stage is incorporated which will govern the amplification of the rf and an if stage. Since this control must be related to the input signal, video is rectified, and a corresponding dc voltage developed which is then applied to the rf and if stages to control their gain.

The video signal used may be tapped off at the detector stage or at the output of the video amplifier. If the output of the video amplifier is selected, an extra rectifier stage is required in order to develop the dc voltage. It should be evident that *if there is a problem in any of the stages just described, there will be an effect on the picture seen on the screen.*

Now that the screen has been lit, and a picture placed on it, the next step is to give the set sound.

THE AUDIO SYSTEM

Again, several circuits are necessary to process the sound signal. These can be seen in Fig. 2-11. Note that part of the audio path is the same as that just described for the video path.

In addition to transmitting the video signal, the broadcast station simultaneously sends the audio signal. As mentioned, the circuit actions from the tuner to the sound take-off are the same as for video except when the audio signal goes through the video detector. The video detector has another function relating to the audio signal that is not the same as its function toward the video signal. Because the transmitter is broadcasting two signals (audio and video) which are separated by 4.5 MHz, we can develop a sound if by the beating of these two carriers in the detector stage. Because the detector diode is a nonlinear device, heterodyning (beating) will take place. The audio information will be contained in a frequency modulated wave around the 4.5 MHz sound if. Produced by this action, the 4.5 MHz if is then delivered to tuned amplifier stages which are used to increase the gain and tune out any video information that may be present.

The sound if must now be detected in order to remove the audio variations from the fm if variations. This process will require a detector stage that is different from the video detector which detects amplitude modulated signals. This stage is usually a discriminator or a ratio detector. The output of the fm detector is then fed to audio amplifier stages before being presented to the speaker which converts the electrical energy into mechanical energy or sound.

TELEVISION RECEIVER CONTROLS

Fig. 2-12 shows a complete block diagram of the television set with the location of the various controls that are used to adjust various circuit functions.

Channel Selector—Selects the desired channel by the selection of tuned circuits.

Fine Tuning—Adjusts the frequency of the local oscillator. Adjust for best picture and best sound should follow.

Contrast—Adjusts the range of the video signal amplitude, controlling the gain of the video amplifier stage. Adjust for the desired black to white level.

Brightness—Adjusts for the average background

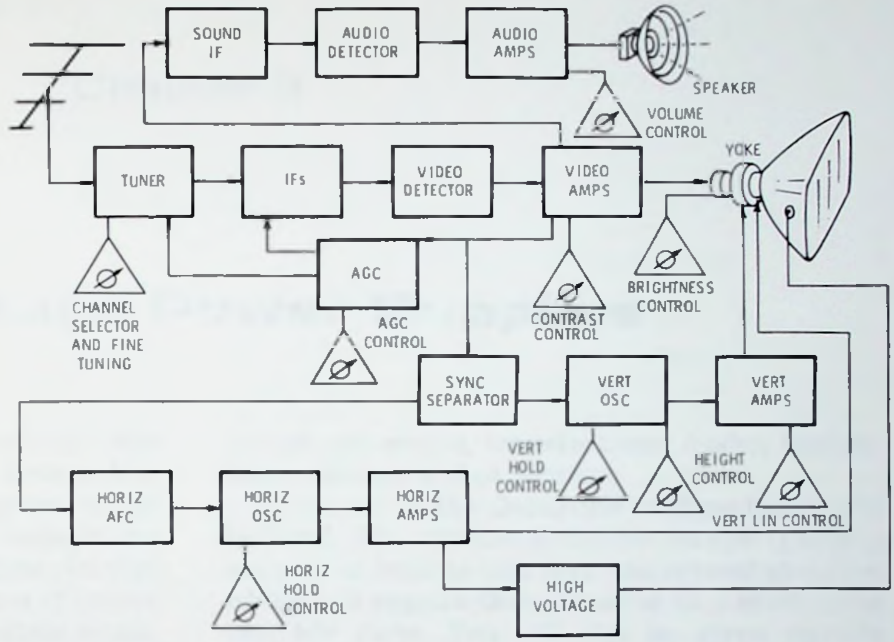


Fig. 2-12. Block diagram showing location of adjustments.

level by controlling the beam current of the picture tube. Adjust for desired picture brightness.

AGC—Follow manufacturer's recommendation for adjustment. Adjusts the gain of the rf and if amplifiers. General rule for adjusting: On strong signal, adjust until bending appears in the picture, then back off slightly. On weak signals, adjust until snow appears, then back off slightly.

Volume—Adjusts audio input voltage to the audio amplifier.

Vertical Hold—Adjusts frequency of vertical oscillator. Adjust for properly locked picture.

Height—Adjusts for full picture deflection in the vertical direction.

Vertical Linearity—Adjust for equal spacing of scan lines between top and bottom of the picture. This produces a picture with the proper perspective, i.e., balls are round, not oblong.

Horizontal Hold—Adjusts frequency of the horizontal oscillator. Adjust for proper horizontal locking.

The remainder of this text will explain the operation of each of the circuits whose functions have been outlined here. These explanations will include the theory of operation, probable defects, the necessary electronic theory to understand the operation, and troubleshooting techniques.

Chapter 3

Low Voltage Power Supplies

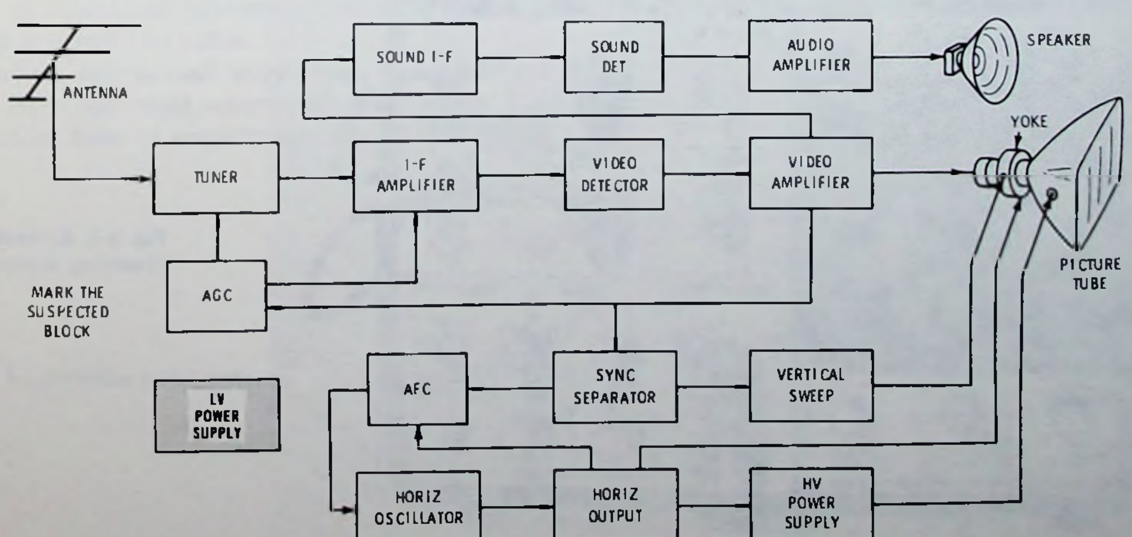
With few exceptions (battery powered only), the monochrome television receiver will have a low voltage power supply circuit. The power supply changes ac "line" voltage into the dc voltages required by various circuits in the receiver. In this chapter we will study the different types of power supply circuits found in modern solid-state monochrome televisions. Electronic fundamentals will also be briefly discussed for those who have not studied them previously or need a review.

It is not necessary to understand *everything* about these fundamentals in order to understand the materials presented here on power supplies. However, the more knowledge of the fundamentals you can acquire, the easier will be your study of monochrome television circuits and troubleshooting. You may wish to review some of the discussions contained in this book with your instructor or use any of the excellent fundamentals texts that are available. The basic principles which will be discussed along with power supply explanations are ac and dc power, series and parallel circuits, voltage, current, resistance, how to use meters and scopes, transformers, diodes, transistors, resistors, and capacitors.

By necessity, the discussion of these basics will be brief. The *s*tudent *a*ctivities *m*anual (SAM), companion book to this text, has several exercises which will explain these theories in a much more complete form. You will also be given circuits to connect and various procedures for using test equipment. The exercises provide a means for you to "tie" written explanations and theories to actual "hands-on" experiences.

AC-DC POWER

Alternating current is the type of electricity distributed throughout the United States and much of the rest of the world. In the United States we have 120 volt, 60 hertz (sometimes called "cycles") ac. This means that the electrical movement inside our electrical system wires alternates directions of movement 60 times each second—therefore, called 60 hertz or cycles. The correct term in use today is hertz though some



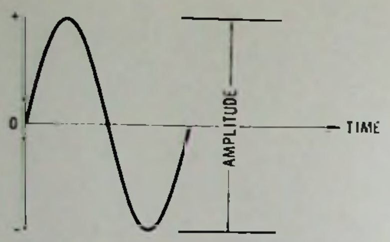
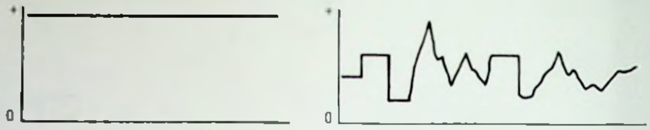


Fig. 3-1. Graph of alternating current.



(A) Pure dc.

(B) Pulsating dc (may exhibit any shape).

Fig. 3-3. Direct current.

people still prefer the term "cycles." If a graph were to be drawn of ac it would look like that shown in Fig. 3-1. Note that the graph plots amplitude against time. One direction of electrical movement is called *positive* and the other direction is called *negative.* Above the zero amplitude or time line on the graph the amplitude and electrical direction is *positive;* below the line it is *negative.* The number of times a cycle of electrical movement, as seen in Fig. 3-2, occurs in one second is

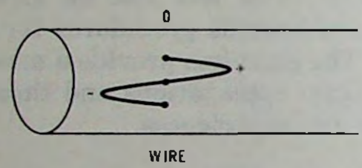


Fig. 3-2. Ac electrical movement inside a wire.

termed the *frequency.* So, if the electricity in a wire moves from a standing point (zero) to its maximum in one direction, then returns to zero again and moves in the other direction to its maximum and to zero once more 10 times a second the frequency is 10 hertz. As mentioned above the US standard is 60 hertz.

Direct current moves only in one direction: it does not change or alternate directions. Batteries supply dc. Radios, televisions, and other electronic equipment must have dc in order to operate properly. Assume an audio amplifier as an example. Suppose ac were to get into the speaker. It would cause the speaker to move in and out as the current changes directions. This would cause an annoying 60 hertz "hum" to be produced. However, if dc is applied to the audio circuits the speaker is *not* made to move in and out since dc does not change directions and the hum is not heard—dc *must* be used in such circuits. A graph of pure dc is shown in Fig. 3-3A. Note that as stated, over a period of time, the amplitude does not change nor does it change directions of flow. Direct current *can* be made to change in amplitude (Fig. 3-3B). If dc changes in amplitude it is called pulsating dc. Direct current can be either positive or negative depending on which direction it is moving.

THE OSCILLOSCOPE

The oscilloscope is used to observe current movement in an electrical circuit. The oscilloscope electronically produces a graph as illustrated in

Fig. 3-4. An oscilloscope. (Courtesy Sencore, Inc.)

Figs. 3-1 and 3-3. An oscilloscope is shown in Fig. 3-4. Within the "scope" are circuits which cause an electron beam to be accelerated toward the screen of the crt exactly as in the television crt. This beam is deflected side to side by a horizontal deflection circuit and up and down by a vertical deflection circuit. Horizontal deflection is usually accomplished by *triggered* circuits which cause the beam to start sweeping across the screen as the incoming signal begins to increase in amplitude. Other scopes will have a *recurrent* sweep which means that the beam sweeps from side to side at the same frequency time after time. The triggered type is best and is preferred by most television technicians.

Vertical deflection is accomplished by the signal applied to the scope through its input lead. So as the input changes amplitude, causing the pinpoint of light on the screen to move up and down, the horizontal circuits are causing the beam to move to the side. A graph of time versus amplitude is then created. To measure the movement of current in a circuit, the ground lead of the scope is attached to the circuit ground, the signal lead of the scope is attached to the circuit "hot" lead, and the frequency of horizontal sweep is set so that one to two cycles of the signal can be seen on the screen. Further explanation and operational exercises are given in the SAM.

VOLTAGE, CURRENT, AND RESISTANCE

Whether the power used is ac or dc, there are three elements of it which *must* be understood. These are *voltage*, *current*, and *resistance*. *Voltage* is the pressure which causes electrical flow and is measured in volts. A flashlight cell normally has 1½ volts of electrical pressure. The household ac is usually around 120 volts.

Current is the actual movement of electrical charges. We say that electrical current is the movement or flow of negatively charged particles called electrons. This movement occurs from negative to positive points. Negative points have an excess of electrons so must be the source of electron flow. Positive is the lack of electrons and thus will attract them. Current is measured in amperes (amps), milliamps, and microamps (Fig. 3-5).

AMP = A	MILLIAMP = mA	MICROAMP = µA
(EXAMPLE 1)	1 AMP = 1000 mA = 1,000,000 µA	
(EXAMPLE 2)	.1 A = 100 mA = 100,000 µA	
(EXAMPLE 3)	.01A = 10 mA = 10,000 µA	
(EXAMPLE 4)	.001A = 1 mA = 1000 µA	
$1\text{mA} = \frac{1}{1000}\text{ A}$	$1\,\mu\text{A} = \frac{1}{1{,}000{,}000}\text{ A}$	

Fig. 3-5. Relationship between units of current measure.

Resistance is the opposition to electrical current flow. The more resistance in the circuit the less current will flow. Also, put another way, the more resistance in the circuit the more voltage it will take to push current through it. All electronic components have resistance in one way or another—some more and some less. Even wires have some

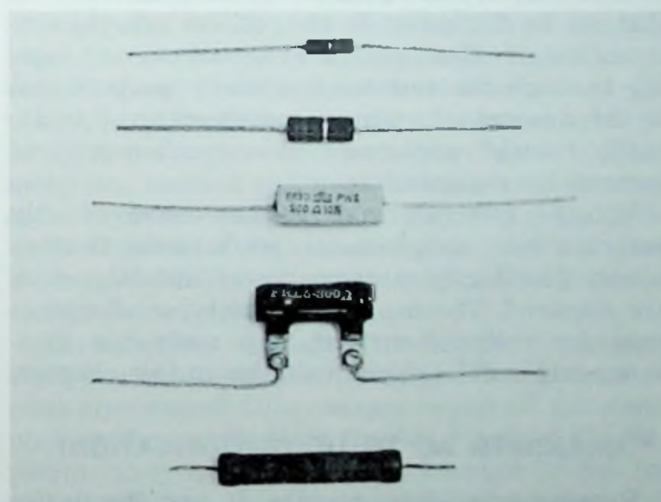


Fig. 3-6. Common resistor types.

BAND COLOR	1ST BAND COLOR	2ND BAND COLOR	3RD BAND ZEROS TO ADD	4TH BAND TOLERANCE
BLACK	0	0	0	NO COLOR 20%
BROWN	1	1	1	
RED	2	2	2	
ORANGE	3	3	3	SILVER 10%
YELLOW	4	4	4	
GREEN	5	5	5	
BLUE	6	6	6	GOLD 5%
VIOLET	7	7	7	
GRAY	8	8	8	
WHITE	9	9	9	
			– MULTIPLY BY –	
SILVER			.01	
GOLD			.1	

SCHEMATIC SYMBOL —ʌʌʌ—

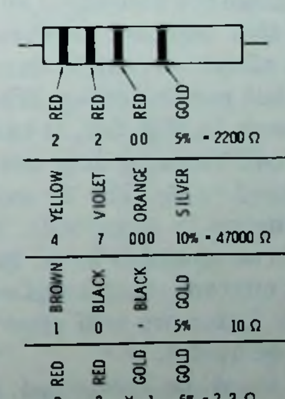


Fig. 3-7. Resistor color code.

resistance though it is very little and usually considered to be insignificant.

A special component, the resistor, has the express purpose of providing resistance. The unit of measure of resistance is the ohm. In Fig. 3-6 several types of resistors are shown. Note that two of the resistors are color coded. The color code is explained in Fig. 3-7. Resistors are purchased by their ohmic rating, tolerance rating, and wattage rating. The tolerance rating is important in critical circuits, such as meters. The tolerance rating means that the resistor cannot vary in resistance more than the tolerance rating. For example, a 1000 ohm 5% resistor is guaranteed to be not less than 950 ohms and not more than 1050 ohms.

Resistors are purchased by their wattage rating as well as their ohms and tolerance ratings. The resistor is the only basic electrical component specified directly in watts. Others may have wattage rating values but it is not always a primary specification used in their purchase. Though the ohms value of a resistor is completely unrelated to its physical size, the wattage is *directly* related to physical size. The larger the resistor in size, the more air it will contact and thus the more heat that can be dissipated by the resistor into the surrounding air. Heat generated by the current flowing through the resistor is directly proportional to the amount of current movement, and is actually "work" performed by current movement through the resistor.

Voltage, current, and resistance are directly measurable by simple meters while power (watts) is not. To directly measure power, special meters are required. The use of and the types of meters used for voltage, current, and resistance measurements will be explained later in this chapter.

CHANGING AC TO DC (RECTIFICATION)

Because televisions require dc and the power companies provide ac, some means must be utilized to change the household ac into dc. The device used for this purpose is the rectifier diode. A diode will allow current to flow through it in one direction but not the other. When placed in a circuit as shown in Fig. 3-8, it can be seen that current flow can move in only one direction—ac has been changed to dc. The dc output of D1 in Fig. 3-8 is changing in amplitude. This is a pulsating dc which is as unusable as ac. In order to be useful the direct current must be of a steady unvarying amplitude. Later we will show how to make the pulsating dc useful.

Diodes must be connected in the correct direction in all circuits. If they are reversed they allow current to flow into the circuit in the wrong direction causing capacitors and solid-state components to be destroyed. Internally the diode has two elements, the anode and cathode. The cathode is usually marked in some way on the outside of the case. One way is to have a drawing of the diode symbol on the case; another is to mark the cathode end with a "+" or to place a stripe around the cathode end. If the diode is not identified, it is relatively easy to do so with an ohmmeter. Connect the ohmmeter leads to the diode so a low resistance reading is produced. The cathode is the lead which is then connected to the negative meter lead. In most meters this will be the black or common lead. However, in some meters the internal battery source may be reversed. It is best to check your meter on a diode that is already marked so you will know which lead on your meter is negative. Remember in all cases, the current flows against the arrow in the diode symbol as shown in Fig. 3-8.

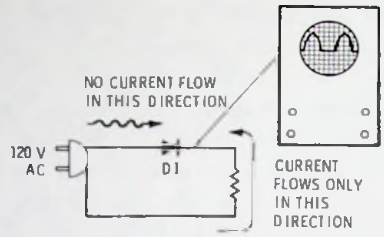


Fig. 3-8. A diode changes ac to dc.

Theoretical concepts of the diode can be found in any electronics fundamentals text. We will not discuss how the diode allows electrical movement to occur in only one direction at this time. For our present purposes it is necessary that you know what it does and not necessarily how it does it. A more theoretical explanation of the diode's "inter workings" will be given at a later point in this chapter.

Diodes are purchased according to their current and voltage ratings. Other ratings are given but these are the most useful to the technician. Diodes are available in many case styles as shown in Fig. 3-9. The case sizes are somewhat related to the current ratings of the diode since more heat is dissipated by more current. Diode current and voltage ratings are maximum ratings and should not be exceeded under any circumstances. Voltage ratings are labeled *reverse voltage* or *peak inverse voltage* (rv or piv) in specifications manuals. These ratings refer to the voltage applied to the diode in its nonconducting direction. Any voltage

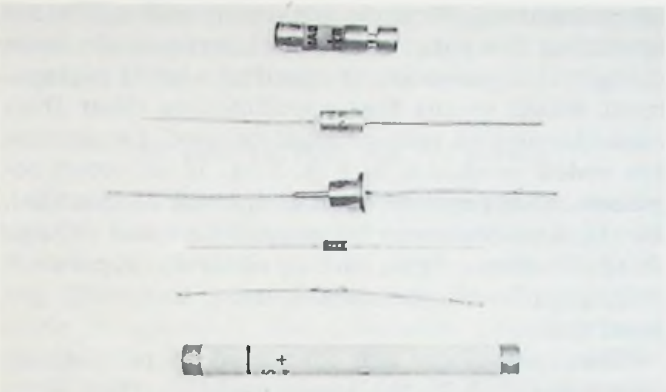


Fig. 3-9. Diodes are available in several case styles.

applied in this direction above the rated value may cause the diode to conduct and be destroyed.

SMOOTHING THE PULSATING DC

As mentioned previously, to be useful the pulsating dc coming from the rectifier diode must be made to maintain a steady unvarying amplitude. In other words the pulse or ripple must be removed. The process of removing the ripple (usually called the ac ripple content) is called "filtering." A capacitor is used to filter the ripple from the dc at the diode output. A filter capacitor is shown in the circuit of Fig. 3-10.

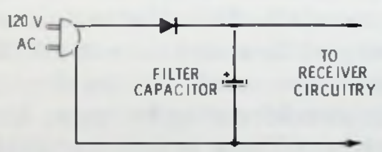


Fig. 3-10. Diode rectifier with filter capacitor.

THE CAPACITOR

The capacitor is useful for things other than filtering and is a very common component. It can be purchased in many types according to the insulation within it and the case style (see Fig. 3-11). Ratings are given according to capacitance and voltage. The technician must know these ratings to purchase a capacitor, and in some instances must also know the type of case or insulation in the capacitor.

Capacitors are constructed as shown in Fig. 3-12. Capacitors are basically two conducting plates separated by an insulator (dielectric). The insulator may be plastic, glass, mica, ceramic, paper, chemicals, and exotic nonconducting metal compounds.

The following is a "simplistic model" explana-

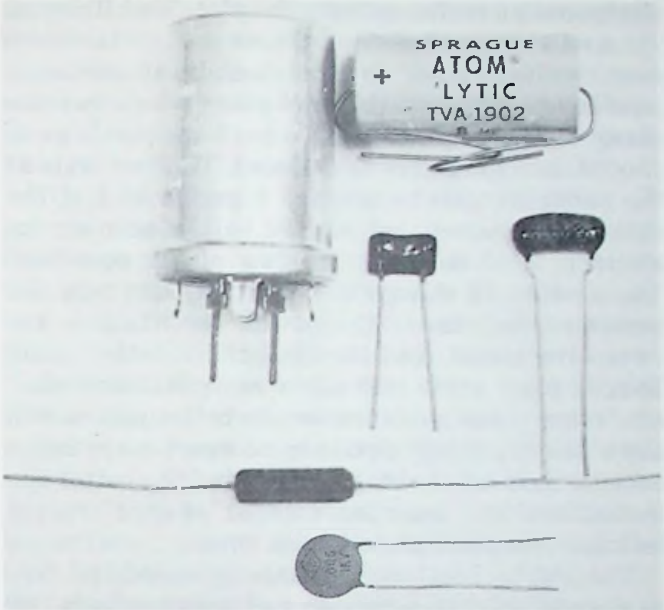


Fig. 3-11. Many types of capacitors are available.

tion of capacitor operation. In physics terms, this explanation is incorrect. It does, however, allow the beginner to have a concept of how the capacitor operates which then permits him to explain capacitor performance in a circuit. For a more complete and technically correct theoretical explanation of capacitor operation you may wish to refer to an engineering or a physics text. Most materials written on the technician level use the same explanation given here. In reality it can be used in almost all technical explanations but does limit the viability of some of the more involved circuit action explanations.

The capacitor can "store" a charge. By forcing electrons onto one plate, electrons on the other plate are repelled (like charges repel) off the other plate and current flows into and out of the capacitor though not *through* it because of the insulation. When the capacitor is charged, no more

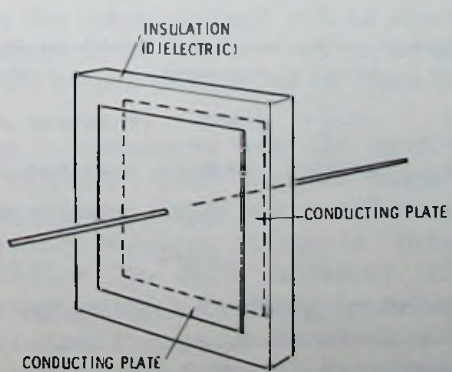


Fig. 3-12. Capacitor construction.

electrons can be forced onto the plate and likewise none will be repelled from the second plate. However, an imbalance in the number of electrons now exists between the two plates—one has too many and the other doesn't have as many as it should. A "charge" is now stored. The two ends of the capacitor can be touched together and if the charge is great enough an arc will be seen as the electron level between the two plates equalizes. The amount of charge the capacitor can hold depends on the size of the plates, the distance between the plates, and the type of insulation used. Larger plate areas will allow more electron storage room. Less distance between the plates will allow the incoming electrons to exert more influence on those of the other plate. And the better the insulation, the less the loss of charge due to leakage from one plate to the other.

The ability to store a charge is called the "capacitance" of the capacitor and it is measured in *farads*. The farad, however, is such a large amount that capacitors are rated in either microfarads or picofarads (see Fig. 3-13). This rating of capacitance is one which must be specified in order to purchase a capacitor. The other is the voltage rating of the device. At some voltage the insulation is likely to become ineffective by arcs occurring through it from one plate to the other. The voltage rating of the capacitor must never be exceeded.

Some capacitors are polarized (have + and − terminals) while others can be placed into the circuit in any manner. If a capacitor is polarized it is referred to as an electrolytic and it must be connected into the circuit according to the polarity markings—capacitor + to circuit +, and capacitor − to circuit −. If this rule is not adhered to, the capacitor is likely to be destroyed and may explode. Unmarked capacitors have no polarity and can be placed in the circuit in any way as mentioned above.

There are other ratings of capacitors such as

	FARADS	MICROFARADS	PICOFARADS
EXAMPLE 1	1 FARAD =	1,000,000 μF =	1,000,000,000,000 μμF OR pF
EXAMPLE 2	.1 FARAD =	100,000 μF =	100,000,000,000 μμF OR pF
EXAMPLE 3		20 μF =	20,000,000 μμF OR pF
EXAMPLE 4		.001 μF =	1000 μμF OR pF
	$1\,\mu F = \frac{1}{1{,}000{,}000}$ FARAD		$1\,pF = \frac{1}{1{,}000{,}000}\,\mu F$

Fig. 3-13. Examples of conversion relationship between units of capacitance measure.

temperature coefficients, maximum and minimum operating temperatures, and tolerance. In some circuits it is necessary to specify an exact replacement which means that specifications other than capacitance and voltage must be used. Capacitors are coded as shown in Fig. 3-14. If an exact replacement is required their codes will be identical. But in most instances the capacitance and voltage (and sometimes, type, such as electrolytic, ceramic disk, etc.) is all that is necessary to specify for purchase.

When capacitors are connected in parallel, as shown in Fig. 3-15, their values add together. Note that connecting in parallel means that even if one of the capacitors were to be taken from the circuit the other would continue to operate. To prove this for yourself, place your finger over C2 in Fig. 3-15 and note that the circuit is still connected to C1 and that it would continue to operate as if nothing had happened to C2.

In parallel, the effective plate area is increased which increases the capacitance. When in parallel, the total capacitance is the sum of the parallel capacitor ratings. The voltage rating of the parallel combination of capacitors is the same as the *lowest* capacitor voltage rating.

If placed in series, capacitor values decrease. That is, the total capacitance value of the circuit is smaller than the smallest capacitor in the series circuit. Observe the circuit in Fig. 3-16. Place your finger over C1. This obstructs the path for electrical current flow and thus if C1 is removed, C2 is no longer connected into the circuit—in fact the circuit is considered to be *open*. A series circuit is one where there is but one path for current flow and if that path is opened no electrical current can flow.

Total capacitance of the series circuit is decreased because the effective thickness of the insulation of the capacitor has increased as the capacitors are connected in series (Fig. 3-16). In this figure it can be seen that the effect of charge must be occurring through two thicknesses of insulation, thus the total capacitance must be reduced and is actually less than that of the smallest capacitor. The formula for finding the total capacitance of two series capacitors is

$$C_T = \frac{C1 \times C2}{C1 + C2}$$

where,

C_T is total capacitance.

Voltage ratings of a series capacitive circuit are *not* found by adding the voltage ratings together except when the capacitive values of each capacitor in the circuit are the same. If the values are not the same, much more knowledge and math are required to calculate the circuit voltage rating.

THE CAPACITOR AS A FILTER

How does the capacitor remove ripple from the rectifier output? It is really very simple! Refer to the simple ac to dc power supply with filter in Fig. 3-17. As a pulse of current comes through the diode it operates the television circuitry *and* charges the capacitor on this one-half of the ac input cycle. During the next half cycle when the diode does not conduct, the capacitor discharges its stored current into the television causing it to continue to operate. With the proper size capacitor, the output voltage varies very little in amplitude. The capacitor must be of great enough capacitance value to easily store enough current for receiver operation during the time when there is no incoming current through the diode. With this action, "filtering" is accomplished. The term "filtering" means to remove the pulses caused by rectification and to produce a pure, dc output with an unchanging amplitude.

THE CONVENTIONAL, UNREGULATED POWER SUPPLY

The simple power supply has been examined and shown to consist of a diode rectifier and a capacitor filter. These are essentials of the power supply. As shown in Fig. 3-18 there are other "blocks" within many power supplies. There are also various forms of the rectifier and filter circuits. Two typical rectifier circuits are often found in monochrome television receivers—the half-wave and the full-wave rectifier circuits. The following is an explanation of full-wave rectifiers as well as the operation of the other "blocks" of the supply shown in Fig. 3-18.

RECTIFIER CIRCUITS

The half-wave rectifier has been discussed. It is simply a diode which allows *half* of the incoming ac wave through, thus the name half wave (Fig. 3-17). The full-wave rectifier uses the full incoming ac wave. It in effect inverts one-half of the wave and causes it to flow in the same direction as the other thereby using both halves of the incoming ac cycle. Naturally, this is more efficient. The half-wave and full-wave rectifier outputs are compared in Fig. 3-19. Note that one important characteristic of the full-wave system is that there is less time for the capacitor to have to operate the receiver, so smaller value capacitors can be used. Note also that the half wave produces one pulse every $1/60$ second and the full wave produces two pulses each $1/60$ second or one each $1/120$ second. This fact will be important in later discussions.

Fig. 3-20 shows a full-wave bridge rectifier. It inverts one-half of the incoming ac wave in the following manner: As incoming wire A is negative, current can only flow through D1 to the negative output line, through the load (receiver circuitry), and through D3 to wire B which is + at this time. Why does current flow through D3 rather than D4? Because electrical current is negative and seeks a positive charge while being repelled by its like or negative charge. On the next half cycle, input wire B is negative and A is positive. Current flows through D2 through the load back through D4 to the positive line. Note that the incoming current was always routed so it flowed out of the negative line. Thus, both halves of the input ac cycle were used. This type of full-wave rectifier needs only two input lines and two output lines.

TRANSFORMERS

Another type of full-wave rectifier circuit requires a center-tapped transformer. A transformer is a device which allows transfer of energy without direct wire connections. It also allows the control of the amount of voltage input to output ratio. Fig. 3-21 shows several types of transformers. Transformer schematic symbols are shown in Fig. 3-22.

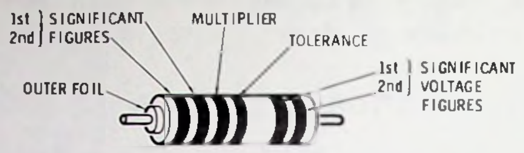
The amount of output voltage obtainable from a transformer depends on the ratio of turns of the output winding (secondary) to the input winding (primary). For example, if the input winding has 100 turns of wire and the output has 100 turns of wire, the output voltage will be the same as the input voltage. However, if the output winding has 50 turns the output voltage will be one-half the input voltage. If the output winding has 200 turns of wire the output voltage will be twice the input voltage.

Energy is transferred from the input winding by magnetic field. Each time the magnetic field about the primary builds out or collapses around the secondary windings, voltage is "induced" in the secondary. The more secondary turns, the more output voltage; the fewer secondary turns the less output voltage. A transformer is often called a *step-up* transformer if its output voltage is more than its input. It is called a *step-down*

CAPACITY IN PICOFARADS

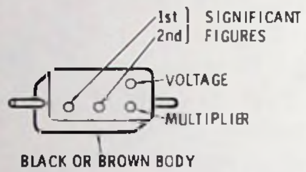
COLOR	DIGIT	MULTIPLIER	TOLERANCE
BLACK	0	1	20%
BROWN	1	10	
RED	2	100	
ORANGE	3	1000	
YELLOW	4	10,000	
GREEN	5	100,000	5%
BLUE	6	1,000,000	
VIOLET	7		
GRAY	8		
WHITE	9		10%
GOLD			5%
SILVER			10%
NO COLOR			20%

MOLDED TUBULAR



ADD TWO ZEROS TO VOLTAGE FIGURES. ONE BAND INDICATES VOLTAGE RATINGS UNDER 1000 VOLTS.

MOLDED FLAT COMMERCIAL CODE



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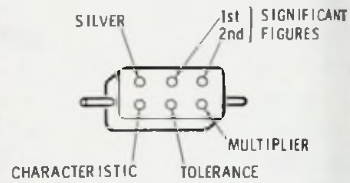

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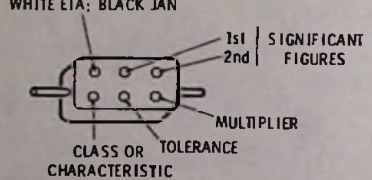


CAPACITY IN PICOFARADS

COLOR	DIGIT	MULTIPLIER	TOLERANCE *	CLASS OR CHARACTERISTIC †
BLACK	0	1	20%	A
BROWN	1	10	1%	B
RED	2	100	2%	C
ORANGE	3	1000	3%	D
YELLOW	4	10,000		E
GREEN	5		5% (EIA) **	F (JAN)
BLUE	6			G (JAN)
VIOLET	7			
GRAY	8			I (EIA)
WHITE	9			J (EIA)
GOLD SILVER		0.1	5% (JAN) ††	
SILVER		0.01	10%	

* OR ± 1.0 PICOFARAD, WHICHEVER IS GREATER.

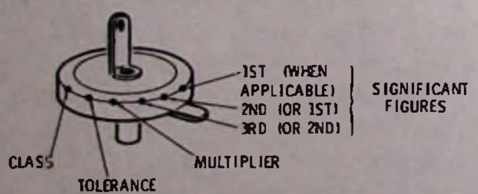
† SPECIFICATIONS OF DESIGN INVOLVING Q FACTORS, TEMPERATURE COEFFICIENTS, AND PRODUCTION TEST REQUIREMENTS.

ALL AXIAL-LEAD MICA CAPACITORS HAVE A VOLTAGE RATING OF 300, 500, OR 1000 VOLTS.

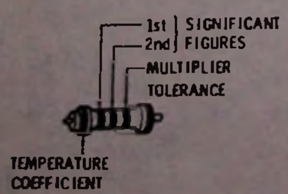
** EIA—ELECTRONIC INDUSTRIES ASSOCIATION STANDARD

†† JAN—JOINT ARMY-NAVY STANDARD

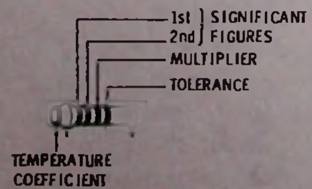
BUTTON SILVER



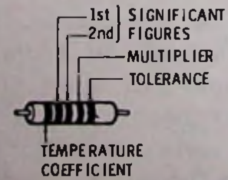
STAND-OFF



TEMPERATURE COMPENSATING TUBULAR



MOLDED-INSULATED AXIAL LEAD



HIGH-CAPACITY TUBULAR

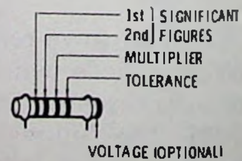
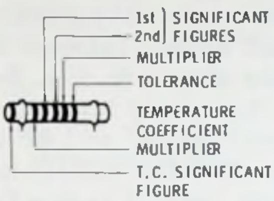
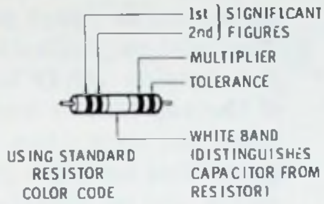


Fig. 3-14. Capacitor color codes. There are many capacitor

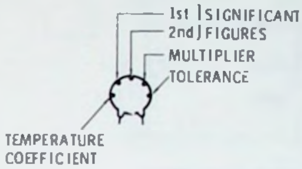
EXTENDED-RANGE T.C. TUBULAR



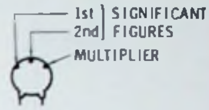
MOLDED



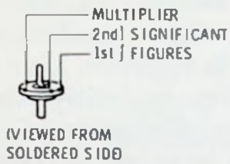
DISC (5-DOT SYSTEM)



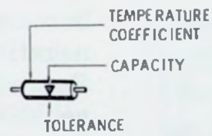
DISC (3-DOT SYSTEM)



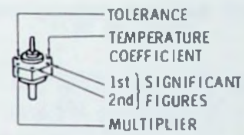
BUTTON



PRINTED VALUE



FEED-THROUGH



TOLERANCE		
JAN LETTER	10 PICOFARADS OR LESS	OVER 10 PICOFARADS
C	± 0.25	
D	± 0.5	
F	± 1.0	± 1%
G	± 2.0	± 2%
J		± 5%
K		± 10%
M		± 20%

STANDARD VOLTAGE RATINGS ARE 500 AND 1000 VOLTS; DEPENDING ON MANUFACTURER

COLOR BAND

TEMPERATURE COEFFICIENTS FOR CERAMIC CAPACITORS

COLOR CODE	TEMPERATURE COEFFICIENT EIA	TEMPERATURE COEFFICIENT JIS*
BLACK	NPO	C
BROWN	N030	
RED	N080	L
ORANGE	N150	P
YELLOW	N220	R
GREEN	N330	S
BLUE	N470	T
VIOLET	N750	U
WHITE	P350/N1000	SL
GOLD	P100	

* JAPANESE INDUSTRIAL STANDARD

CAPACITY IN PICOFARADS

COLOR	DIGIT	MULTIPLIER	TOLERANCE: 10 PICOFARADS OR LESS	TOLERANCE: OVER 10 PICOFARADS	TEMPERATURE COEFFICIENT PPM/°C	EXTEND RANGE TEMPERATURE COEFFICIENT: SIGNIFICANT FIGURES	EXTEND RANGE TEMPERATURE COEFFICIENT: MULTIPLIER
BLACK	0	1	± 2.0	± 20%	0 (NPO)	0.0	-1
BROWN	1	10	± 0.1	± 1%	-33 (N033)		-10
RED	2	100		± 2%	-75 (N075)	1.0	-100
ORANGE	3	1000		± 2.5%	-150 (N150)	1.5	-1000
YELLOW	4	10,000			-220 (N220)	2.2	-10,000
GREEN	5		± 0.5	± 5%	-330 (N330)	3.3	+1
BLUE	6				-470 (N470)	4.7	+10
VIOLET	7				-750 (N750)	7.5	+100
GRAY	8	0.01	± 0.25		+30 (P030)		+1000
WHITE	9	0.1	± 1.0	± 10%	GENERAL-PURPOSE		+10,000
SILVER					BYPASS & COUPLING		
GOLD					+100 (P100, JAN)		

coding systems. Only the most often used are shown here.

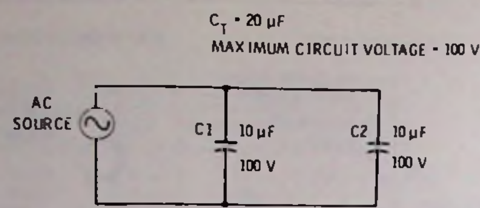


Fig. 3-15. Parallel capacitors.

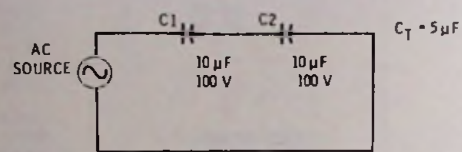


Fig. 3-16. Series connected capacitors.

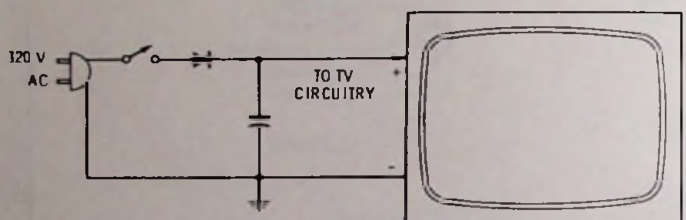


Fig. 3-17. A simple power supply (half wave).

When a transformer winding is center tapped, half the output voltage will appear between the center tap and each end of the secondary winding. The total output voltage will appear between the two outside (end) leads. As shown in Fig. 3-23 if the top lead is positive the center tap will be more negative than the top lead. It will at the same time be more positive than the bottom lead which will be negative at this time. It is this fact which allows the transformer powered full-wave rectifier to operate with only two diodes.

A center-tapped transformer-fed, full-wave rectifier circuit is illustrated in Fig. 3-23. The center tap is grounded and *it becomes the negative lead of the power supply.* When transformer line 1 becomes positive, line 3 is negative. Line 2 is more negative than line 1 and more positive than line 3. Because of the direction of placement of D2 the negative line (3) will have no current coming from it. Instead, current will flow from line 2 through the load back through D1 to the positive line, operating the receiver. On the next half cycle line 3 is positive and line 1 is negative. Line 2 is now more negative than line 3 and current flows

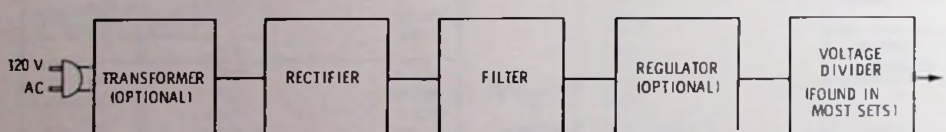


Fig. 3-18. Power supply block diagram.

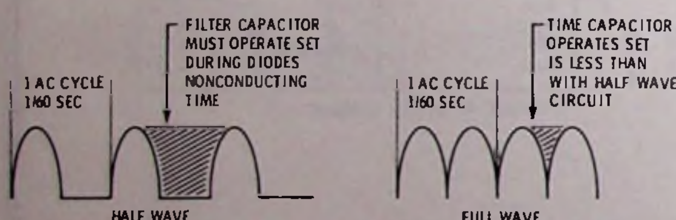


Fig. 3-19. Comparison of half-wave and full-wave rectifier output waveforms.

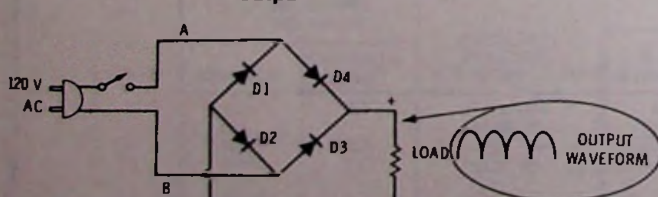


Fig. 3-20. A full-wave bridge rectifier circuit (unfiltered).

from it to operate the receiver, back through D2 and to the positive line. Each half cycle of incoming power was caused to flow in the same direction and each half cycle was used.

The transformer may be used with any type of rectifier circuit. It is usually used to provide the transformer if the output voltage is less than the input. Some transformers will have both step-up and step-down windings on them and are used to supply the various voltages required by the entire receiver—these are called "power transformers."

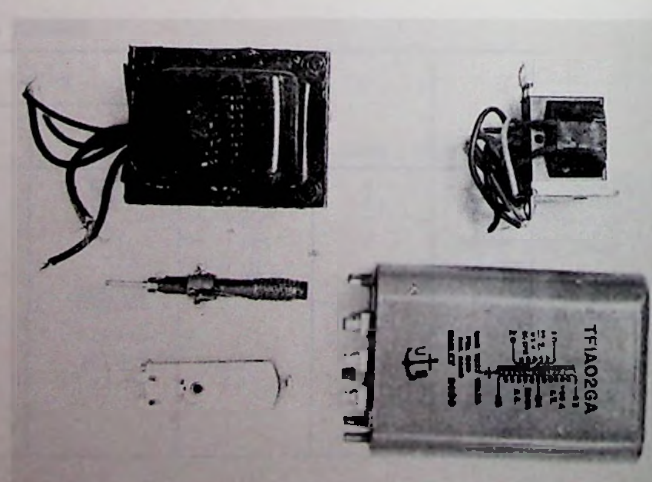


Fig. 3-21. Several types of transformers.

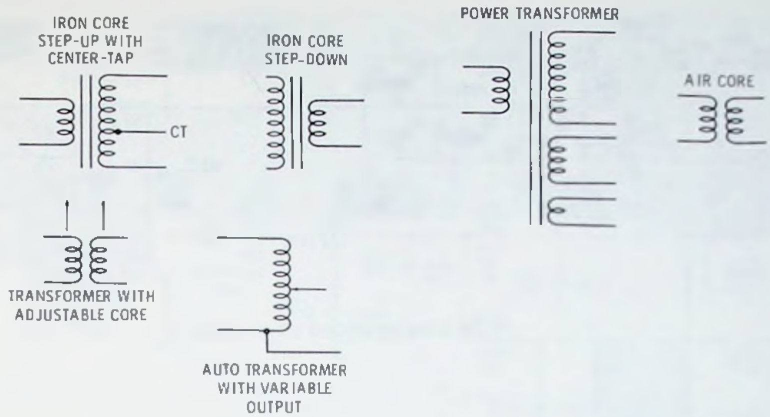


Fig. 3-22. Transformer schematic symbols.

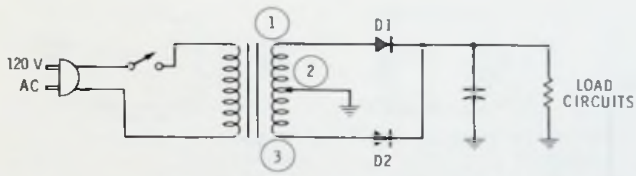


Fig. 3-23. Center-tapped transformer fed full-wave supply.

proper operating voltage for the receiver. If a transformer is used to power the set it is referred to as a transformer operated set. If operated straight from the power line the receiver is referred to as "line" operated. Fig. 3-24 shows an example of both.

To this point it has been explained how the ac line power is converted to a usable dc for use in the television receiver. We have shown that the incoming voltage can be stepped-up or -down or taken directly from the ac outlet, rectified, and filtered. Two other "controls" can be performed on this voltage before it is used by the receiver circuitry. This was shown in Fig. 3-18 in block diagram form. The voltage can be regulated so it will remain constant regardless of the load put on the supply or the change in incoming voltage levels. Voltage regulation will be further explained later in the chapter. One other thing can happen to the voltage before it is used by the set. The main supply can be divided into several supplies as shown in Fig. 3-25. The method used to do this is called "voltage dividing" and is based on the fact that different resistances will cause different voltages to appear or be "dropped" across them. This voltage is called a "drop" because it is found across the resistor and is not available for use anywhere else in the circuit. It is thus "dropped" from further circuit use. In order to explain this principle a very important theoretical law must be discussed—Ohm's law.

OHM'S LAW

The relationship between voltage, current, and resistance is explained by Ohm's law. Three simple formulas make up Ohm's law though they are all derived from one primary formula. The Ohm's law formulas are:

$$V = I \times R \text{ or } R = \frac{V}{I} \text{ or } I = \frac{V}{R}$$

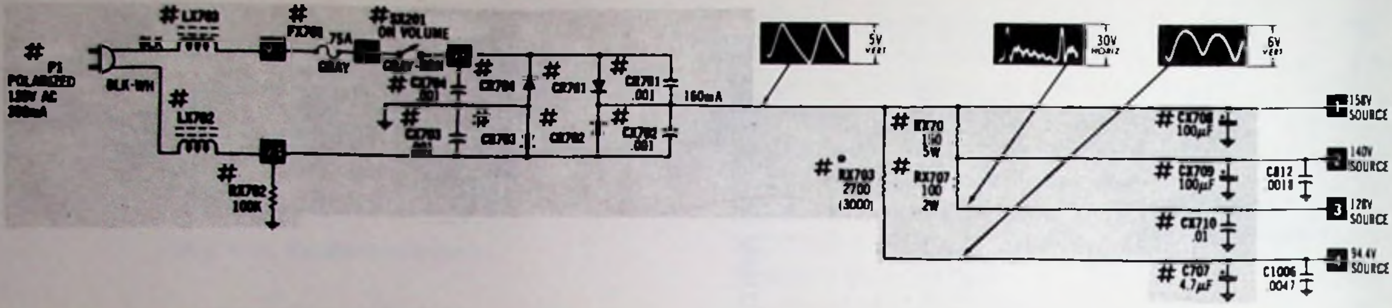
where,

V is voltage in volts,
R is resistance in ohms,
I is current (*i*ntensity) in amperes.

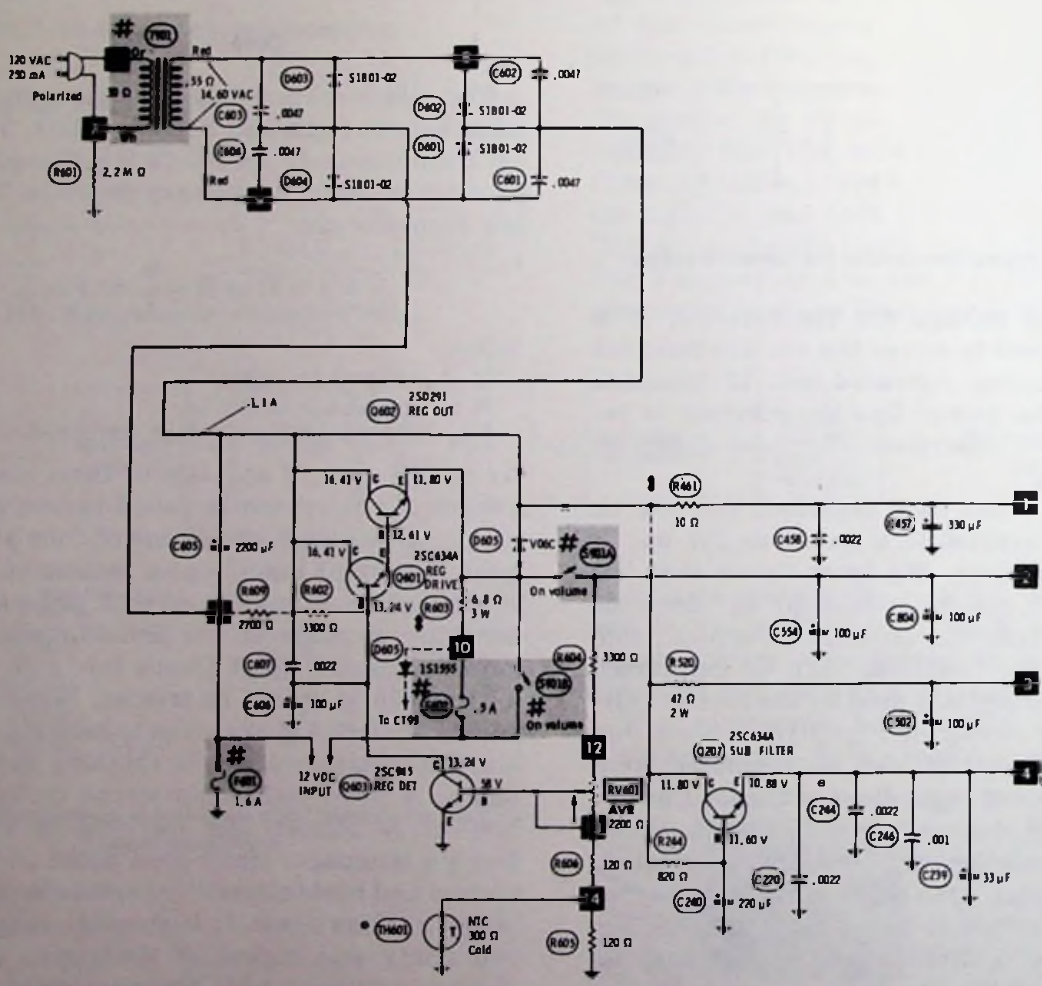
As can be seen, if any two of these elements are known, the third can be found by one of the formulas. A thorough knowledge of Ohm's law is the most important knowledge a technician can have. It allows him to analyze current paths and circuit behavior. Because of the limited space available here, we cannot treat Ohm's law with the detail with which it should be treated. Some simple exercises in the SAM are given to help you gain more knowledge and practice in thinking in Ohm's law terms. A good technician learns to think Ohm's law—it is almost like learning to think in a foreign language. Many good books on basic electronics and basic electricity contain in-depth treatments of Ohm's law. It is strongly suggested that you study this aspect of electronics thoroughly and learn to use it well. Some examples are shown in Fig. 3-26.

Series Circuits

Resistors are often connected in series (Fig. 3-27). When connected in series, there is only one path for current flow and if the path is opened all current flow ceases. There are three rules which explain the behavior of V, I, and R in series circuits:



(A) Line operated power supply.



(B) Transformer operated power supply.

Fig. 3-24. Line operated and transformer operated power supplies.

1. Current is the same everywhere in the circuit.
2. The values of the resistors are added together to give the total circuit resistance.
3. The voltages across each resistor will be proportional to the value of the resistors and will add together to equal the source voltage.

Proof of rule one:

$$I_T = \frac{V_T}{R_T} = \frac{15}{15} = 1\ A$$

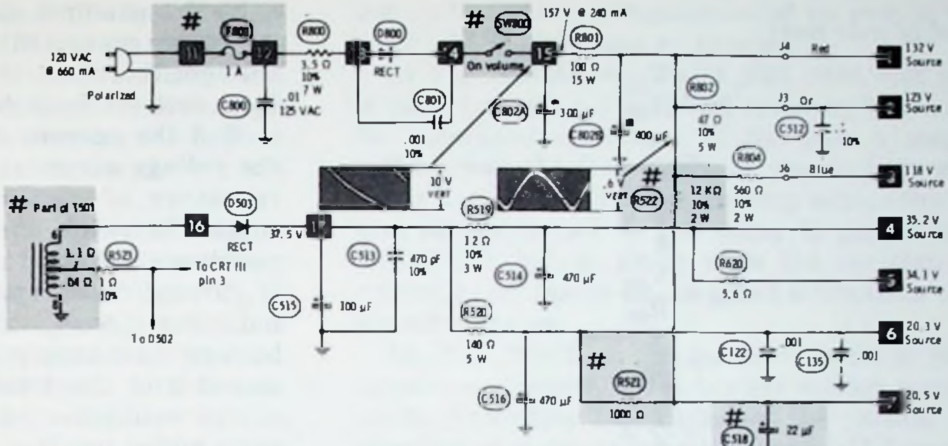
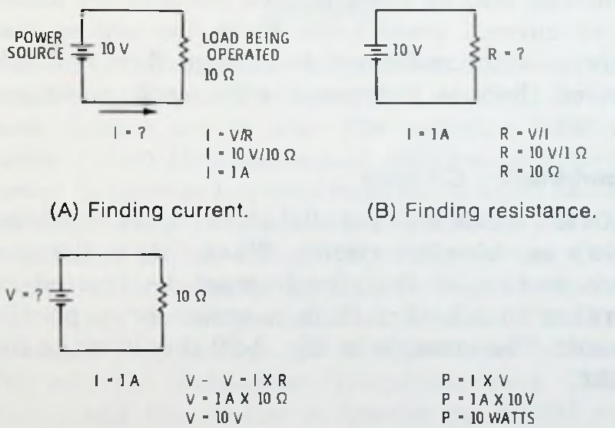


Fig. 3-25. Power supply with voltage divider circuit.



(A) Finding current. (B) Finding resistance.

(C) Finding voltage. (D) Power dissipated by R.

Fig. 3-26. Some examples of Ohm's law.

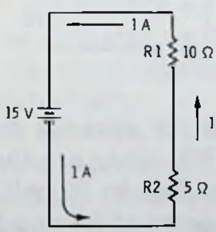


Fig. 3-27. Example of series circuit.

where,

I_T is the total current,
V_T is the total voltage,
R_T is the total resistance.

Proof of rule two:

$$
\begin{aligned}
R_T &= R1 + R2 \\
&= 10 + 5 \\
&= 15\,\Omega
\end{aligned}
$$

Proof of rule three:

$$
\begin{aligned}
V_{R1} &= I_{R1} \times R_{R1} \\
&= 1 \times 10 \\
&= 10\text{ V}
\end{aligned}
$$

$$
\begin{aligned}
V_{R2} &= I_{R2} \times R_{R2} \\
&= 1 \times 5 \\
&= 5\text{ V}
\end{aligned}
$$

$$
\begin{aligned}
V_T &= V_{R1} + V_{R2} \\
&= 10 + 5 \\
&= 15\text{ V}
\end{aligned}
$$

Because there is a single path for current flow, whatever current is allowed to flow in the circuit flows at all points. It is like a water hose—put one gallon in and one gallon comes out!

Note that as rule 3 suggests, the voltage across R1 is twice the voltage across R2—Because the resistance of R1 is twice the resistance of R2 it takes twice the electrical pressure (voltage) to push the same current through R1 than through R2.

Parallel Circuits

When connected in parallel (Fig. 3-28), there is more than one path for current to flow. If any circuit (path for current flow) opens, the others continue to operate unaffected. There are three rules which explain the behavior of V, I, and R in parallel circuits:

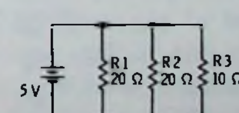


Fig. 3-28. Example of parallel circuit.

1. Current in each branch circuit is dependent on the resistance of that circuit and the total current is the sum of all branch currents.
2. The voltages across all the branch circuits are the same voltage.
3. Total resistance is equal to less than the smallest branch resistance.

Proof of rule one:

$$I_{R1} = \frac{V_{R1}}{R_{R1}}$$
$$= \frac{5}{20}$$
$$= \frac{1}{4}\text{ A}$$
$$I_{R2} = \frac{V_{R2}}{R_{R2}}$$
$$= \frac{5}{20}$$
$$= \frac{1}{4}\text{ A}$$
$$I_{R3} = \frac{V_{R3}}{R_{R3}}$$
$$= \frac{5}{20}$$
$$= \frac{1}{4}\text{ A}$$

Proof of rule two:

$$V_{R1} = I_{R1} \times R_{R1}$$
$$= \frac{1}{4} \times 20$$
$$= 5\text{ V}$$
$$V_{R2} = I_{R2} \times R_{R2}$$
$$= \frac{1}{4} \times 20$$
$$= 5\text{ V}$$
$$V_{R3} = I_{R3} \times R_{R3}$$
$$= \frac{1}{4} \times 20$$
$$= 5\text{ V}$$

Proof of rule three:

$$\frac{1}{R_T} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$
$$= \frac{1}{20} + \frac{1}{20} + \frac{2}{20}$$
$$= \frac{4}{20}$$
$$4R_T = 20$$
$$R_T = 5\ \Omega$$

or

$$R_T = \frac{V_T}{I_T}$$
$$= \frac{5}{1}$$
$$= 5\ \Omega$$

In the example observe that each resistor i in effect connected directly across the sourc voltage; therefore, the same voltage is applied t each resistor/branch circuit. Observe, too, tha to find the current through each branch circui the voltage across the resistor is divided by the resistance of that resistor/branch circuit. The current in each branch is dependent only upon the resistance of that branch and the voltage across it. If current must come from the battery for each individual circuit it then seems reasonable that the battery must supply currents separately for each circuit and the total current coming from the source would then be equal to all the branch currents added together. It also seems reasonable to conclude that as more branch circuits are added, more current must come from the source than before—total resistance to current flow from the source then is decreased with each additional circuit.

Combination Circuits

Often series and parallel circuits are combined into a combination circuit. When this is the case, each section of the circuit must be treated according to whether it is a series or a parallel circuit. The example in Fig. 3-29 should make this clear.

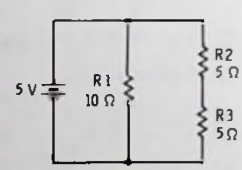


Fig. 3-29. Resistors connected in series and in parallel.

Whatever current flows in R3 must likewise flow in R2—they are then in series. However, current can flow in R1 without any effect on the circuit made up of R2 and R3. Resistor R1 is in parallel with the series circuit of R2 and R3.

Total resistance is found by first treating R2 and R3 as a series circuit and adding their resistance values together—5 + 5 = 10 ohms. The circuit is now seen to be made up of two parallel 10 ohm resistances. By using the parallel resistance formula shown previously the total resistance is calculated to be 5 ohms. We can at this point explain a shortcut for finding parallel resistance totals. If the values of the parallel resistors are the *same*, divide the value of one of the resistors by the number of resistors in parallel. In this instance 10/2 = 5.

Current through the branches is calculated as before. Resistors R2 and R3 are in series so the same current flows through both. To find the current through R2 and R3, add R2 to R3 and divide the total (20 Ω) into the voltage across them (5 V)—5/10 = 0.5 A. To find the current through R1, divide R1 into the voltage across it—5/10 = 0.5 A. To find the total current in the circuit, add both current legs (0.5 + 0.5 = 1 A).

Voltage across R1 is the source since R1 is connected directly across the battery. The voltage across R2 and R3 must be calculated. $V_{R2} = I_{R2} \times R_{R2} = \frac{1}{2} \times 5 = 2\frac{1}{2}$ volts. $V_{R3} = I_{R3} \times R_{R3} = \frac{1}{2} \times 5 = 2\frac{1}{2}$ volts. Note that V_{R2} and V_{R3} added together equal their source voltage which is in this case the 5-volt battery shown in Fig. 3-29.

METERS

Most technicians use a "combination" meter to measure voltage, resistance, and current. Several such meters are in use. The volt-ohm milliammeter (vom) is portable and requires no external power to operate but does have an internal battery for measuring resistance. It is probably the most popular of all the meters presently in use. Other meters often require ac line voltage to operate and so are not as portable as the vom. This type of meter may include the vacuum tube voltmeter (vtvm), the field-effect transistor vom (FET-vom), and the digital voltmeter or digital vom (dvm or dvom). All these may be lumped together as electronic voltmeters (evm). All but the vtvm, because of its high voltage requirements, are also commonly found operated by battery as well as the ac line, making them as portable as the vom. The dvm is fast becoming the most popular meter to be used by the service technician.

A major difference exists between the vom and the evm which makes the evm more desirable. Because of the low input impedance (total opposition to ac current) of the vom it often "loads" the circuit being tested causing incorrect voltages to be read. Though impedance is actually the total opposition a circuit exhibits to ac, for our purposes here it can be considered to be "resistance." The vom input impedance is typically 20,000 ohms per volt; the input impedance of an evm is typically 10,000,000 ohms or greater.

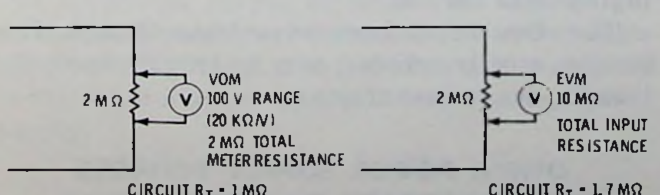


Fig. 3-30. Comparison of vom and evm loading effects.

In Fig. 3-30A note that a 20K ohm/volt meter is placed across a 2 megohm resistor. This makes the combined resistance of the pair 1 megohm rather than the 2 megohm of the resistor alone. What happens to the voltage drop across this portion of the circuit as the meter is placed in the circuit? It halves along with the resistance of course, resulting in an incorrect evaluation of the circuit voltages.

In Fig. 3-30B a 10 megohm evm is placed across the 2 megohm resistor for voltage measurement. According to Ohm's law the parallel combination of resistors is approximately 1.7 megohm or close to the original 2 megohm—the reading is thus much closer to being correct than if the vom were used.

Very few resistors, of a high enough value to cause evm reading inaccuracies, are to be found in common television circuitry. However, there are many resistors which could cause measurement inaccuracies with a vom, especially on its lower ranges. An evm must always be used in sensitive circuits, such as oscillators and high frequency circuits, where a low impedance vom may cause them to stop operating or change frequencies.

As shown in Fig. 3-30 voltages are always measured by placing the voltmeter *across* (in parallel) the component whose voltage drop is to be measured. To measure current the meter must be connected in *series*. This means that the circuit must be opened and the meter inserted into the open circuit. In order to measure water flow in a hose a flow meter must be inserted into the hose —Electrical current can usually be thought of as behaving like water.

Resistance is checked by placing the ohmmeter in parallel with the resistance to be checked—with the circuit power *off*. Attempts to measure resistance with the power *on* can destroy the meter. Measurement of in-circuit resistance is best accomplished by removing one end of the resistor from the circuit. If this is not done, resistance of other components in the circuit may influence the measurement. Exercises are given in the SAM to allow you to prove all the above applications and to give you practice in reading the meters.

VOLTAGE DIVIDER POWER SOURCES

Fig. 3-31 illustrates a conventional power supply with a voltage divider used to create more

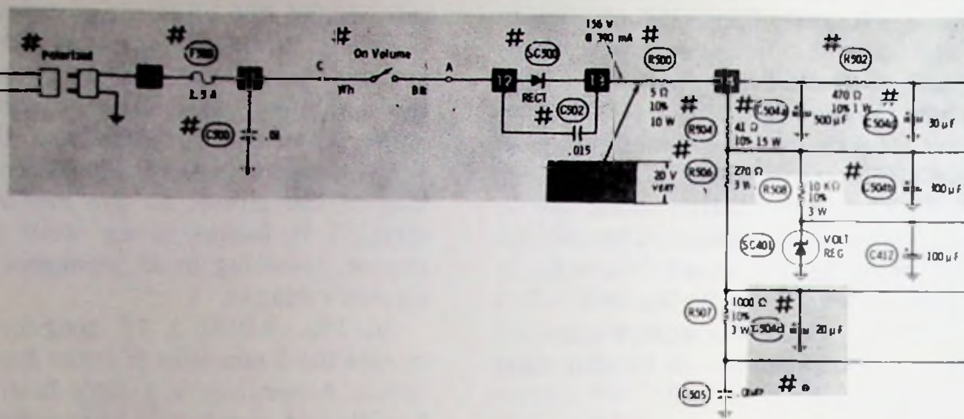


Fig. 3-31. A line operated power supply with a voltage divider output circuit.

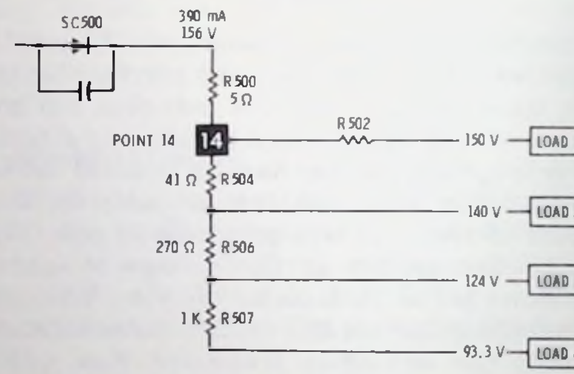


Fig. 3-32. Simplified power supply voltage divider.

than one voltage supply from a single source. The power supply in Fig. 3-31 uses a half-wave rectifier, SC500, and filter capacitors C504A, C504b, C504c, and C504d. Resistors R504, R506, and R507 are voltage divider resistors which allow the basic 150 volt source to be divided into 140 volt, 124 volt, and 93.3 volt supplies. Another supply of 16.21 volts is also derived from the same source but in a slightly different manner because of the zener diode SC401. This type supply will be discussed later with other regulated voltage circuits.

Fig. 3-32 shows a redrawn circuit of Fig. 3-31, simplified for easier understanding. As the current used for various circuits in the receiver flows through the divider resistors, voltage drops are created which are directly proportional to the amount of resistance the current must flow through. For instance, by Ohm's law we can show that 1.95 volts is dropped across R500—$V = I \times R = 0.390 \text{ A} \times 5 \text{ ohms} = 1.95 \text{ V}$. This leaves approximately 154 volts at point 14 to be divided by the voltage divider resistances. One load is connected directly across this 154 volt source and the current flowing into this load causes a 4 volt drop across R502, leaving 150 volts for use by load 1 circuit.

Load 2 requires 140 volts, so R504 must drop 14 volts—from 154 volts at point 14 to 140 volts at the load circuit input. Load 3 requires 124 volts. Resistor R506 must then drop 16 volts from the 140 volt source at the bottom of R504. It can be seen that R506 and R504 must drop a combined 30 volts. Now, load 4 requires only 93.3 volts so resistor R507 must further drop the voltage from 124 volts at the bottom of R506 to the 93.3 volts needed—R507 must drop 30.7 volts.

This is a relatively simple method of supplying several voltages from a single source although it does have its disadvantages. For example, if either of the series resistors opens, say R506, the circuits receiving current past that point will be without operating currents. Also, because the currents through the resistors are cumulative when one circuit opens and draws no current, the other voltage sources will rise in value. If R507 opens, the approximately 0.031 amp in its circuit will no longer flow—$I = \frac{V}{R} = \frac{30.7 \text{ V}}{1000 \text{ ohms}} = 0.0307$ amp. This 0.031 amp also flows through R504, R506, and R500 causing some voltage drop across each. Now without this portion of the current flowing through these resistors the portion of the voltage drop created by that current will be missing and the voltages left for use by the circuits will be higher than normal.

The circuit does have advantages though. It is simple, usually reliable, easy to troubleshoot, and inexpensive to manufacture.

OTHER POWER SUPPLY SOURCES (SECONDARY B+ SUPPLIES)

In Fig. 3-33 the source of supply for the 41.4

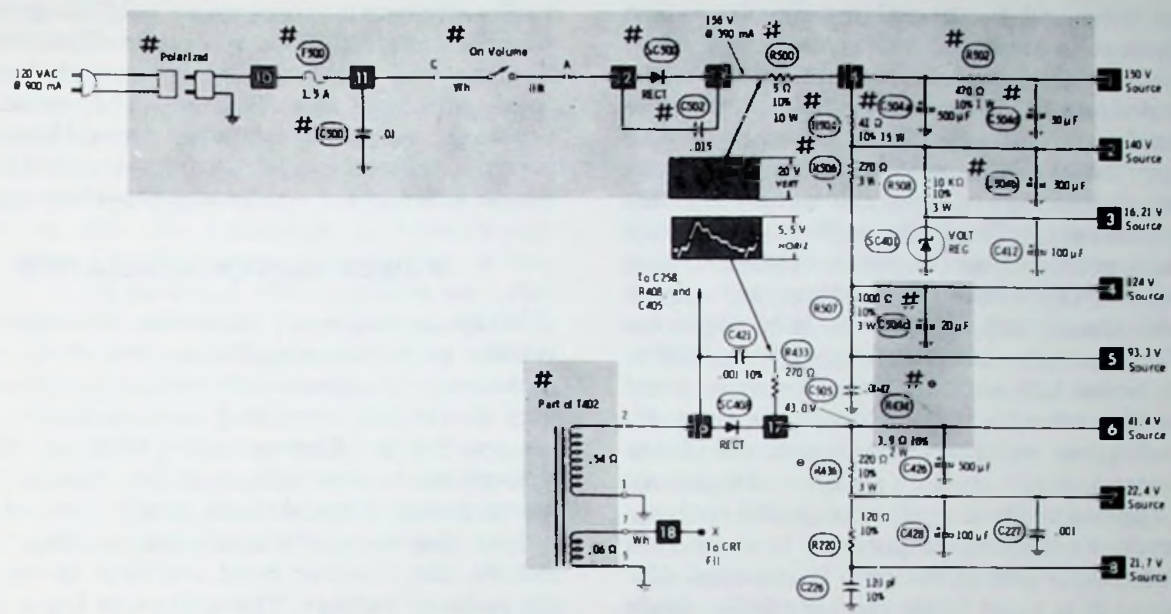


Fig. 3-33. A complete monochrome television power supply.

volt, 22.4 volt, and 21.7 volt supplies is a part of T402, the horizontal output transformer. In some monochrome receivers all the signal circuits are supplied power from such sources called secondary B+ supplies. This means that if the horizontal circuits cease functioning, there will be no signal circuit operating voltages and the receiver will be "dead." These supplies may be taken from the horizontal output, horizontal driver, or horizontal output transformer circuits. Voltages may be produced either during scan or retrace times. Such supplies are normally called either retrace or scan derived supplies. Note that except for their source (horizontal output transformer) these supplies appear identical to other low voltage power supplies. There is one important difference, however, which must be remembered when replacing components in these circuits. Circuit frequency is 15,734 Hz instead of 60 Hz which means that special high frequency rectifiers must be used.

Most receivers using sweep derived power supplies use conventional primary supplies as explained earlier to power the horizontal oscillator and horizontal output circuits. This supply may be line or transformer operated and either regulated or unregulated. The power supply is serviced in the same manner as any conventional primary supply.

SWEEP RECTIFIED POWER SUPPLIES

The flyback transformer (horizontal output transformer) in conventional television receivers wastes large amounts of available energy. Tremendous energy is available from the flyback because of the frequency at which it is pulsed. Yet in the past it has been used only for developing the high voltage, focus voltage, boost voltage, and high voltage rectifier filament voltage. Engineers are now taking advantage of this available power by using it to totally power the set—including the picture tube filament.

The advantages of sweep rectification make it quite attractive to the manufacturer. It eliminates the large, heavy (and costly) power transformer and its associated heat. The special flyback transformer used for sweep rectification is smaller, operates cooler, and the output can be regulated and filtered easier than that from a 60-Hz power transformer.

The term sweep rectification is used for either pulse or scan rectification though some technicians refer to any power supply taken from the flyback as being scan rectified. The difference is as illustrated in Fig. 3-34. The pulses shown are produced

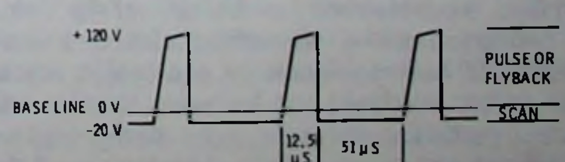


Fig. 3-34. Flyback pulses used to supply voltages by scan or pulse rectification.

at retrace time and the negative going base line between pulses is produced during scanning time. If the rectifier is placed in the circuit so as to allow conduction of the positive pulses we have pulse rectification. If the rectifier is allowed to conduct on the negative portion of the wave we have scan rectification. There are some very important differences. The pulse voltage is usually many times greater than the scan voltage. Thus, it is extremely important to replace any diodes taken from the circuit, exactly as they were removed. For example, assume the positive pulse in Fig. 3-34 to be 120 volts and the negative scan voltage to be −20 volts. The −20 volts is the voltage needed (scan rectification) but if the diode were reversed, +120 volts (pulse rectification) would be applied to the circuit in opposite polarity at six times the needed amplitude. It should be added that this is somewhat of a theoretical discussion since it is most likely that if such a diode is reversed the flyback circuit will not operate. It is also important to use exact replacements for the rectifiers as mentioned earlier. Pulse time is approximately 12 microseconds and scan time is approximately 51 microseconds. By comparison, the half-wave pulse duration of a 60-Hz power line source is approximately 8800 microseconds. The replacement rectifier must be capable of high speed switching.

OTHER POWER SUPPLY COMPONENTS

Transformers, rectification, and filter components have been discussed. There are other components in the power supply which are also important for proper operation of the television receiver. In Fig. 3-33 C502 is used to filter out any noise created by the diode as it switches on and off. Capacitor C500 is used to filter out interference pulses on the incoming ac line and those produced inside the tv which might get into the power line and interfere with other sets. And, F500 protects the receiver from damage from over-voltage on the ac line or from damage caused by short circuits within the receiver.

Note that many components in the circuit just described are marked as being *safety related* (shaded portions of the schematic) and should be replaced only by exact or equivalent replacement parts. For fuses and circuit breakers this does not mean simply replacing a 1 amp fuse with a 1 amp fuse. It means the *identical*-type fuse. The reason for this is that US and foreign fuse standards are not always identical. Though rated at the same value, one may "hold" longer and a a higher current than the other. That differenc in time and current may be enough to destro some sensitive circuits. For ALL repair part use *exact replacement parts from the manufacturer* if possible. If this is not possible buy a *brand name exact equivalent replacement.*

POWER SUPPLY REGULATION

Many monochrome television receivers employ voltage regulator circuits as part of the receiver power supply. A constant voltage supply is necessary for stable sync and picture quality due to the sensitivity of transistors and ICs to changing voltage and over-voltage. Also, because during heavy power demand times, power companies may reduce the voltage distributed to electrical customers, the receiver must continue to operate off the reduced voltage. There are two types of regulators currently being used in monochrome television receivers: the zener and the series transistor regulators. They may be used on either a conventional or sweep rectified B+ supply.

Zener Regulators

The simplest of all regulators is the zener diode. The zener is designed to maintain a fixed voltage across itself when the "zener" or reverse-voltage breakdown point is exceeded. Fig. 3-35 shows a simple zener regulated supply. The voltage source is a 36 volt unregulated dc. The zener and the load draw enough current from the supply that the voltage drop across R_1 is the difference between the source voltage and that needed, regulated voltage at R_L. If the source voltage increases, zener current increases enough to produce an added voltage drop across R1 that will continue to keep 28 volts across the zener and, therefore, R_L. Note that the zener is placed in the circuit so as to normally be nonconducting.

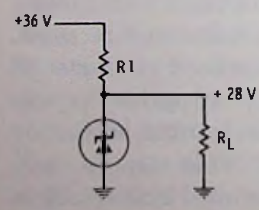
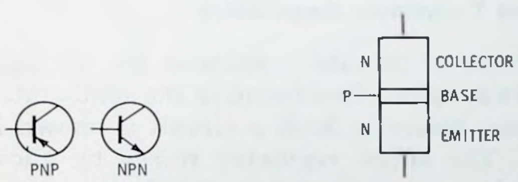


Fig. 3-35. A simple zener regulator.

Series Transistor Regulators

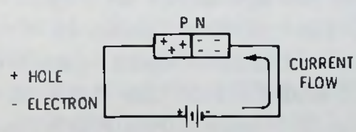
Before the transistor regulator circuit can be fully understood, it is necessary to have some knowledge of how the transistor itself works. Because of space available it will be necessary to limit our discussion on transistor operation, but the SAM will provide more detailed explanations with exercises to allow you to prove for yourself the theoretical concepts presented here.

Fig. 3-36A shows the schematic symbols of the most common types of transistor—the bipolar npn and pnp. Fig. 3-36B shows a symbolic representation of how the transistor is constructed. The npn transistor is shown as consisting of two wafers of n-type material with a p-type material sandwiched between them. A pnp transistor is just the opposite. An n-type material is silicon or germanium "doped" with another element (an impurity) having more electrons than can fit into the crystal lattice structure of the silicon or germanium. A free electron is made available for current flow with each impure atom added to the crystal. A p-type material is silicon or germanium doped with an element having one less electron than will fit into the crystal lattice structure of the silicon or germanium. A "hole" for electron reception is then made available for each impurity atom used.

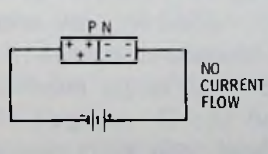


(A) Schematic symbols. (B) Npn transistor construction detail (symbolic).

Fig. 3-36. Transistor symbols.



(A) Forward biased pn junction.



(B) Reverse biased pn junction.

Fig. 3-37. Junction conduction of n- and p-type material.

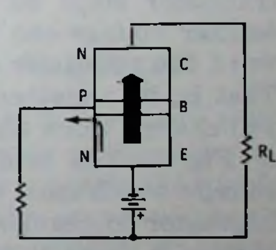
Junctions between n- and p-type material will conduct when current is applied in one direction but not when applied in the other direction (Fig. 3-37). When a negative supply is applied to the n-type material the free electrons in that material are repelled to the junction where they can be made to cross over the junction and fall into holes in the p-type material. A voltage of approximately 0.2 volt and 0.6 volt is necessary to cause the electrons to cross the junction in germanium and silicon junctions, respectively. Once the electron has crossed the junction, positive battery potential attracts it into the battery leaving the space that the electron previously filled empty and ready for another electron. This manner of connection of supply voltage to the n- and p-type material is called *forward bias* and the junction conducts.

When the supply voltage is reversed, with positive supply connected to n-type material and vice versa, no conduction occurs. Instead, the positive supply attracts electrons from the junction and the negative supply attracts the holes away from the junction. Since they cannot combine, no current crosses the junction and no current flows. This manner of connection of supply and materials is called *reverse bias*.

You may have noticed that we have just described the operation of a diode rectifier. If so, you are correct. This is precisely how the rectifier works. It is merely a pn junction of silicon or germanium. Most diodes used in power supplies are silicon. Silicon can withstand greater heat, handle higher voltages and currents, and "leaks" less. Leakage of diodes refers to the amount of current flow which occurs when it is reverse biased (Fig. 3-37B). This current should be so small as to be negligible—in the microamp range.

Transistors, having two junctions rather than one, operate much differently than diodes. The base and emitter junction (Fig. 3-38) is usually forward biased. When forward biased, current from the emitter moves into the base region and

Fig. 3-38. A small base-emitter current controls a large emitter-collector current.



there because of the strong collector voltage and the extremely thin base region the current carriers are pulled on through to the collector. Note that the collector is reverse biased. At least 98% of the current entering into the base region from the emitter continues into the collector. A very small base current is used to cause the conduction from base to emitter but once inside the base material the collector voltage causes it to continue to the collector. A small control current in the base thus controls a large collector current—this is called amplification.

The base is seen to be the control element of the transistor. By causing the transistor to conduct more, or less, current by changing the base bias, the transistor reacts somewhat like a variable resistor. The voltage drop across a resistor, remember, is directly proportional to the resistance. This concept is important to the following discussion of series transistor voltage regulators.

Series transistor voltage regulation is the type most often encountered in television receivers. Fig. 3-39 shows such a regulator and illustrates why it is called a series regulator. The series or "pass" transistor is used as a variable resistance in series with the load. The base of the pass transistor is held at a constant voltage supplied by another regulator circuit—a zener diode. The transistor is made variable by the fact that the base-to-emitter junction of a silicon transistor always attempts to maintain 0.6 volt across itself. Increase the voltage across the junction and it conducts heavy enough (its resistance changes) to

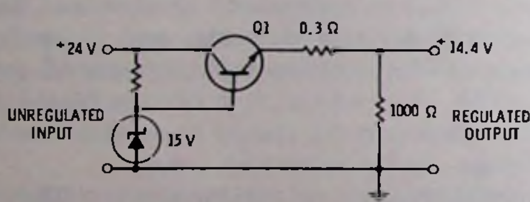


Fig. 3-39. A series transistor regulator.

bring the voltage back down to 0.6 volt. Decrease the base-to-emitter voltage below 0.6 volt and the transistor stops all conduction. If the base-to-emitter voltage can be varied from 0.6 volt upward the transistor conduction rate will change. That is, its resistance to current flow through it will change. Since the base voltage in the example of Fig. 3-39 is held constant, it is the emitter voltage which must change in order to cause the transistor to change its rate of conduction. And change it does! With the emitter supplying the output current to the load, if the load resistance decreases (load current increases) the voltage drop across it is less. The voltage at the emitter is, therefore, more negative than before. With the emitter more negative the base-to-emitter voltage is greater and the heavier forward bias causes the transistor to conduct more (its resistance decreases). With the pass transistor's resistance decreased, the voltage drop across it is decreased and the load has more voltage available to it.

If the load current decreases (resistance increases) the voltage drop across the load increases. The positive voltage at the emitter is increased as the voltage across the load is increased. The transistor is, therefore, biased off and its conduction decreases (resistance increases) an the voltage drop across it increases leaving less voltage for the load.

The emitter voltage attempts to follow the base voltage and since the base voltage is fixed, th emitter voltage also tries to stay fixed. For this reason this circuit configuration is often referred to as an emitter follower. In Fig. 3-39 the base voltage is 15 volts. The supply output will attempt to keep an output equal to the base voltage minus the 0.6 volt drop across the emitter-to-base junction. The output of this circuit will be regulated at approximately 14.4 volts.

Shunt Transistor Regulators

Shunt or parallel transistor B+ voltage regulators are also often found in the solid-state monochrome receiver. Such a circuit is shown in Fig. 3-40. The shunt regulator works by allowing a transistor, connected from the B+ line to ground, to conduct heavier when the output B+ increases. As the transistor, such as Q1 in Fig. 3-40, conducts heavier more voltage is dropped across R1 and R2 and leaving less voltage output. As B+ output decreases the transistor decreases conduction and less voltage is dropped across the series resistors leaving more voltage output. Thus, the shunt regulator is used to regulate B+ supplies.

The output voltage of Q1 in Fig. 3-40 is set by zener CR1. Its current path is from ground through the emitter-to-base junction of Q1, through CR2 and CR1 to the B+ line. Only when the voltage on B+ source No. 8 is greater than 13 volts will CR1 conduct. When it conducts its current flows through the emitter-to-base junction of Q1 causing it to conduct, lowering the B+ line voltage as just discussed. As the line voltage drops below 13 volts CR1 stops conducting, Q1 stops conducting, and the B+ output rises again. The B+ output is held to a voltage equal to the sum of the voltage drops across CR1, CR2, and the emitter-to-base junction of Q1.

Power supply voltage regulators found in black and white televisions may be simple as shown in Fig. 3-40 or somewhat more complex as that shown in Fig. 3-41. In Fig. 3-40, the regulator transistor is biased to the required voltage by zener diode CR1 as just discussed. The circuit of Fig. 3-41, however, is much more complex. In this receiver,

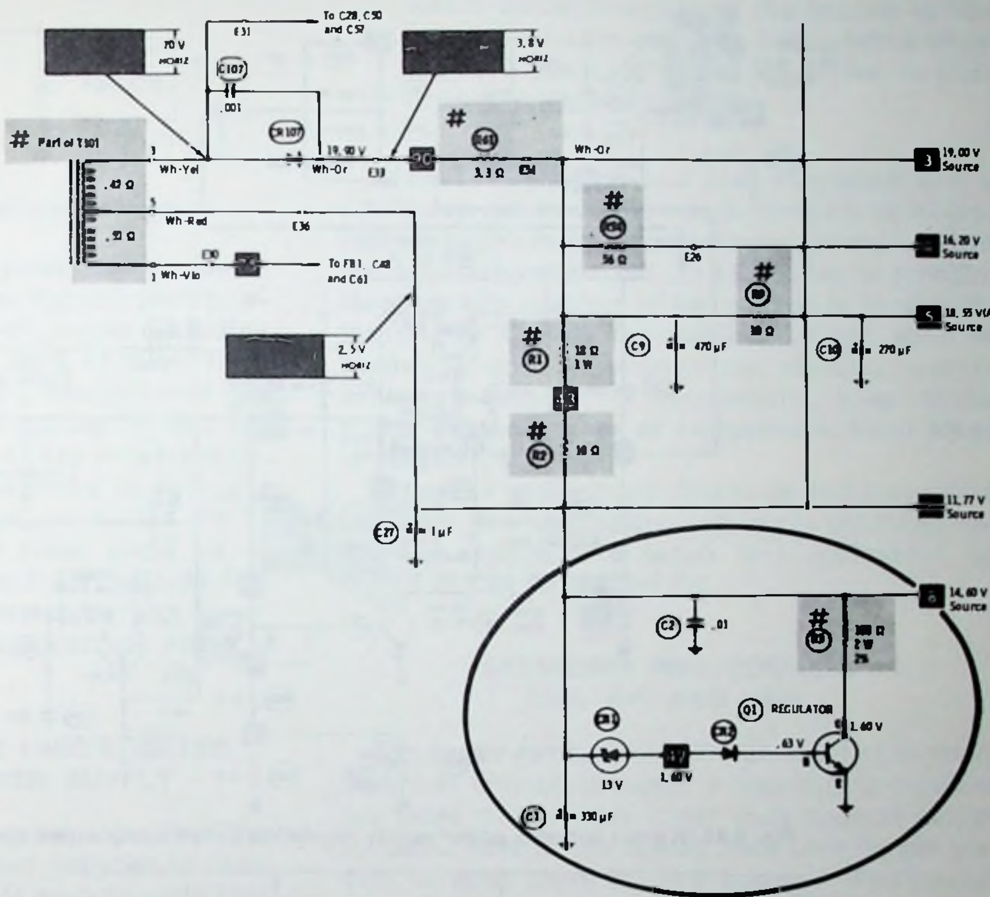


Fig. 3-40. A simple monochrome receiver shunt regulated power supply.

source output voltage is "sensed" across a voltage divider network and bias to the pass transistor, Q602, is provided by RV601 for voltage adjustment. The adjustable bias and the sensed supply output level is applied to Q603, amplified and applied to Q601, the regulator driver, then finally used to cause the pass transistor Q602 to change conduction as previously explained in reference to Q1 in Fig. 3-39.

Thus, as the voltage output of the supply changes, the base bias of Q603 changes causing Q601 to control the conduction of Q602 and the output voltage to be brought back to normal as set by RV601.

Another voltage regulator system which we may find used in tv systems in the near future is the "three-terminal" voltage regulator. Although an IC, it has the appearance of a transistor. It has the same case style as many power transistors and only three leads, hence the name three-terminal voltage regulator. Fig. 3-42 shows both the schematic diagram and case style of a typical three-terminal device. Fig. 3-43 shows a circuit using a three-terminal regulator.

Other IC regulators are available. These are multipin units and must be treated as any other IC. These regulators are usually used as control devices for a pass transistor and not only provide voltage control but current overload protection as well.

BATTERY POWERED TELEVISION

Few television receivers are battery-only powered. Several receivers, however, will be found to be ac *or* battery powered. In most cases the supply systems of these sets are quite simple as shown in Fig. 3-44. This set has an external ac power pack which includes a step-down transformer, and rectifiers. It is plugged into the receiver via plug S05. When this power pack is plugged into jack PL5 the receiver's internal batteries are disconnected and the rectified ac is applied through F1, SW51, and across filter capacitor C706. As the ac power pack is removed from PL5 the batteries are again connected by the switching action of PL5 and the set becomes battery powered. The batteries used here are not rechargeable as are

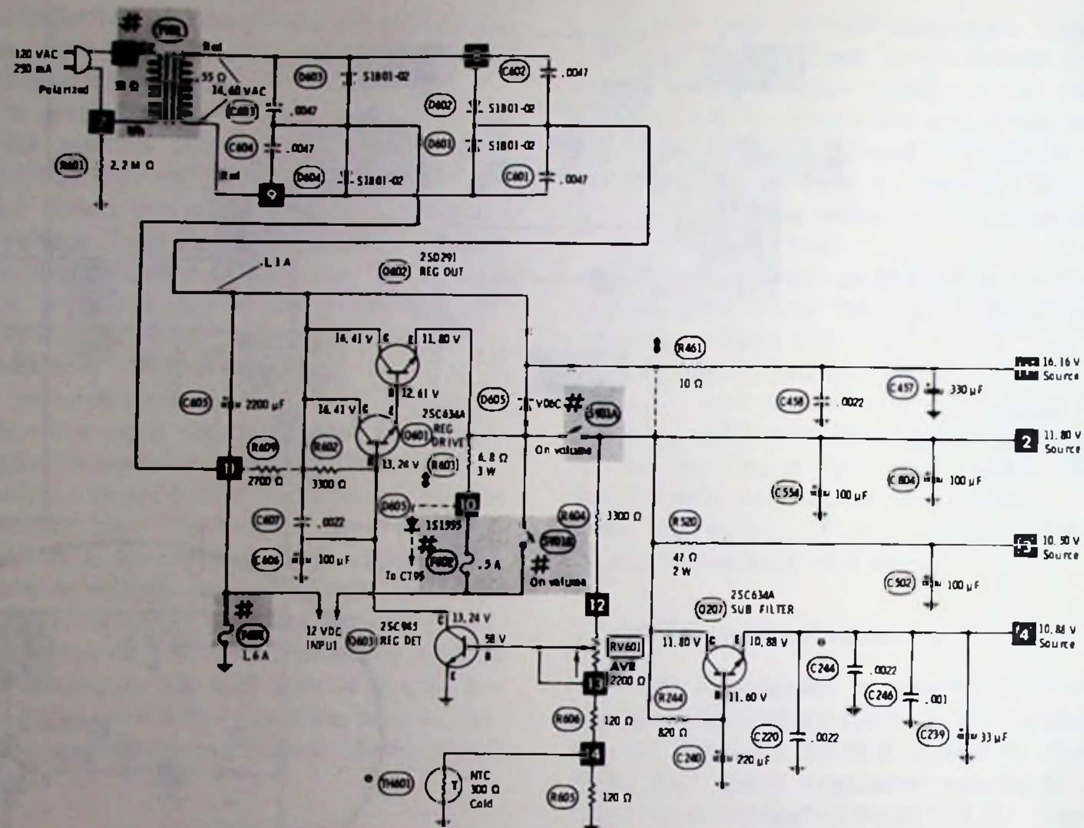
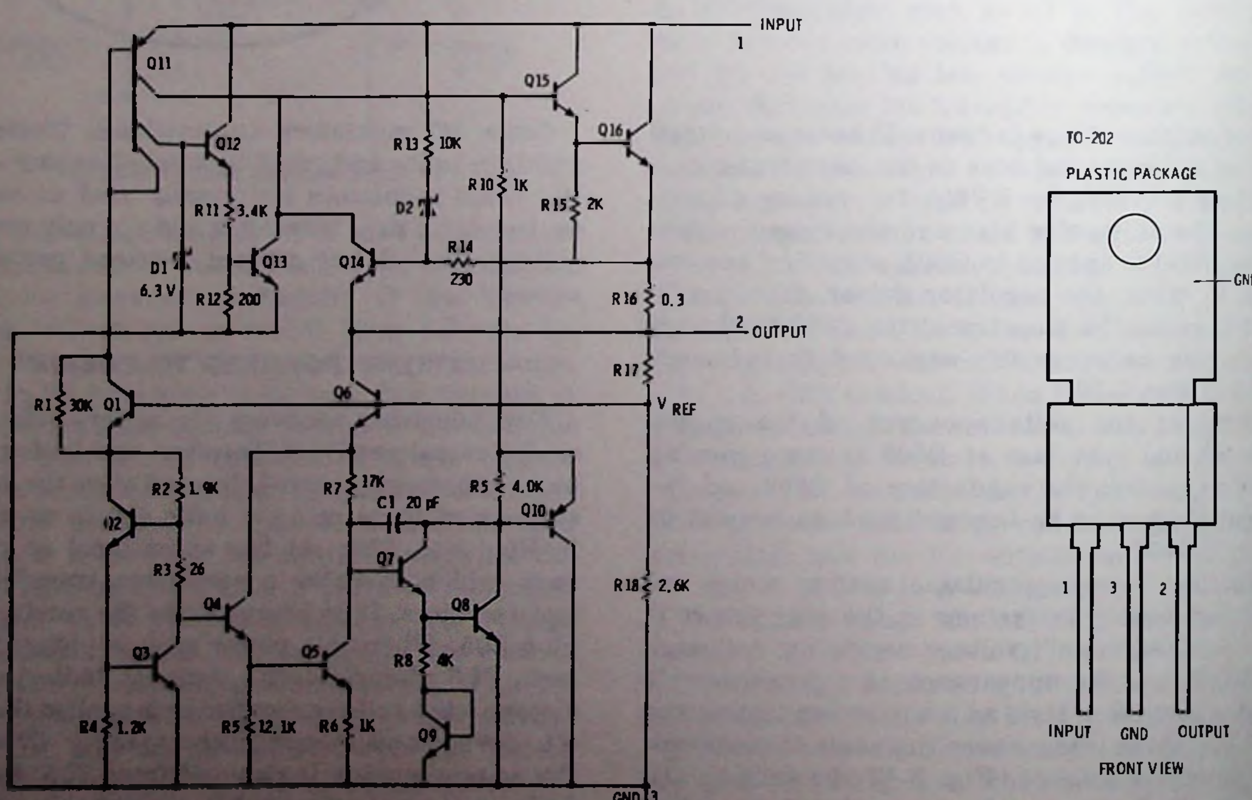


Fig. 3-41. A more complex power supply regulation circuit using series transistor regulation.



(A) Schematic diagram.

(B) Case.

Fig. 3-42. Three-terminal voltage regulator. (Courtesy General Electric Co.)

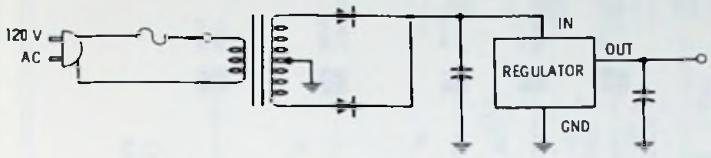


Fig. 3-43. Power supply with three-terminal regulator.

those shown in Fig. 3-45. The power supply shown in Fig. 3-45 can be ac powered, battery pack powered, or by an external 12 volt source including the automobile power source, such as taken from the cigarette lighter receptacle. The primary difference between these two supplies is that the batteries of the set in Fig. 3-45 are rechargeable. Note that as the receiver is operating on ac power the batteries remain connected across the B+ to ground lines of the supply from point 99 to ground through D76, R710, and SW2. Diode D76 protects the set against incorrect battery insertion and R710 limits the charge current which is applied to the cells.

TROUBLESHOOTING THE UNREGULATED CONVENTIONAL POWER SUPPLY

The conventional primary power supply (Fig. 3-46) is the easiest of all power supplies to troubleshoot. The technician should keep in mind that the low voltage power supply (B+ supply) is the source of operating voltages for every section of the receiver and that defects in parts of the supply will result in a dead set while others may result in one or more sections of the set being dead. The more usual problems in the conventional power supply are *shorted* diodes or filter capacitors, *open* diodes (rare), open filter capacitors, dropping resistors, fuses, switches, leaky filter capacitors, and occasionally an open or shorted transformer.

The following symptoms generally indicate a trouble in the low voltage power supply:

1. A completely dead set, that is, a set with no raster, sound, channel indication light, or lighted tube filaments.
2. A set which hums.
3. A set with a small picture or raster (see Fig. 3-47).
4. A set which blows fuses or circuit breakers immediately after the set is switched on.
5. A set with horizontal weaving of raster or vertical expansion and compression of the raster (often called "breathing").
6. A set with one or two bars (black or white) which move slowly from the bottom of the screen to the top (see Fig. 3-48). Often when the bars reach the top of the screen vertical instability will be observed.

After the symptom has been diagnosed and a conclusion reached as to which circuit is defective, logical troubleshooting procedures are used to find the defective component. The first step in troubleshooting any problem or any circuit is to visually inspect the chassis for obvious defects, such as burned or cracked components, smoking components, excessively hot components, loose wires, shorts between wires or components, loose plugs or modules, etc.

After the preliminary diagnosis and inspection are made, the technician must begin troubleshooting the supply with bench test equipment, as shown in Charts 3-1 and 3-2.

SERVICING PROCEDURE— LOW B+ AND HUM

The power supply is not always open or shorted. The most difficult to repair power supply troubles are those which cause lower than normal output voltages, hum in the sound, hum bars in the picture, or other more subtle symptoms. The oscilloscope is usually most effective in locating these defects.

Hum problems are not always due to a failure in the power supply. Heater to cathode leakage in tubes may cause video or audio hum problems. Scoping the output of the power supply and testing tubes will determine where the hum originates.

The cause of power supply hum is usually an open or leaky filter capacitor or a shorted choke. The bars which appear to float upward on the screen are caused by unfiltered ac voltages getting into the video handling circuits. In the picture tube, the video modulated with ac causes the cathodes to increase and decrease emission at the ac pulse rate. The same type of problem occurs in the audio circuits and the speaker is caused to pulse at the ac pulse rate. The origin of the ac may be determined by observing the number of bars on the screen or listening closely to the frequency of the audio hum. One hum bar or a 60-Hz tone is caused by a 60-Hz source, such as a half-wave rectifier source or tube leakage. Two hum bars or a 120-Hz tone indicates a defect in a full-wave rectified source.

A scope check at the filter capacitors will show the amount of ac ripple present (Chart 3-3). This

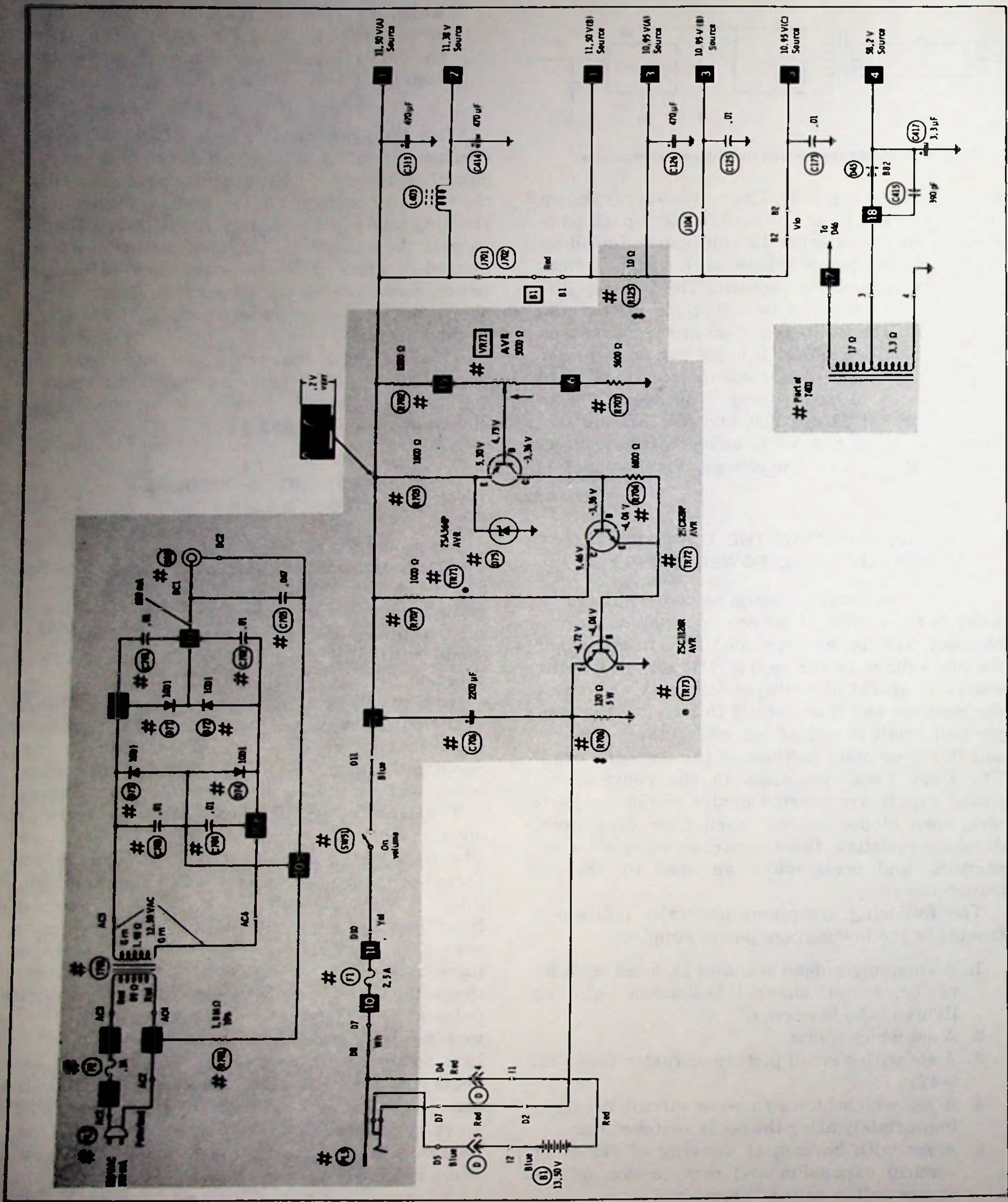


Fig. 3-44. An ac/battery powered receiver power supply.

now charge as shown in Fig. 4-16C. At this time, without anything to sustain the capacitor charge it will attempt to discharge through L again—this time in the opposite direction. It does, and L is charged again only to discharge a fraction of a second later causing C to be charged again in its original polarity. This back and forth "oscillatory" current movement will continue until energy in the circuit is used through the production of heat as it goes through the circuit resistances.

The term resonance implies that the circuit has a resonant or "natural" frequency at which this oscillation occurs. A good example of natural frequency is demonstrated when a fine crystal glass is broken when a certain frequency is produced in the same room. This particular frequency causes the glass to oscillate, just as a tuning fork held beside another of the same frequency will cause the second to vibrate—and the glass vibrates itself apart. In an electrical circuit the size of the capacitors and inductors determines the resonant frequency by how long it takes them to charge and discharge.

In the powered oscillator circuit, such as the one in Fig. 4-13, energy must be put into the circuit to replace that which is lost, as heat is created in the circuit resistance. Each time Q1 conducts, energy is put into L1, replacing lost energy and keeping the tank circuit energized and operating—oscillation is sustained. If no replacement energy is fed back into the tank it will cease to oscillate after a few cycles.

Not all oscillators use a tank circuit to keep oscillation going. Instead they may use resistor-capacitor combinations as seen in Fig. 4-17. The

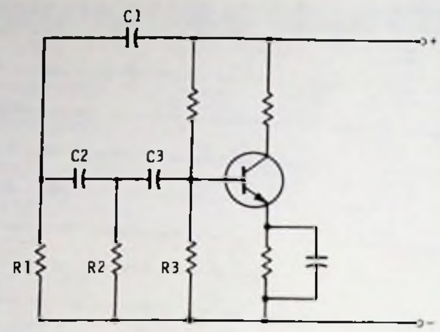


Fig. 4-17. A phase shift oscillator circuit uses resistors and capacitors for "timing."

basic operation is the same. Feedback from the output to input is necessary and it must be fed back in such a way as to reinforce the input signal causing the transistor to saturate, then cut itself off and so on. The feedback circuit is primarily C1, C2, and C3 though R1, R2, and R3 also affect the feedback time constant. Therefore, the timing components of this circuit are C1, C2, C3, R1, R2, and R3. If either of these components changes value, the oscillator will change frequency.

As mentioned in Chapter 2, a specific frequency of pulse (15,734 Hz) is required to cause the picture tube electron beam to scan horizontally across the face of the tube for synchronized picture creation. This pulse is produced by the horizontal oscillator circuit and kept in phase with the broadcast station sync signal by the apc circuit.

Several types of oscillator circuits have been used in monochrome receiver horizontal systems. The most widely used type is the Hartley circuit shown in Fig. 4-8A. It is usually readily recog-

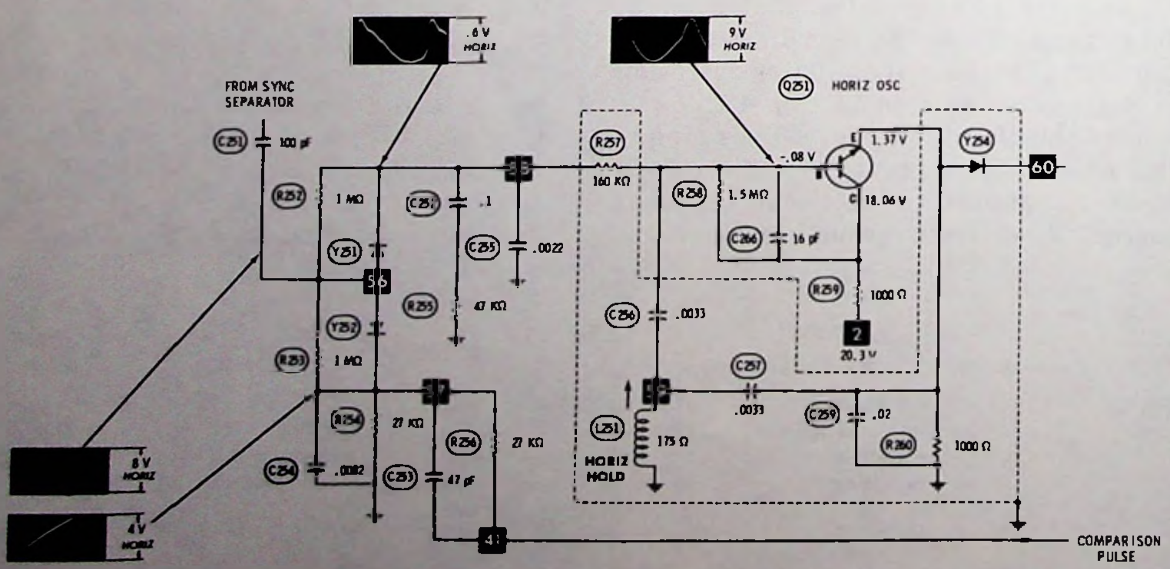


Fig. 4-18. Colpitts-type horizontal oscillator.

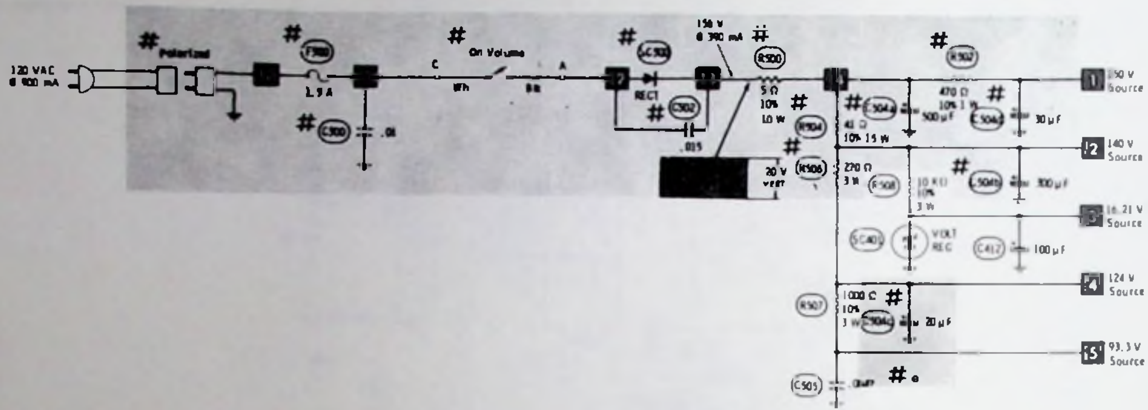


Fig. 3-46. A conventional power supply.

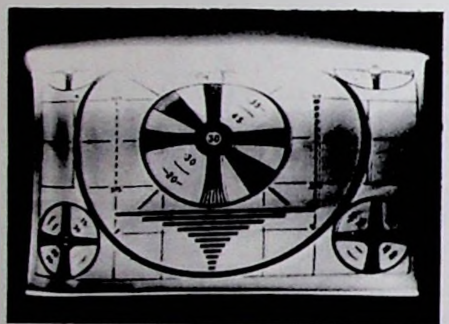
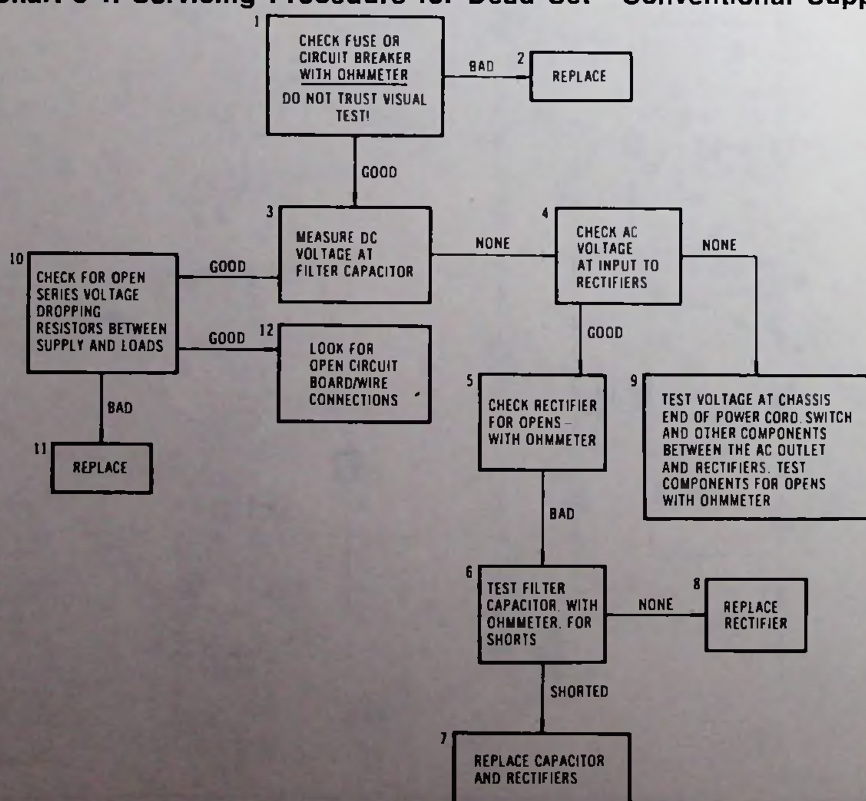


Fig. 3-47. Small raster, symptom of low B+ voltage.

Chart 3-1. Servicing Procedure for Dead Set—Conventional Supply



(Refer to Fig. 3-44 for a typical supply as discussed here.)

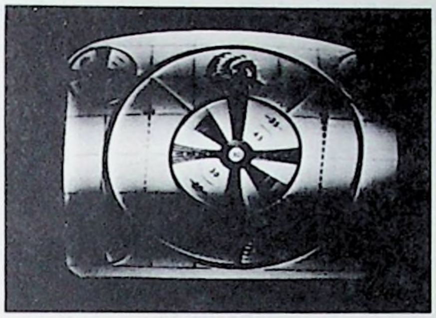
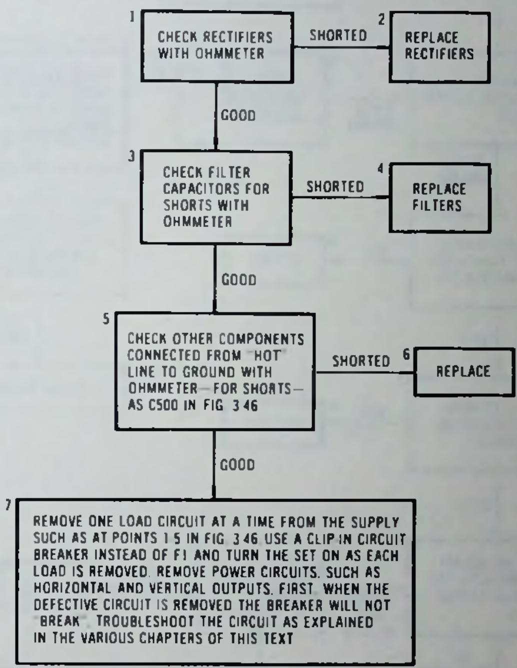


Fig. 3-48. Picture with hum bars caused by excessive ac ripple.

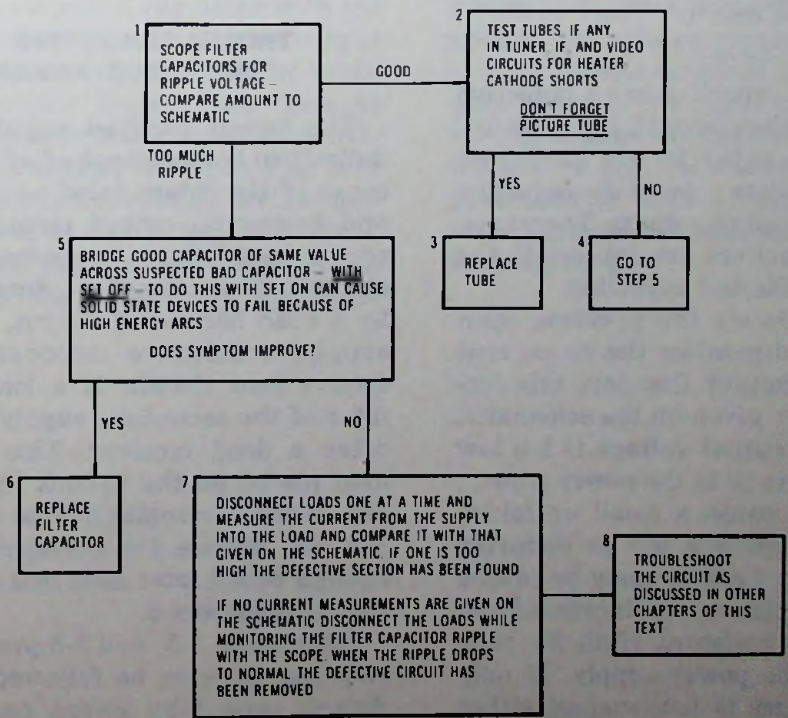
should be compared with the ripple values given as normal on the schematic diagram. Excessive ripple may be caused by defective capacitors (sometimes a defective diode) or choke, or a defect in the load circuit which draws more current than normal. The old technician's trick of bridging a known good capacitor across the suspected capacitor is effective in finding an open filter. Bridging caps in solid-state sets should only be done with the power off since arcing at the filters can cause diode, transistor, and IC failure. Leaking capacitors are better found by disconnecting the suspected capacitor and replacing it with a good one. Capacitors used for substitution should be approximately the same value as the one being replaced. The voltage rating must be the same or

Chart 3-2. Shorted Set (Fuses Blow)—Conventional Supply



(Refer to Fig. 3-46 for a typical supply.)

Chart 3-3. Low B+ and Hum—Conventional Supply



(Refer to Fig. 3-44 as an illustration.)

Chart 3-4. Dead Set—Sweep Supply

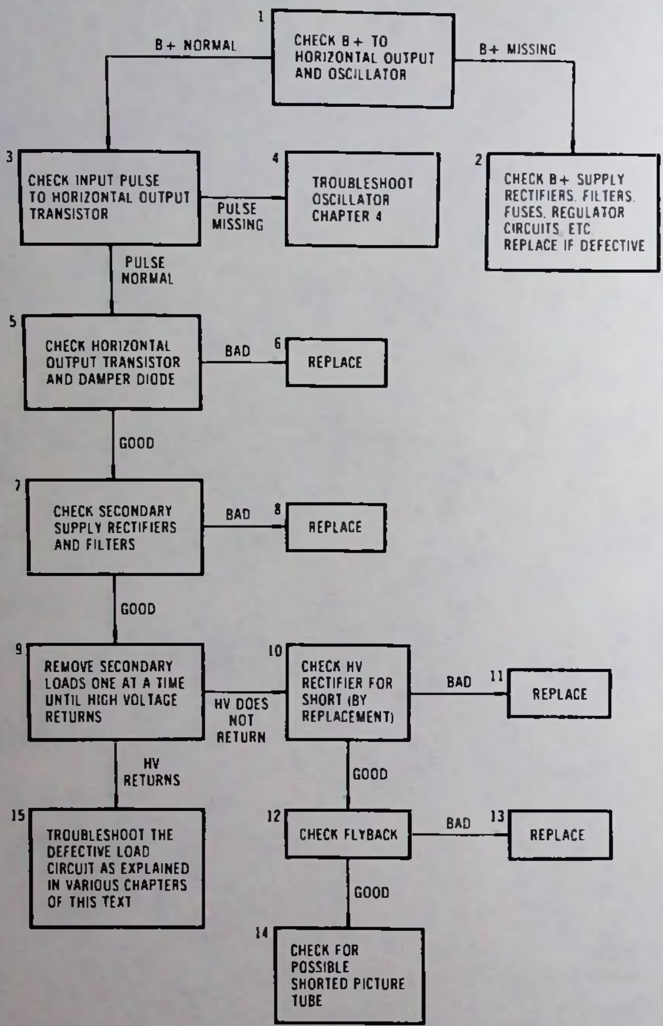
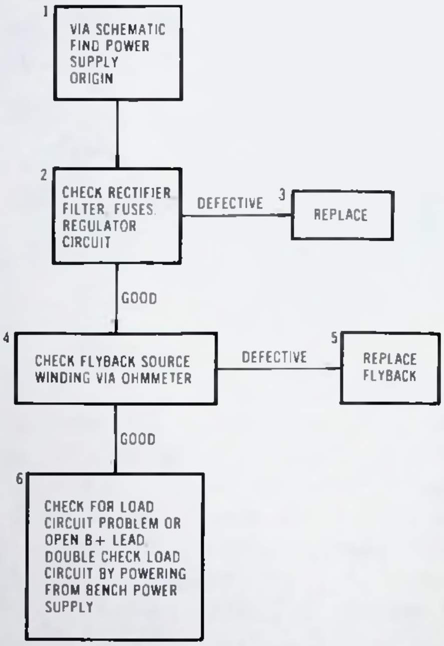


Chart 3-5. Dead Circuit—Sweep Supply



(Dead circuit—audio, if, tuner, etc.—caused by loss of B+)

higher. If a multisection capacitor has a defective section the entire capacitor should be replaced. With several capacitors being in one container, whatever environment exists around the defective capacitor also exists around the others. Therefore, the remaining good capacitors are subject to the same cause of defect as the bad capacitor.

If these tests do not locate the problem, open the suspected circuit and monitor the dc current coming from the supply output. Compare this current reading with the one given on the schematic. If it is too high and the output voltage is too low the problem is not likely to be in the power supply.

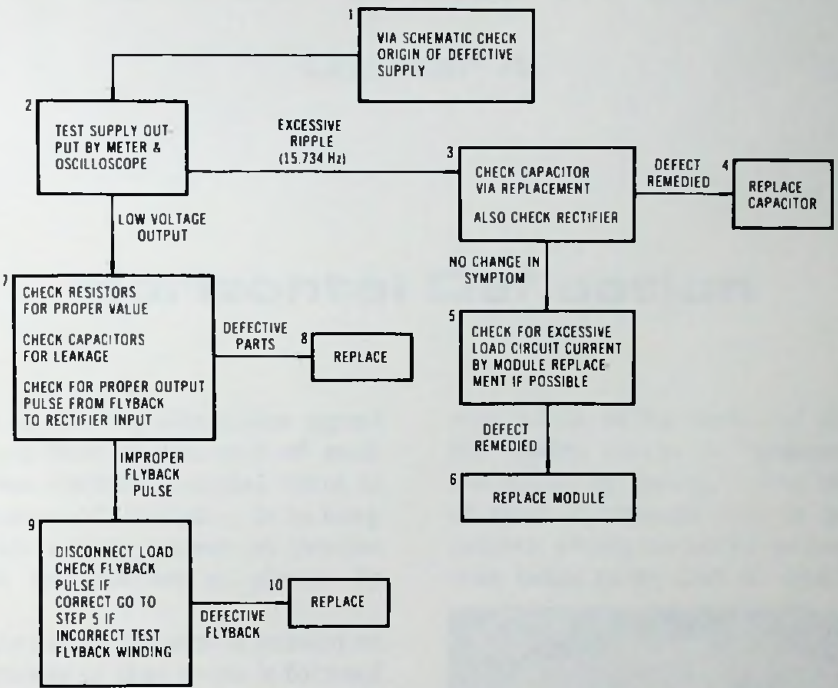
Low B+ voltage may cause a small or folded raster, dim or distorted picture, low or distorted sound, and unstable sync. Low B+ may be caused by defective rectifiers, filters, or increased resistance of power supply resistors. If all B+ voltages are low, suspect the power supply. If only one of the supply voltages is low suspect either the load or the components directly related to that particular supply output. For example, if the 124-volt supply in Fig. 3-46 is low, either the circuit(s) drawing current from that source is defective or C504c is defective. If R506 changes value both the 124-volt and 93.3-volt supplies will change output levels.

TROUBLESHOOTING THE SWEEP RECTIFIED POWER SUPPLY

The sweep rectified supply can be the most difficult to troubleshoot of all power supplies. Because of the interrelated nature of power supply and horizontal output circuits it sometimes becomes very difficult to determine which circuit is at fault. For example, a dead set may be caused by a dead horizontal output, a dead B+ primary supply, a defective secondary supply, or a defective load circuit. If a load (the rectifier) or filter of the secondary supply shorts, the result is often a dead receiver. This occurs because the load placed on the flyback by the shorted circuit causes the horizontal output to refuse to operate. We will discuss the horizontal output circuit in enough detail later that this concept can be more clearly understood.

Charts 3-4, 3-5, and 3-6 present normal troubleshooting steps to be followed for servicing most defects caused by sweep rectified power supply faults.

Chart 3-6. Malfunctioning Section—Sweep Supply



(Example: Defective audio caused by low power-supply voltage, excessive ripple, etc. One-supply faults.)

TROUBLESHOOTING VOLTAGE REGULATOR CIRCUITS

Essentially, troubleshooting a voltage regulator circuit consists of measuring the input and output voltages, determining if it is regulating, and the cause of the incorrect output. A regulator with the correct unregulated input but an incorrect output is obviously not operating as it should. The problem may be the regulator device itself such as Q1 in Fig. 3-40, or its controlling zener diode. Or in the case of a circuit as that shown in Fig. 3-41 either of the transistors or the voltage divider network may be defective. In this example it would be necessary to check voltages at the input to each transistor, then the outputs. If the input (base) voltage is correct but the output voltage (collector of Q603, emitter of Q601, and emitter of Q602) is not, first test the transistor then the bias and other external components, such as R602, C606, and C607. The transistors are usually best tested by replacement since a slight leakage in the device can cause some rather severe problems, such as low voltage, ripple, etc.

With a three-terminal regulator it is necessary only to check the input voltage and if it is correct, to change the device. If it is not correct test the source and the connections. These units are purchased by their voltage output and cannot be made variable. As fixed output devices there is no variable input.

Chapter 4

Horizontal Deflection

Shown in Fig. 4-1 is a composite video signal (see Chapter 2). Note that at the end of each line of broadcast video (picture) signal there is a sync pulse. The purpose of this pulse is to keep the receiver horizontal sweep system in precise synchronization with the station as shown in Fig. 4-2.

At the broadcast station a camera is caused to view a scene and the image of that scene is focused onto a special "image" plate in the camera tube. An electron beam is swept across the image plate in the same manner as across the receiver picture tube face. That is, it is swept rapidly from side to side while being deflected downward slowly so the entire image is "scanned" by the electron beam, line by line as shown in Fig. 4-3. At the end of each horizontal line, a pulse created in the camera sweep circuitry causes the scanning electron beam to be shut off and to rapidly "retrace"

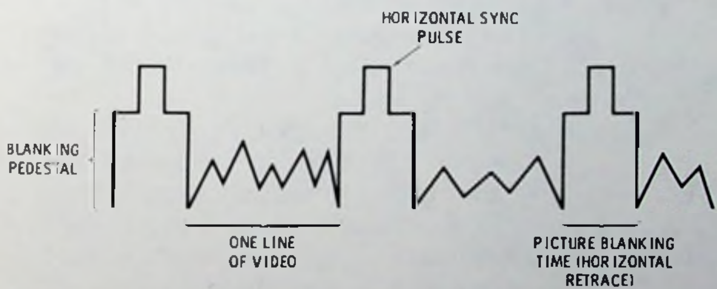


Fig. 4-1. Composite video signal.

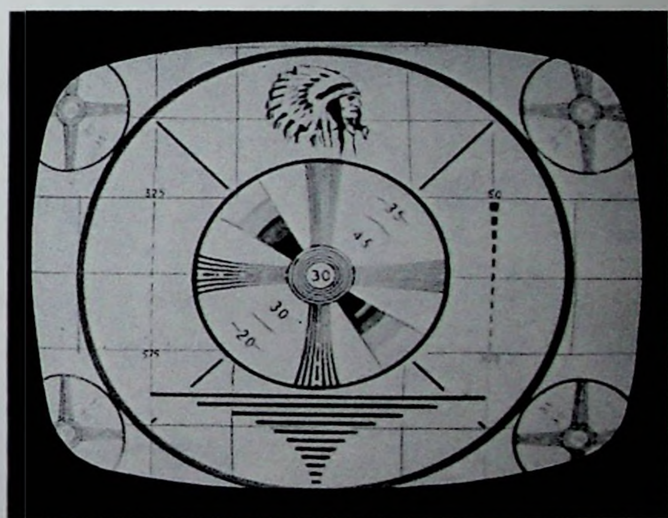


Fig. 4-2. A perfectly synchronized picture.

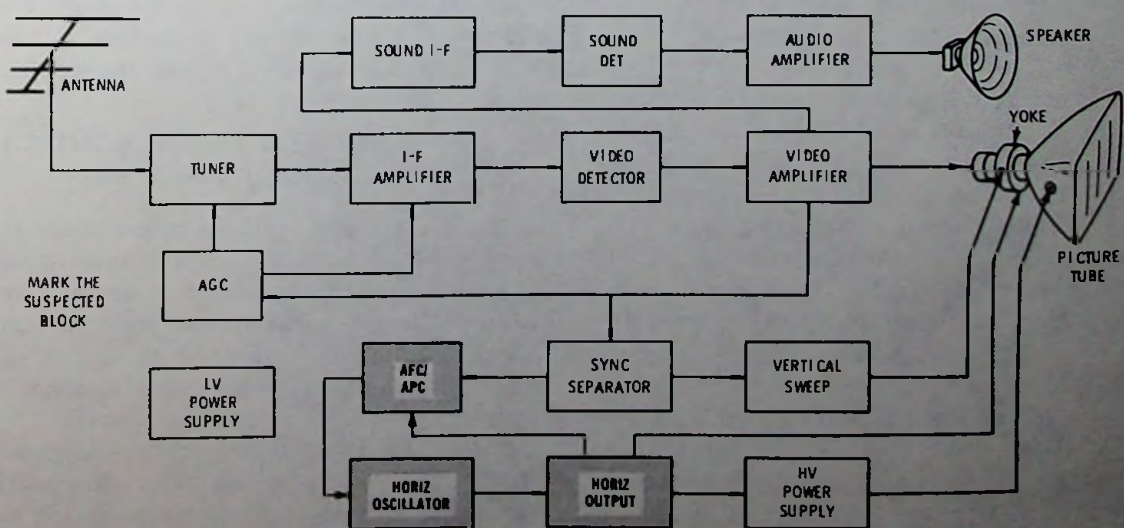
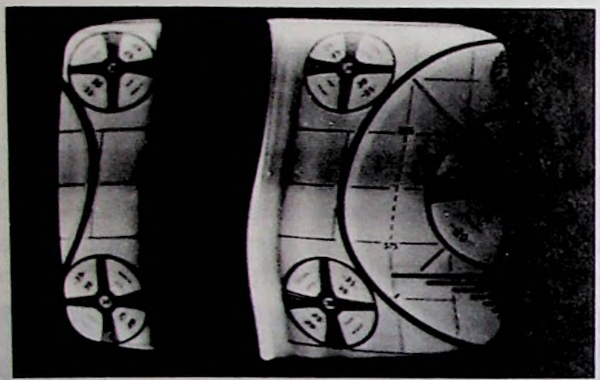
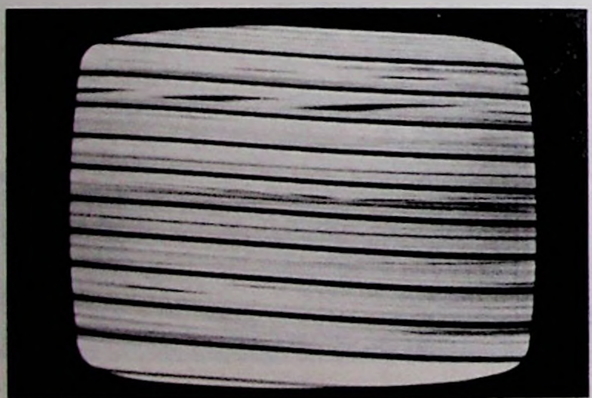


Fig. 4-3. A picture produced by scan lines.



(A) Loss of horizontal sync.



(B) Severely out of horizontal sync.

Fig. 4-4. Examples of out-of-sync pictures.

to the left side of the image plate to begin another scan line. This same pulse is broadcast along with the image or video information and its purpose is to cause the scanning electron beam in the picture tube to scan at the same rate as the beam in the broadcast camera. The result is a synchronized picture or one being reconstructed precisely as it is being developed. Without this synchronization the picture might be seen half on one side of the screen and half on the other as shown in Fig. 4-4A. Or, the picture might "flip" to the side as shown in Fig. 4-4B.

In the receiver, when the electron beam is swept to the right side of the picture tube, the beam is (1) cut off by the high level of the blanking pedestal (Fig. 4-1), (2) caused to retrace to the left side of the screen, and then (3) swept to the right of the screen producing picture information. These functions are produced by the horizontal circuits and synchronized with the broadcast studio via the horizontal sync pulse and blanking pedestal.

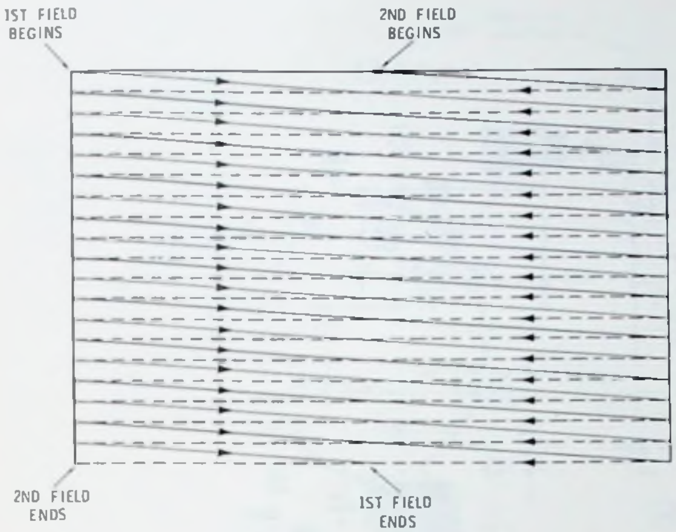
As the electron beam is retracing from right to left it is blanked and cannot be seen on the screen. This period of time is called *retrace* or *flyback* time. It occurs in approximately 12.5 millionths of a second (12.5 microseconds). The actual sweep time necessary to produce a line of picture information is about four times as long or 51 microseconds. To scan the entire picture tube screen, 262½ scan lines are required. These 262½ scan lines produce only half an entire picture, because during this time only the even or the odd numbered scan lines are produced. During the next scan of the picture tube screen the remaining lines are filled in and a total picture results. A complete picture is produced in this manner each 1/30th second and a "half" picture of even or odd lines, called a "field," is produced in 1/60th of a second. Technicians call this process of picture production "interlaced scanning" because the two fields are interlaced to provide a sharper picture with no flicker at a slow scan rate. A completed picture created in this way is called a "frame." This process is shown in Fig. 4-5.

Several circuits are required to produce the horizontal sweep of the electron beam and synchronize it to the station broadcast signal. These circuits include the automatic phase control (apc), the horizontal oscillator, amplifiers, and the horizontal output circuit. Each of these circuits will be explained in the following pages along with common symptoms created when they are defective and troubleshooting methods used by the bench technician in repairing them.

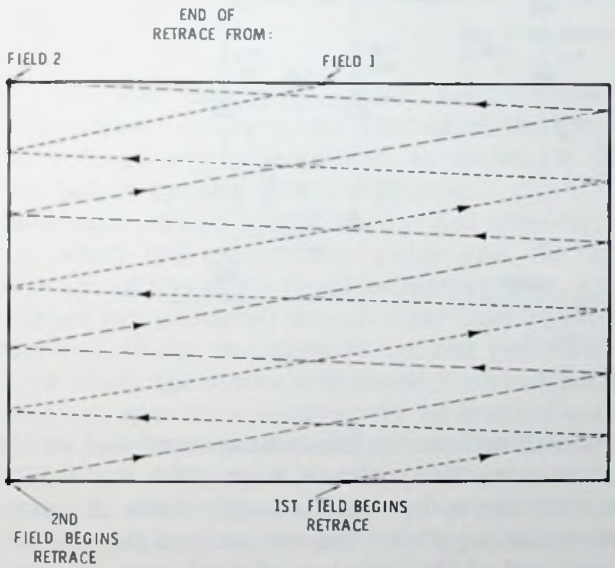
AUTOMATIC PHASE CONTROL (APC) CIRCUITS

Horizontal sync pulses are stripped from the composite video signal by the sync separator circuit and fed into a circuit called the apc circuit. Simultaneously, a sample of the horizontal output signal is applied to the apc as shown in Fig. 4-6. These two signals are compared against each other and a correction voltage is produced.

There are two circuit control methods used in the modern monochrome television receiver: (1) the use of a pulse to trigger a circuit into action



(A) Active downward scanning.



(B) Inactive upward scanning (vertical retrace).

Fig. 4-5. Interlace scanning.

and, (2) the use of the pulse to create a "correction" or "control" voltage. The horizontal apc is of the latter type. A control or correction voltage is produced when the two pulses as shown in

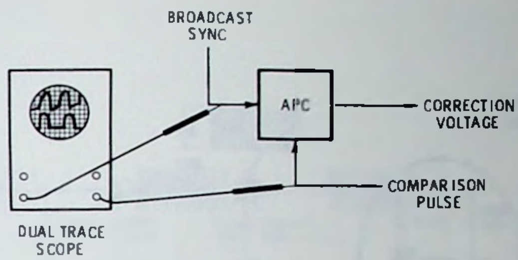
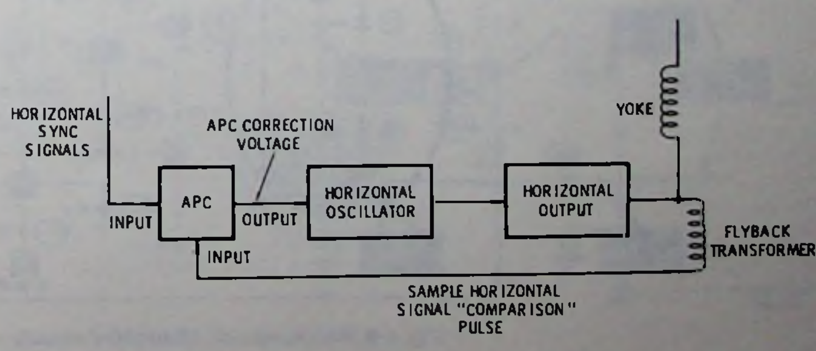


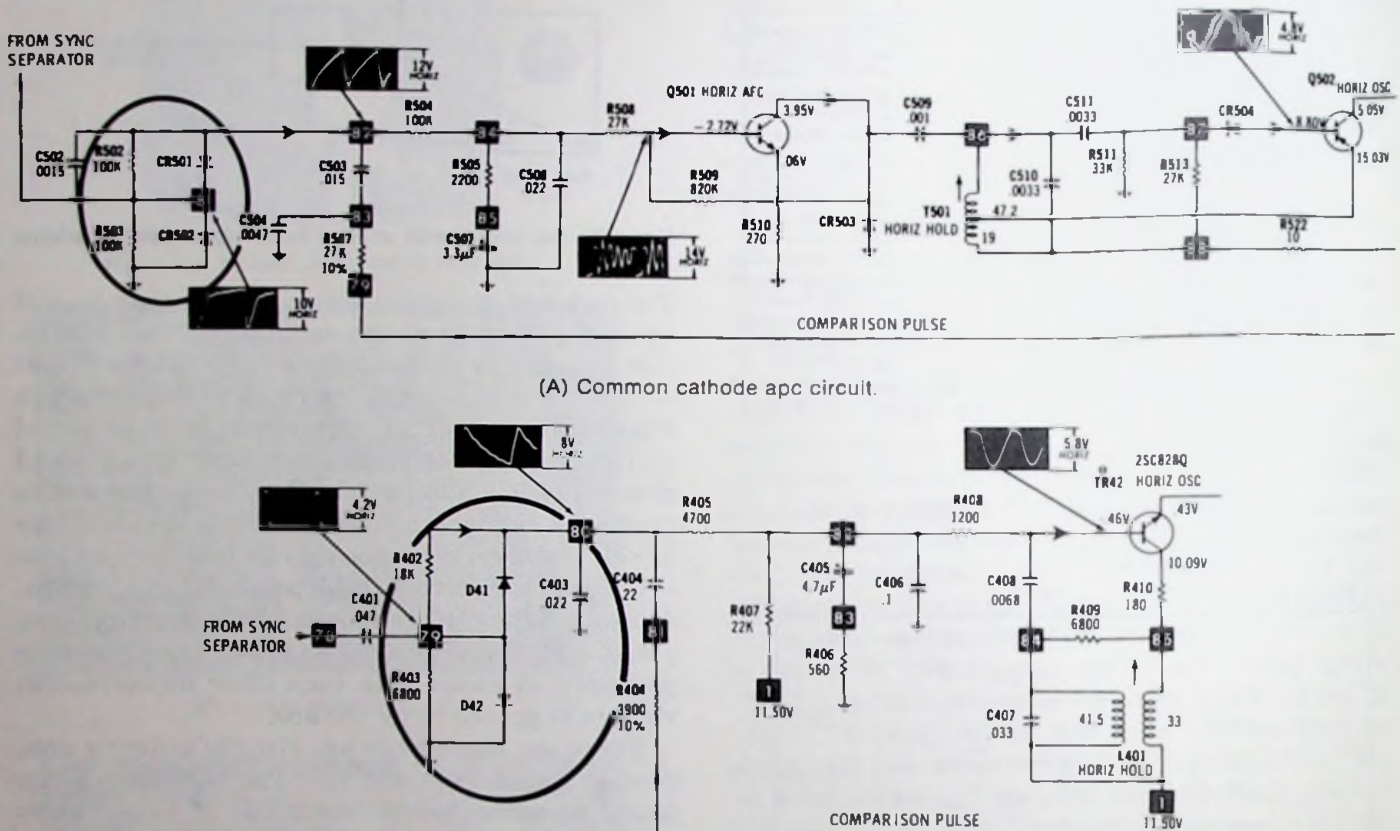
Fig. 4-7. Apc circuit with applied input signals out of phase.

Fig. 4-7 are not precisely in phase, that is, not occurring exactly at the same time. This correction voltage is then used to control the output of the horizontal oscillator circuit (illustrated in Figs. 4-6 and 4-7). In this way if the horizontal oscillator drifts from the proper frequency and phase, the incoming sync pulse causes the apc to produce a correction voltage causing the oscillator to shift to meet the same timing as the sync pulse —the picture is then held perfectly in synchronization. When the two signals, the incoming sync pulse and the comparison pulse, are occurring perfectly in phase with each other no correction voltage is produced by the apc.

There are three basic apc circuits utilizing dual diodes, transistors, and ICs. The type most often found in monochrome televisions of today, however, is the dual diode system as shown in Fig. 4-8. The diodes may have any arrangement. They may be common cathode meaning that the cathodes are connected together as in Fig. 4-8A. They may be common anode meaning that the anodes are connected together as in Fig. 4-8B. Or, the diodes may have any other arrangement as in Fig. 4-9. Automatic phase control systems are also often referred to as balanced or unbalanced. It is considered to be a balanced circuit when the comparison pulse is applied to the dual diode center tap and unbalanced when fed to one end of the diode circuit. These are shown in Figs. 4-10 and 4-8, respectively. When a balanced system is used the incoming sync pulse is split into positive and negative pulses with the positive fed to one

Fig. 4-6. Functional block diagram of a horizontal sweep system.





(A) Common cathode apc circuit.

(B) Common anode apc circuit.

Fig. 4-8. Common apc circuits.

end of the diode unit and the negative applied to the other. The comparison pulse is applied to the diode common connection and the correction voltage is taken from the center tapped resistors which act as a load for the diode circuit. When the unbalanced circuit is used only one sync signal is connected to the diode circuit, which will also have connections for the comparison pulse and the output correction voltage. Figs. 4-8A and 4-8B illustrate the unbalanced circuit. Note the single sync pulse input and the comparison pulse applied to one end of the unbalanced diode apc circuit. In Fig. 4-10 the balanced circuit shows out-of-phase sync pulse inputs applied to each end of the apc

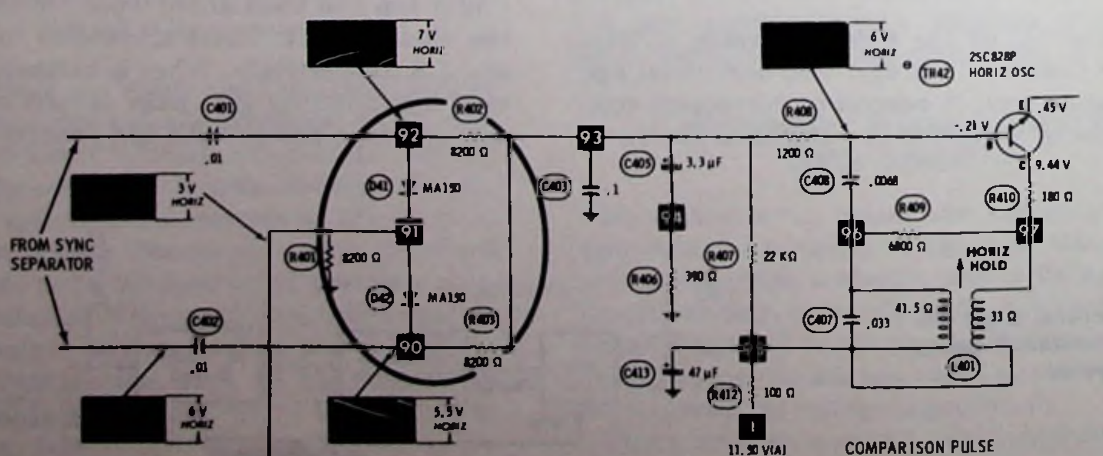


Fig. 4-9. Balanced dual diode apc circuit.

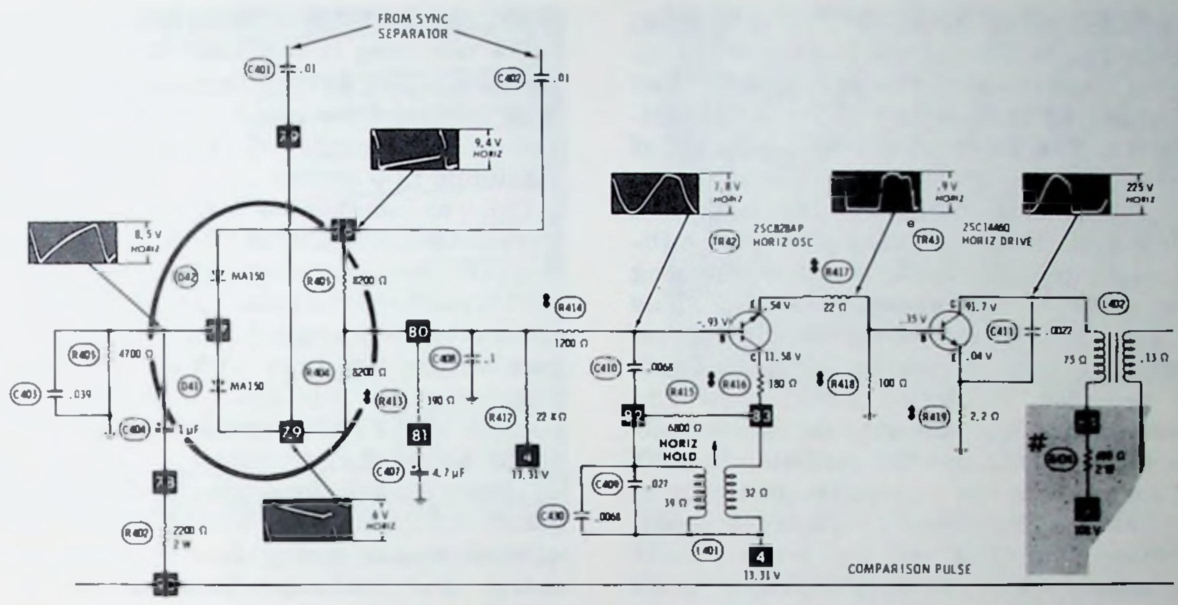


Fig. 4-10. Balanced dual diode apc circuit.

unit and one comparison input to the common diode element. Observe, too, that often the correction voltage will be amplified as shown in Fig. 4-8A before applied to the oscillator.

Basically, what occurs in the apc circuitry is that when the comparison pulse and the sync pulse are of the same frequency and phase, equal voltages are produced across their load resistors. However, if the two signals are not perfectly in phase one of the diodes will conduct more than the other and a greater voltage will be created across one of the load resistors than across the other. Thus, a net difference in voltage is produced resulting in a correction voltage to cause the oscillator to pull back on frequency. Once correct frequency or phase is established no more correction voltage is produced and the oscillator ceases to change frequency and remains locked to the incoming sync signal.

If the apc circuit is included inside an IC horizontal system as shown in Fig. 4-11 it may or may not be identified on the IC. Of course as such it will not be possible to troubleshoot anyway. For any IC circuit the troubleshooting method is: (1) check the input and output signals; (2) if input is available without an output, check the supply voltage; (3) if supply voltage is good either the IC or an attached external component is defective—check the "external" components; and (4) replace the external component if found

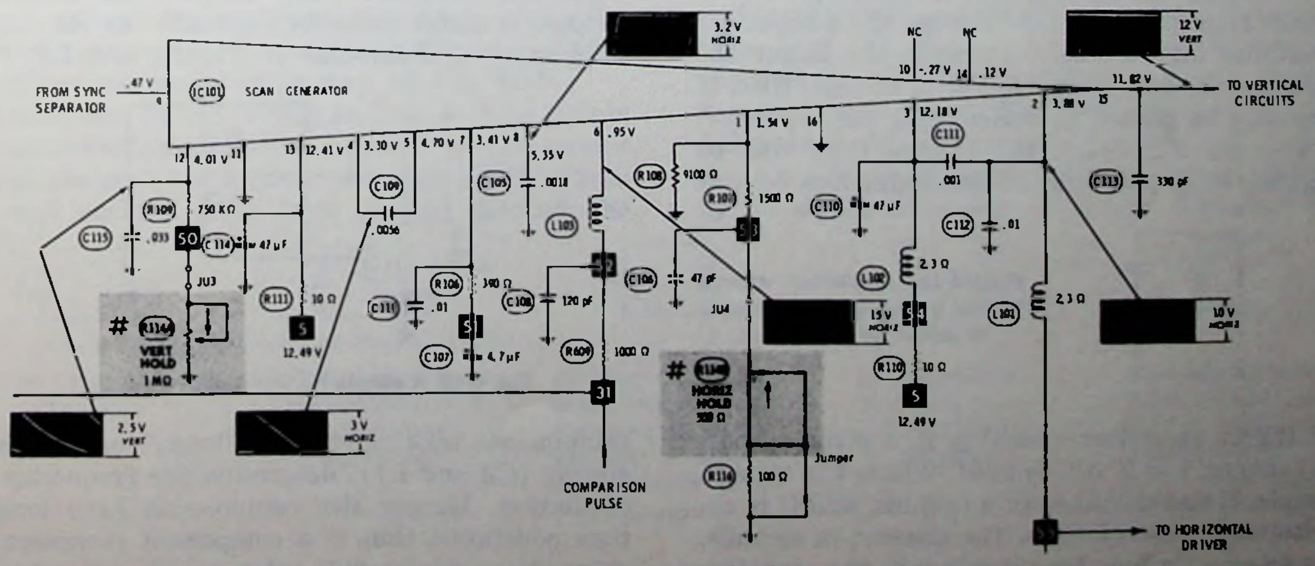


Fig. 4-11. IC apc circuit.

to be defective, or replace the IC if no external component is faulty. The fault is usually in the IC.

Of equal importance to the apc, and in fact usually considered to be a part of it, is the antihunt network. The antihunt network consists of a resistor-capacitor circuit located between the apc and the horizontal oscillator. Its purpose is to provide a fast changing initial correction voltage to the oscillator followed by a slower changing correction voltage of the same polarity. This brings the oscillator rapidly onto the correct frequency without over-correction. If this circuit were not provided, oscillation would occur and the apc would provide a pulsating correction voltage. This would then cause the oscillator to shift back and forth about the correct frequency or in essence "hunt" for the correct frequency or phase. The continued "hunting" of the proper phase causes horizontal scan to be misplaced and "gear-teeth" or "pie crust" effects to be seen about the vertical edges of the picture elements. The antihunt network consists of R413, C407, and C408 in Fig. 4-10.

THE HORIZONTAL OSCILLATOR

An oscillator is an electronic circuit which produces an output voltage pulse while being powered by a steady, pure dc supply. That is, it creates a regularly recurring pulse whose frequency can be determined by the values of the circuit capacitance and inductance. The television receiver has several oscillator circuits—the horizontal oscillator is just one of these.

Capacitors were explained in Chapter 3, and it was found that they store a charge. What we did not tell you at that time was that it takes a certain amount of time to "charge up" a capacitor depending on its size. Naturally, the larger the capacitor the longer it takes it to charge. Also, if a resistor is placed in series with the capacitor, as seen in Fig. 4-12, the charge time will be lengthened. If you wish to determine how long it will take a capacitor to charge in a given circuit, the formula $t = R \times C$ is used. Where t is time in seconds, R is resistance in megohms, and C is capacitance in microfarads. The answer, in seconds, tells us exactly how long it will take the capacitor to charge to 63.2% of full charge. If we wish to know how long it will take to reach full charge (98-99%), our answer in seconds must be multiplied by five. Example: $t = 1\ \mu f \times 1\ M\Omega = 1$ second $\times 5 = 5$ seconds—the capacitor will charge to maximum in 5 seconds.

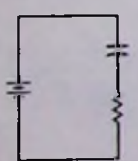


Fig. 4-12. Capacitor charge time is increased as resistance is added to the circuit.

Coils, or inductors as they are sometimes called, were not explained in any detail in Chapter 3. But, they, too, store a charge. Their charge is held in the magnetic field which is produced about the coil when current is applied to it and maintained. Remember that any wire with current flowing in it has a magnetic field about it. And, the time relationship to the full magnetic field charge is identical to that of the capacitor.

These time relationships of coils and capacitors, naturally, make them useful in any circuit requiring regular timing. In any oscillator it is the charge and discharge times of capacitors and coils that produce the regular pulse frequency of the circuit. This is why the statement was made earlier that the oscillator frequency can be determined by the values of circuit capacitance and inductance.

Technically speaking, the oscillator is an amplifier with feedback. Unless designed not to oscillate, an amplifier will oscillate when some of its output is "fed back" to its input in the correct phase as to reinforce the input signal. This type of feedback is regenerative and causes the amplifier to oscillate much in the same fashion as holding a public address system microphone in front of its speaker. Most everyone has at one time or another heard the ear piercing squeal this produces.

A simple oscillator circuit is illustrated in Fig. 4-13. The feedback path couples the amplifier output (emitter-collector current) to its input (the base) and consists of C1, C2, and L1. The components making up the "tank," or resonant circuit (C2 and L1), determine the frequency of oscillation. Larger size components have longer time constants, thus if a component increases in value the oscillator will pulse slower. Likewise, if

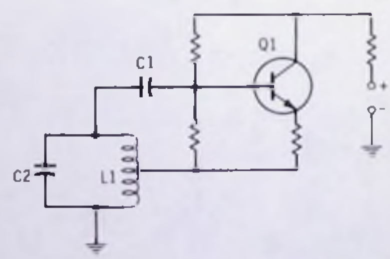


Fig. 4-13. A simple Hartley oscillator circuit.

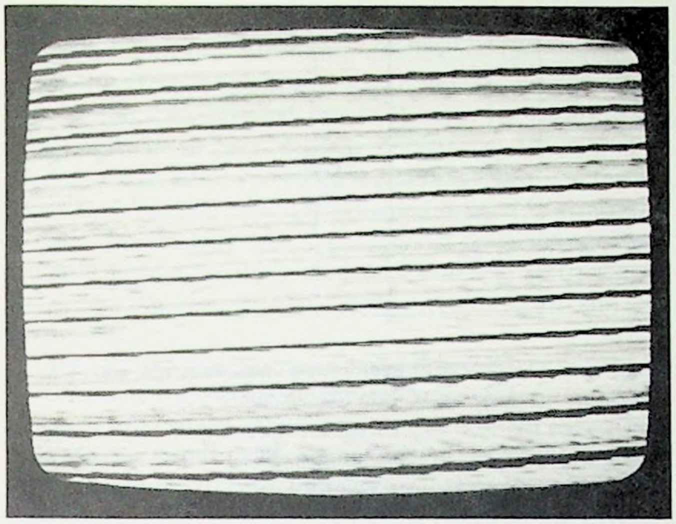


Fig. 4-14. Symptom produced by a horizontal oscillator running too slow.

a component decreases in value the oscillator frequency will increase. The technician looks for those components which are most likely to cause the set to exhibit its symptom. For example, if it is determined that the horizontal oscillator is running too slowly the technician would look for those components which normally increase in value. Inductors and capacitors cannot be made to increase in value since this would basically mean the addition of more turns of wire, different core, different insulation, or more plate area. So increased value resistors are suspected for slow oscillator symptoms. Conversely, for fast oscillator symptoms, shorted or leaky capacitors or shorted inductors are suspected and so should be checked first.

Slower than normal horizontal oscillator operation produces the symptom as seen in Fig. 4-14. Faster than normal horizontal oscillator operation produces the symptom as seen in Fig. 4-15.

Operation of the circuit in Fig. 4-13 is simply a controlled on-off action created by the circuit itself. As power is applied to the circuit Q1 turns on and current flows from ground through the

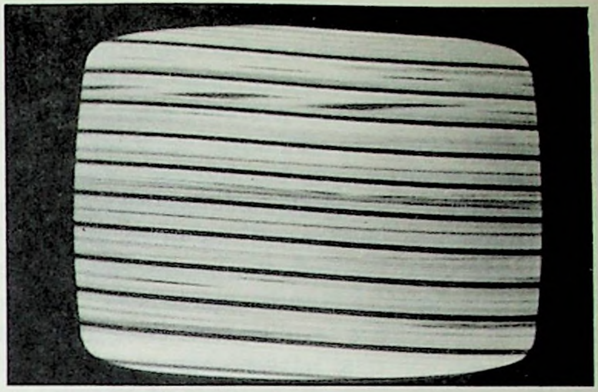
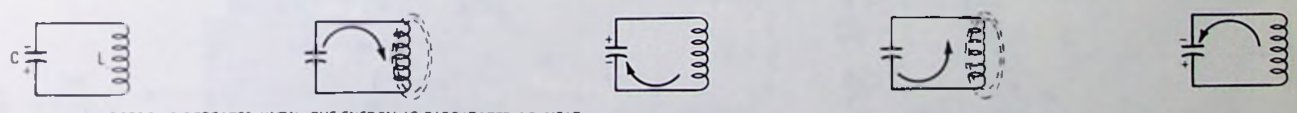


Fig. 4-15. Symptom produced by a horizontal oscillator. running too fast.

lower section of L1 to the emitter, to the collector, and to B+. This current flowing through L1 induces a voltage at the top of L1 which makes the base of npn transistor Q1 positive, driving the transistor into saturation. At saturation there is no longer a changing current flow through the bottom of L1. And, with no changing current level, there will be no induction into the top of L1 which, therefore, falls to zero. The lower positive base voltage causes Q1 to decrease conduction. The falling current in the bottom of L1 causes an opposite polarity voltage to be induced in the top of L1 cutting Q1 off. The cycle of occurrences then repeats itself causing a regular recurring on-off cycle—oscillation.

The parallel circuit of L1 and C2 is called a tank, or resonant, circuit. Briefly, a resonant circuit is one in which currents oscillate or move first one way and then the other. In the circuit of Fig. 4-16 note that if energy is first applied to the circuit as a charge on the capacitor, the capacitor will discharge through L causing a magnetic field to be built out about L. As the capacitor is discharged, the field about L will have no current flow to sustain it so it, too, must collapse. When it collapses it induces a current which will flow in the same direction as it was being caused to flow by the discharging capacitor. The capacitor will



NOTE: PROCESS IS REPEATED UNTIL THE ENERGY IS DISSIPATED AS HEAT.

(A) Capacitor charged.

(B) Capacitor discharging into coil—magnetic field builds up.

(C) Magnetic field collapses producing voltage which causes current flow to continue and capacitor to be charged.

(D) Capacitor discharges into coil—magnetic field builds up.

(E) Magnetic field collapses causing voltage to be produced to keep current flow moving in same direction — capacitor charges as shown.

Fig. 4-16. Resonant circuit current flow.

now charge as shown in Fig. 4-16C. At this time, without anything to sustain the capacitor charge it will attempt to discharge through L again—this time in the opposite direction. It does, and L is charged again only to discharge a fraction of a second later causing C to be charged again in its original polarity. This back and forth "oscillatory" current movement will continue until energy in the circuit is used through the production of heat as it goes through the circuit resistances.

The term resonance implies that the circuit has a resonant or "natural" frequency at which this oscillation occurs. A good example of natural frequency is demonstrated when a fine crystal glass is broken when a certain frequency is produced in the same room. This particular frequency causes the glass to oscillate, just as a tuning fork held beside another of the same frequency will cause the second to vibrate—and the glass vibrates itself apart. In an electrical circuit the size of the capacitors and inductors determines the resonant frequency by how long it takes them to charge and discharge.

In the powered oscillator circuit, such as the one in Fig. 4-13, energy must be put into the circuit to replace that which is lost, as heat is created in the circuit resistance. Each time Q1 conducts, energy is put into L1, replacing lost energy and keeping the tank circuit energized and operating—oscillation is sustained. If no replacement energy is fed back into the tank it will cease to oscillate after a few cycles.

Not all oscillators use a tank circuit to keep oscillation going. Instead they may use resistor-capacitor combinations as seen in Fig. 4-17. The

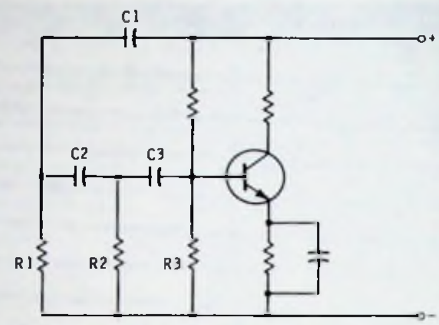


Fig. 4-17. A phase shift oscillator circuit uses resistors and capacitors for "timing."

basic operation is the same. Feedback from the output to input is necessary and it must be fed back in such a way as to reinforce the input signal causing the transistor to saturate, then cut itself off and so on. The feedback circuit is primarily C1, C2, and C3 though R1, R2, and R3 also affect the feedback time constant. Therefore, the timing components of this circuit are C1, C2, C3, R1, R2, and R3. If either of these components changes value, the oscillator will change frequency.

As mentioned in Chapter 2, a specific frequency of pulse (15,734 Hz) is required to cause the picture tube electron beam to scan horizontally across the face of the tube for synchronized picture creation. This pulse is produced by the horizontal oscillator circuit and kept in phase with the broadcast station sync signal by the apc circuit.

Several types of oscillator circuits have been used in monochrome receiver horizontal systems. The most widely used type is the Hartley circuit shown in Fig. 4-8A. It is usually readily recog-

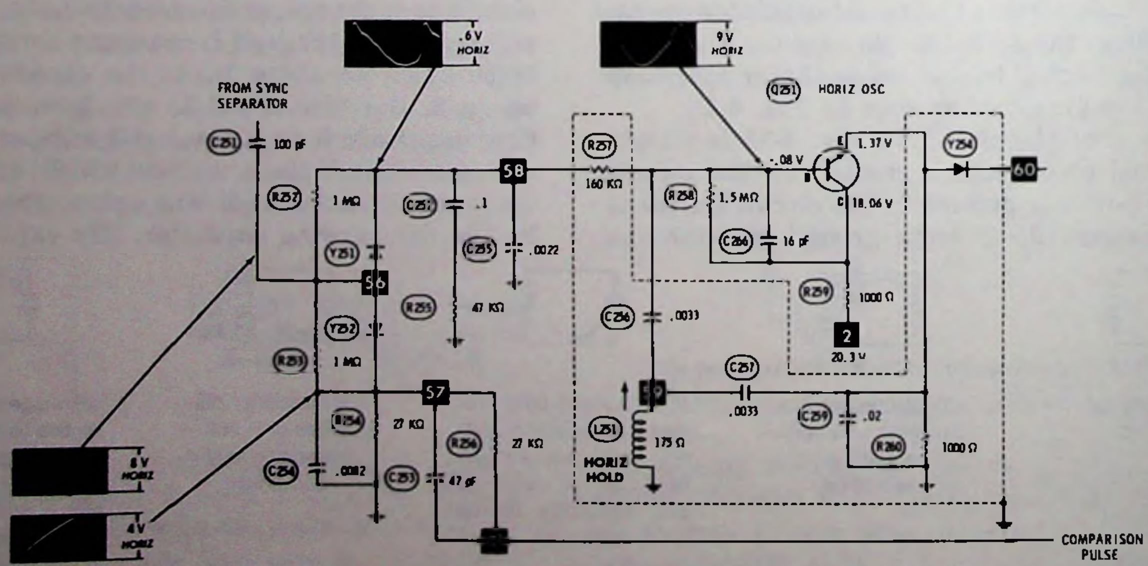


Fig. 4-18. Colpitts-type horizontal oscillator.

nizable by the tapped coil. A second widely used oscillator is the blocking oscillator as shown in Fig. 4-9. Watch for the transformer used to couple signal from the transistor output to its input; this identifies it as a blocking oscillator circuit. Yet another often used oscillator is the Colpitts shown in Fig. 4-18. Its distinguishing feature is the horizontal hold coil paralleled with two capacitors (C257 and C259) and the feedback path being attached to a common terminal between the capacitors.

Some few monochrome receivers are using an integrated circuit sweep system which incorporates much of the vertical and horizontal circuitry. Such a system is illustrated in Fig. 4-11. Note that there are no identifications of what type circuitry is inside the IC. Here the technician must be totally dependent on the knowledge of inputs and outputs in order to troubleshoot the horizontal circuitry.

Color receivers have used a horizontal system called the "countdown" circuit for a number of years though it is only recently begun to show up in monochrome sets. The basic operation of the countdown circuit is the same as those it replaces. It has a *master* oscillator (used for both horizontal and vertical), and counting circuits to "count" or divide the higher master oscillator frequency down to the required 15,734 Hz horizontal frequency. A comparison pulse is still required for the apc and an input from the sync separator is also required for correct synchronization with the station.

The master oscillator is usually inside the IC and operates at 31,468 Hz or twice the normal horizontal frequency. The IC divides the 31,468 Hz down to 15,734 Hz while the apc keeps the master oscillator in phase with the incoming broadcast signal. The countdown output is a square wave for application to the driver or buffer amplifier before application to the horizontal output circuit.

Really, since the system is inside an IC it is not necessary that the technician know all the theoretical details of how it works. The technician does, however, need to know its inputs and outputs in order to make an effective diagnosis. And, as just explained, the inputs and outputs are the same as for those circuits it replaces—that is, a comparison pulse input, a sync separator input and a pulse output used to drive the horizontal buffer/driver and then the output.

HORIZONTAL OUTPUT CIRCUITS

To this point it has been explained that an incoming sync pulse is used by the apc to keep the horizontal oscillator in "step" with the broadcast station signal. The output of this oscillator is now applied to the horizontal output circuitry or, in some cases, to a driver or buffer amplifier placed between the oscillator and the output. In either

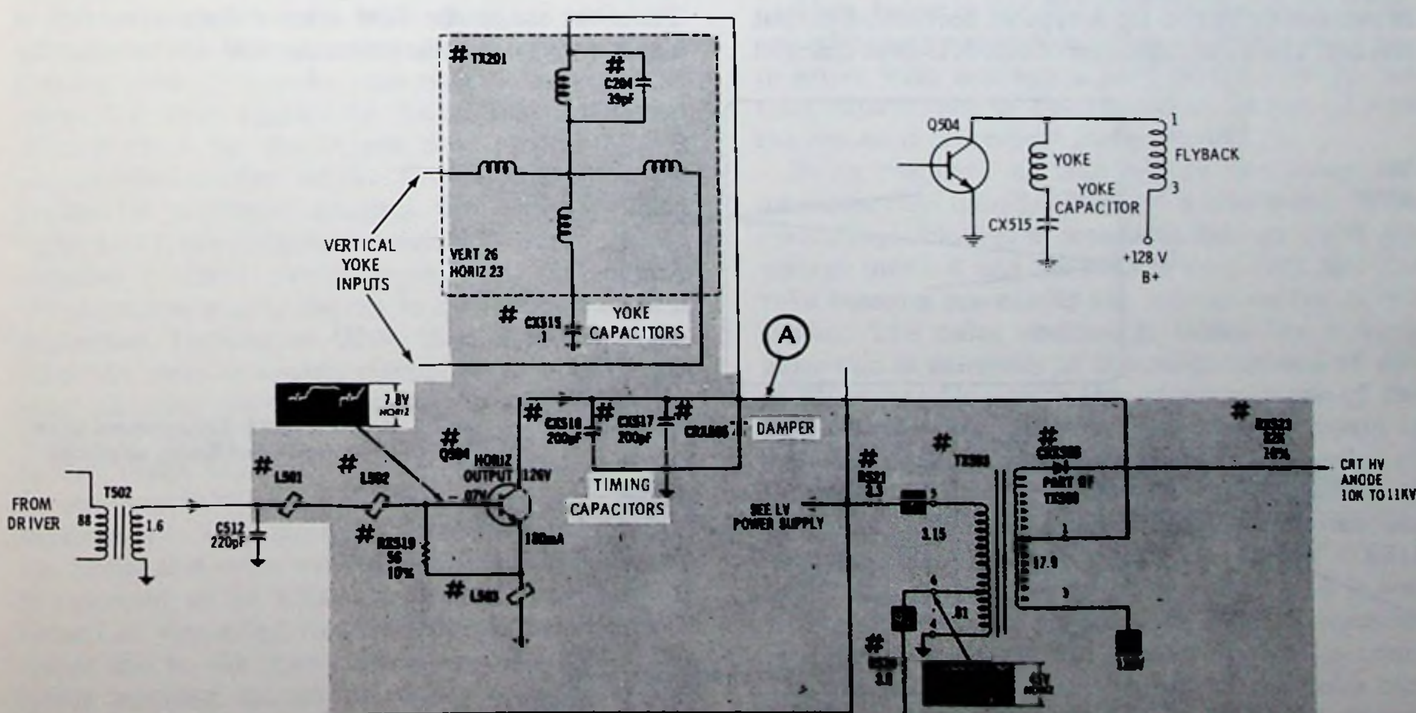


Fig. 4-19. A typical horizontal output circuit.

case the oscillator signal is used to control the horizontal output and thus the electron beam scan. The horizontal output is also used in many sets to provide from one to several low voltage supplies for the purpose of operating the remainder of the set. In all cases it is used to produce the high voltage necessary for the picture tube to cause electron acceleration to the screen.

The horizontal output circuit is a tuned (resonant) circuit, primarily tuned to resonate at 10 kHz. However, in order to cause rapid retrace between scan times, the circuit is changed to resonate at 40 kHz by the addition of other components into the resonant circuit. This circuit makes use of oscillatory current within the yoke coil and capacitors to cause horizontal sweep and beam retrace.

In the explanation which follows, you will find the damper, horizontal output, yoke capacitors, and timing capacitors to be very important to this timing sequence of the horizontal sweep. Learn to locate these components quickly on the schematic for they are essential for proper system operation. Note that the damper diode is connected across the horizontal output transistor from emitter to collector, the timing capacitor(s) is in parallel with the damper and horizontal output transistor and the yoke capacitor is in series with the yoke current path. This should make these components easy to locate.

The following explanation of horizontal sweep is related to Fig. 4-19, a typical horizontal output circuit. The yoke capacitor, CX515, is kept charged to near the 128 volt B+ value because it is in series with the B+ from pin 3 of the flyback, to pin 1 of the flyback, through the yoke, CX515, and back to B−, or ground.

The circuit just described is constructed so the amount of discharge during sweep is a small amount of the total charge of the capacitor, making the discharge linear as shown in Fig. 4-20. Remember that the first portion of discharge is linear and later portions of the discharge are quite the opposite. During sweep, the circuit is resonant at 10 kHz. We will see shortly how it is also made to resonate at 40 kHz by damper and horizontal output switching action and the use of "timing" capacitors.

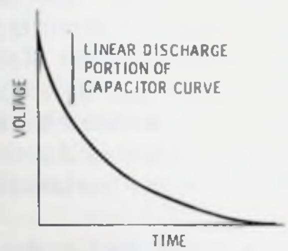


Fig. 4-20. Capacitor discharge curve.

Any deflection system, regardless of type, must produce a linear increase of magnetic energy in the horizontal yoke windings to move the electron beam from its resting point in the center of the screen to the extreme right at a constant rate in approximately 25.5 microseconds. This corresponds to the time from points O to A in Fig. 4-21. Then the magnetic field must collapse to zero in approximately 6.25 microseconds to return the

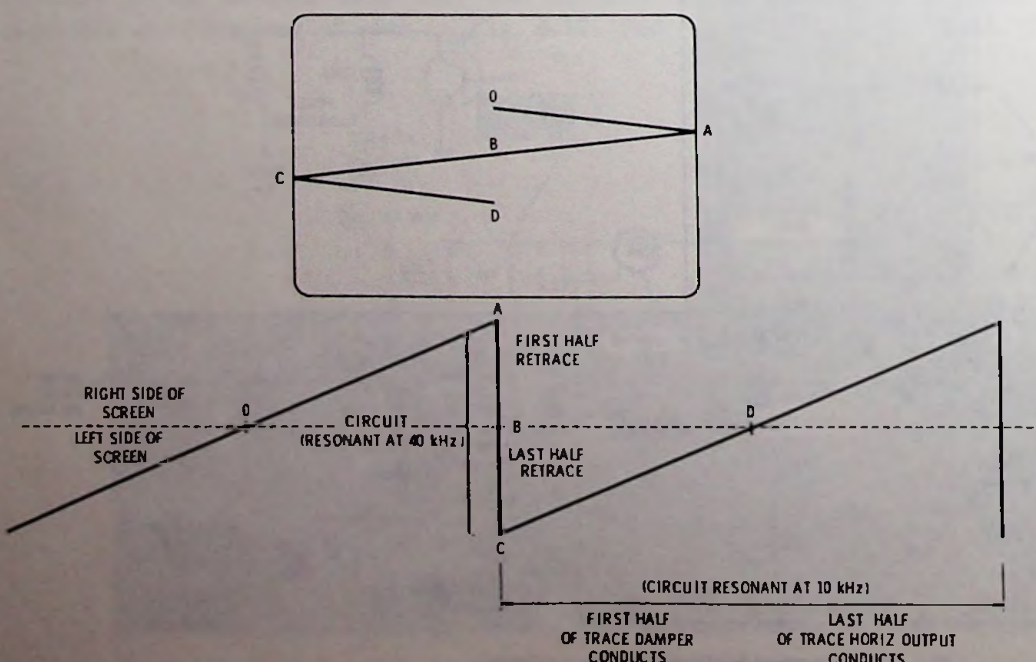


Fig. 4-21. Yoke current waveform and timing sequence.

beam to the center of the screen (points A to B in Fig. 4-21). It must now rapidly build up to a maximum in the opposite direction during the next 6.25 microseconds in order to deflect the beam to the extreme left (points B to C). Finally, this field must diminish to zero during the next 25.5 microseconds to allow the beam to return to the center of the picture tube (points C to D). This process will produce one scan line and one retrace sequence. Retrace requires 12.5 microseconds. Scan takes place in 51 microseconds. Retrace is the period in which no picture information is presented to the picture tube; in fact the picture tube is blanked out during this time. In essence it is a swift retracing of the beam from one side of the screen to the other between scan lines. Scan is the term applied to the time and effect of the electron beam moving from one side of the screen to the other as it changes in intensity to create differing amounts of picture information.

The method used to accomplish these current changes in the required times for trace and retrace is the use of the time for one-half of a cycle at the proper resonant frequencies. As mentioned, these frequencies are approximately 10 kHz for trace and 40 kHz for retrace. One-half cycle at 10 kHz is 51 microseconds and one-half cycle at 40 kHz is 12.5 microseconds. Since the current increases to maximum and decreases again to zero in each half cycle the deflection circuit requirements are met.

Let us assume that the tv receiver has just been turned on. The beam is at rest in the center of the picture tube. The yoke capacitor is charged as current is first applied to the set. It is charged directly from the B+ supply through the flyback as explained earlier. At this time a pulse from the horizontal oscillator reaches the base of Q504 (Fig. 4-19), the output transistor. It saturates and becomes a short circuit across the B+ supply which cannot supply energy to CX515 as long as it is shorted. Turning on Q504, then, effectively isolates the yoke resonant circuit from outside energy, allowing the energy stored in yoke capacitor CX515 to be discharged into the yoke. The circuit is now much like the resonant circuits discussed in our explanation of oscillators—almost like a tank circuit. This circuit now consists of CX515, the horizontal yoke windings and the flyback and is resonant at 10 kHz. Fig. 4-22 illustrates this circuit in simplified form. Circuit current flow is linear due to the linear discharge of CX515. The linear increase in current causes a magnetic field to build up around the yoke. This magnetic field increases in a linear manner as does the current

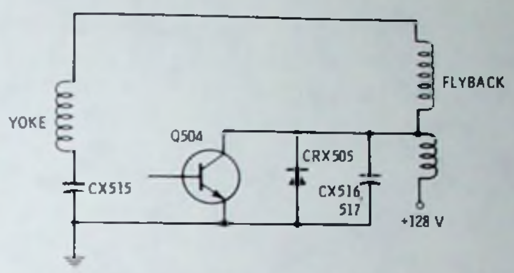


Fig. 4-22. Simplified horizontal output circuit of Fig. 4-19.

through the yoke. The magnetic field is of the proper polarity to cause electron beam deflection to the right side of the picture tube. After 25.5 microseconds, as the beam reaches the extreme right side of the screen, Q504 is cut off by the sharp drop of the input pulse (it loses forward bias). Transfer of energy from the charged capacitor to the magnetic field of the yoke now ceases. It is time for retrace.

With no current in the yoke coils to sustain the magnetic field it begins to collapse. According to Lenz's law this collapsing field induces a voltage which opposes the decrease of current that is flowing in the yoke. The induced voltage is positive at point A in Fig. 4-19. The damper diode is thus reverse biased, the horizontal output transistor is cut off, and capacitors CX516 and CX517 become the only path to ground for the induced oscillatory currents. During times when either the transistor or damper are conducting, these capacitors, being in parallel with Q504 and CRX505, are effectively shorted out. But, now that they are in *series* with and are a part of the circuit, the total capacitance of the circuit is decreased and the resonant frequency jumps to 40 kHz.

Being resonant at this higher frequency the magnetic field quickly drops to a minimum. With such a rapid change in magnetic field strength the voltage induced into the yoke is very high and the yoke becomes essentially the voltage source of the circuit. The pulse created is called the flyback pulse and is generally in the neighborhood of 400 to 800 volts. Also, with this rapid collapse of the magnetic field in the yoke, the electron beam is deflected back to its resting place in the center of the picture tube. And, since the pulse created at this time is so much greater than the B+ supply voltage which charges CX515, it causes CX515 to become charged to the same polarity as it was before the collapse of the yoke field. Remember this induced voltage will always oppose its cause (in this instance the cutting off of the yoke current) and thus the seemingly incorrect charge polarity. Being resonant at 40 kHz, this one-fourth cycle of 40 kHz energy (from maximum to zero field charge) lasts for 6.25 microseconds. At the end of this time there is no more induced voltage across the yoke and CX515 is fully charged.

Because the circuit is resonant, the charge in the capacitance is quickly transferred to the yoke again as a magnetic field during the following 6.25 microseconds. Since electrons must now flow from the capacitor to the yoke instead of the reverse as before, the magnetic field also has the opposite polarity. As current flows from CX515 into the yoke, the electron beam is deflected to the extreme left side of the picture tube.

Now the magnetic field begins to collapse again. A voltage is induced by the collapsing field which attempts to keep the current flowing. The polarity of this voltage is such that point A is now negative and diode CRX505, the damper, is forward biased. With the damper conducting, capacitors CX516 and CX517 and the B+ supply are again shorted out of the circuit. The capacitance of the circuit is now greater and the resonant frequency of the yoke circuit is 10 kHz. One-fourth cycle at this frequency (magnetic field drops from maximum to minimum) is equal to 25.5 microseconds and one-half the screen is scanned for picture production. At this point the cycle begins again. The horizontal output transistor begins to conduct and the yoke capacitor, CX515, begins to discharge through the yoke to complete the scan from the screen center to the right side. Since the transistor is conducting, the capacitors are still shorted out and the resonant frequency is still 10 kHz. Completion of the scan will then take another 25.5 microseconds, or a total of 51 microseconds for a complete scan line to be produced.

Special attention should be called to the fact that damper diode conduction causes scan of the left side of the screen and horizontal output conduction causes scan of the right side of the screen.

As a summary, note that the B+ supply is connected across the series combination of the yoke capacitor and yoke. The B+ energy is used to replenish losses in the circuit. This is accomplished during retrace when neither Q504 or CRX505 are shorting out the supply. The damper acts as a switch to cause transfer of energy from the yoke to the capacitor during one-half of the scan time (from left side to center). The horizontal output transistor acts as a switch during the second half of scan to cause transfer of energy from the capacitor to the yoke. Both are nonconducting during retrace time. The circuit component values increase the resonant frequency of the circuit to 40 kHz and one-half cycle of oscillation occurs over the 12.5 microseconds of retrace. The yoke ends up charged with magnetic energy in the direction to deflect the electron beam to the far left at the end of retrace time. The collapse of the magnetic field again induces voltage to forward bias the damper to start the next trace period.

It should also be mentioned that all sets do not have damper diodes. An example of such a circuit is shown in Fig. 4-23. In a case such as this, the collector-base junction of the horizontal output transistor serves as the damper. Note that in the conventional horizontal output circuit, the transistor and diode conduct in opposite directions. That is, during scan time when the oscillatory currents have one polarity, the transistor will be made to conduct, and when the opposite polarity is present, the damper conducts.

In Fig. 4-23 the output transistor is an npn type and as an amplifier will only conduct when the collector is positive with respect to the emitter. If the collector is made negative at a time when the base has no pulse and is essentially grounded, the base-collector junction is forward biased and conduction occurs. Thus, damper action is achieved.

OTHER HORIZONTAL CIRCUITS

Most solid-state receivers use a "buffer" or "driver" amplifier between the oscillator and horizontal output circuits. The purpose of such a circuit is to provide amplification to the relatively small oscillator output signal. It also buffers the output transistor from the oscillator so that taking current from the oscillator to drive the output does not cause the oscillator to shift frequency. These circuits are simple amplifiers and should present no problem to the technician. Fig. 4-24 shows a typical driver circuit. Note that it is a common emitter amplifier consisting of only five components including the transistor.

One important factor concerning the driver/buffer circuit is its coupling to the output transistor. This is always via a transformer such as L402 in Fig. 4-24. The purpose of using a transformer is to provide a system whereby if the drive signal is lost to the output, the output transistor is not destroyed. By using the transformer for coupling there is no direct connection between prior circuits and the output transistor. So, if any circuit previous to the output ceases to function, the output transistor is merely cut off. This occurs there is no forward bias to the transistor—and it because it is biased off by returning the base to

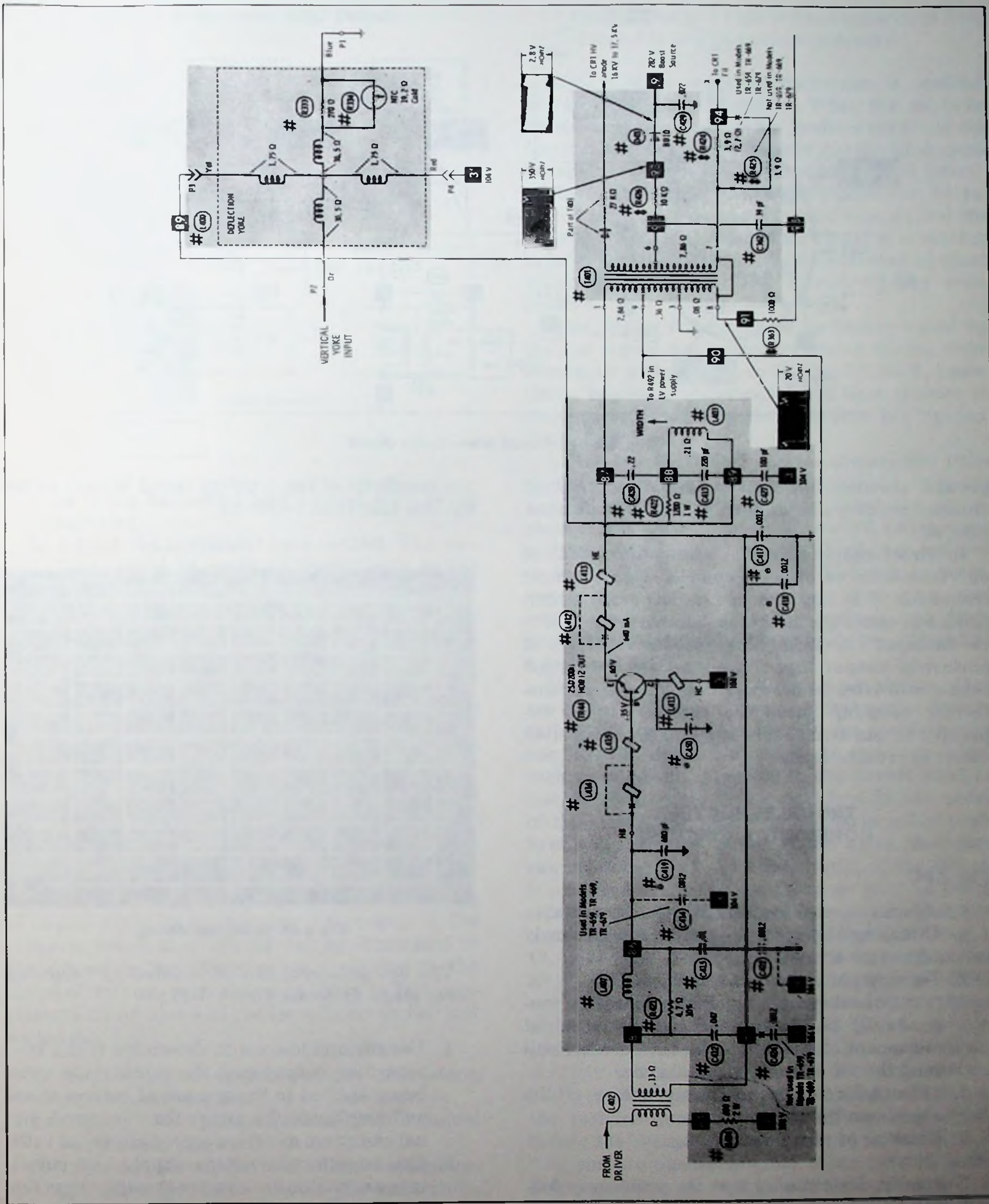


Fig. 4-23. Horizontal output circuit without damper diode.

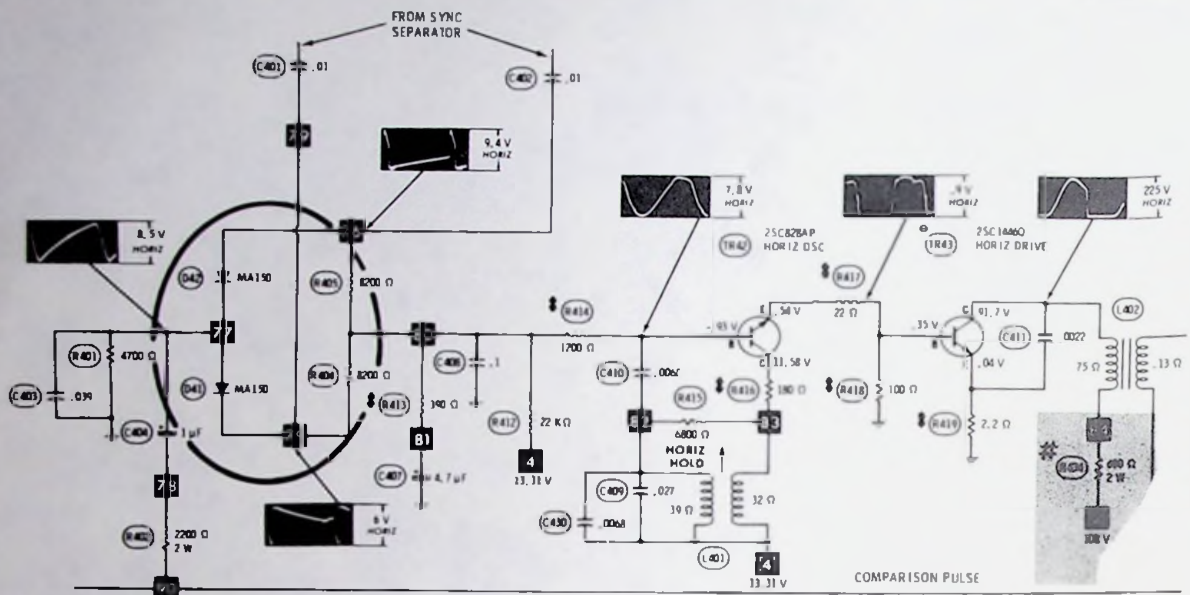


Fig. 4-24. Horizontal driver/buffer circuit.

ground through the driver transformer. And, without input pulse applied to the transformer, cuts off.

In direct coupled circuits where the output of one transistor is directly connected to the next transistor it is not uncommon for prior circuit failure to cause the next transistor in the series to be damaged. In older, tube model receivers if horizontal output tube drive was lost the output tube would often be destroyed. So the use of transformer coupling saves the replacement of expensive output transistors and makes the receiver easier to troubleshoot.

TROUBLESHOOTING HORIZONTAL CIRCUITS

The APC

Symptoms created by defective apc circuits are:

1. "Floating" horizontal—picture moves slowly across the screen.
2. Tearing picture as seen in Fig. 4-25.
3. "Soft" horizontal lock. Picture locks in momentarily but is so sensitive that a slight movement of the horizontal hold control will send the set out of horizontal sync.
4. "Piecrusting" around the perimeter of the objects on the screen.
5. Bending of picture at the top.

Normally, determining that the problem is definitely in the apc circuit is the most difficult part of apc troubleshooting. This is true because of the simplicity of the circuitry found in most monochrome television receivers.

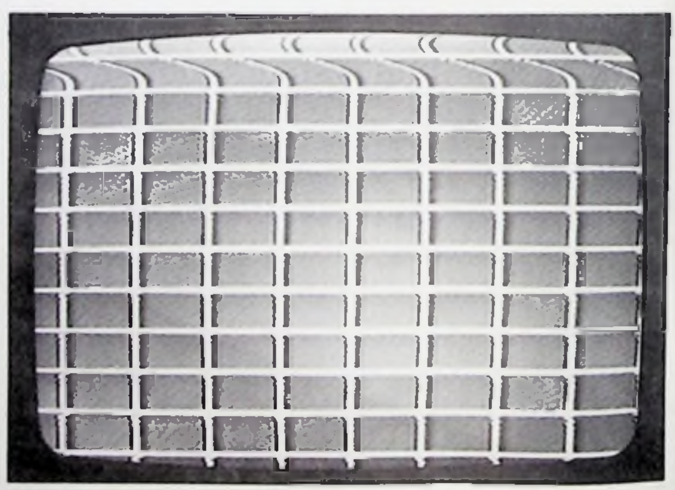
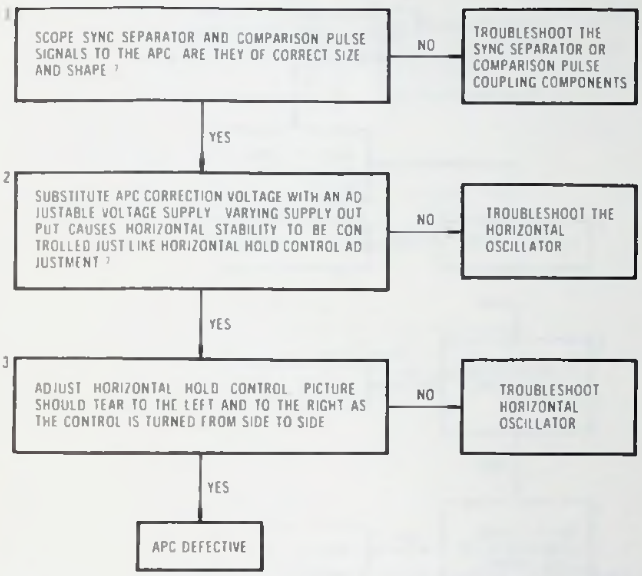


Fig. 4-25. Horizontal tearing.

The apc problems can be isolated by following these steps (also see Chart 4-1):

1. Use the oscilloscope to determine if the sync separator output and the comparison pulse being applied to the apc are of correct shape and amplitude. Be aware that too much signal can cause as severe a problem as too little.
2. Use an external voltage supply and substitute an outside voltage for the apc correction voltage. By varying the supply output, the horizontal stability should be controlled just

Chart 4-1. Isolation of APC Defect



as if the horizontal hold control were being adjusted.

3. Adjust the horizontal hold control. The picture should be made to "tear" both to the right and to the left if the oscillator is operating correctly.
4. If all the above tests are positive—that is, the apc has the correct inputs, the external source will control the horizontal hold, and the horizontal hold control has normal range, the trouble is in the apc circuit. Test No. 1 proves the circuitry previous to the apc to be operating correctly. Tests No. 2 and No. 3 prove the horizontal oscillator to be doing its job properly. That leaves the apc to be the culprit. Now all that is left is to check the few components which make up the apc.

The most effective method of troubleshooting is to play the odds by checking components in the order in which they usually fail as illustrated in the following list. Components are listed in the order of failure, with the most likely to fail components listed first and the least likely to fail last on the list.

1. "Active" power devices (output transistors, power rectifiers, etc.)
2. "Active" low power devices (small signal transistors, ICs, etc.)
3. "Passive" power devices (high wattage resistors, large value electrolytic capacitors, flyback transformers, yokes, etc.)
4. "Passive" low power devices (high resistance units and high voltage capacitors first, then other low power components)

And, in some cases the technician is justified in "shotgunning" the circuit. When the set is an inexpensive one or an older model where it is not feasible to charge the customer for the time spent in repair, or when you are just plain in "a hurry" *all* the components in the apc circuit can be replaced in less time than it would take to find the defective part and replace it. There is a savings in labor which offsets the additional cost of parts which in this circuit are, of course, very inexpensive.

Most of the defects listed as being caused by the apc circuit are caused by faulty diodes, transistors, or when inside an IC, the IC itself. Sometimes, however, the problem will be a resistor of changed value or a capacitor which has opened, shorted, or become leaky.

As the sync separator and the comparison pulse source are cleared from being suspect, test the apc diodes with the ohmmeter. Good apc diodes should have almost identical forward and reverse resistance readings. This means that they are well matched. When replacing apc diodes it is necessary to do so with the correct part type or an exact replacement type. Replacing a *single* apc diode does not always work—they should be replaced as a matched pair.

We have checked the diodes first because they are *active* devices and we know that active devices fail most often, and are usually the problem with apc circuit faults. Naturally, if they are good, each resistor and capacitor in the circuit must be tested. They would be checked first in the order of the most likely failure or the large value units first and then the smaller value units. Resistors can often be checked in the circuit, if the circuit is analyzed first to be sure that no parallel paths exist for the ohmmeter current to flow in while the measurement is being made. Referring to Fig. 4-18, note that if an ohmmeter is applied across R252, ohmmeter current will flow through R252 and Y251 and thus you will measure the resistance of *both* rather than just R252. In Fig. 4-18, however, the resistance of R255 can be measured accurately in the circuit because no other current paths exist. If parallel paths do exist, one end of the resistor must be removed from the circuit before the resistance measurement is made.

If you are unsure whether other current paths exist, measure the resistance in the circuit. If it measures more than the rated resistor value it is defective because there is no way to make a resistance measure greater than its rated value—unless it is defective. Any other current path as just discussed will cause a parallel path and the resistance will measure *less* than the smallest parallel branch. If the resistance measures less than the rated value, pull one end and measure again to be sure of its value.

Checking capacitors in circuits, such as the apc circuit, is best done by removing one end of the capacitor and using a capacitor substitution box to replace the capacitor removed from the circuit. If the set performs well with the new component connected, the one removed must be bad—replace it with an exact replacement type. Capacitors can be analyzed with a digital analyzer (Fig. 4-26).

Fig. 4-26. Digital capacitor analyzer. (*Courtesy Sencore, Inc.*)

Almost always, in the case of pie crusting or picture top-bending, a resistor or capacitor in the antihunt network will be faulty. With an incorrect value resistance or capacitance in the circuit it may attempt to oscillate causing the pie-crust effect. Or, the antihunt network time constant may have increased so it cannot react fast enough

Chart 4-2. APC Troubleshooting Chart

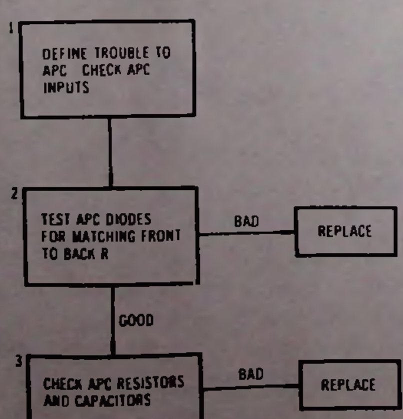


Chart 4-3. Troubleshooting a Dead Transistorized Oscillator

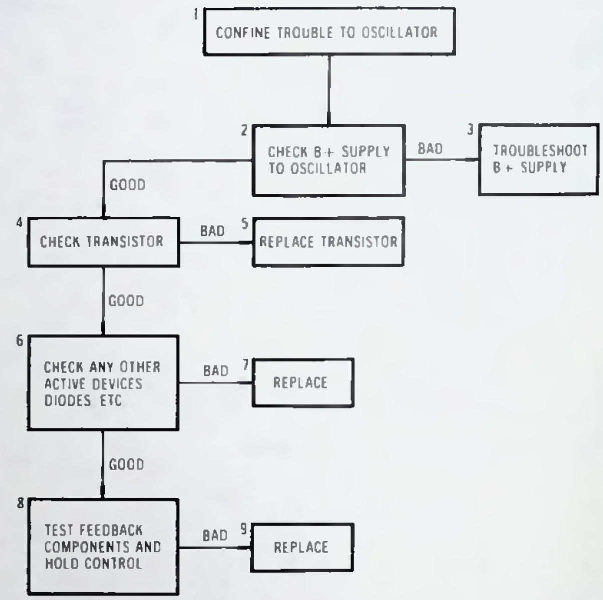


Chart 4-4. Troubleshooting a Dead IC Oscillator

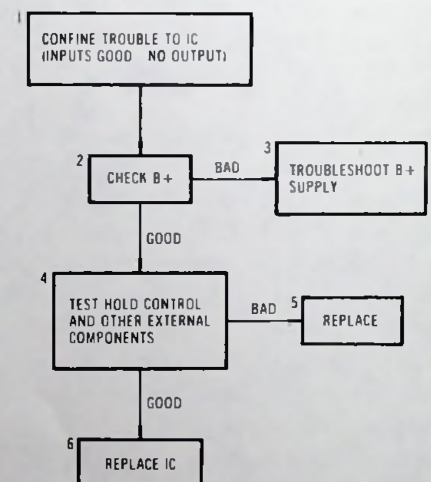


Chart 4-5. Troubleshooting an IC Oscillator With Low Output

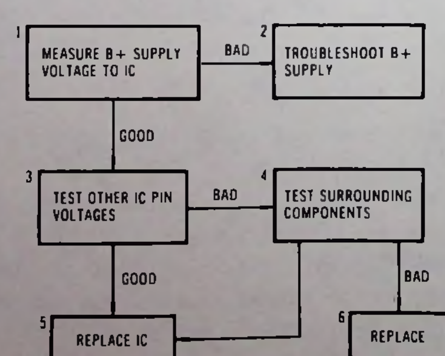


Chart 4-6. Troubleshooting a Transistor Oscillator With Low Output

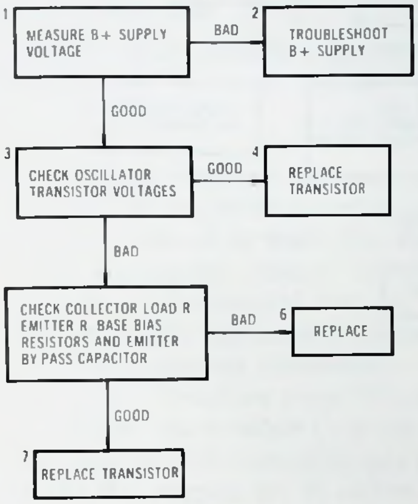


Chart 4-7. Troubleshooting a Transistor Oscillator With Incorrect Frequency Output

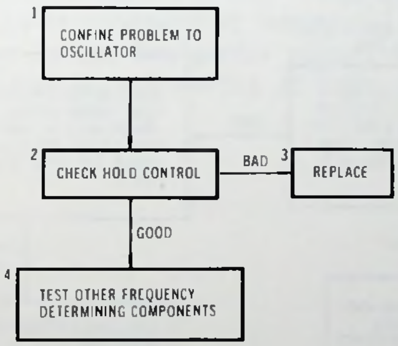
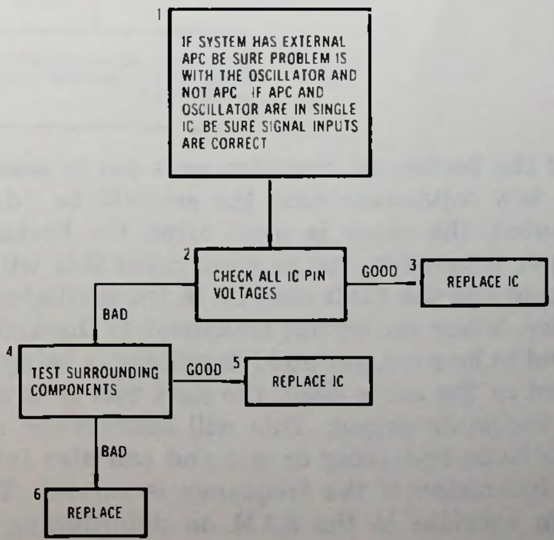
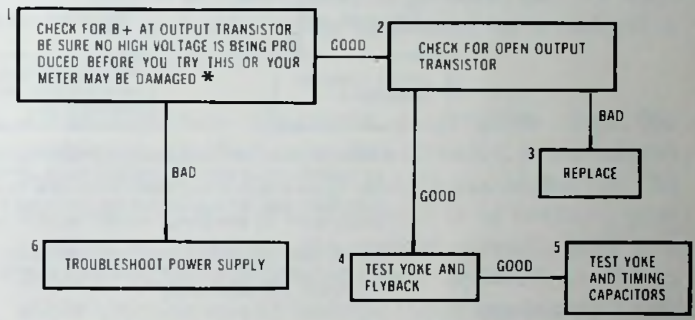


Chart 4-8. Troubleshooting an IC Oscillator With Incorrect Frequency Output



to bring the oscillator under control as each frame is scanned. Usually, by the time a few lines of picture information have been displayed the oscillator will have been pulled back on frequency. But while this process is in progress, the top of the picture, being out of phase with the incoming sync pulse, has been reproduced slightly out of

Chart 4-9. Dead Set



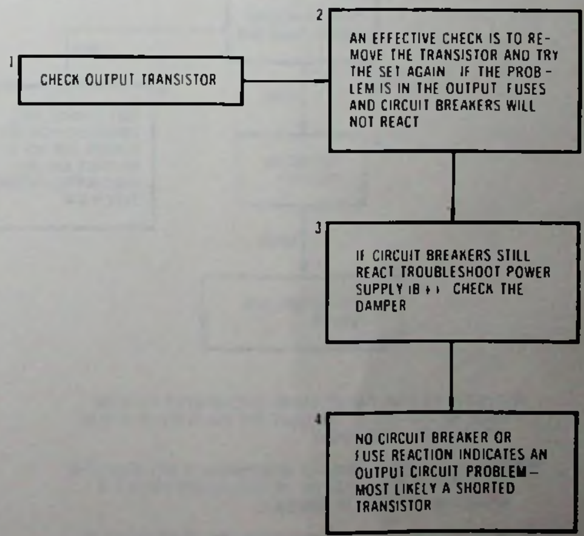
* BEST METHOD TO BE SURE NO METER DAMAGING PULSE VOLTAGE EXISTS IS TO CHECK WITH AN OSCILLOSCOPE. THE SCOPE SHOULD BE SET TO MEASURE A MINIMUM OF 1200 VOLTS THOUGH THE NORMAL HORIZONTAL OUTPUT PULSE IS LESS THAN 800 VOLTS. IF NO PULSE IS FOUND IT IS SAFE TO TEST FOR B+ WITH THE METER OR YOU MAY USE THE DC FUNCTION OF THE SCOPE TO MEASURE IT.

sync—it is bent as shown in Fig. 4-25. To troubleshoot apc use Chart 4-2.

The Horizontal Oscillator

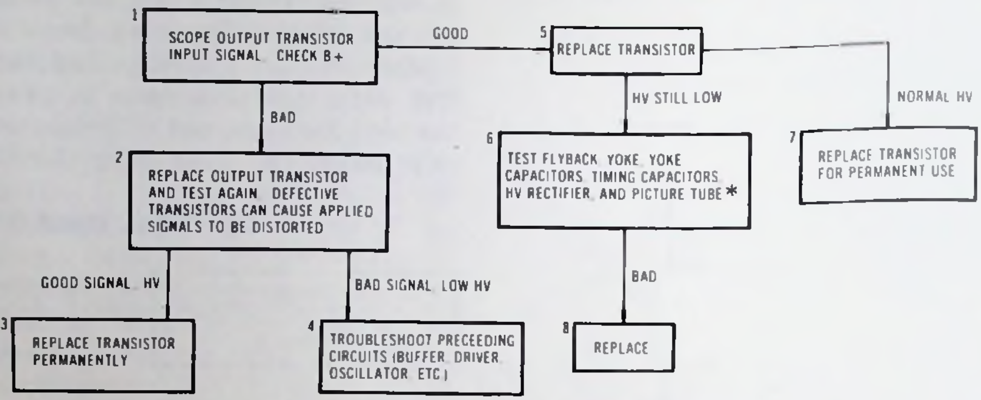
Two things must be determined about the horizontal oscillator as you begin to troubleshoot it.

Chart 4-10. Fuse or Circuit Breaker "Blows"



(1) Is it oscillating, and (2) is it oscillating at the correct frequency? Though another defect can be present, most faults will fall into one of these categories.

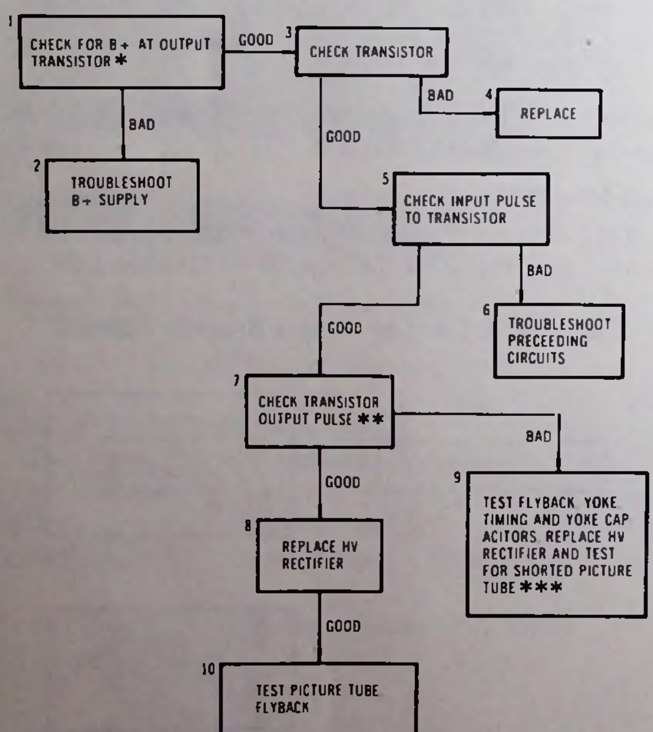
Chart 4-11. Insufficient High Voltage



*TESTING OF TIMING AND YOKE CAPACITORS IS USUALLY BEST DONE BY REPLACEMENT UNLESS EXTREMELY ACCURATE DIGITAL CAPACITANCE TEST EQUIPMENT SUCH AS THAT SHOWN IN FIG 4 26 IS USED THESE CAPACITORS TIME THE RESONANCE OF THE CIRCUIT AND IF THE FREQUENCY IS OFF THE HIGH VOLTAGE MAY WELL BE INSUFFICIENT

PICTURE TUBES WITH INTERNAL SHORTS CAN LOAD THE HIGH VOLTAGE SO HV SHOULD BE CHECKED WITH A RELIABLE HV METER WITH THE PICTURE TUBE DISCONNECTED

Chart 4-12. No High Voltage



*CHECK FOR B+ ONLY AFTER MAKING SURE NO METER DAMAGING PULSE VOLTAGE EXISTS PROCEDURE FOR THIS IS SHOWN IN DEAD SET TROUBLESHOOTING CHART

**TRANSISTOR OUTPUT PULSE FOR MONOCHROME TV WILL USUALLY BE 400 TO 800 VOLTS TO TEST USE AN OSCILLOSCOPE CAPABLE OF MEASURING A MINIMUM OF 1200 VOLTS

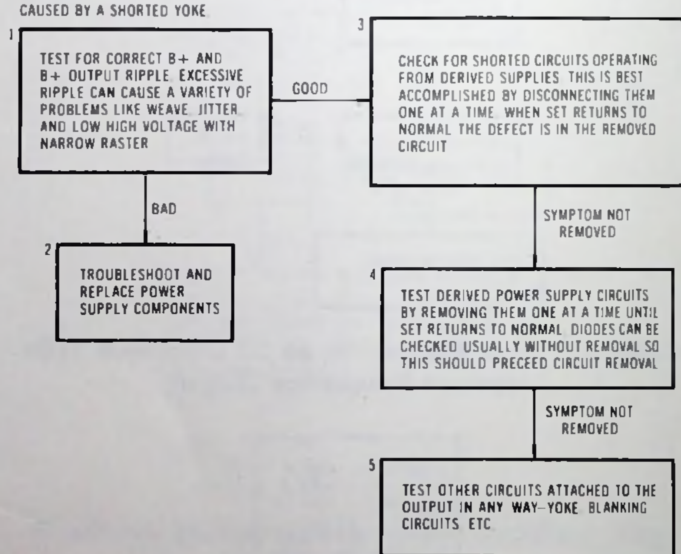
***CAPACITORS IN THIS CIRCUIT ARE CRITICAL AND TESTS SHOULD BE MADE BY REPLACEMENT OR WITH HIGH QUALITY DIGITAL CAPACITANCE TESTING EQUIPMENT THE HV RECTIFIER CANNOT BE TESTED WITH AN OHMMETER

A SHORTED PICTURE TUBE WILL "GROUND" THE HIGH VOLTAGE TEST FOR NORMAL HIGH VOLTAGE WITH THE HV LEAD TO THE TUBE DISCONNECTED NORMAL HIGH VOLTAGE INDICATES A DEFECTIVE TUBE WHICH MOST TUBE TESTERS WILL NOT SHOW FAULTY USE CAUTION SINCE THE HIGH VOLTAGE IN THIS AREA CAN BE VERY HAZARDOUS

Chart 4-13. Loading Symptoms

SYMPTOMS SUCH AS HORIZONTAL BEND WEAVE AND NARROW RASTER ARE CAUSED BY LOADING THE OUTPUT CIRCUIT

KEYSTONE PICTURE IS ALMOST ALWAYS CAUSED BY A SHORTED YOKE



If the horizontal circuitry goes out in many of the new solid-state sets, the set will be "dead." Granted, the cause is most often the horizontal output transistor, but in some cases this will not be true and the fault may lie in the oscillator circuitry. When the output transistor is checked and found to be good, yet no high voltage is being produced or the set is dead, the next test is to scope the oscillator output. This will confirm the oscillator to be operating or not and can also inform the technician if the frequency is correct. There is an exercise in the SAM on determining frequency via use of the oscilloscope.

If the oscillator is not functioning correctly use Charts 4-3 through 4-8.

Horizontal Output Circuits

Symptoms created by defective horizontal output circuits are:

1. *Dead set*—If the receiver in question makes extensive use of derived power sources and the horizontal circuit is dead, the fault may be in any horizontal circuit which would cause a lack of horizontal output. But, in most instances this defect will be caused by a bad horizontal output transistor.
2. *Fuses or circuit breakers may "blow"* as the set is turned on. Remember that the damper and horizontal output transistor are in parallel with the B+ output. So, if either of these devices happens to short, fuses or circuit breakers react *immediately* as the set is turned on.
3. *Insufficient high voltage*—Because the high voltage is produced by horizontal "flyback" pulses in the horizontal output or flyback transformer, a lowering of pulse amplitude will lower high voltage. A change in resonant frequencies will also cause low high voltage.
4. *No high voltage*—In many sets the sound will be normal but there will be no raster. Lack of raster can be caused by no high voltage. And, high voltage production is dependent upon horizontal output circuit operation.
5. *Other symptoms* such as horizontal bend, weave, keystone shaped picture, narrow raster, and others can be caused by a defective output circuit.

After symptom diagnosis determines that the problem is in the horizontal circuits, a waveform check should be made of the input signal to the horizontal output transistor. If it is correct, proceed to troubleshoot the output circuits and any other circuits which might interact with it. These other circuits might include those operating from the derived power sources and the B+ supply operating the horizontal output circuit.

Attempt to determine which part of the circuit would most likely cause the displayed symptom. The basic approaches in Charts 4-9 through 4-13 should be kept in mind.

Chapter 5

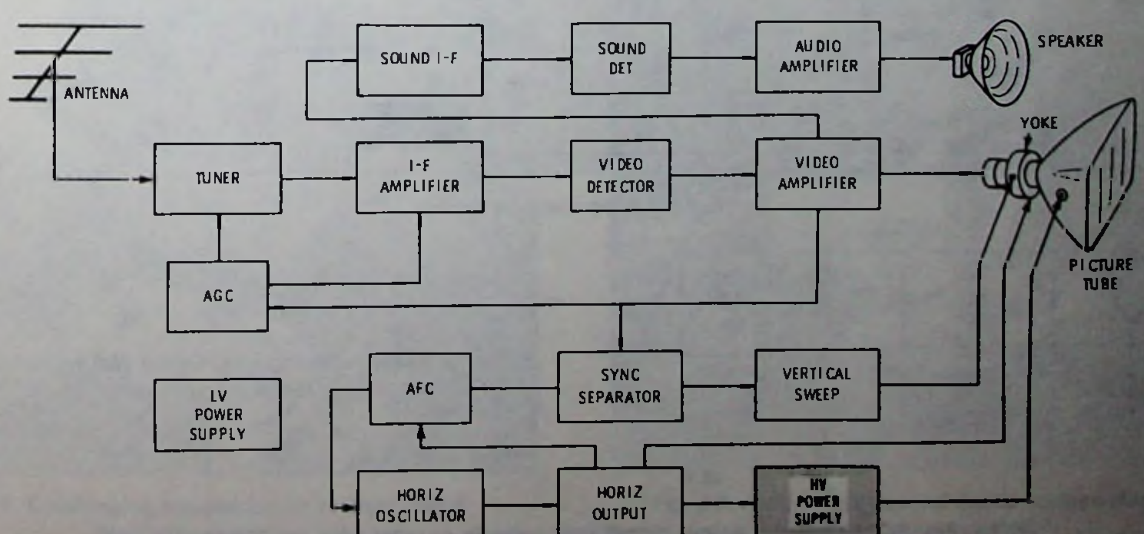
High Voltage Circuits

Before a picture tube can produce a picture it must have a high positive voltage applied to its second anode. This voltage acts as an accelerating potential to "draw" the electrons toward the picture tube screen where they strike phosphors causing them to glow. The anode potential must be in the thousands of volts depending on the size of the tube. Larger tubes require perhaps as much as 20 kilovolts (20,000 volts). Smaller tubes will require somewhat less voltage, as little as 4 kilovolts for the mini-screen sets.

Fig. 5-1 illustrates a cross section view of a black and white picture tube. Here it can be seen that the second anode is a conductive graphite coating (called the Aquadag) on the inside glass wall. The graphite is deposited from the faceplate to about halfway into the tube neck. It is connected to the phosphors which coat the face of the tube and *through* the side glass wall to the high voltage lead. An external graphite coating is connected to the chassis ground usually by wire springs or spring leaf.

As a by-product of the flyback pulse in the yoke circuit, high voltage is produced. In Fig. 5-2 the yoke circuit is in parallel with the flyback. In some circuits, such as that in Fig. 5-3, the yoke circuit is in series with part of the flyback transformer. In either case when the fast collapsing magnetic field in the yoke produces the 400–800 volt pulse explained in Chapter 4, that voltage is applied to the flyback transformer. The flyback transformer then steps up this voltage to the amount required by the set. This is an ac output, and the picture tube must have dc so a rectifier is used. In Fig. 5-3 this rectifier is Y259 and in Fig. 5-2 it is CRX506. As in the power supplies discussed in Chapter 3, this power supply must be filtered to keep the output at a steady, unvarying level. The filter in this system is the picture tube. An excellent capacitor exists between the outside and inside graphite coatings. The glass envelope makes an excellent capacitor insulator. It is so good in fact that the picture tube will hold a charge for days if the conditions are right. Naturally, a charge of a few thousand volts can be a big surprise to the unwary. *Always* discharge a picture tube before attempting to disconnect the second anode lead *no matter how long the set has been off!*

A safe method of discharging the picture tube is



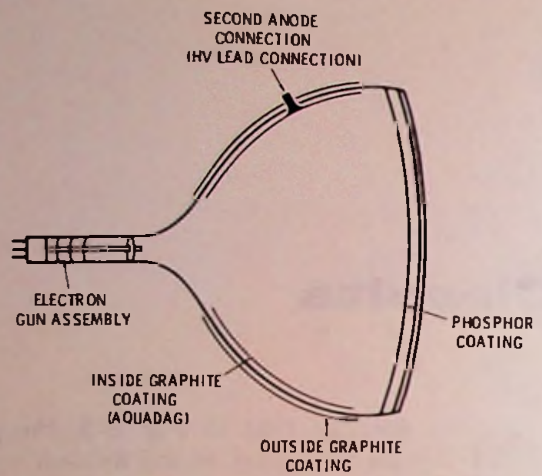
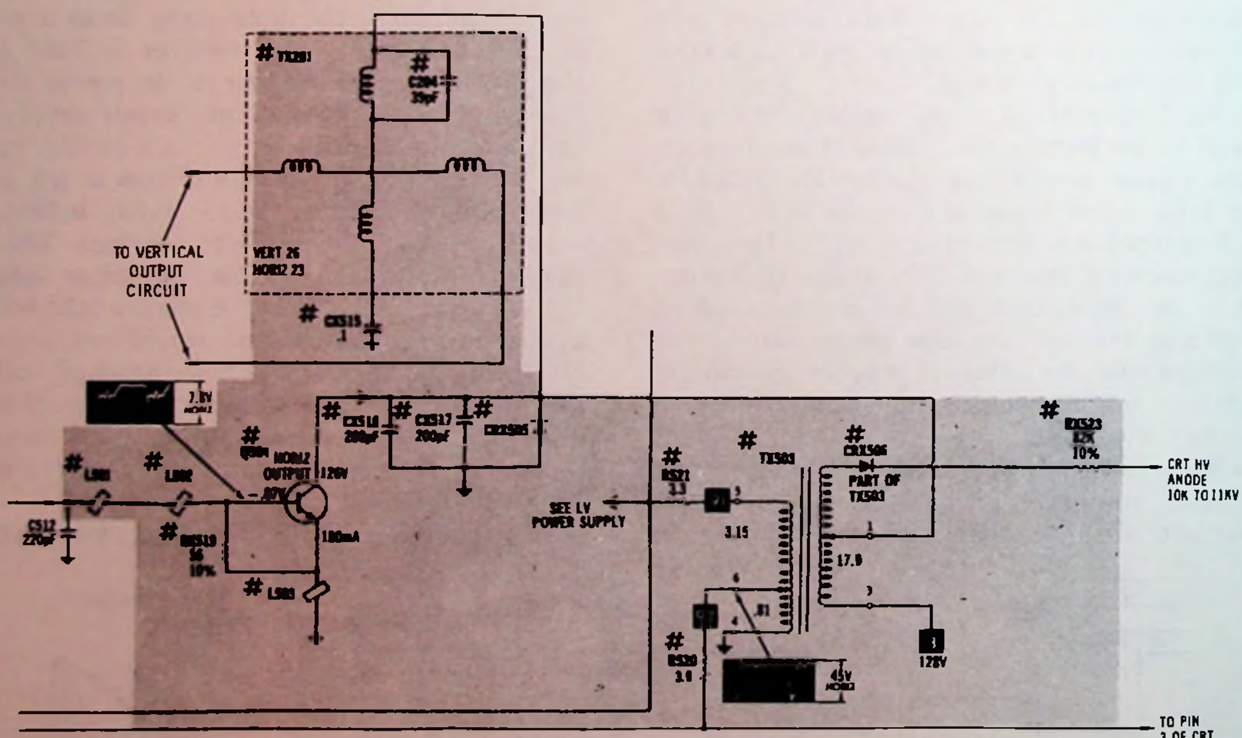


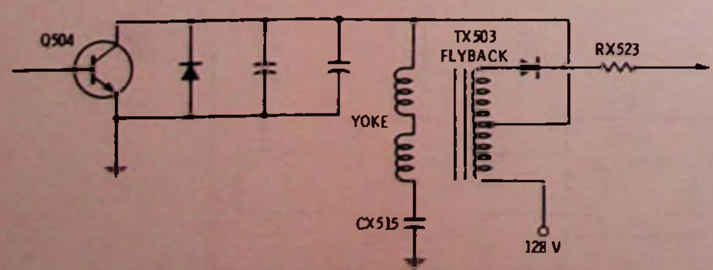
Fig. 5-1. Black and white picture tube construction.

through a high voltage probe as in Fig. 5-4. Use the probe just as you would if measuring the high voltage. You can watch the meter as it falls to zero indicating that no voltage is left in the picture tube "capacitor." To be safe this should be done at least two times before handling the second anode lead. Because the picture tube will sometimes seem to recharge itself immediately after being discharged—only to strike again. It is not a good idea to short the second anode directly to ground. To do so will sometimes damage the seal around the second anode by the high energy arc that accompanies shorting to ground. If a high voltage probe is not available, discharge the tube to ground through a 10 megohm, 1 watt resistor. Use long blade screwdrivers with well insulated handles and alligator clips as shown in Fig. 5-5.

During high voltage production, a path for current in the high voltage circuit is as shown in Fig. 5-6. Current comes from the more negative point in the circuit (ground), through the video output transistor and is boiled off the cathode of the picture tube because of the heat applied to the

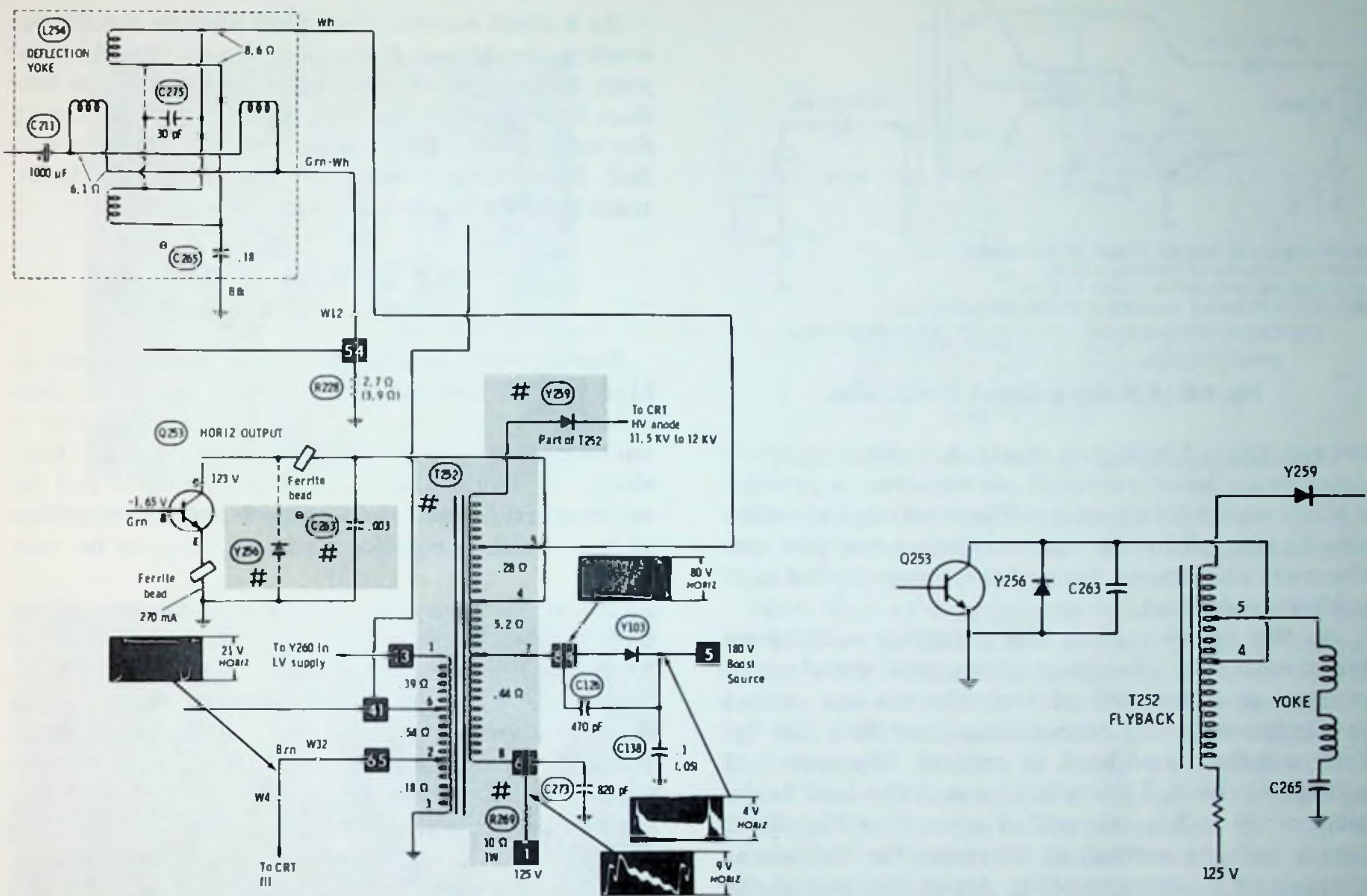


(A) Yoke in parallel with flyback.



(B) Simplified drawing shows yoke clearly in parallel with horizontal output and flyback.

Fig. 5-2. Horizontal output circuit with yoke in parallel with the flyback.



(A) Yoke in series with flyback. (B) Simplified drawing.

Fig. 5-3. Horizontal output circuit with yoke in series with the flyback.

cathode. The video output transistor allows more or less current to flow through the circuit as it acts as a variable resistance. It, thus, allows more and less beam current to produce brightness

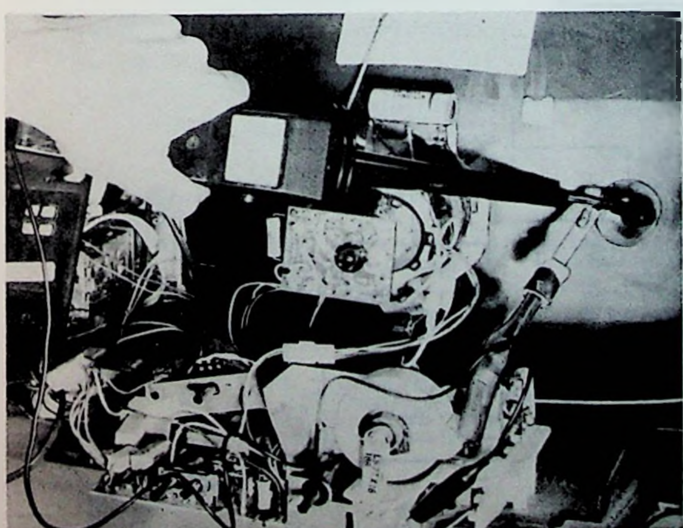


Fig. 5-4. Discharging second anode voltage with a high voltage probe.

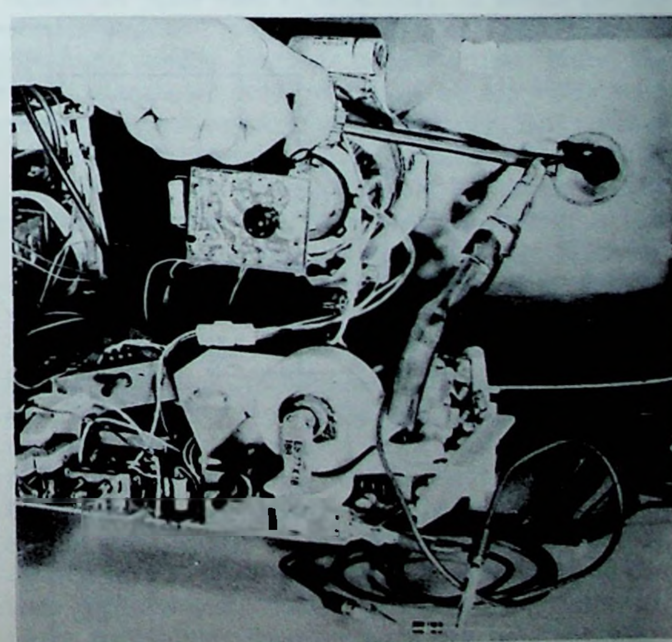
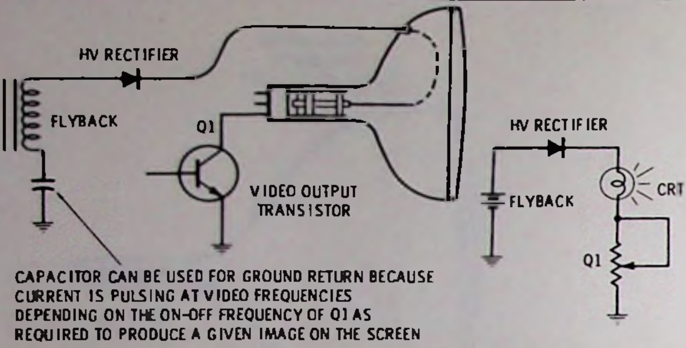


Fig. 5-5. Discharging second anode voltage through a 10 megohm resistor.



(A) Capacitor used for ground return.

(B) Simplified circuit.

Fig. 5-6. High voltage circuit current path.

ranges from black (no electron beam) to white (maximum beam current), as required to produce a black and white picture. The electron gun emission is shaped into a beam by other electron gun elements and drawn toward the screen by the high positive potential.

As the beam strikes the phosphor coating on the screen, the phosphor glows and the electron current is taken out of the tube via the second anode through the high voltage rectifier, the flyback winding, and back to ground. The source of voltage is the flyback winding and the load is the picture tube. The simplified circuit in Fig. 5-6B uses a battery symbol to illustrate the flyback as source and a bulb symbol to depict the load of the picture tube.

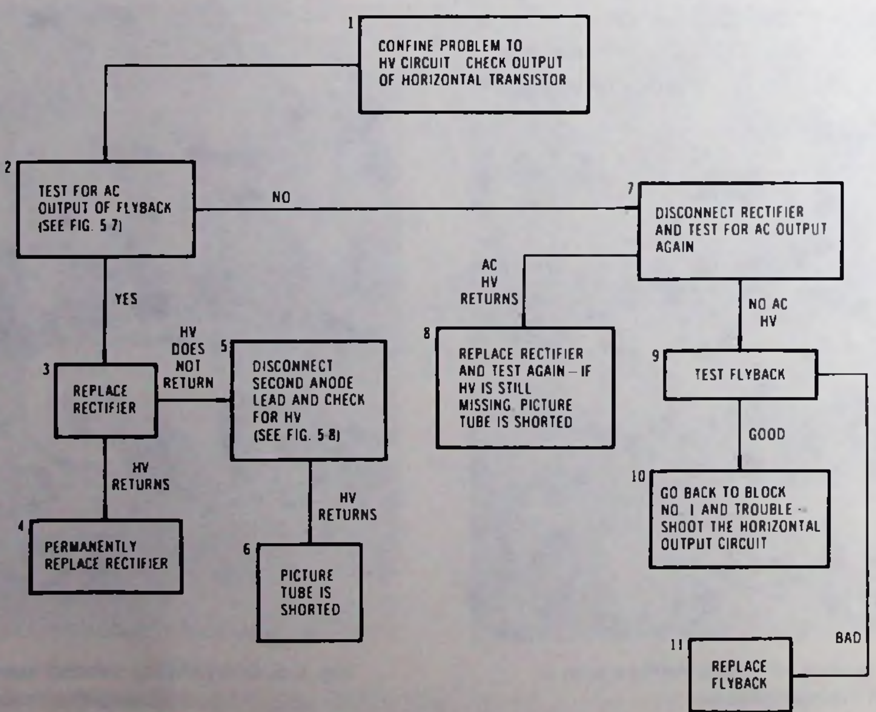
As a short summary of high voltage circuit operation, the 400- to 800-volt pulse produced by the yoke during retrace is used by the flyback to produce by step-up action, the high voltage necessary for tube operation. This ac voltage is then rectified, filtered, and used by the picture tube to attract the electron beam to the screen.

TROUBLESHOOTING THE HIGH VOLTAGE CIRCUIT

Surprisingly little difficulty is encountered in high voltage circuits of solid-state receivers. Considering the amount of voltage encountered it would seem that more problems would exist. Reliability of modern solid-state components and insulating materials have caused the failure rates of high voltage rectifiers and flybacks to be very low.

The most often found symptom of high voltage circuits is that of *no high voltage.* Though *low high voltage* is sometimes encountered it is almost always caused by a horizontal output problem or in some instances by a bad picture tube. Naturally, one of the first checks which should be made is to determine whether the problem is in the high voltage circuitry or the horizontal output circuitry. The best way to accomplish this is to measure "output pulse" of the horizontal output transistor. Do this as explained in Chapter 4. Once the

Chart 5-1. Problem Is Confined to High-Voltage Circuit



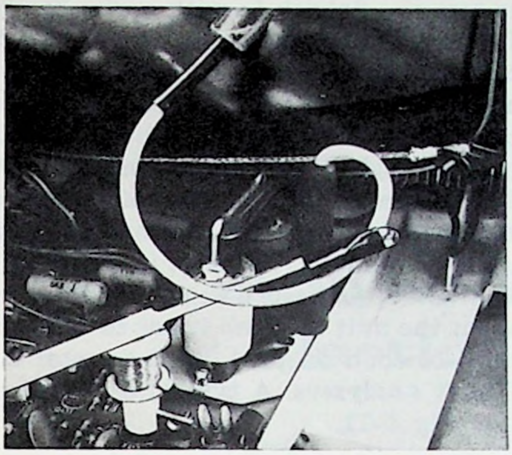


Fig. 5-7. Testing for ac output of flyback transformer.

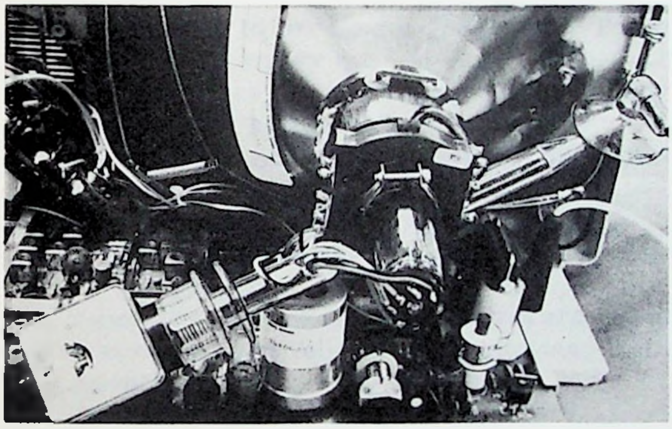


Fig. 5-8. Testing for high voltage with second anode lead disconnected. CAUTION: this test is hazardous. Be sure hv lead is secured to probe. Do not touch or allow hv lead or probe to touch ground.

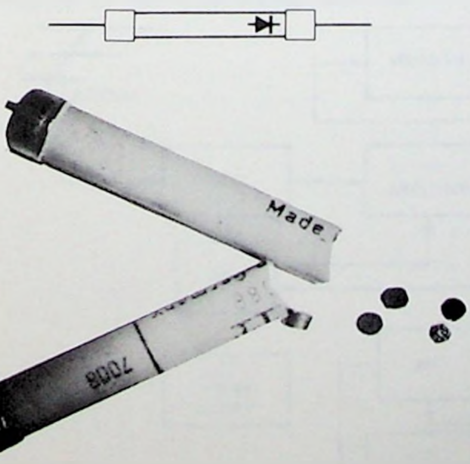


Fig. 5-9. High voltage rectifier construction.

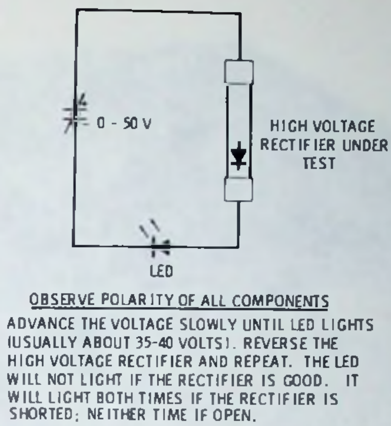


Fig. 5-10. A circuit for testing high voltage rectifiers.

difficulty has been confined to the high voltage circuit the tests outlined in Chart 5-1 should determine the exact cause of the problem.

Most high voltage failures will be caused by the rectifier or flyback since they are the principal components in the circuit. So, the first test is the easiest one—check the rectifier. However, don't try this with your ohmmeter—it won't work. The high voltage rectifier is made of "stacked" or series diodes. In our study of diodes we found that a silicon diode requires approximately 0.7 volt to cause conduction. If 20 diodes have to be placed in series to make one diode capable of withstanding 20 kV (20 diodes rated at 1 kV each) then it would take 14 volts to even make the rectifier conduct. That is 0.7 volt per diode times the 20 diodes equals 14 volts that is necessary to make the assembly conduct. See Fig. 5-9 for an illustration of the high voltage rectifier construction. Now, the usual ohmmeter voltage supply is 1½ volts with some using a 9-volt transistor battery. But neither will produce enough voltage to make the rectifier conduct and therefore it cannot be checked. The rectifier will test *open* with such a meter. A test jig can be constructed as shown in Fig. 5-10 but the easiest test is to simply replace the rectifier with a known good one.

Flybacks made in the more recent years use better insulation techniques and so do not short as often as the older units did. If replacing the rectifier does not restore high voltage and the other circuits have been checked out as described in the horizontal output circuit troubleshooting section of Chapter 4, check the flyback. This is usually left to last because of the difficulty of the test. In most cases the flyback must be removed. Some resistance measurements can be done with the flyback in the set but resistance measurements will not detect a 1 or even a 10 turn short, which

Fig. 5-11. A typical flyback tester. (*Courtesy Sencore, Inc.*)

will cause the set not to work. The only reliable way to test the flyback is with a ringing type of test. In such a test a pulse is fed into the flyback and it is caused to oscillate. The tester will determine if the flyback "rings" or oscillates well enough to be good. As little as one shorted turn on any of the flyback windings can be detected by some instruments. But they are not reliable unless the flyback is removed from the chassis and is well away from any metal. If metal is near the transformer it will often absorb enough of the magnetic field about the unit to cause it not to oscillate well enough to be counted good. Such a tester is often found on tv analyzers. A typical flyback tester is shown in Fig. 5-11.

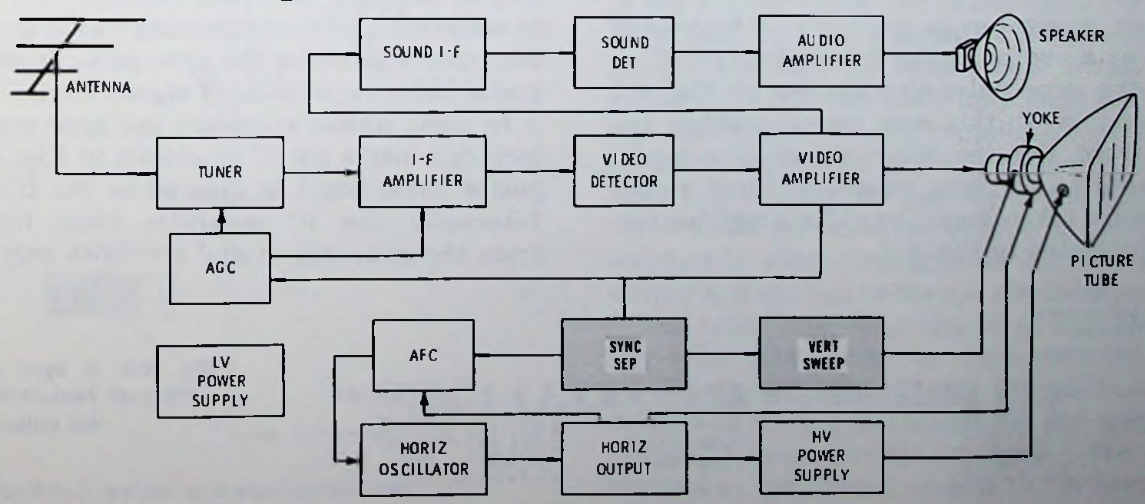
Chapter 6

Sync Separator and Vertical Scan Circuits

Let us mention once again that in the normal course of television repair it is necessary to do the following:

1. Get the set to *produce a full raster.* To do this it is necessary to:
   A. Make sure the low voltage power supply is operating normally.
   B. Have the horizontal sweep circuits operating properly.
   C. Produce the necessary high voltage.
   D. Have the vertical sweep circuits operating properly.
2. Cause the receiver to *display a picture* which means that the following circuits may need attention:
   A. Tuner
   B. Video if.
   C. Video.
   D. Agc.
3. Cause the picture to be properly *synchronized* with the broadcast signal of the station. Synchronization is accomplished by proper operation of the following circuits:
   A. Sync separator.
   B. Vertical oscillator.
   C. Horizontal afc/apc.
   D. Horizontal oscillator.
4. To produce clear, undistorted *sound* with adequate volume.

We have addressed the past three chapters of this text to the first major step in this normal four-point repair sequence, to the point of producing vertical scan of the picture tube. Because of the necessity of understanding the manner in which a broadcast signal is utilized in synchronizing the picture, this chapter will also deal with step three—picture synchronization, origin of sync pulses, and sync pulse separation. It might also be pointed out that usually when the raster is restored to a set having been repaired for a defective raster, synchronization is not a problem. That is, synchronization can be accomplished by normal adjustment of controls. Only in sets having more than one defect will there be a synchronization problem once the raster has been restored. And, overall, multiple prob-



lems are not the usual repair encountered by the service technician. That is not to suggest that such does not occur, but rather that they are by far in the minority of the normal service repairs.

With the circuits we've discussed in the last three chapters a set could produce high voltage and horizontal scan. With just these circuits operating, a lighted narrow horizontal line would be displayed as seen in Fig. 6-1. As learned earlier, in Chapter 2, the electron beam must be moved

Fig. 6-1. No vertical scan.

downward on the picture tube screen as well as across, in order to cause a full raster to be developed. And for the displayed picture to be held steady, it must be synchronized with the broadcast signal. Synchronization of the picture requires the use of broadcast sync pulses "stripped" from the composite broadcast signal. It is the job of the sync separator circuit to "strip" the sync pulses from the composite video. In the following paragraphs first the sync separator actions and then the vertical deflection circuits will be explained.

SYNC SEPARATOR

The sync separator is normally a transistor operating as a switch, being biased into cutoff so that only the sync pulse tips as seen in Fig. 6-2 make it conduct. In this way the sync pulses are stripped from the incoming signal. Composite video is used as the sync separator input signal and is usually taken from the video amplifier circuits as illustrated in Fig. 6-3.

Of the total composite video signal, about 25% is sync pulse amplitude as shown in Fig. 6-2. But, to be on the safe side and not have the sync separator triggered by video, blanking pulse, or noise, it is biased to be turned on only by the upper 10% of the composite video signal. Of course, if attempted to turn on via video, blanking pulse, or noise pulses, sync stability would be very poor.

Signal Biased Sync Separators

Triggering on the tip of the pulse is accomplished by allowing the separator transistor to be biased by the incoming signal itself. In Fig. 6-4 Q3 is biased by the voltage divider consisting of R30, R31, and R32, but not biased to the point of conduction during video signal reception. However, as sync pulses arrive at the base of Q3, it conducts and capacitor C33 is charged according to the polarity shown in the figure. This accumulated charge causes Q3 to be *reverse biased* and to cease conduction. The time constant of C33, R29, and R31 is such that C33 will maintain a charge of near (actually about 90%) that of the peak incoming video signal amplitude. As the next sync pulse arrives the upper 10% of the signal is enough to override the remaining 90% of the reverse bias charge on C33, and Q3 conducts. This occurs with the arrival of each incoming sync pulse allowing the sync separator to conduct only on the upper 10% of the video signal amplitude. In this way the sync pulses are separated from the composite video.

Though other types of biasing systems, such as a fixed bias circuit, may be used, signal biasing is used most because of the need for accurate sync pulse separation from signals of varying levels. Since the turn-on point of the sync separator transistor is determined by the incoming level of signal, by choosing capacitor-resistor time constants to maintain a 90% of incoming signal level charge, the transistor strips the sync pulse from the composite video regardless of signal level.

In some newer receivers the sync separator is included inside an IC as shown in Fig. 6-5. Composite video input is applied to the IC at pin 9. Internally, the IC separates video information from the sync pulses and amplifies only the sync

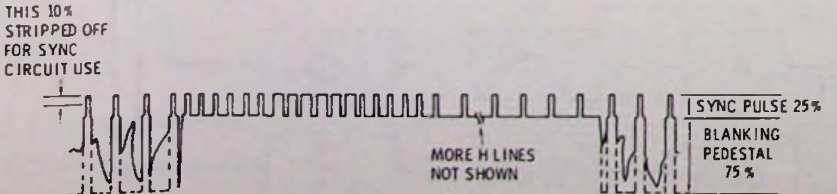


Fig. 6-2. A sync pulse train with both horizontal and vertical pulses.

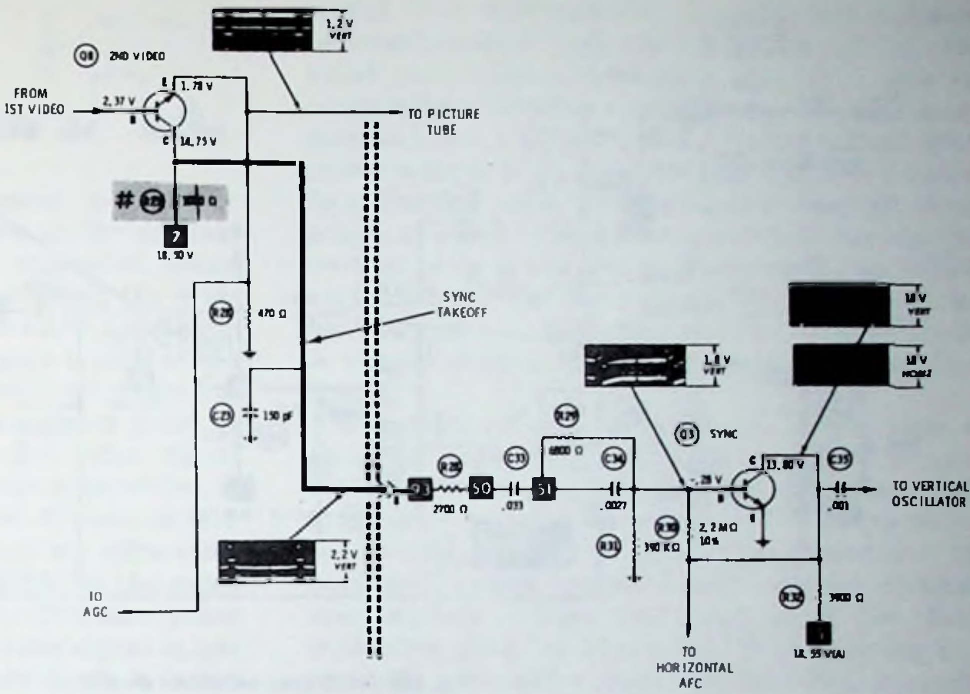


Fig. 6-3. Sync signals are extracted from composite video taken off from the video circuits.

pulses. Capacitor C403 is the sync separator charging capacitor used to set up biasing to develop conduction level of the sync separator circuit, or, in other words, the sync "clip" level. Sync signal exits the separator at pin 12 and is fed to pin 14 through R408. The sync signal is now inverted and amplified in the IC to be taken from pin 15 as a negative going 12-volt sync pulse.

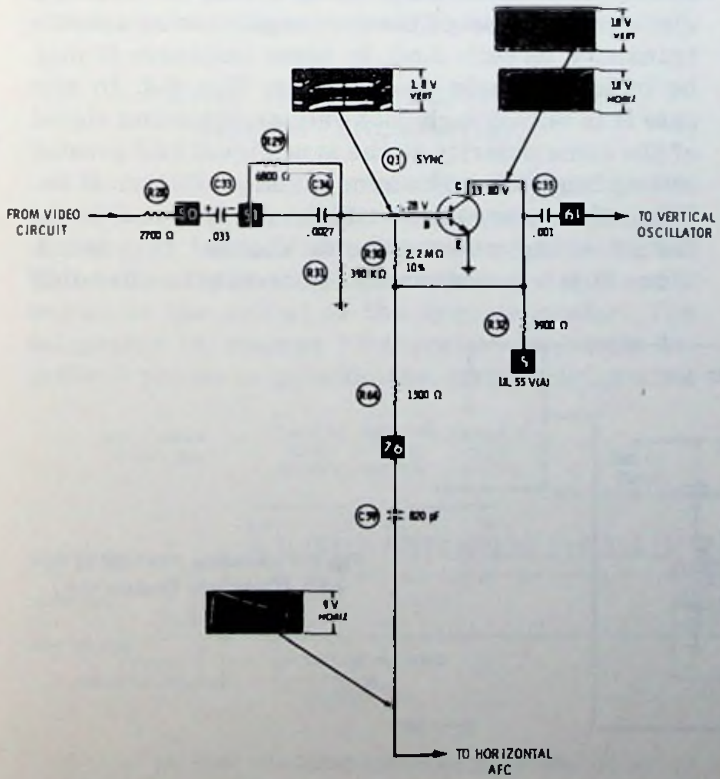


Fig. 6-4. A typical sync separator circuit.

Other Sync Separator Related Circuits

Other circuits are often used in conjunction with the separator. An example of a sync inverter is shown in Fig. 6-6 and a noise cancelling circuit is illustrated in Fig. 6-7. Both of these circuits are sometimes used with the separator circuit. The inverter amplifies and inverts sync polarity. The noise cancelling circuit eliminates any noise in the composite video which could be mistaken by the sync separator as a legitimate sync signal and cause sync instability.

The sync inverter of Fig. 6-6 is a typical common emitter amplifier. The sync signal is applied to the base of Q204 and taken from its collector. Note that the input signal is a 0.7-volt positive going pulse and its output is a 5-volt negative going pulse—it has both amplified and inverted the input signal. It then supplies a high amplitude signal of the correct polarity to the vertical oscillator to trigger it on. The *horizontal* signal is not taken from the inverter output in this case. Instead, it is taken directly from the sync separator output and applied to the apc circuitry.

The noise cancelling circuit of Fig. 6-7 cancels any noise pulse riding on the composite video before it can be used to falsely trigger the sync circuits. Any noise pulse which has the amplitude to "sneak" through the sync separator can cause the vertical or horizontal circuits to "believe" that it

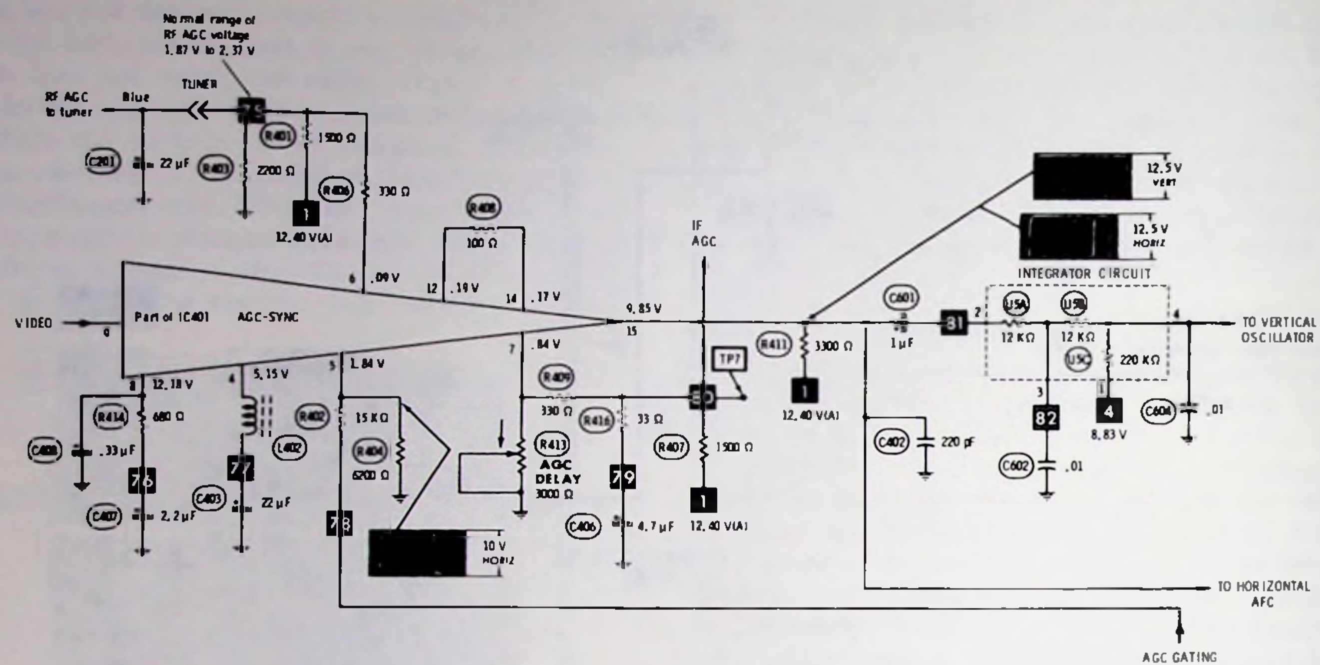


Fig. 6-5. An IC sync separator circuit.

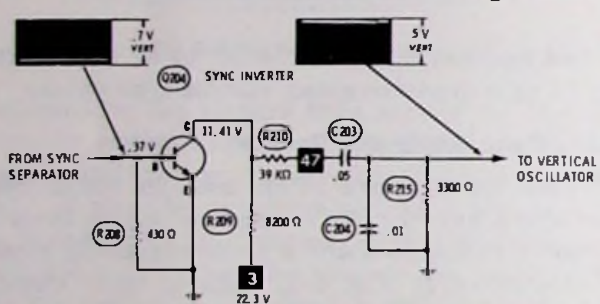


Fig. 6-6. Sync inverter circuit.

is a sync pulse. The result is a sync circuit being turned on when it shouldn't be, and the picture rolls or tears. You have no doubt observed a television being operated near interference (even a running automobile) which caused the synchronization of picture information to be quite erratic. The instability of the picture in such an instance is caused by electrical noise being received by the tv and added onto the received broadcast signal. Fig. 6-8 shows an interference pulse riding on the composite video signal.

The noise cancelling element may be a single diode on the input of the sync separator or a multi-transistor circuit. And, in some instances it may be included inside an IC, as in Fig. 6-5. In any case it is biased such that only an incoming signal of the same polarity as the sync signal and greater in amplitude than the sync signal, will turn it on. When the noise canceller turns on, if it is a diode, the offending noise spike is shunted to ground. When it is a transistor or IC circuit the offending

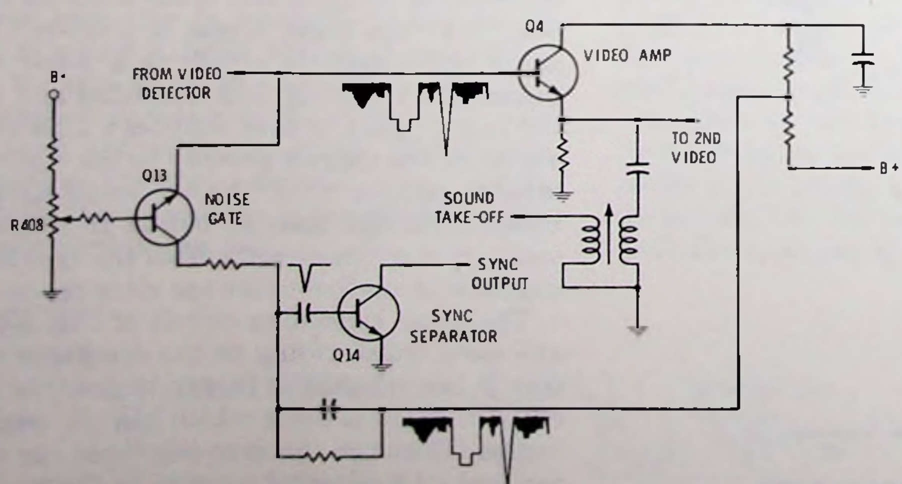


Fig. 6-7. A noise cancelling circuit. (*Courtesy Quasar Co.*)

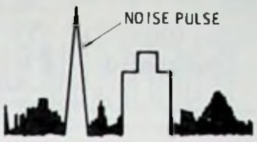


Fig. 6-8. A noise spike riding on a composite video signal.

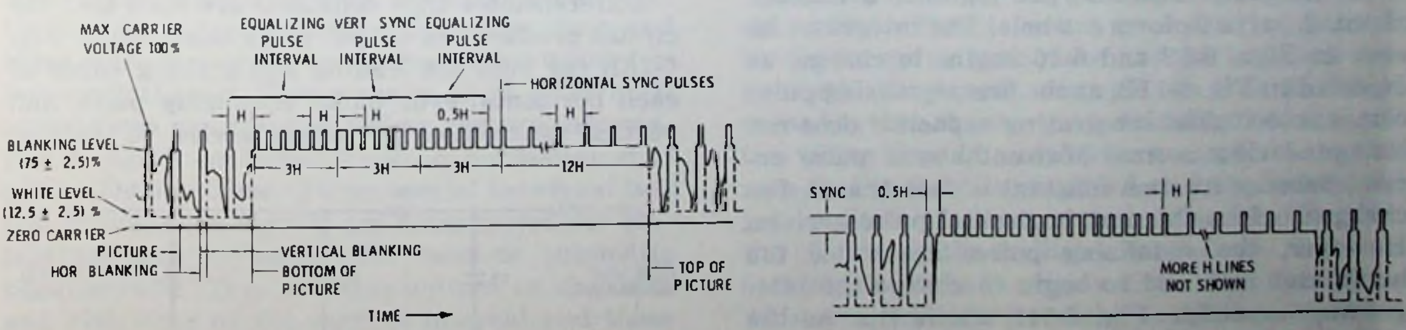
noise pulse is inverted and applied to the sync separator circuit at the same time as the original noise spike inputs to the sync separator. Being of the opposite polarity as the original, the original interfering pulse is cancelled and no erratic sync stability is viewed. A noise gate typical of the type found in many monochrome television receivers is shown in Fig. 6-7. If a noise pulse of sufficient amplitude occurs in the video signal arriving at the base of Q4, the video amplifier, it also biases Q13, the noise gate, *on*. Transistor Q13 is a common base amplifier with an adjustable base bias via R408. The bias is set so the noise gate transistor will not conduct until a noise pulse of greater amplitude than the video signal is applied to its emitter. When it does conduct, being a common base circuit, no signal inversion occurs, as it would if the circuit were a common emitter type. But, the sync separator takes its input from the *collector* of Q4. So, the operational method of the noise gate as described earlier is preserved—the noise gate signal has not been inverted but the sync signal has, so as they are fed to the sync separator transistor, Q14, they are of opposite polarities and the interfering pulse is cancelled.

SYNC TRAIN INTEGRATION AND DIFFERENTIATION

The next task, after removing the sync pulses from the composite video, is to separate the horizontal sync signal from the vertical sync signal. This is done by two resistor-capacitor circuits connected to the output of the sync separator. The *integrator* in essence "integrates" or "puts together" pulses to provide the vertical triggering signal. The *differentiator* actually differentiates between pulses to keep the horizontal system provided with station broadcast sync. In order to completely understand what this means it is necessary to know a bit more about the broadcast sync pulses—these are shown in Fig. 6-9. The bottom four lines of video and their accompanying sync pulses are shown first. These are followed by the vertical sync pulse train. Note that the entire vertical sync train rides atop a blanking level signal. This assures that the scanning electron beam is cut *off* during the entire vertical retrace interval.

The vertical sync pulse train begins with a series of "equalizing" pulses at twice the normal horizontal rate, then follows the actual vertical sync pulse which is *serrated* at twice the horizontal rate. Then more equalizing pulses and 12 horizontal pulses complete the train of vertical sync signals. Notice the position of the first equalizing pulse in Fig. 6-9A. This drawing depicts the sync pulse train for field No. 1 (even numbered lines) which begins in the top left corner of the screen as shown in Fig. 6-10A. In Fig. 6-9B the first equalizing pulse is one-half horizontal line from the last horizontal sync pulse. For field No. 2 (odd numbered lines) scan begins at the middle of the screen. This half line difference in time between odd and even fields continues through the entire field so that vertical sync pulses for successive fields have the correct timing required for interlacing.

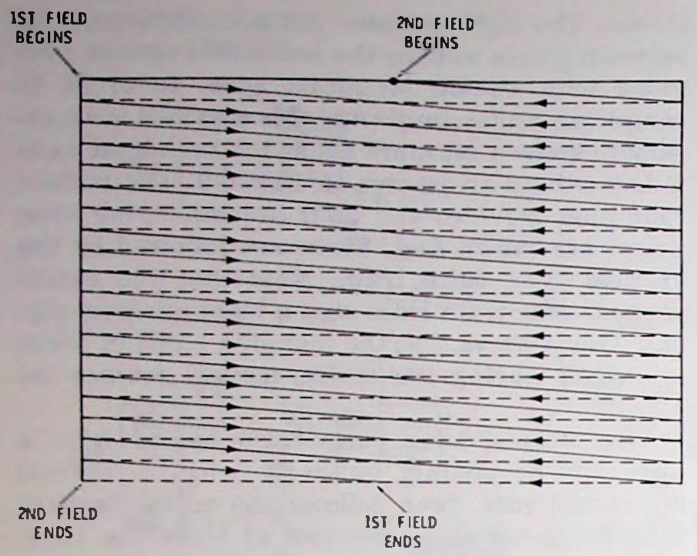
Equalizing pulses actually have the effect of timing the turn-on for the vertical flyback which, in turn, determines at what point the following vertical scan will begin (see Fig. 6-10). As the sync pulses are removed from the blanking pedestal they appear as seen in Fig. 6-11A. Once taken from the composite video signal these sync pulses are applied to the vertical and horizontal sync systems through the integrator and differentiator circuits.



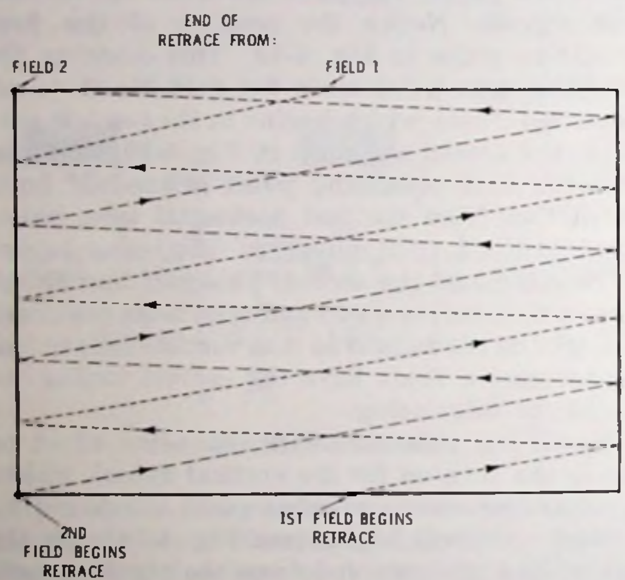
(A) Even numbered scan lines of a field.

(B) Odd numbered scan lines of a field.

Fig. 6-9. Sync and blanking pulses for successive fields.



(A) Active downward scanning.

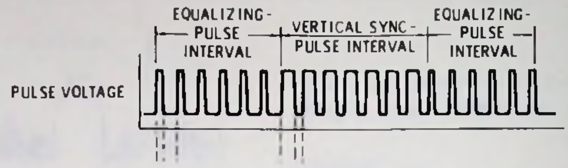


(B) Inactive upward scanning (vertical retrace).

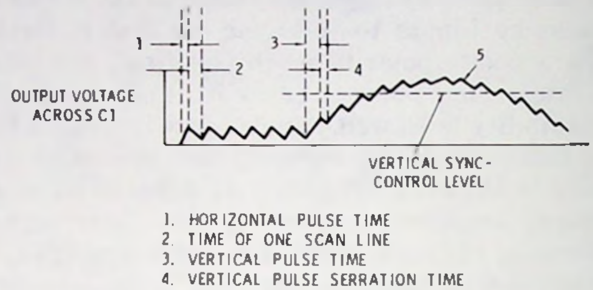
Fig. 6-10. Simplified illustrations of interlaced scanning.

The Integrator Circuit

To integrate means to put together a number of small parts to form a whole. The integrator as seen in Figs. 6-12 and 6-16 begins to charge, as depicted in Fig. 6-11B, as the first equalizing pulse comes into it. The integrating capacitor does not charge during normal horizontal sync pulse arrival because its time constant is such that it discharges before the next horizontal pulse arrives. However, the equalizing pulses are twice the horizontal rate and so begin to charge the integrating capacitor. Fig. 6-11B shows that as the wider vertical sync pulses are applied to the integrator the capacitor charges more toward peak



(A) Vertical sync pulse group.



(B) Output of integrating circuit.

Fig. 6-11. Vertical pulse separation by integration.

input signal level with each pulse. At about the third vertical pulse a level has been achieved that will trigger the vertical oscillator.

Even though retrace blanking is accurately established by the placement of the blanking pedestal, vertical retrace may not take place at the proper instant unless the critical charge on the integrating capacitor occurs at precisely the same point for each successive vertical sync signal. The equalizing pulses keep the horizontal oscillator synchronized and time the placement of the vertical pulses so that the vertical oscillator is triggered at exactly the correct time to produce interlaced scanning.

The Differentiator Circuit

For horizontal scanning of the picture tube to begin at the correct point for interlaced scan, the horizontal oscillator must be kept in sync with the broadcast signal even during vertical retrace. The equalizing pulses and the serrations in the vertical sync pulse provide this function.

Differentiator time constants are such that the circuit produces an output pulse as shown in Fig. 6-13B for both the leading and trailing edges of each horizontal sync pulse, equalizing pulse, and vertical sync pulse. The pulses labeled "C" in Fig.

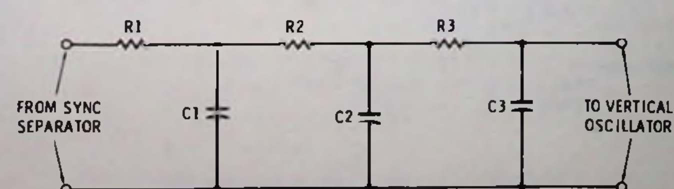
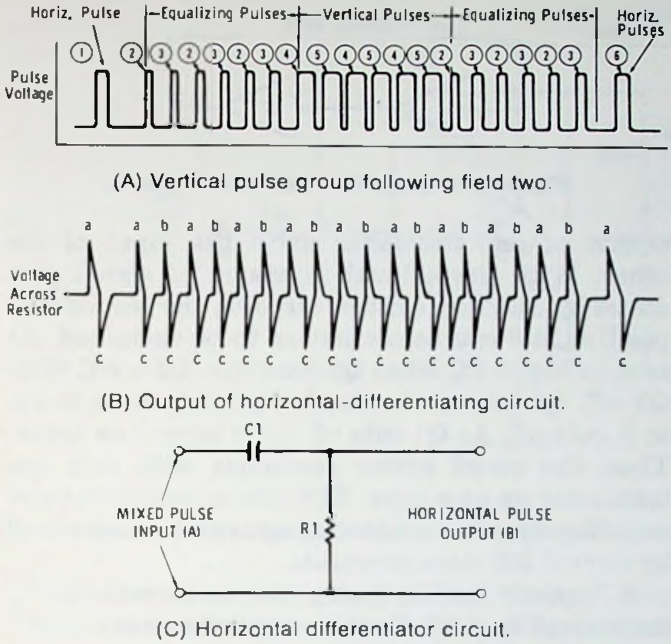


Fig. 6-12. A typical discrete component integrating circuit.



(A) Vertical pulse group following field two.

(B) Output of horizontal-differentiating circuit.

(C) Horizontal differentiator circuit.

Fig. 6-13. Action of horizontal differentiating circuits during vertical pulse period.

6-13B are created by the *falling* edge of the pulses and are rejected by the horizontal afc/oscillator circuitry because of their polarity. Pips labeled "A" are used for oscillator control while those labeled "B" are discarded since they fall in the center of scan time when the oscillator circuitry is not receptive to control. The "B" pips are created by equalizing pulses and vertical pulse serrations which are double the horizontal sync rate of 15,734 Hz. The vertical pulse being so serrated allows control of horizontal sync and at the same time provides a wider pulse time necessary for the integrator circuit to control the vertical flyback turn-on point.

BLANKING

A total of 21 lines is required for vertical blanking and retrace. Three lines are blanked as the equalizing pulses start their work, three more are blanked during the actual vertical pulse time, and three more during the equalizing pulses which follow vertical sync. Then a series of 12 other horizontal lines are blanked before picture information is again contained between horizontal sync pulses. During these 12 lines special broadcast test and information signals are transmitted for station use and for some color receiver automatic color circuits. They are transmitted on the 18th and 19th lines of the vertical interval and these lines are of necessity "un-blanked" during this time.

Blanking is carried out by the blanking pulses and by feeding a vertical sync pulse from the output circuit to a video amplifier. The pulse reverse biases the video amplifier, turning it *off*. As we discuss video circuits in Chapter 9 it will be seen that when the video amplifiers are cut off, the electron beam inside the picture tube is also turned off. The beam remains off and the screen black until the vertical pulse is removed from the video amplifier at the end of vertical retrace. In this way there are no "retrace" lines to interfere with viewing the picture. When seen, retrace lines appear as a few bright lines zig-zagging from the bottom to the top of the screen.

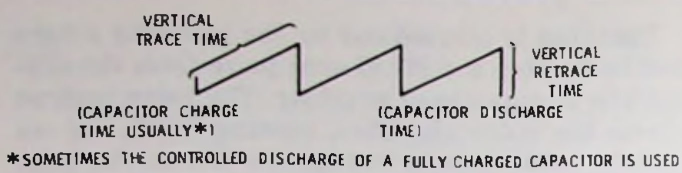
VERTICAL OSCILLATORS

Now that we have explained how sync pulses are extracted from the composite broadcast signal, let's see how these pulses are used by the vertical deflection system.

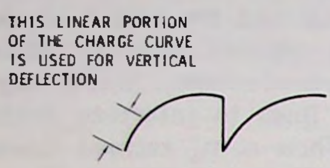
Actually, the vertical oscillator "free runs" and needs no sync pulse input to cause oscillation. If this were not so there would be no vertical deflection unless a broadcast signal were being received. The vertical oscillator frequency is adjusted by the vertical hold control so that it free runs slightly slower than the 59.94 Hz broadcast vertical sync signal. As the sync pulse is applied to the oscillator, it is triggered on just thousandths of a second before it would have self-triggered. Thus, the incoming sync pulse is used directly by the oscillator for sync stabilization. Remember that this is not the case with the horizontal oscillator, as explained in Chapter 4.

Almost every conceivable type of oscillator circuit has been used in tv vertical circuits at one time or the other. In more modern sets, however, only three of these are widely used. Primarily the multivibrator, blocking oscillator, or an IC system is most often used in today's monochrome receiver.

Actually, nothing more is required of the vertical oscillator than to switch on and off as dictated by the incoming sync pulse and its internal time constant components, respectively. The oscillator is used to time the charge or discharge of a capacitor whose linear "ramp" charge or discharge as seen in Fig. 6-14 is amplified and applied to the yoke coils to produce vertical deflection. Usually, the *off* time of the oscillator is the *trace* time and oscillator *on* time is *retrace* time. This is because while the oscillator "switch" is *off* the capacitor is charging and the linear portion of its charge time "ramp" voltage is amplified as just explained.



(A) Linear vertical sawtooth.



(B) Charge curve of a fully charged capacitor.

Fig. 6-14. Waveforms of sawtooth forming capacitor.

When the oscillator turns on it discharges the capacitor rapidly and retrace occurs. Any circuit which can meet these requirements will work as a vertical oscillator.

Multivibrator-Type Vertical Oscillators

The most often used type of vertical oscillator is the multivibrator. A multivibrator requires two transistors to operate. Each transistor operates as an amplifier with feedback used to make the output of one transistor drive the input of the other. With the natural inversion of signal produced by common emitter circuits, the feedback is positive and causes oscillation to be sustained. As seen in Fig. 6-15, when Q1 conducts, Q2 is off. With Q2 off, Q1 has no feedback signal to keep it on, so it cuts off. As Q1 cuts off Q2 is turned on again. Thus, the on-off action continues with only one transistor on at a time. The rate at which the circuit "flip-flops" is its frequency, and is determined by circuit RC time constants.

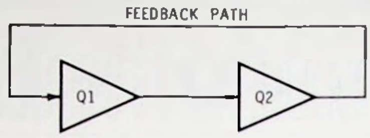


Fig. 6-15. Multivibrator "equivalent" circuit.

A typical multivibrator vertical oscillator is drawn in Fig. 6-16. Here the typical two transistor circuit is used, but in some sets such as that in Fig. 6-17 only one transistor is labeled as the vertical oscillator (vertical discharge). Yet, the system is that of a multivibrator with another transistor in the vertical system, either a driver or

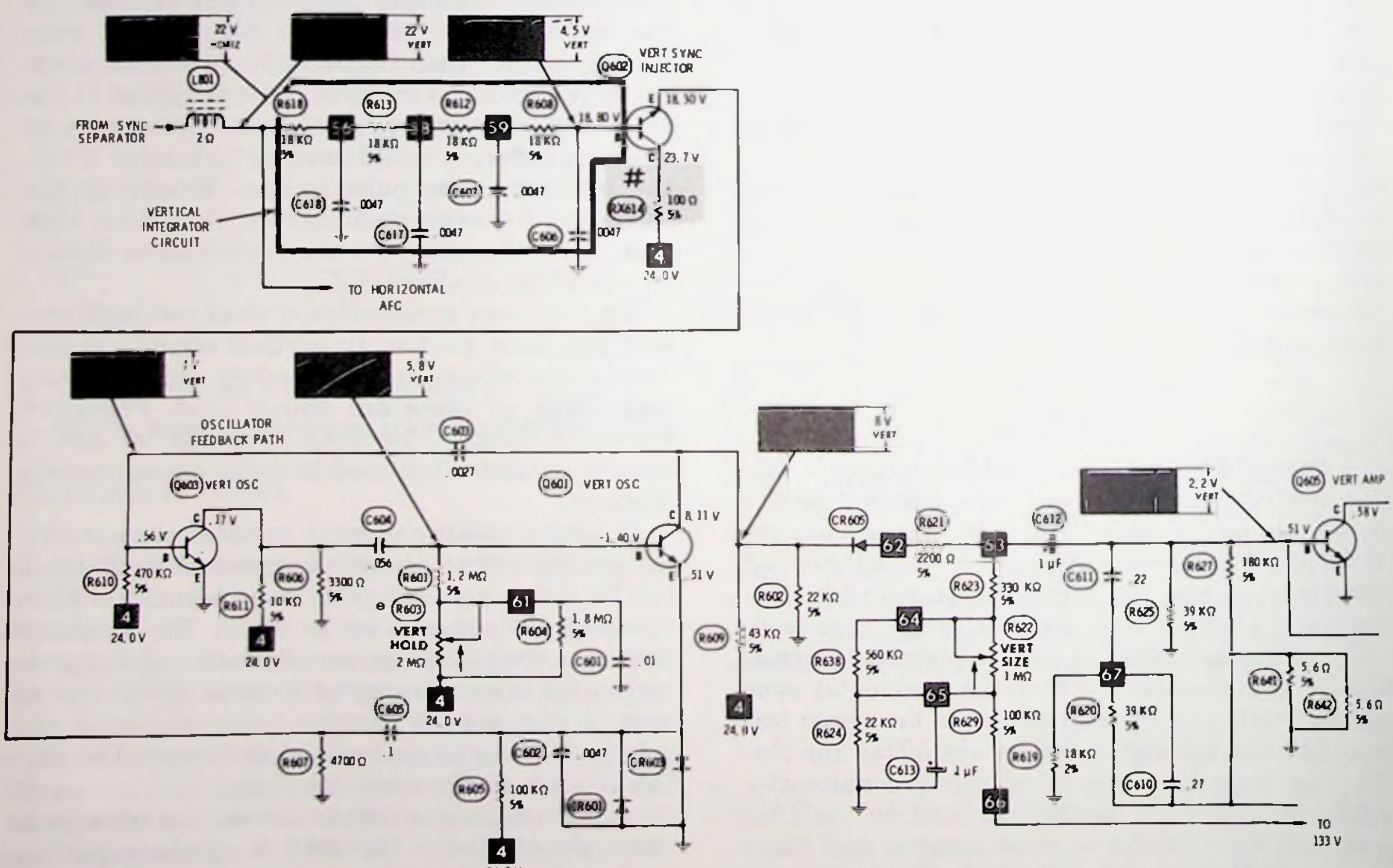


Fig. 6-16. Vertical multivibrator oscillator identifying both transistors as oscillators.

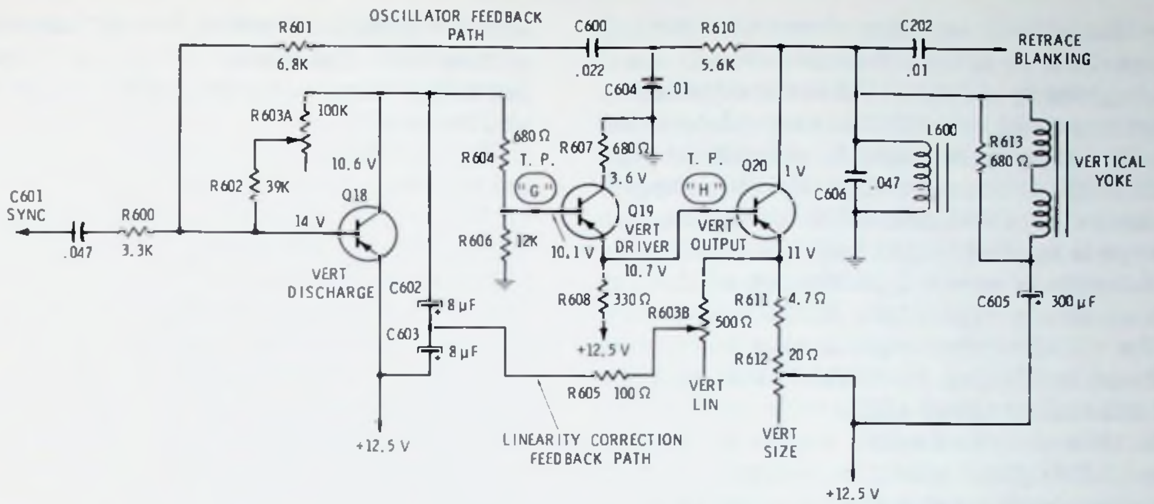


Fig. 6-17. Vertical multivibrator with only one transistor identified as being part of the oscillator. (*Courtesy Quasar Co.*)

output, also functioning as a part of the oscillator circuit. Both systems are widely used in modern monochrome television receivers. In Fig. 6-16, the sync separator supplies a negative going sync pulse to the vertical integrator circuit which consists of R608, R612, R613, R618, C606, C607, C617, and C618. Transistor Q602 is used to match the impedance of the integrator circuit to the vertical oscillator, and operates as a simple amplifier.

From Q602 the integrated vertical sync pulse is coupled to a clamp circuit made of CR601 and CR603. Diode CR603 provides a dc current path for the emitter of Q601 to ground and limits the peak positive input pulse to +0.6 volt. Diode CR603 is biased by voltage provided by the 24 volt B+ source through R605. Diode CR601 is a clipper used to clip the incoming sync pulse to a −0.6 volt level. The clipping action of these diodes provides noise pulse limiting as explained earlier in this chapter.

During trace time, CR603 is forward biased and CR601 is reversed biased by the B+ supply through resistor R605. As CR603 is forward biased, Q601 will be biased off by the +0.6 volt drop across the diode, applied to its emitter. Transistor Q603 is forward biased and conducting at this time. Its emitter is returned to ground and its base to B+ by R610. When Q603 turns on, the collector voltage drops rapidly as most of the B+ voltage is dropped across the collector load resistor, R611. The rapid drop in collector voltage initially appears as a negative going pulse which is coupled through capacitor C604 to the base of transistor Q601 and ensures that Q601 will remain in the off condition. Capacitor C604 will then charge toward the B+ level through R601 and R603, the vertical hold control. When capacitor C604 has charged to approximately 1.4 volts, Q601 will turn on. When Q601 turns on, the collector voltage will drop rapidly forming a negative going pulse which is coupled through capacitor C603 to the base of Q603. This negative going pulse reverse biases Q603 causing it to turn off. Capacitor C603 will then charge toward B+ through R610 placing a positive voltage on the base of Q603. Transistor Q603 will turn on when C603 gains enough positive charge, thus repeating the cycle.

The vertical oscillator is synchronized to the broadcast station by the application of the integrated vertical sync pulse to the emitter of Q601, initiating its turn on. The emitter of Q601 is held at +0.6 volt during trace time by CR603. At initiation of retrace, however, the negative going sync pulse arrival turns off CR603 and turns on CR601. The pulse at the emitter of Q601 will drop the emitter to −0.6 volt, limited by the clipping action provided by CR601—Q601 now conducts. Transistor Q601 will have a negative going collector pulse which turns on CR605 providing a discharge path for C612 and forms the leading edge of the sawtooth waveform. When Q601 turns off, C612 will charge through R622, R623, R629, and the emitter-base junction of the first vertical amplifier transistor, Q605. The charge rate will be linear producing the ramp portion of the sawtooth across R625. This sawtooth pulse is now applied to the following amplifier circuits and finally to the yoke to create a linear downward deflection of the scanning electron beam inside the picture tube.

Fig. 6-17 is a diagram of the vertical sweep circuitry of a system identifying only one transistor as the vertical oscillator (discharge) when in reality the circuit is that of a multivibrator. Feedback for this circuit is taken from the vertical output transistor to maintain oscillation.

At the beginning of trace, Q18 is not conducting and capacitors C602 and C603 are completely discharged. The capacitors begin to charge through R604 and R606 from ground to the B+ supply. As the charge on C602 and C603 increases, this ramp charge is applied to Q19 and Q20 causing the electron beam to be swept from the top of the picture tube screen to the bottom. While this is happening, the voltage across Q18 is also increasing. This voltage is divided by R602, R603 and the emitter-base resistance of Q18 and is used to forward bias this circuit. As Q18 begins to conduct at the end of vertical scan, its collector voltage becomes more positive and the forward bias for Q19 and Q20 is reduced. Note that Q19 is an emitter follower and can be considered virtually a direct connection between Q18 and Q20. With the output transistor now being cut off the magnetic field about the yoke and L600 begins to collapse, causing retrace to begin. Also, the induced voltage in the yoke and L600 causes the collector of Q20 to go negative. This negative pulse is coupled from the collector of Q20 back to the base of Q18 by R610, C600, and R601 driving it into saturation. As Q18 is saturated it becomes a low resistance path for sawtooth forming capacitors C602 and C603 to discharge through quickly. When the magnetic field about the yoke and L600 has collapsed no more negative voltage will be produced at the collector of Q20 and its voltage returns to zero. As this more positive going voltage is fed back to Q18 it causes the transistor to be turned off. Now, with Q18 off, the sawtooth forming capacitors will begin to charge again, repeating the cycle of trace and retrace.

The oscillator is synchronized by the negative going incoming sync pulse and causes Q18 to turn on just before it would normally turn on in its free running mode. This holds the receiver in synchronization with the station broadcast signal.

Note that in each circuit a feedback path from the oscillator output back to its input is readily recognizable. The components in this path, which include the vertical hold control, determine the oscillation frequency of the oscillator. The vertical hold control allows this frequency to be adjusted so that the natural free-running frequency of the oscillator is slightly slower than the correct station sync frequency. Then, as the incoming sync pulse is applied to the oscillator it is triggered into action.

Blocking Oscillator Vertical Circuits

Blocking oscillators in the past have been single transistor circuits employing a special transformer through which the feedback passed before reaching the transistor input. The feedback was such that the transistor would conduct and the feedback would cause it to cut off. It would then be caused to turn on again only to be cut off by its own feedback. Oscillation was sustained in this manner. Newer blocking oscillators are somewhat different and use two transistors and no transformer, yet the operation is the same.

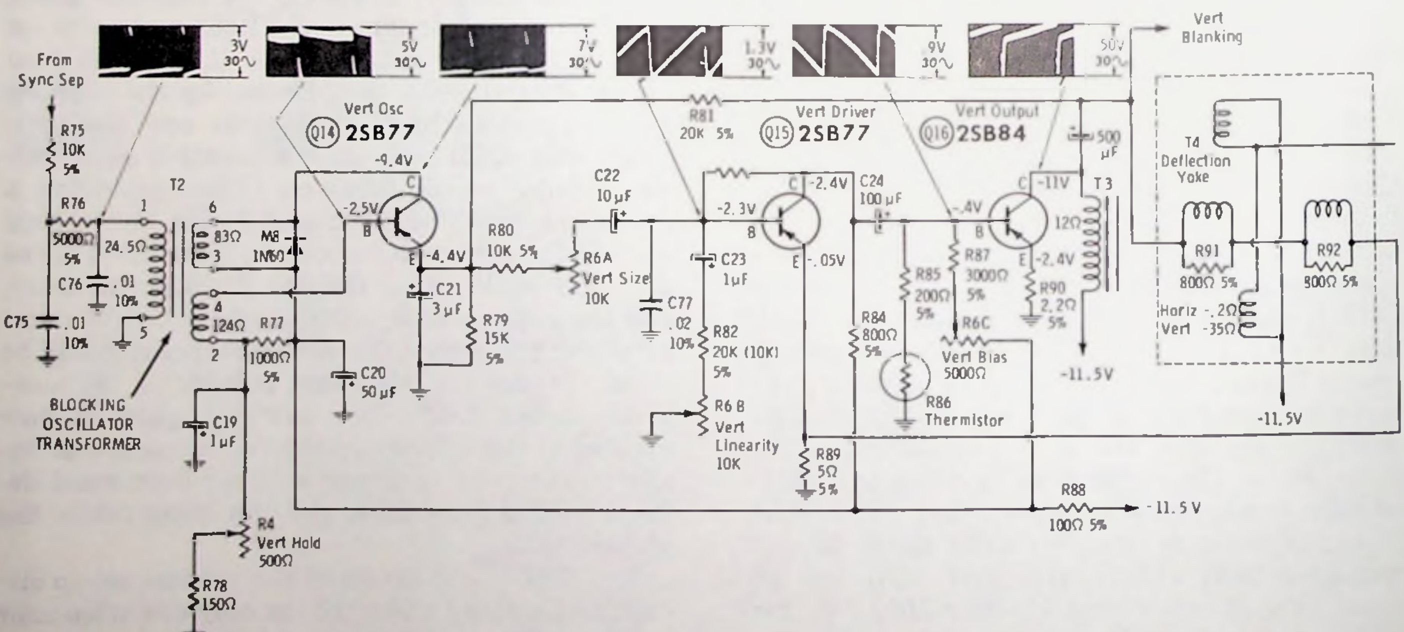


Fig. 6-18. Vertical circuit with transformer-type blocking oscillator.

Transformer-Type Blocking Oscillator — The circuit shown in Fig. 6-18 is a triggered blocking oscillator which uses the familiar transformer for producing the "blocking" action. Positive feedback is coupled from the collector of Q14 to its base via the tightly coupled transformer windings. As Q14 conducts, its base is driven strongly by the signal fed back from the collector. The signal applied to the base-emitter junction causes C21 to charge so the emitter becomes negative and Q14 is thus cut off. Transistor Q14 remains off until C21 discharges through R79 to a level that allows Q14 to turn on again. Then, as Q14 begins to conduct again the cycle repeats itself and oscillation is sustained. Frequency of oscillation is, of course, determined by the bias on the transistor, which determines when it will come out of cutoff. This is adjusted by the vertical hold control, used in this circuit to vary the transistor base bias. By varying the base bias, the emitter voltage necessary to cause turn-on is also varied. If the base bias voltage is lowered, a lower emitter voltage is necessary to turn on the transistor. A lower emitter voltage means that C21 must discharge for a longer period to reach the lower voltage thus the frequency is slower. For a faster frequency, a higher emitter voltage would be necessary so the capacitor would not have to discharge to as great a degree. Incoming sync pulses serve to change the base bias to start transistor conduction as in other types of oscillator circuits. The sawtooth signal used for vertical deflection is taken from C21 and R79. Capacitor C21 charges rapidly during transistor conduction time but discharges linearly during transistor off time. Retrace period then is during transistor conduction time and trace time is transistor off time.

Transformerless Blocking Oscillator—In the transformerless blocking oscillator the feedback loop is direct and does not employ capacitors or transformers as can be seen in Fig. 6-19. Transistor Q21 is the electronic switch which turns on at a predetermined rate or upon arrival of the sync pulse to discharge the sawtooth forming capacitor, C603. Transistor Q22 performs the function of the transformer in Fig. 6-18.

Resistors R604, R602, and R600 provide emitter-base bias for Q21—R602 is variable for control of oscillator frequency (vertical hold control). Components R605, C603, R604, and R608 shape the circuit output pulse to form the required sawtooth shape. Capacitor C602 in conjunction with R607 acts as a filter to "decouple" the vertical pulse signal from the power supply to prevent the pulse frequency from being distributed to other circuits through the power supply leads. Resistor R606 is a feedback and load resistor common to both transistors. A negative sync pulse is applied to the base of transistor Q21 through the vertical integrator made up of C600, C601, and R601. This sync pulse biases transistor Q21 *on* just prior to its free-running turn on, and initiates vertical retrace and synchronizes the oscillator to the broadcast signal.

When operating power is applied to the circuit, the sawtooth forming capacitor begins to slowly charge positively through R607, R608, and R609. Both transistors are off at this time, due to the charging current of C603. The charging voltage across C603 is amplified and used to cause the

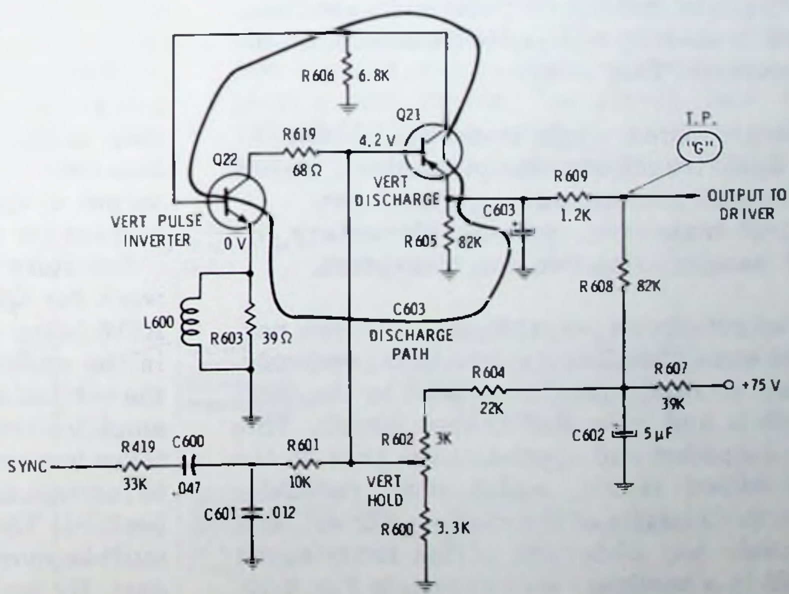


Fig. 6-19. Transformerless blocking oscillator. ***(Courtesy Quasar Co.)***

beam to sweep from top to bottom of the picture tube. At the bottom of the raster C603 will have charged sufficiently to cause Q21 to be biased on. As it turns *on*, a pulse is developed across collector load resistor R606, which is also directly coupled to the base of Q22 turning it on. As Q22 comes on, a negative pulse is developed by the voltage drop across R602 and R604. This negative pulse is coupled directly to the base of Q21 causing it to go into saturation. Emitter-collector resistance of a saturated transistor is on the order of a few ohms and essentially shorts out capacitor C603 allowing it to discharge. The rapid discharge of C603 initiates vertical retrace and drives the electron beam to the top of the raster. The difference in trace and retrace times is due to the fact that C603 charges through approximately 122K ohms and discharges through approximately 40 ohms (Q21 and Q22). The discharge of C603 causes the emitter of Q21 to become less positive, which in turn lowers the collector current, the collector signal level and thus the bias to Q22. Transistor Q22 turns off and its collector goes positive, as does the direct coupled base of Q21. Transistor Q21 is biased off, so both transistors will remain off until C603 charges to a value that will forward bias and turn on Q21 and repeat the cycle.

Frequency determining components are R607, R608, R609, and C603. The vertical hold control and its associated components set the bias of Q21, and thus its turn-on point and the oscillator frequency.

VERTICAL OUTPUT CIRCUITS

Three types of vertical output circuits are found to be used in modern solid-state monochrome television receivers. They are:

1. A single ended, single transistor circuit.
2. A dual transistor, complementary circuit using one npn and one pnp transistor.
3. A dual transistor, quasi-complementary circuit usually using two npn transistors.

Each output circuit, regardless of the type, performs the same function. As explained previously, a sawtooth or ramp signal is created by the oscillator switch and capacitor charge circuit. This signal is amplified and applied to the yoke *by the vertical output circuit,* which must faithfully maintain the linearity of the ramp so a linear scan is produced. Any distortion of the ramp signal will result in a nonlinear scan as seen in Fig. 6-20.

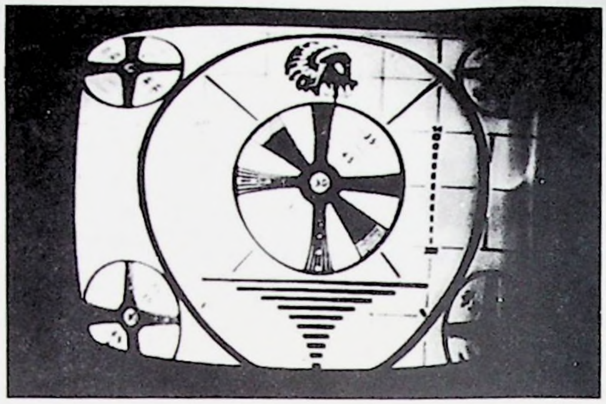


Fig. 6-20. Nonlinear vertical sweep.

Single Transistor Vertical Output Circuit

A typical single transistor output circuit is shown in Fig. 6-21. It is illustrated along with the circuit oscillator and driver because it is actually a part of the oscillator, and because the feedback paths are essential to its proper operation.

In Fig. 6-21 vertical driver Q23 amplifies the ramp signal produced by capacitors C604 and C603 and passes the signal on to Q24, the vertical output. These two amplifiers produce enough current gain to drive the vertical deflection coils of the yoke. Transistor Q23 is operating as an emitter follower which means that as the base signal turns on the transistor and more current flows through it, a voltage drop of the same polarity as the base signal is created across the emitter resistor. Thus, the output across the emitter resistor "follows" the base voltage in polarity. It is impossible to achieve voltage gain from such a circuit but current gain can be quite high. Note that the input signal voltage to Q23 is 7.5 volts peak-to-peak and its output is only 5.25 volts peak-to-peak, showing a loss in signal level. Power gain cannot easily be shown by waveforms but does exist because of current amplification. The output of Q23 produces the necessary controlling current for the base of Q24.

Resistors R615 and R616 form a self-bias network for Q24 with R616 being adjustable. With R616 being variable the amount of degeneration in the emitter circuit of Q24 can be varied and the vertical size adjusted. Degeneration (or loss of amplification) is produced as the emitter resistance increases, causing the voltage drop across it to increase and the emitter voltage to become more positive. The transistor is an npn so the emitter must be more negative than the base for it to conduct. By making it slightly less negative there is

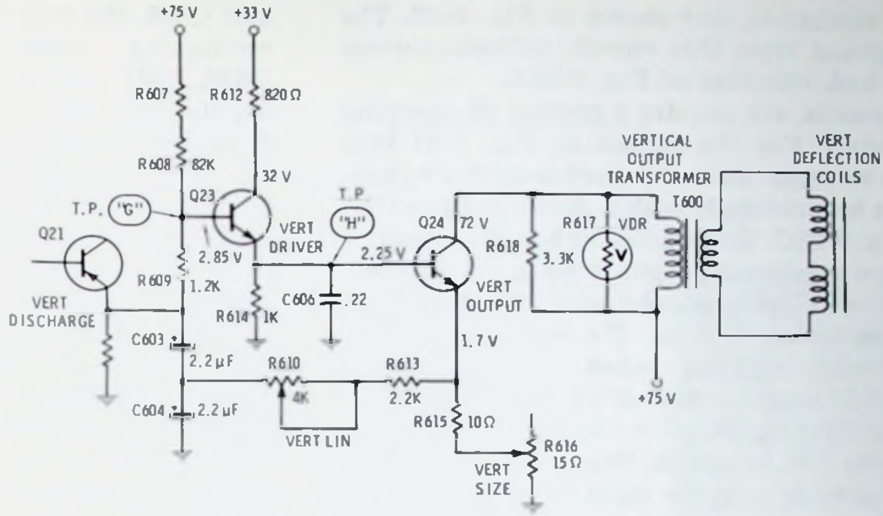


Fig. 6-21. A single transistor vertical output. (*Courtesy Quasar Co.*)

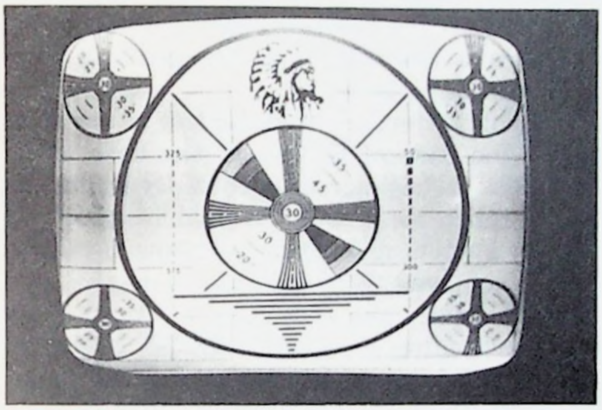


Fig. 6-22. Nonlinear vertical sweep.

less forward bias and the gain or amplification of the transistor is reduced.

When the drive signal at the base of Q24 goes negative with respect to the emitter the transistor is reverse biased and turns off. At this time vertical retrace is initiated. At the instant of vertical retrace, a high positive pulse is produced by the collapsing magnetic field about the yoke. This voltage is impressed on the collector of Q24 and could destroy it if the induced voltage exceeds the collector-emitter breakdown voltage of the transistor. The pulse amplitude is directly proportional to the speed of collapse of the yoke magnetic field, which is directly proportional to the speed at which Q24 is turned off. Capacitor C606 controls the speed at which Q24 is turned off by its discharge time. A smaller capacitor will allow a faster turn off while a larger capacitor would make the turn off time longer. Thus, by controlling the turn off time of the output transistor the induced voltage amplitude is also controlled. However, if the positive pulse created by the yoke does approach the transistor breakdown voltage, R617, a voltage dependent resistor (vdr) offers further protection for Q24. As the voltage across R617 increases, its resistance decreases providing a lower resistance shunt path for the pulse.

Because of component (usually the transistor) characteristics and the design used for the circuit, few circuits will produce a linear scan of the picture tube screen. The circuit just discussed (Fig. 6-21) tends to produce a compressed bottom and an expanded or stretched top raster, causing

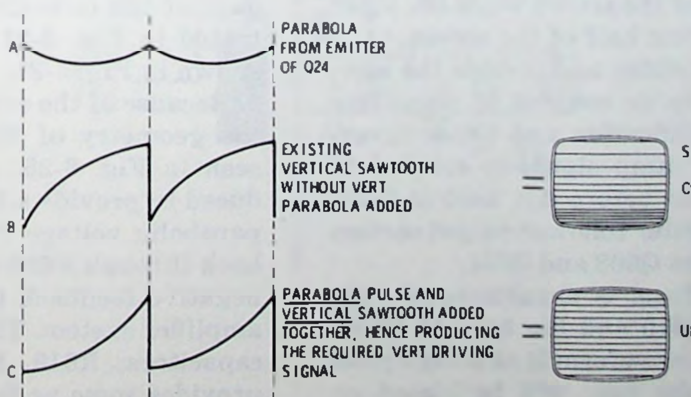


Fig. 6-23. Waveform correction is necessary in some circuits to produce linear vertical scan. (*Courtesy Quasar Co.*)

a picture similar to that shown in Fig. 6-22. The output current from this circuit, without correction, will look like that of Fig. 6-23B.

Most circuits will require a method of ensuring a linear scan. For the circuit in Fig. 6-21 that method is to compensate for the transistor's characteristics by driving it with a signal such as that seen in Fig. 6-23C. The transistor has the tendency to produce a nonlinear output if the input is linear, so we drive it with a nonlinear signal and its output then *becomes* linear. To do this a portion of the sawtooth signal is taken from the emitter circuit of Q24 and coupled back to a wave shaping network consisting of C603 and C604. Capacitor C604 shapes the sawtooth into a parabola (Fig. 6-23A) and adds it to the existing sawtooth produced by the oscillator. The result is the nonlinear signal applied to the base of Q24 as seen in Fig. 6-23C. So by driving the output with a corrected signal its output to the yoke is such as to produce linear scan. Adjustment of R610 provides the waveshaping circuit with the needed sawtooth level to create the amount of correction necessary for linear scan.

Complementary Output Circuits

The output circuit of Fig. 6-24 is referred to as a complementary output because it uses one npn and one pnp transistor. Being opposites they "complement" one another. In this circuit one output transistor conducts during scanning time for the top half of the screen and the other conducts during scanning time for the bottom half of the screen. The reason for the popularity of this circuit is that the drive circuitry can be simple, the transistors can be small, low powered devices, and no heat sink is required. Concerning simple drive circuitry, because the transistors are opposites the same signal will turn one transistor *on* and the other *off* simultaneously. This must be done in the complementary circuit because one transistor is used to scan the top of the screen while the other is used to scan the bottom half of the screen.

Transistor Q605 amplifies and inverts the sawtooth waveform that is dc coupled to transistor Q606 for further amplification and phase inversion. From Q606 the ramp signal is coupled to Q607 and inverted again before it is used to drive the complementary emitter follower output section consisting of transistors Q608 and Q610.

The sawtooth waveform is simultaneously applied to the base of Q610 and the base of Q608. Initially, the sawtooth waveform is at a high positive level. So, Q610, the npn, will be biased *on* and Q608, the pnp, will be biased *off*. With Q610 conducting, current flows from ground through R642, R641, C622, the yoke, Q610, and to the B+ supply. This current flow causes the beam to be deflected from the top of the screen to the center and to charge C622. The resultant positive voltage on the emitter of Q610 and the negative going pulse on its base will turn Q610 *off*.

As the sawtooth driving signal falls to below 10.6 volts, Q610 will turn *off* and Q608 will turn *on*. When Q608 begins to conduct C622 behaves like a source and discharges to ground through R641, R642, Q608, the yoke, and back to C622 causing the electron beam to move from the center of the screen to the bottom. When the beam is deflected to the bottom of the screen the sawtooth will be at its most negative peak (in some circuits this will be opposite). At this time the oscillator is triggered by the incoming sync pulse; the ramp forming capacitor will be discharged and vertical retrace will be initiated.

A 0.6 volt difference of potential is maintained between the base of Q610 and the base of Q608 by the voltage drop across CR602. By maintaining this difference when Q610 is switching *off*, Q608 is already switching *on;* thus a balanced switching action is achieved. Without this there would be a time lag between the switching *off* time of Q610 and the switching *on* time of Q608, as the input signal would have to continue past the turn *off* point of Q610 by 0.6 volt to cause Q608 to turn *on*. Diode CR604 limits the peak pulse at the output to a safe operating value.

A highly linear, temperature and gain sensitive scanning current is produced by first developing a sawtooth waveform across R641 and R642 which represents the yoke current. This sawtooth waveform is then coupled through an ac feedback network to the base of Q605. At this point it is compared to the sawtooth waveform developed by the horizontal oscillator circuit. Any differences in the waveforms are caused to be corrected by the high gain of the circuitry. A similar circuit was illustrated in Fig. 6-21 and its resulting output was shown in Fig. 6-23.

Because of the curvature of the picture tube and the geometry of the sweeping electron beam as seen in Fig. 6-25, some correction must be produced to provide a linear sweep. To achieve this a parabolic voltage from C622 (Fig. 6-24) is fed back through R626 to Q605. This also provides the negative feedback to set the bias for the vertical amplifier system. The RC network of resistors and capacitors, R619, R620, R627, C610, and C611, provides some ac feedback that sets the gain and

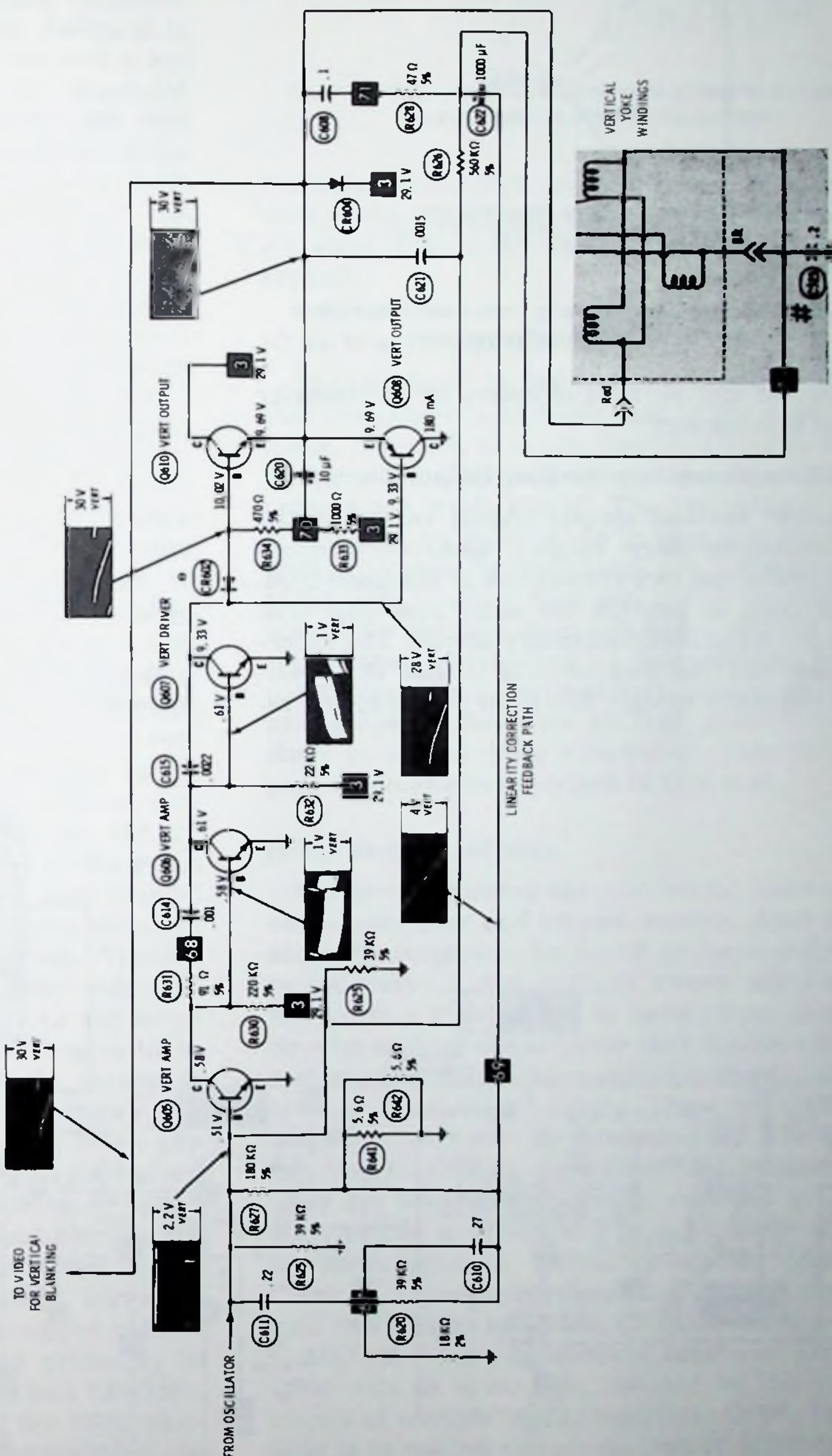


Fig. 6-24. Complementary output circuit.

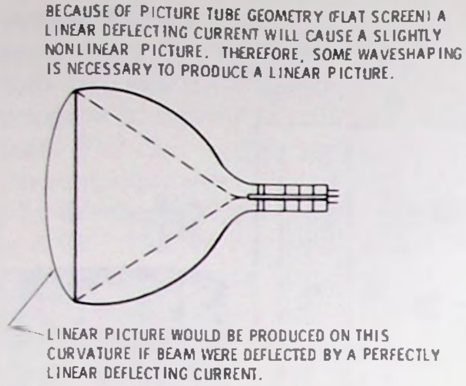


Fig. 6-25. Picture tube geometry makes some deflection waveform "shaping" necessary.

linearity of the vertical circuitry so no linearity control is necessary.

Quasi-Complementary Vertical Output Circuits

Another vertical output circuit in use is the quasi-complementary output. Quasi-complementary circuits use two transistors of the same type, usually npn, to provide the same push-pull–type action as in the complementary circuit. The difference between the two circuits is that the quasi-complementary circuit, like older tube circuits, requires a phase splitter (in most cases) to provide each transistor with a different input polarity. To conduct, the npn must have a positive going input while the pnp must have a negative going input. It is called "quasi"-complementary because it is not a true complementary circuit, but is made to behave as one. That is, it does not automatically turn one transistor on and the other off with the *same* signal, but must have a phase splitter network or a complex biasing network so one transistor is off while the other is on. This is usually done by phase splitter circuits which will provide opposite polarity signals to the two transistors. In the true complementary circuit no phase splitter is necessary since the transistor base materials are opposite (one n and one p) and the same signal applied to both at the same time will cut one transistor *on* and the other *off*.

The illustration in Fig. 6-26 is that of a quasi-complementary circuit. Note again that both transistors are of the same type (npn). Though it is more expensive to produce and often more difficult to repair because of the extra circuitry, reliability of the quasi-complementary circuit more than offsets the extra expense and repair difficulty. What makes it more reliable is the fact that both transistors can be npn which are inherently more

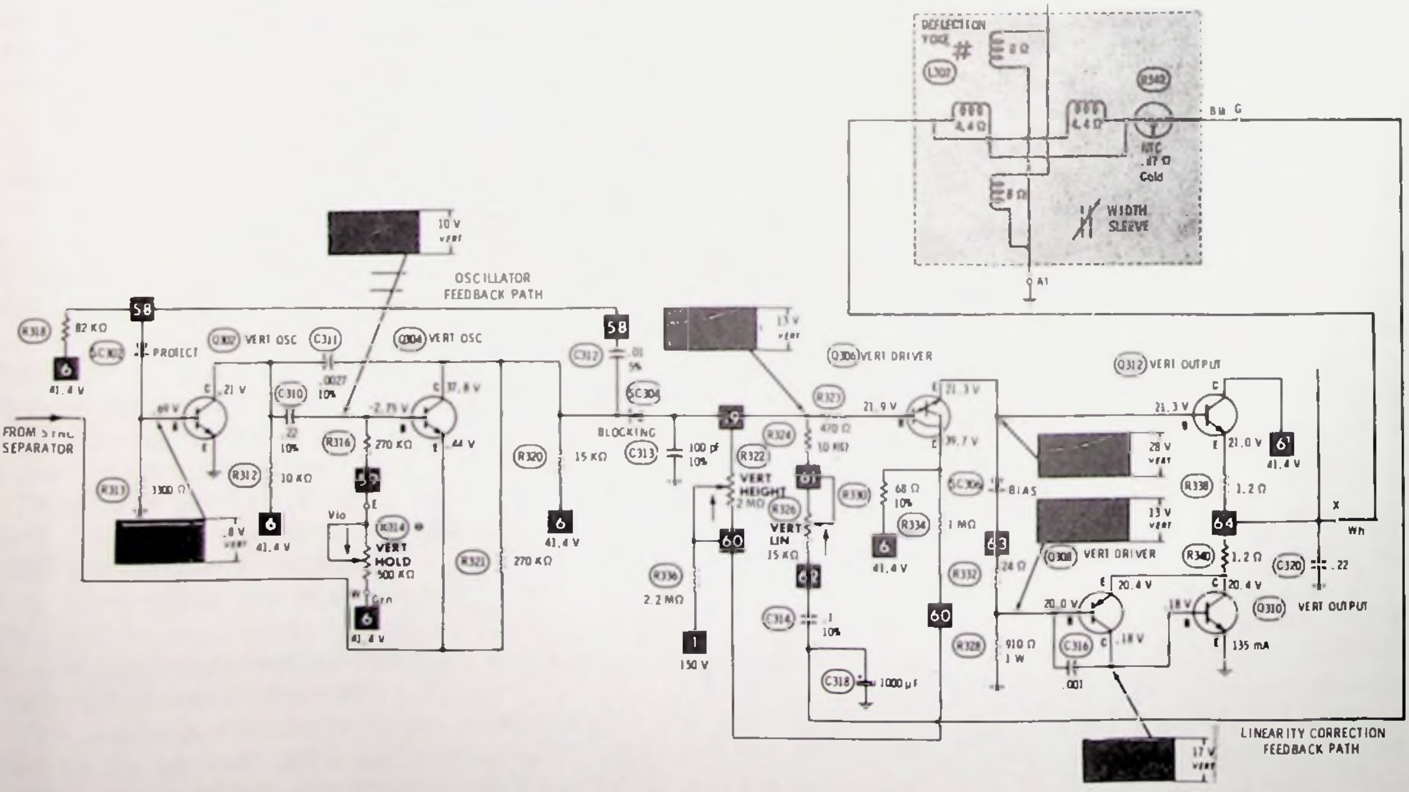


Fig. 6-26. A quasi-complementary output circuit.

reliable and less prone to heat and over-voltage destruction than pnp's.

Transistors Q312 and Q310 are the outputs driven by transistors Q306 and Q308. Both outputs are not driven by the same driver transistor. Transistor Q306 is actually two transistors in one case connected in a Darlington pair configuration. The gain of such a transistor is very high since the total gain is equal to the gain of one transistor multiplied times the gain of the other. This provides good amplification of the small ramp waveform of the sawtooth forming capacitor, and drives output transistor Q312 directly. Output transistor Q310 is not driven by Q306 because it must have an opposite polarity signal to keep it *off* when Q312 is *on* and *on* when Q312 is *off*. So Q308, a common emitter amplifier is placed between Q306 and Q310 to invert the drive signal, and provide an opposite polarity drive signal than that applied to the base of Q312.

As the output of Q306 is most positive, output transistor Q312 is *on* allowing current to flow through it, charging C318 and causing current to flow through the yoke producing deflection of the electron beam from the center of the screen to the bottom. This positive signal is also applied to Q308, inverted and used to keep Q310 off at this time. As the ramp signal cuts off, Q312 ceases conduction and the inductive voltage produced by the collapsing magnetic field in the yoke causes vertical retrace to occur. As the beam reaches the top of the screen the more negative part of the ramp signal applied to Q308 is inverted and coupled to Q310 which conducts allowing current stored in C318 to flow through it and the yoke. Vertical scan from the top of the screen to the center is accomplished by this current flow. As the beam nears the center of the screen, Q312 begins to be biased *on* and the remainder of the screen is scanned as explained earlier. Fig. 6-27 shows how the bias of transistors Q312 and Q308 allow one transistor to cause scan of the top of the screen and the other to cause scan of the bottom.

A few quasi-complementary output circuits are to be found that have no phase inverter circuit. Such a circuit is illustrated in Fig. 6-28. However, note the complex biasing arrangement of capacitors, resistors, and diodes attached primarily to the base of TR34. Transistors TR34 and TR35 are biased so that one will conduct on the most positive part of the ramp signal and the other on the least positive part of the signal. Current flow in the yoke circuit occurs in the same way as in any quasi-complementary circuit, with capacitor C311 charging during scan of one-half of the screen and

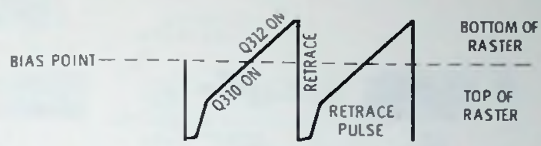


Fig. 6-27. One transistor causes scan of top of screen and the other causes scan of the bottom.

discharging through the other transistor during scan of the other half of the screen. Naturally, in a system such as this the biasing components are critical.

IC Vertical Output Circuits

Though found in few monochrome receivers at this time, there is no doubt that in the near future many, if not all, new sets produced will be similar to the one in Fig. 6-29. As can be seen, even the outputs are inside the IC. The "workings" of the IC are not known but it can be seen that the output section receives its input from pin 7 and its output to the yoke is taken from pin 1. For troubleshooting such a circuit a thorough knowledge of circuit waveshapes and testing of components, such as diodes, capacitors, and resistors, is necessary. This knowledge is the same as that gained through study of and working with other "discrete" component circuits as described in this text.

Other Vertical Circuits

We have discussed the two major vertical circuits—oscillator and output circuits. And, indeed, some receivers will be found to have only these two circuits in the vertical sweep section. But more sets will be found to have other necessary circuits such as the inverter just discussed in the section on quasi-complementary outputs, drivers, cross-over amps, and others. These circuits are a necessary part of the receiver they are in and function to produce better vertical performance. They are usually very simple switches or amplifier circuits, as those in Fig. 6-30. Here Q210 is a simple common emitter amplifier operating Class A. Its only peripheral components used for load and biasing are R220, C208, R222, and Y203.

Also, in Fig. 6-30 vertical feedback amplifier Q209 acts as a variable resistor in the emitter circuit of another signal amplifier, Q208. Its purpose is to control the conduction of Q208 to provide linearity correction as illustrated in previously described circuits. And, again, it is a simple amplifier with few biasing and load components—a simple matter to troubleshoot.

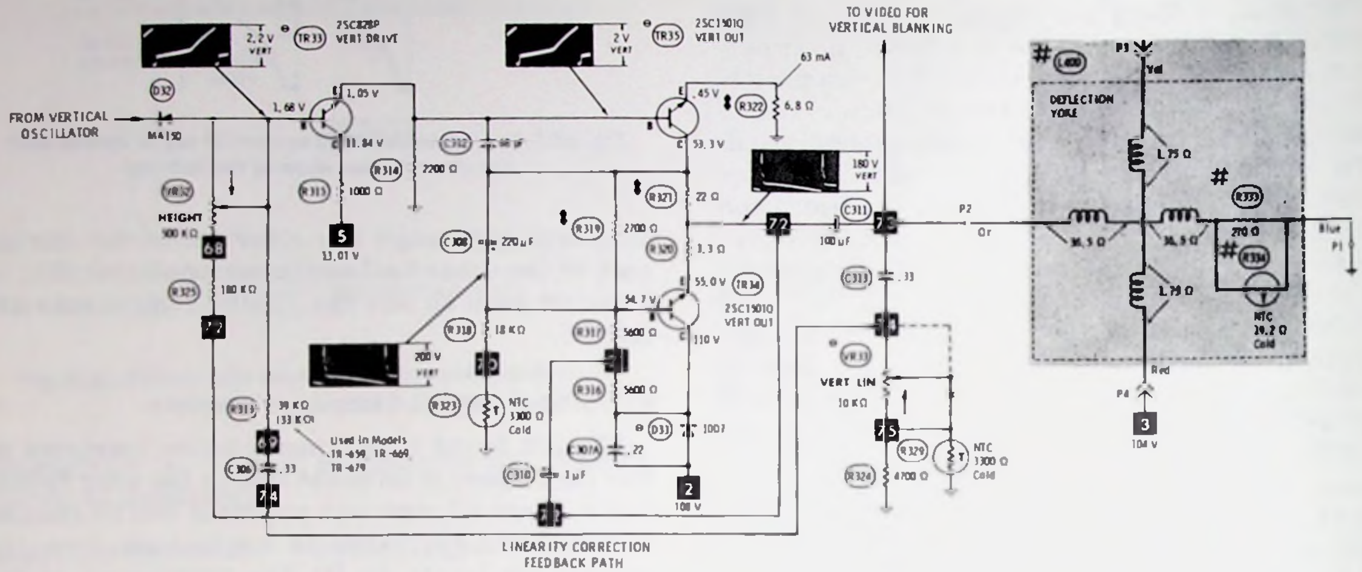


Fig. 6-28. A quasi-complementary output circuit without phase inverter.

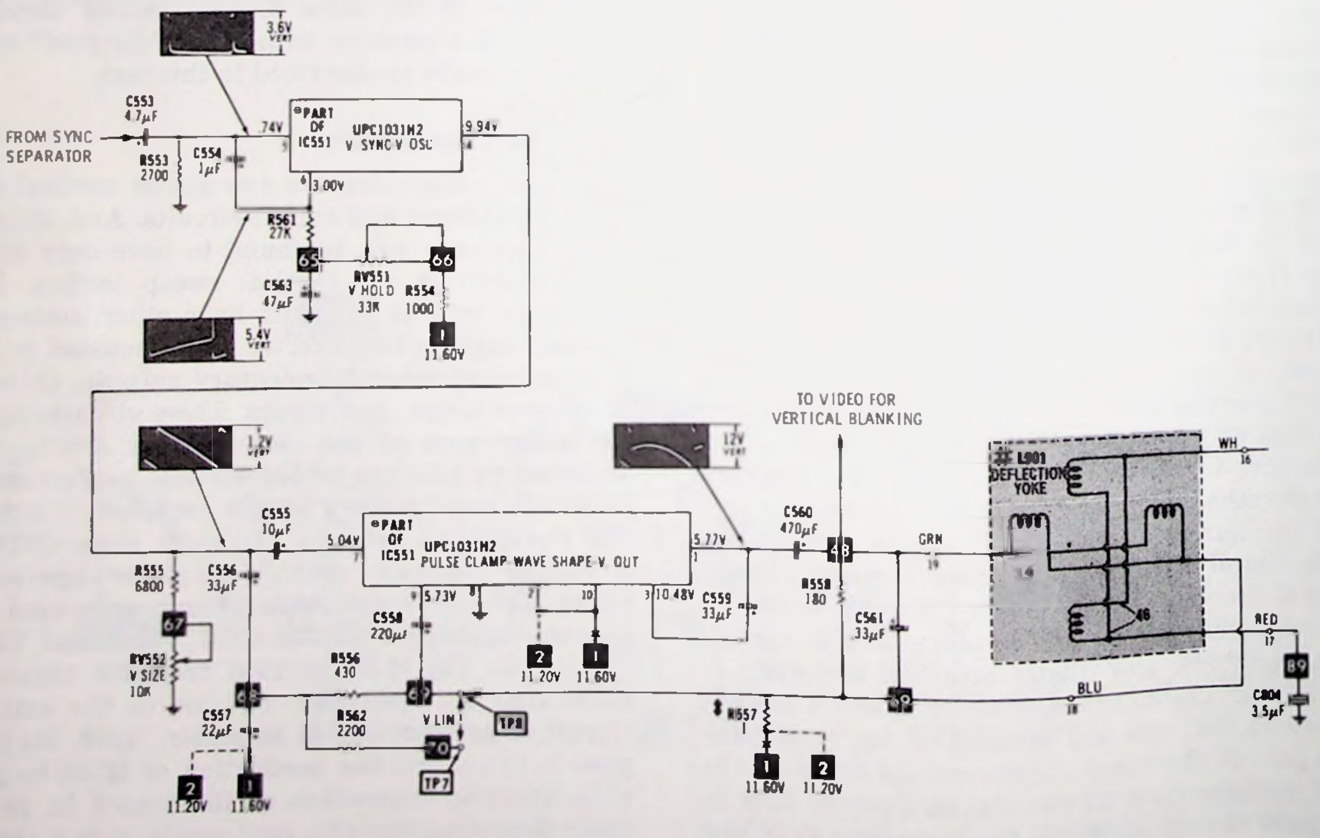


Fig. 6-29. An IC vertical output circuit.

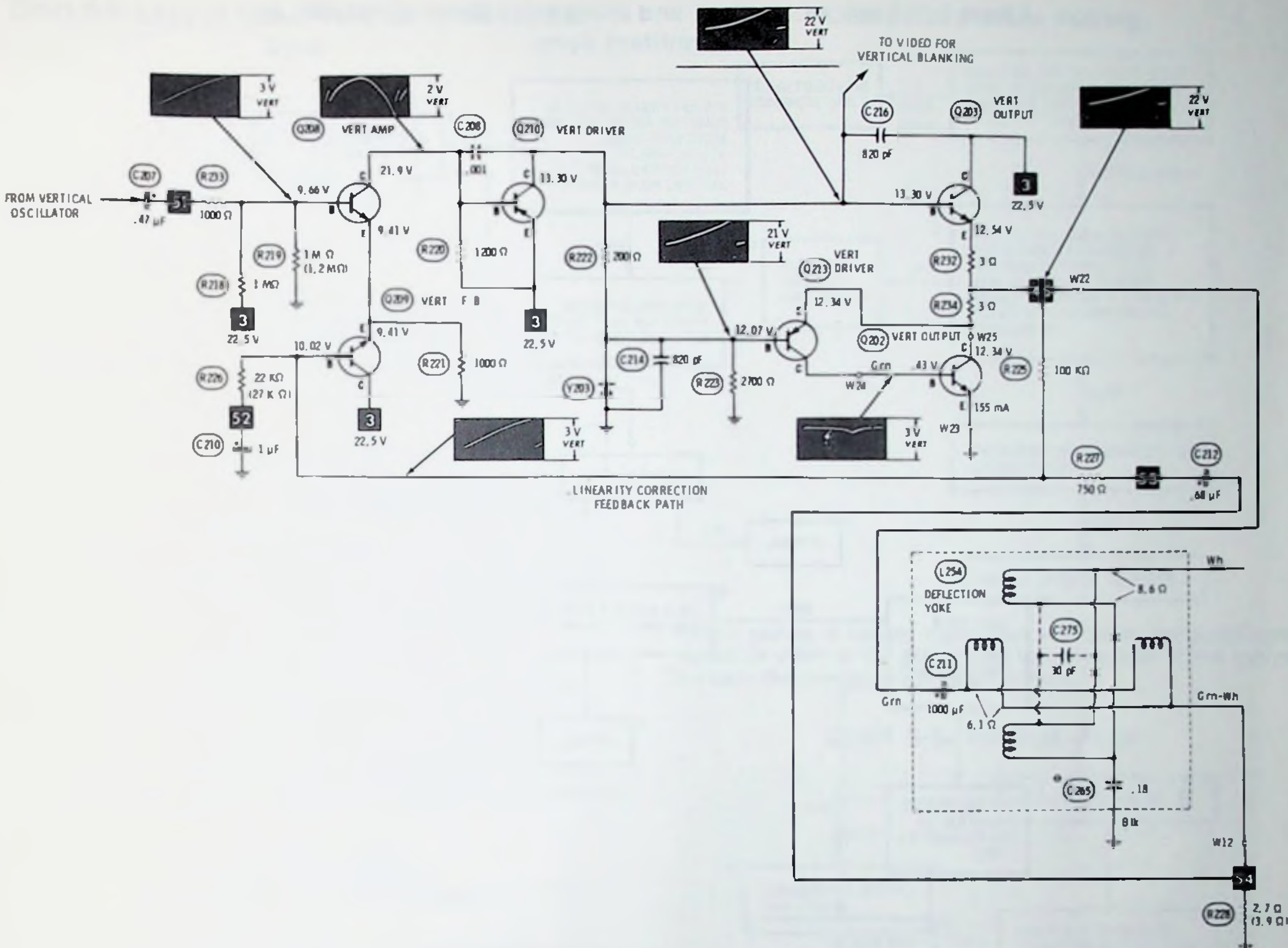


Fig. 6-30. Other vertical circuits used in some receivers.

TROUBLESHOOTING THE SYNC SEPARATOR CIRCUITS

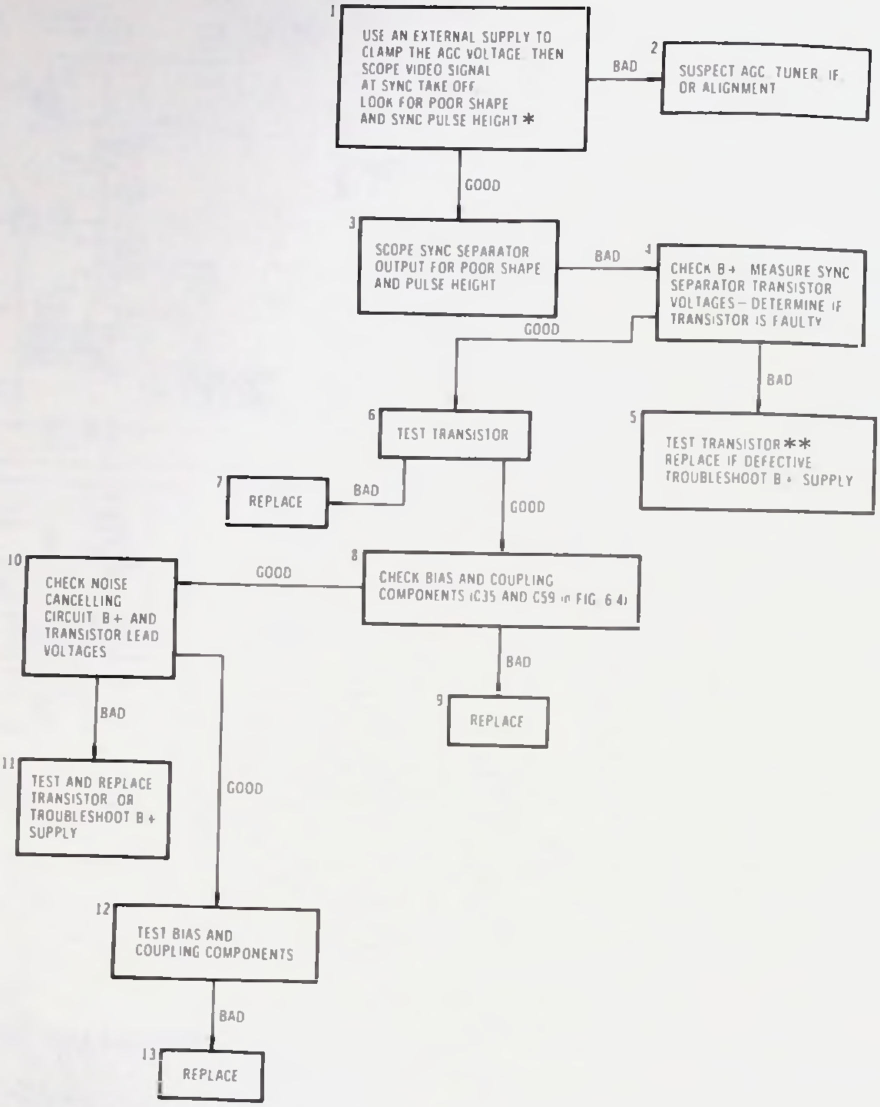
Symptoms caused by defects in sync separator circuits are:

1. Loss of vertical and horizontal sync (Fig. 6-31)
2. Intermittent sync—usually both vertical and horizontal
3. Loss of vertical *or* horizontal sync (usually in the integrator or differentiator circuits)
4. Picture pulling
5. Vertical picture jitter

It is almost impossible to troubleshoot a sync separator without the aid of an oscilloscope. The reason for this is that problems in preceding circuits often cause the same symptom as a sync separator defect. When the composite video signal is of too great an amplitude, perhaps caused by defective agc, the if amplifiers may become overloaded. Overloaded amplifiers usually cause clipping of the signal and in this case the loss of some or all of the top-most part of the signal—the sync pulses. For this reason the first step in troubleshooting an apparent sync separator problem is to

Fig. 6-31. Loss of vertical and horizontal sync.

Chart 6-1. Lack of Vertical and Horizontal Sync—Unstable or Intermittent Sync



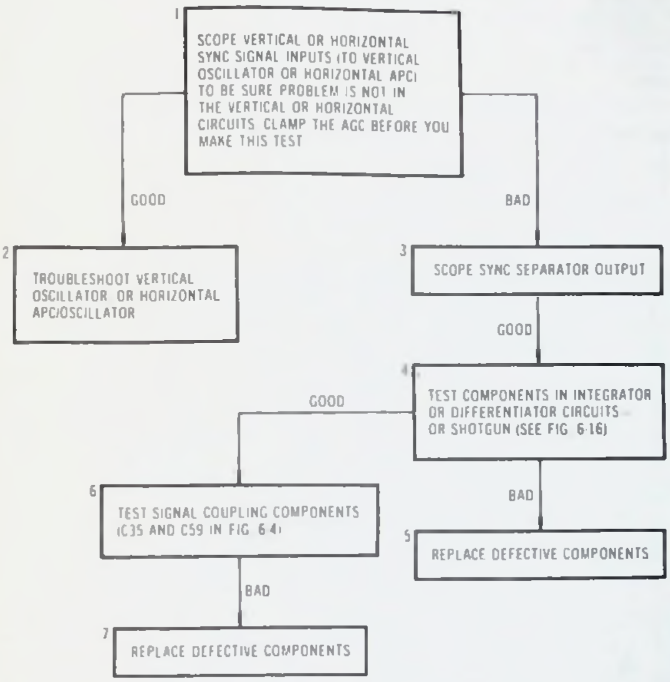
* PULSE HEIGHT AND SHAPE IS VERY IMPORTANT IN RECEIVERS WITH UNSTABLE SYNC ESCPECIALLY IF INSTABILITY SHOWS UP PRIMARILY ON WEAK STATIONS. BE SURE SYNC HEIGHT IS 25% OF TOTAL SIGNAL AMPLITUDE AND THAT PULSES ARE PROPERLY SHAPED NOT SQUAT AND WIDE NOR SPIKED BUT RELATIVELY RECTANGULAR

** REPLACE TRANSISTOR ANYWAY IF PROBLEM IS INTERMITTENT

scope the video detector or sync take-off point. The sync pulse amplitude should be about 25% of the total signal amplitude.

Later you will learn how the agc is also dependent on the sync system. But for the present just accept that this is true and that a defect in the sync system could cause the agc to "create" the illusion of an agc problem. Now with this being the case scoping the video detector/sync take-off point will not be an effective measure if the sync pulse is abnormal in amplitude. If when scoping this signal the sync pulse is indeed incorrect the agc line should be "clamped" to its normal voltage as given in the technical literature for the set. This is done by using any adjustable, well-filtered, low voltage supply and connecting it between ground and the agc bus. *Be sure to maintain correct polarity.* With the agc voltage clamped to its normal operating voltage, scope the video signal as mentioned above. It should now be normal unless a problem exists in the if circuitry. With a normal sync pulse amplitude if the sync problem remains, the trouble is definitely in the sync circuit. Charts 6-1 through 6-4 give the usual troubleshooting routine used in tracking down sync separator, integrator, and differentiator defects.

Chart 6-2. Loss of Either Vertical or Horizontal Sync



Loss of either vertical or horizontal sync stability but not both is almost always caused by integrator or differentiating circuits or coupling components.

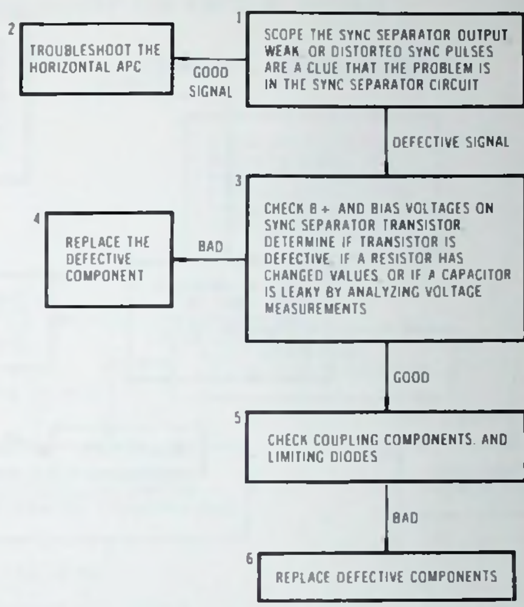
TROUBLESHOOTING VERTICAL OSCILLATORS

Symptoms caused by defects in the vertical oscillator are:

1. No vertical deflection.
2. Loss of vertical sync—vertical hold control will not cause picture lock-in.
3. Vertical jitter.
4. Intermittent vertical deflection, sync, and jitter.

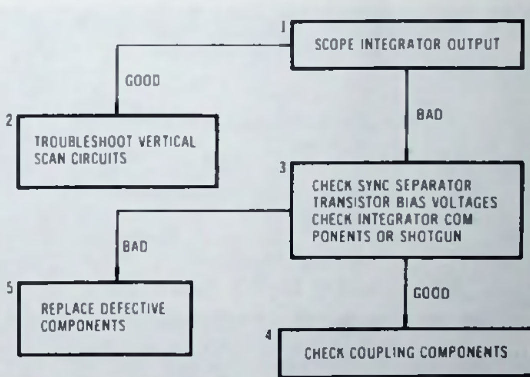
The oscilloscope should be used to troubleshoot the vertical sweep section because the proper operation of that circuitry depends on correct waveforms and no other instrument can identify correct versus incorrect waveforms. Signal injection is also helpful in determining the defective stage when there is no vertical deflection. A simple test jig consisting of a 6.3 volt transformer, a 0.5 μF capacitor, and a 100 ohm resistor, as shown in Fig. 6-32; or a tv analyst with vertical pulse output can be utilized. Connect one lead of the tester or analyst to the chassis ground and use the other lead as the test probe to inject 60 Hz signals into the vertical circuitry. When the signal is injected

Chart 6-3. Picture Pulling



Picture pulling is usually associated with weak horizontal sync signals or video in the sync. If the vertical edges of the picture are bent, the sync separator is not at fault.

Chart 6-4. Vertical Jitter

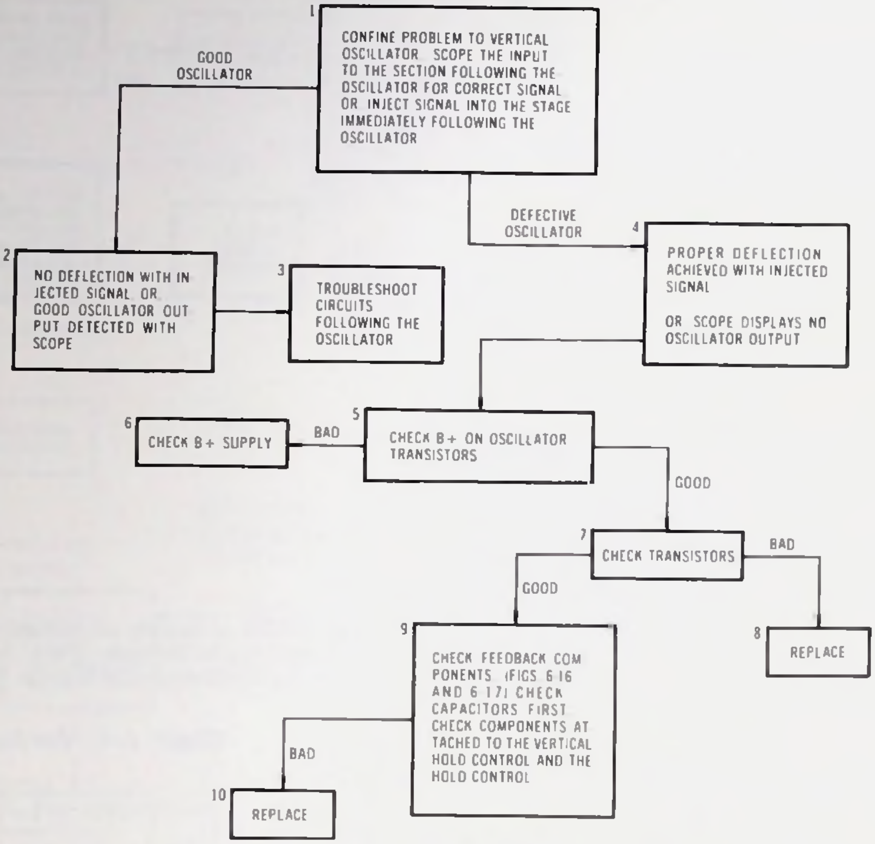


Vertical jitter is caused by distorted sync pulses or by sync pulses mixed with interference.
If vertical jitter is accompanied by other symptoms, circuits other than the integrator should be checked. Vertical jitter by itself is usually caused by defective integrator components or components within the vertical scan circuits. It can also be caused by poor connections, especially in output and feedback circuits. When this is the case, evidence of the jitter will be seen in all parts of the vertical circuitry.

into the input of the vertical output circuit and deflection returns, that circuit is good. Then, go to the input of the next circuit, usually a driver amplifier, and again if deflection returns *that* circuit is good. Continue this until deflection is not obtained as the signal is injected. Thus, the bad circuit is found.

When a signal is injected into the vertical oscillator and deflection is created yet there is no

Chart 6-5. No Vertical Deflection



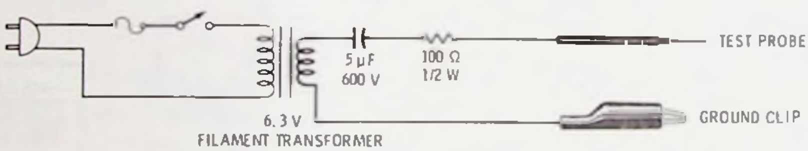


Fig. 6-32. Simple vertical signal injector. (A low voltage ac supply within the set may be used if available.)

deflection without the input test signal, the fault usually lies in the oscillator feedback circuit. The fact that the signal goes through the oscillator usually indicates that the transistor is good. The feedback circuit is necessary for sustaining oscillation. When it is open or shorted, the oscillator transistor acts like an amplifier. In this case the feedback components and those clustered about the vertical hold control must be tested.

If the home-made tester is used there will be vertical deflection but no synchronization. The picture will not be linear either, but the fact that deflection occurs at all is an indication that the circuits between the injection point and the yoke are good.

Intermittent vertical functions are most often caused by thermal opens in transistors. As the transistor heats, it opens causing it to cease functioning. Cooling spray is the best way to find thermal intermittents. Also, watch for poor connections, faulty solder connections and grounds.

Use Charts 6-5 through 6-7 to troubleshoot the vertical oscillator. They may leak, effectively lowering the capacity, or a parallel connected capacitor may open causing the total circuit capacitance to decrease.

In the case of a slow oscillator where the time constant of the feedback (frequency determining) components has lengthened look for components increased in value. Resistors normally increase in value when defective so they should be tested first. It is impossible for a capacitor to increase in capacitance since this would necessitate plate area increase, different type of dielectric, or closer spacing of the plates. But capacitors in series do short making the total circuit capacitance greater.

TROUBLESHOOTING VERTICAL OUTPUT CIRCUITS

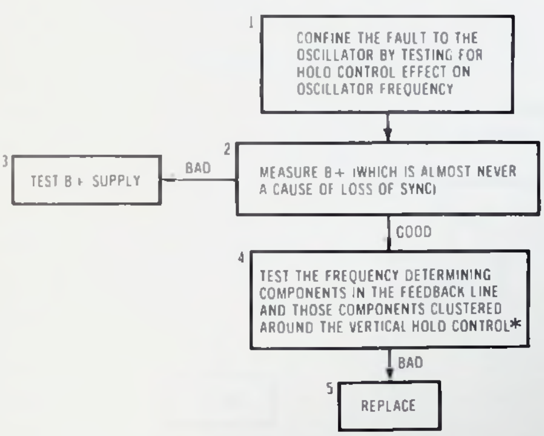
Symptoms caused by defects in the vertical output circuits are:

1. No vertical deflection
2. Vertical foldover (Fig. 6-33)
3. Decreased vertical size (Fig. 6-34)
4. Vertical nonlinearity (Figs. 6-20 and 6-22)
5. Keystoning (Fig. 6-35)

Troubleshooting the vertical output circuits may be carried out with signal injection or signal tracing. For most of the symptoms given above, the oscilloscope is the most useful tool because most of the problems deal with incorrect pulse amplitude or shape. Use Charts 6-8 through 6-12 to troubleshoot the vertical output.

Fig. 6-33. Vertical foldover.

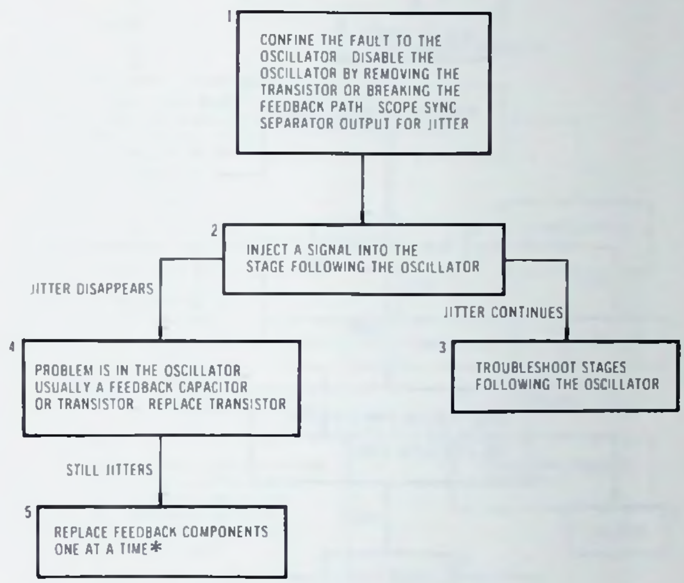
Chart 6-6. Loss of Vertical Sync



*IF THE PICTURE ROLLS UPWARD THE OSCILLATOR IS RUNNING TOO SLOW IF IT ROLLS DOWNWARD THE OSCILLATOR IS RUNNING TOO FAST FAILURES WHICH SHORTEN THE TIME CONSTANT CAUSE A SPEEDY OSCILLATOR FAILURES WHICH LENGTHEN THE TIME CONSTANT CAUSE A SLOW OSCILLATOR TO SHORTEN A TIME CONSTANT THE CAPACITOR MUST DECREASE IN VALUE OR THE ASSOCIATED RESISTANCES MUST DECREASE IN RESISTANCE SINCE RESISTORS RARELY DECREASE IN VALUE THE DIFFICULTY IS USUALLY A CAPACITOR

With this symptom the receiver is out of sync with the station, and the vertical hold control does not have enough range to cause the vertical oscillator to lock in to the broadcast picture. The hold control does have some control over the vertical roll speed. By adjusting the vertical hold control, the vertical roll speed can be seen to change. This change indicates the oscillator to be operating, but at the wrong frequency.

Chart 6-7. Vertical Jitter



*IF THE SYMPTOM APPEARS WHEN THE SET HEATS UP SPRAY THE FEEDBACK COMPONENTS WITH A FREEZE SPRAY IF JITTER STOPS AS A COMPONENT IS SPRAYED REPLACE THAT COMPONENT

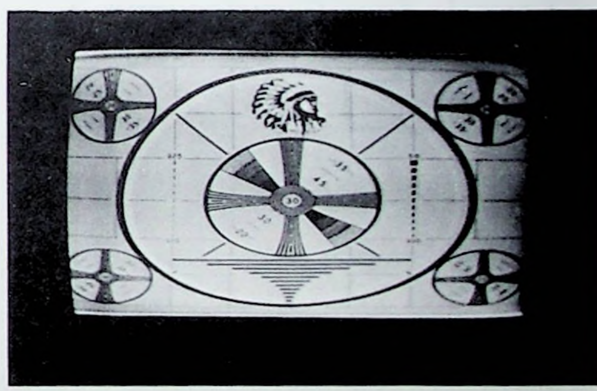


Fig. 6-34. Decreased vertical size.

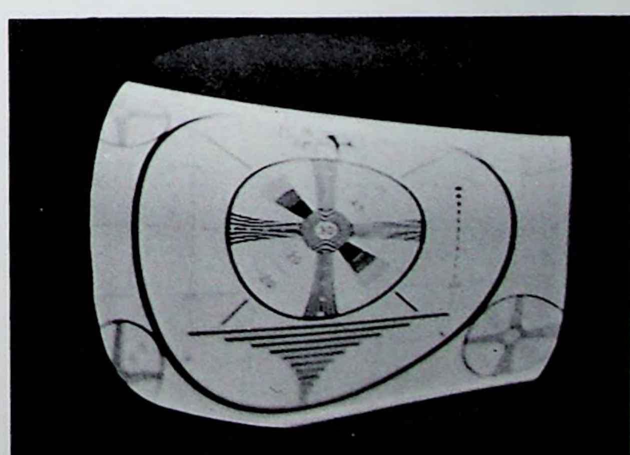


Fig. 6-35. Keystone picture.

Chart 6-8. No Vertical Deflection

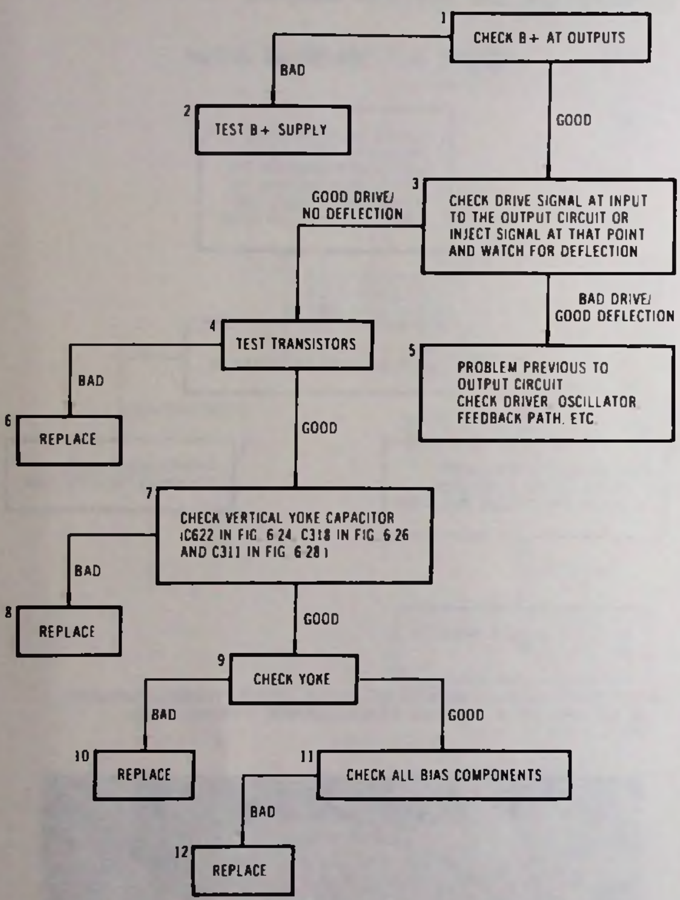
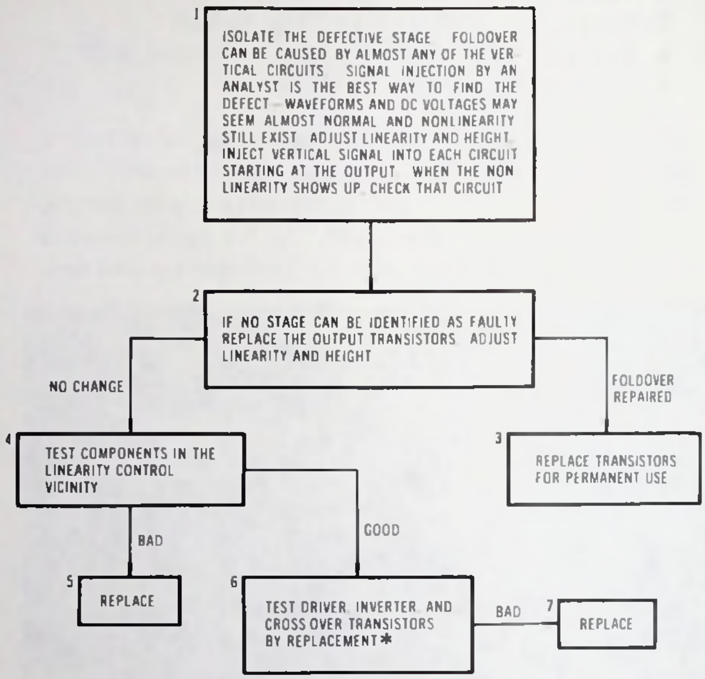


Chart 6-9. Vertical Foldover (Severe Nonlinearity)



*THESE ARE ACTIVE COMPONENTS AND ACCORDING TO OUR METHOD OF REPLACING THE MOST LIKELY TO FAIL COMPONENTS FIRST THIS APPEARS INCORRECT HOWEVER THE LINEARITY CONTROL AND COMPONENTS ATTACHED TO IT FOR WAVESHAPING PURPOSES HAVE MORE DIRECT CONTROL ON THE WAVEFORM AND ARE MORE LIKELY TO CAUSE FOLDOVER THAN THESE TRANSISTORS BECAUSE OF THE NATURE OF THE DEFECT IT IS OFTEN THE MOST DIFFICULT VERTICAL PROBLEM TO FIND AND OFTEN IS A MATTER OF REPLACING COMPONENTS ONE AT A TIME UNTIL THE FAULTY ONE IS FOUND

Chart 6-10. Decreased Vertical Size

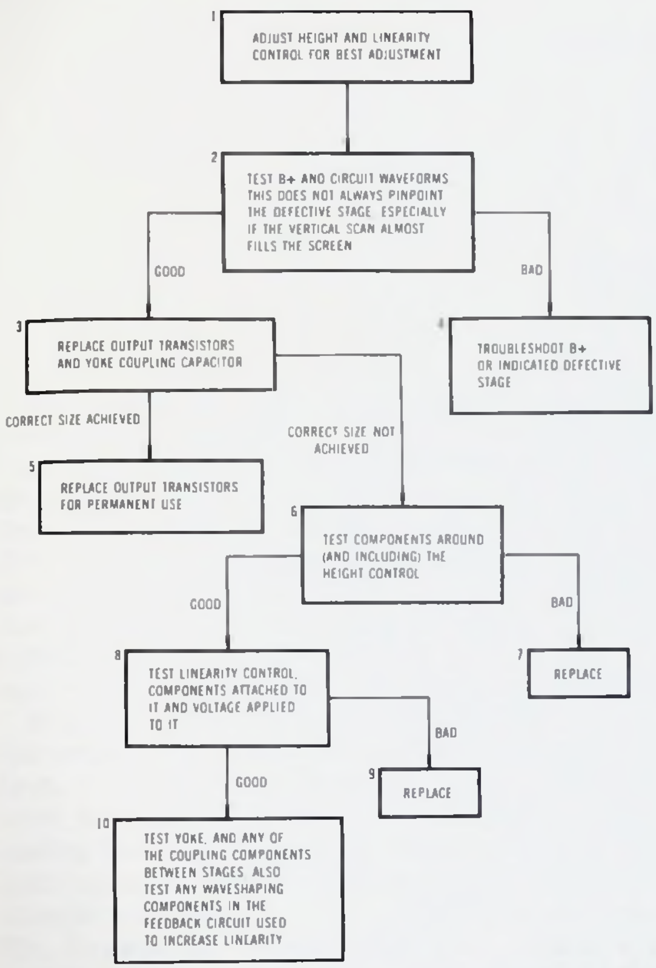


Chart 6-11. Vertical Nonlinearity

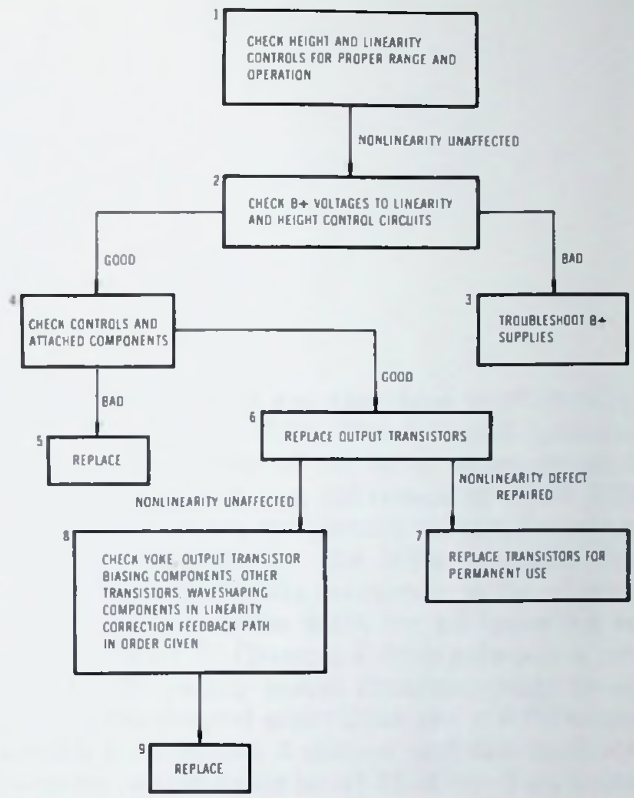
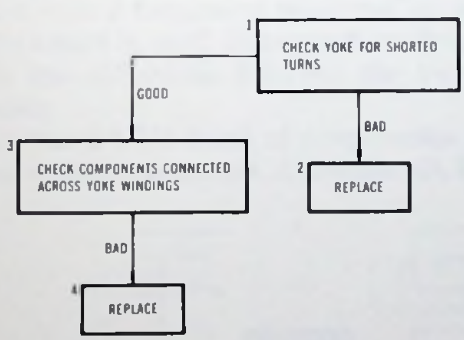


Chart 6-12. Keystoning



Chapter 7

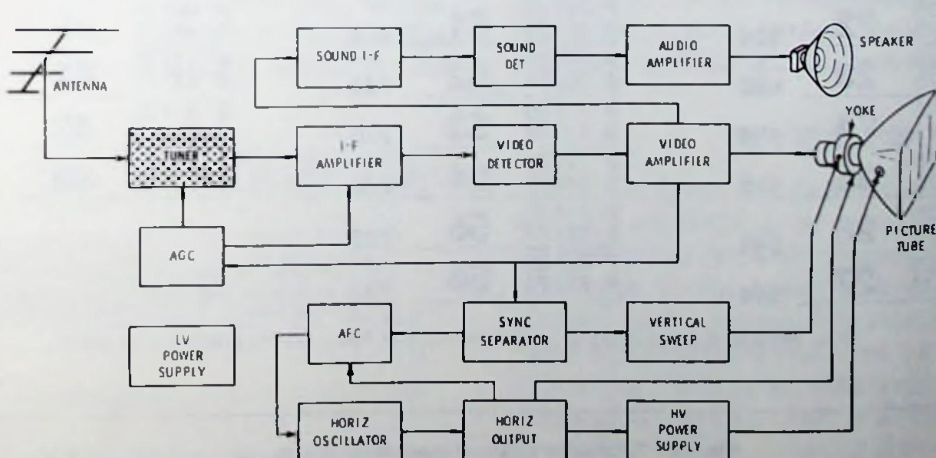
Tuners

Two tuners are found in the modern solid-state monochrome television receiver—one for vhf (very high frequency) and one for uhf (ultra high frequency). The vhf tuner is for Channels 2 through 13 covering frequencies from 54 to 216 MHz. The uhf tuner covers frequencies of 470 to 890 MHz for Channels 14 through 83. The broadcast frequency for each channel actually spans a 6 MHz "channel" of frequencies. Frequencies for each vhf and uhf channel are shown in Fig. 7-1.

Referring to the block diagram in Fig. 7-2, the vhf tuner input is the rf (radio-frequency) signal from the antenna. The tuner input circuit is tuned to the 6 MHz band of frequencies representing the selected channel. This selection of frequencies to be received is done, of course, by the channel selector knob on front of the receiver. The frequencies representing this channel are amplified by the rf amplifier and coupled to the mixer stage. In the mixer the received frequencies are mixed with a frequency produced by an oscillator. The result is an if (intermediate frequency) which is the difference between the two mixed frequencies.

Within the 6 MHz band of frequencies are the audio and video frequencies. For example, Channel 4 audio is 71.75 MHz and the video is 67.25 MHz, a difference of 4.5 MHz. The internal oscillator produces a frequency of 113 MHz when the set is tuned to Channel 4 so a difference of 45.75 MHz is created by mixing the picture carrier frequency of Channel 4 with the 113 MHz oscillator frequency. This 45.75 MHz frequency is the video if frequency and it is the same for *all* incoming selected channels. If Channel 5 were selected, a new oscillator frequency would simultaneously be selected by the channel select knob and the difference between the Channel 5 carrier and the oscillator frequency would again be 45.75 MHz. This action holds true for all channels. It is also true for the audio signal which is mixed with the same oscillator frequency. The result of this mixing is the output if frequency of 41.25 MHz—the sound if carrier frequency. So, the tuner output is a 6 MHz wide band of frequencies including the sound if carrier, video if carrier, and the video and sound sidebands as seen in Fig. 7-3.

The uhf tuner, as illustrated in Fig. 7-2, consists of a diode mixer and an oscillator. The incoming channel is selected by tuned circuits as in the vhf tuner, then applied to the mixer along with an oscillator-produced frequency. Again, the



P	S	Channel No.	Freq. Limits
			54
55.25	59.75	2	60
61.25	65.75	3	66
67.25	71.75	4	72
			76
77.25	81.75	5	82
83.25	87.75	6	88
			174
175.25	179.75	7	180
181.25	185.75	8	186
187.25	191.75	9	192
193.25	197.75	10	198
199.25	203.75	11	204
205.25	209.75	12	210
211.25	215.75	13	216
			470
471.25	475.75	14	476
477.25	481.75	15	482
483.25	487.75	16	488
489.25	493.75	17	494
495.25	499.75	18	500
501.25	505.75	19	506
507.25	511.75	20	512
513.25	517.75	21	518
519.25	523.75	22	524
525.25	529.75	23	530
531.25	535.75	24	536
537.25	541.75	25	542
543.25	547.75	26	548
549.25	553.75	27	554

P	S	Channel No.	Freq. Limits
			554
555.25	559.75	28	560
561.25	565.75	29	566
567.25	571.75	30	572
573.25	577.75	31	578
579.25	583.75	32	584
585.25	589.75	33	590
591.25	595.75	34	596
597.25	601.75	35	602
603.25	607.75	36	608
609.25	613.75	37	614
615.25	619.75	38	620
621.25	625.75	39	626
627.25	631.75	40	632
633.25	637.75	41	638
639.25	643.75	42	644
645.25	649.75	43	650
651.25	655.75	44	656
657.25	661.75	45	662
663.25	667.75	46	668
669.25	673.75	47	674
675.25	679.75	48	680
681.25	685.75	49	686
687.25	691.75	50	692
693.25	697.75	51	698
699.25	703.75	52	704
705.25	709.75	53	710
711.25	715.75	54	716
717.25	721.75	55	722
723.25	727.75	56	728

P	S	Channel No.	Freq. Limits
			728
729.25	733.75	57	734
735.25	739.75	58	740
741.25	745.75	59	746
747.25	751.75	60	752
753.25	757.75	61	758
759.25	763.75	62	764
765.25	769.75	63	770
771.25	775.75	64	776
777.25	781.75	65	782
783.25	787.75	66	788
789.25	793.75	67	794
795.25	799.75	68	800
801.25	805.75	69	806
807.25	811.75	70	812
813.25	817.75	71	818
819.25	823.75	72	824
825.25	829.75	73	830
831.25	835.75	74	836
837.25	841.75	75	842
843.25	847.75	76	848
849.25	853.75	77	854
855.25	859.75	78	860
861.25	865.75	79	866
867.25	871.75	80	872
873.25	877.75	81	878
879.25	883.75	82	884
885.25	889.75	83	890

P = Picture Carrier Freq. S = Sound Carrier Freq. All frequencies in MHz

Fig. 7-1. Television channel frequency spectrum.

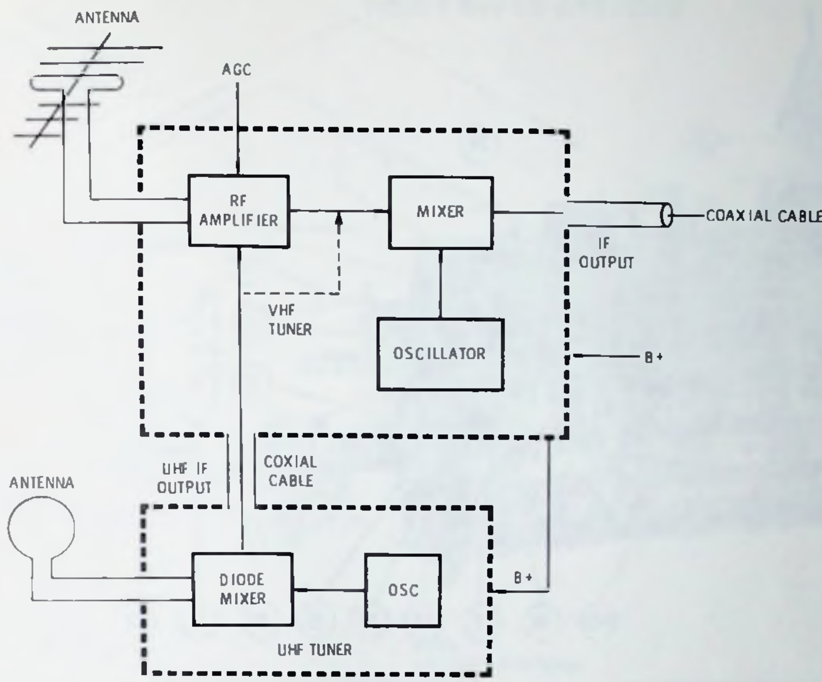


Fig. 7-2. Functional block diagram of a monochrome television tuner system.

output is the if frequencies but this time instead of coupling these signals directly into the if amplifier stage they are applied to the rf amplifier or mixer stage of the vhf tuner. The vhf oscillator is disabled during uhf reception so the vhf tuner functions as an if amplifier circuit.

The vhf tuner is usually found to be one of two types. The turret type is shown in Fig. 7-4, while the rotary switch type is shown in Fig. 7-5. They are shown here as found in printed service literature showing parts placement and layout. The turret type uses plastic or ceramic strips which serve as coil forms for the several coils necessary to tune each channel. Each channel requires one strip, which has coils for tuning the rf amplifier, mixer and oscillator circuits, to the channel being received. As the selector knob is turned, another coil strip makes contact with stator bar spring contacts as shown in Fig. 7-6. In the uhf position B+ voltage is removed from the vhf oscillator and

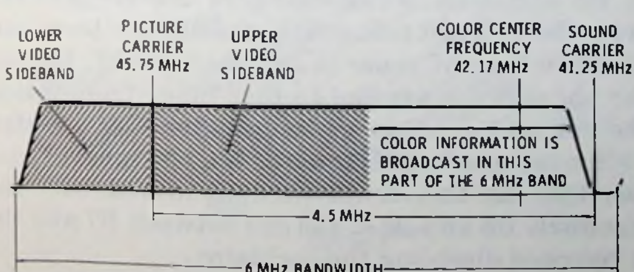


Fig. 7-3. Frequency spectrum for the 6 MHz If bandwidth.

the rf and/or mixer circuits are tuned to the if frequency.

The rotary switch tuner has rotary wafer switches for each tuner stage. Each wafer has contacts for the 12 vhf channels and one position for uhf operation. All the switch wafers are ganged on a single shaft that extends out of the front of the tuner for channel selection.

FINE TUNING

Fine tuning is carried out by tuning the oscillator frequency slightly so the video if frequency is precisely 45.75 MHz. The usual method of manual fine tuning is to push in the fine-tune knob to engage a plastic gear that turns a small slug in and out of the oscillator coil causing it to change frequencies. When the oscillator is perfectly tuned the if frequency is correct for passage through the if stages and the best picture results.

THE VHF TUNER

The primary function of the rf (radio frequency) amplifier is to provide enough rf signal into the mixer for a clean snow-free picture. Noise generated in the tuner and if circuits produces "snow" on the screen. The mixer circuit produces most of this snow which is in turn amplified by the if circuits. If there is enough signal into the mixer the signal-to-noise ratio will be great enough to produce a picture virtually free of snow. A snow-

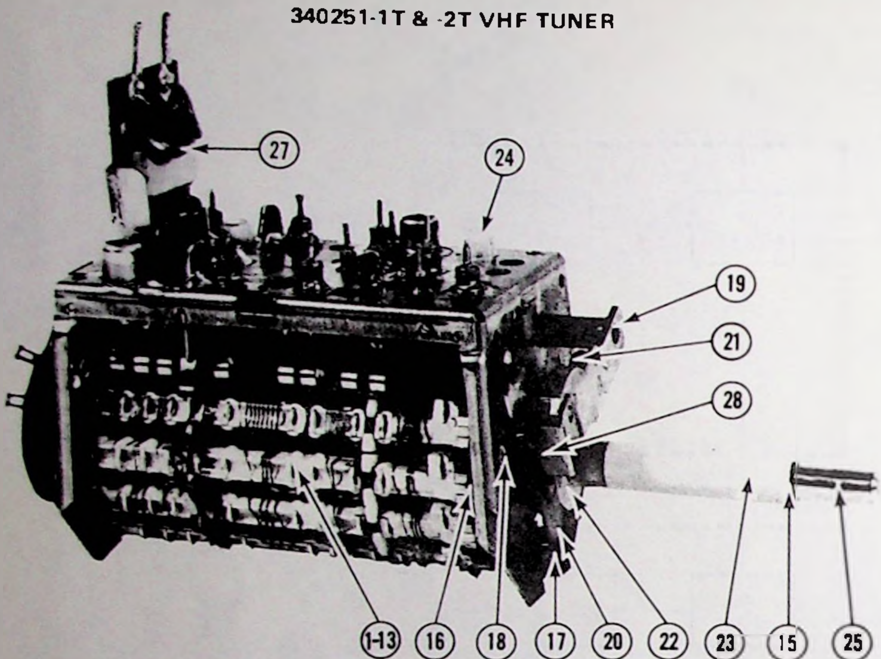


Fig. 7-4. Turret-type vhf tuner.

REF.	DESCRIPTION
1-13	STRIPS
15	"C" RING
16	GEAR SCREW
17	SHAFT RETAINER & DETENT SPRING
18	BEARING PLATE
19	LEVER
20	RETAINER CLIP
21	SPRING
22	CLUSTER GEAR
23	FINE TUNING SHAFT & GEAR

REF.	DESCRIPTION
24	OUTPUT COIL ASSEMBLY
25	INDEX SHAFT
27	BALUN ASSEMBLY
28	RETAINER CLIP
Q1	TRANSISTOR, RF AMP
Q2	TRANSISTOR, MIXER
Q3	TRANSISTOR, OSCILLATOR
	COVER
	WAFER SWITCH (-1T ONLY)

free picture requires a signal-to-noise ratio of about 30 to 1. If a picture has excessive noise, the problem is either a weak antenna signal or an rf amplifier which is not amplifying as it should.

The rf amplifier provides isolation between the tuner oscillator and the antenna. If the oscillator were to become coupled to the antenna a miniature broadcast station would be the result, causing interference in the surrounding sets. That interference appearing on the screen of another set would look like cw (continuous wave) broadcast station interference, producing diagonal lines in the picture. The rf amplifier serves as a "buffer" between the oscillator and the antenna. It might be mentioned that the FCC places strict limits on the amount of radiated signal allowable from tv, fm, and other receivers.

The rf amplifier in Fig. 7-7 is an npn transistor, Q1. The input circuit to the base of Q1 is tuned by switching in coils, such as shown between spring terminals B2, B2A, and B3. The collector circuit of Q1 is tuned by the coil switched to terminals B4 and B5, and coupled to the base of Q2, the mixer, which is tuned by the coil at terminals B5A and B6. At the same setting of the channel selector the oscillator, Q3, is tuned by the coil at terminals B7 and B8. Tuner if output is selected and tuned by transformer T1. Note that when uhf is selected, coils are connected to terminals B1 and B2, B4 and B5, and B5A and B6 to tune the tuner to 45.75 MHz (if frequency). Shorting strips are connected to terminals B2A and B3 to ground the vhf antenna input to suppress interference, and to B8 and B8A which switches the B+ voltage from the +12 volt terminal to the uhf B+ terminal. So when the vhf tuner is switched to uhf, B+ for the uhf tuner is applied to that tuner from inside the vhf unit. This is sometimes done by a wafer switch mounted on the rear of the vhf tuner. Note, too, that as this B+ switch is moved between terminals B8 and B8A, the coil between B7 and B8 is removed disabling the oscillator.

Tuner rf amplification is controlled by agc (automatic gain control) voltage coupled to the

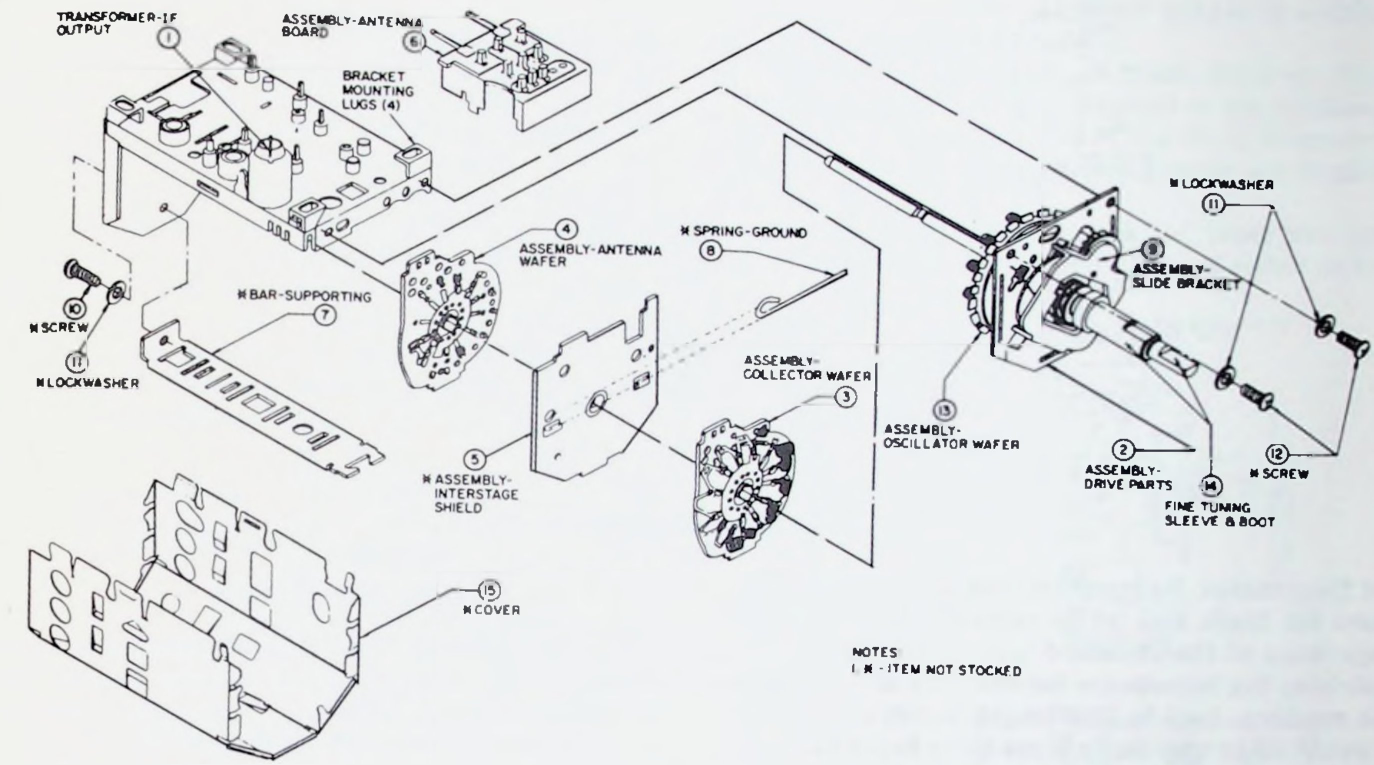


Fig. 7-5. Rotary or wafer switch vhf tuner.

base of Q1 through R1. As signal strength nears the level which would cause Q1 to be overdriven, agc voltage is fed back from the video circuit to cause the transistor to decrease its gain. There are two methods to cause the rf amplifier to decrease its gain. One is to reverse bias the transistor and the other is to drive it into saturation. Either method will cause it to have a lowered gain. In Fig. 7-7 where the transistor is an npn, reverse bias would have to be caused by a negative agc voltage. Saturation of Q1 would require a positive bias voltage. In this circuit, saturation agc is used

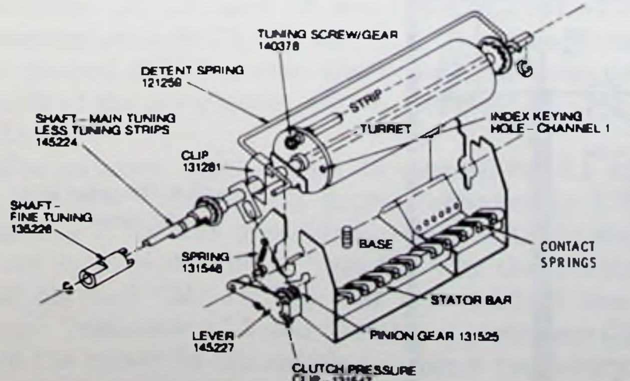


Fig. 7-6. Mechanical detail of the turret tuner showing contact springs and stator bar.

and the agc bias voltage will vary from +2.5 to +3.5 volts.

The oscillator coil connected between terminals B7 and B8 is adjustable and serves as the fine tuning adjustment. Fine tuning is of the "memory" type meaning that each oscillator coil switched into the circuit has a slug which is adjustable for correct oscillator output frequency. Each channel can be tuned and its associated oscillator slug preset. In older receivers one adjustable coil was connected in the oscillator coil circuit and it had to be retuned for each channel, as the channel was selected. The output of oscillator Q3 is coupled to the collector of the mixer, Q2, while the rf input to the mixer is to its base. The output frequency selected for the if is tuned by T1 and the associated stray capacitance provided by lead to chassis and component to chassis capacitance.

In Fig. 7-7 the assembly identified as CR1 contains an fm trap to reject commercial fm broadcast signals which cause interference. Also contained in CR1 is a high pass filter to pass frequencies of Channel 2 and above and reject frequencies below Channel 2, to keep out interfering signals from business band, citizens band, and ham band broadcasts. These circuits are often called the preselector because they select the correct signals and reject those outside of the tv chan-

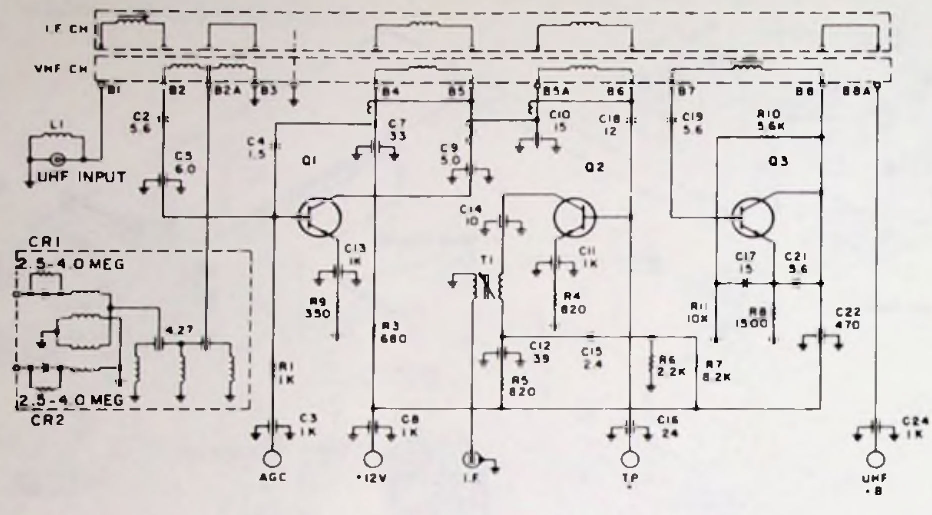


Fig. 7-7. A typical monochrome tv vhf tuner.

nel frequencies. Its input impedance is usually 300 ohms for black and white receivers to match the impedance of the standard television antenna. By matching the impedance between the antenna and the receiver, lead-in line length is not critical as it would otherwise be. In some more expensive sets a 75 ohm matching circuit may be included in this network for matching coaxial cable to the system without the necessity of a separate matching transformer, such as those often seen connected to cable company outlets. These transformers match the 300 ohm line to a 75 ohm line with minimum loss of signal. Impedance matching is necessary on signal lines, to estimate signal loss and ghosting. Maximum power is transferred from one circuit to another when the output impedance of the source is the same as the input impedance of the load. A laboratory exercise contained in the SAM will prove this.

THE UHF TUNER

The uhf tuner in Fig. 7-8 is illustrated as seen in the service literature. As usually shown, the schematic diagram layout is practically identical to the physical layout of the tuner. The diagram is drawn this way for ease of showing inductors L2, L3, and L8. They are "equivalent" inductors and are actually heavy copper strips which act as the small inductors needed at the high frequency of uhf reception. Tuner cavities which would otherwise be difficult to show schematically can be easily represented on a diagram of this type.

The uhf tuner is much simpler in construction than the vhf tuner because it uses continuous tuning rather than switched, "step" tuning. A multisection variable capacitor is used to provide continuous tuning as its shaft is rotated. In some sets a "detent" system is used as in vhf tuners to cause

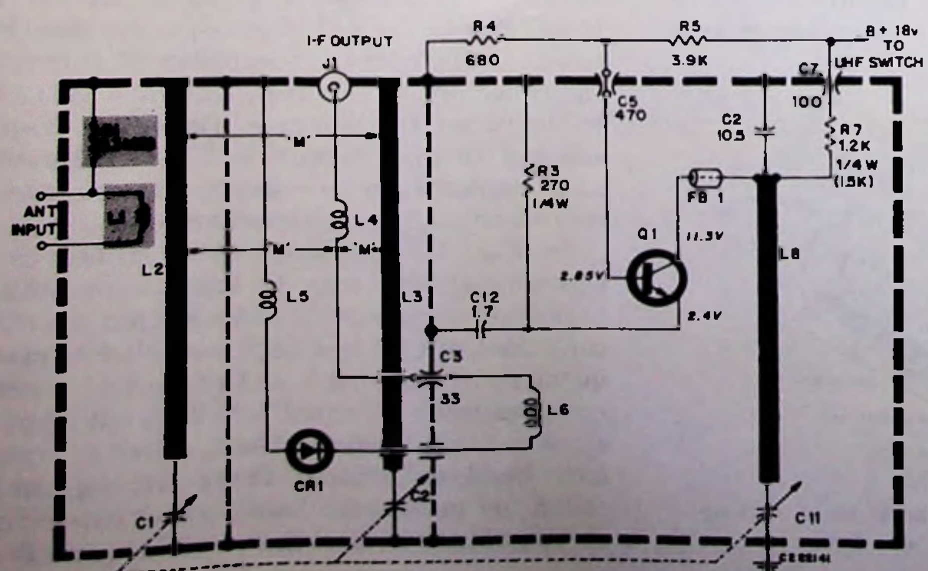


Fig. 7-8. Diagram of a uhf tuner.

the selector to click into place for channel selection. When used, detent tuning only causes the capacitor to be rotated in little "jumps" rather than in a smooth, continuous rotation. Detent is created by a mechanical means of causing the tuner shaft to turn in steps or "clicks." A simple example of this is illustrated in Fig. 7-9 where a spring is shown pressing against a bearing, which in turn rides on a gear on the tuner shaft. As the shaft is turned, the bearing slips into each gear notch causing a click and the tuner shaft to be held in that position. A fine tune knob is also available in conjunction with detent tuning to allow precise station tuning.

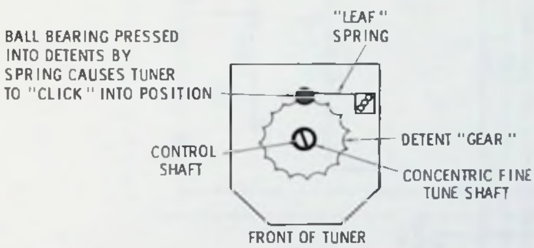


Fig. 7-9. Simple detent system.

The uhf circuitry is also simpler than vhf circuitry as can be seen in the diagram of Fig. 7-8. Monochrome uhf tuners often do not have rf amplifiers but only a diode mixer and a transistor oscillator, which is similar to the vhf oscillator. The uhf oscillator operates at a much higher frequency since it must beat with signals in the 470 to 890 MHz range and produce a 45.75 MHz if difference output. And as in the vhf tuner it produces a continuous wave signal of 45.75 MHz *higher* than the incoming rf signal.

In the circuit of Fig. 7-8 observe that the tuner is divided into three compartments or cavities identified by dotted lines. Each cavity corresponds to a resonant transmission line. Equivalent inductances L2, L3, and L8 are tuned by variable capacitor sections C1, C2, and C11. The capacitors are ganged on a common shaft for simultaneous tuning of the preselector, mixer, and oscillator circuits.

The antenna signal input is coupled by L1 to L2 which is tuned to the desired channel by C1. Coupling from this preselector stage to L3 in the mixer is provided by a "window" in the cavity wall marked "M" in Fig. 7-8 (for mutual coupling). Inductance L3 and variable capacitance C2 tune the mixer to the selected channel frequency. Diode CR1 is the mixer. The local oscillator signal input is coupled to CR1 via L6, C12, and feedthrough capacitor C3. Oscillator Q1 is tuned by inductance L8 and C11. Mixer output is coupled to the if connector by coil L4.

Diode CR1, the mixer, is much different from the vhf transistor mixer. Because of the nonlinear conduction characteristics of the diode it becomes an excellent mixer when two signals are applied to it.

Antenna connections to the uhf tuner are usually through a splitter circuit located either on the

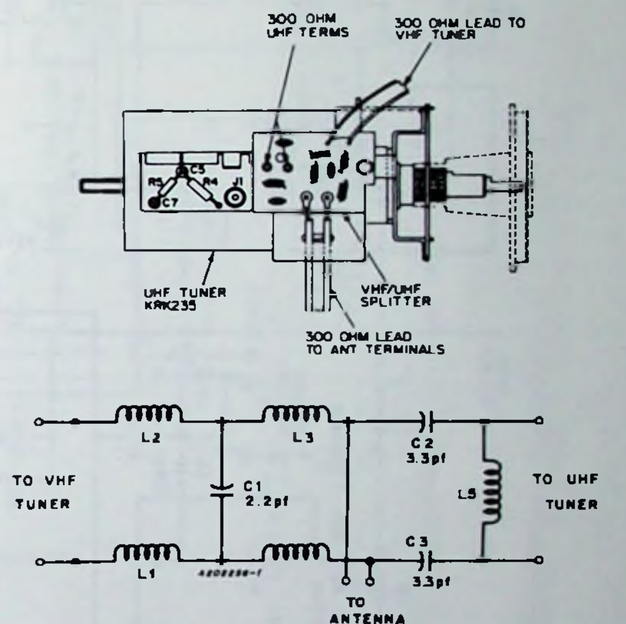


Fig. 7-10. Uhf-vhf signal splitter.

antenna terminal plate on the rear of the receiver, or on the vhf-uhf assembly as shown in Fig. 7-10. The splitter is tuned to receive the high uhf frequencies and has blocking capacitors to isolate the antenna from the chassis—a safety factor discussed in Chapter 1.

OTHER TUNER COMPONENTS AND CIRCUITS

As most homes have color receivers, black and white televisions are manufactured primarily as

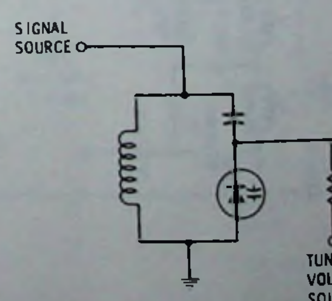
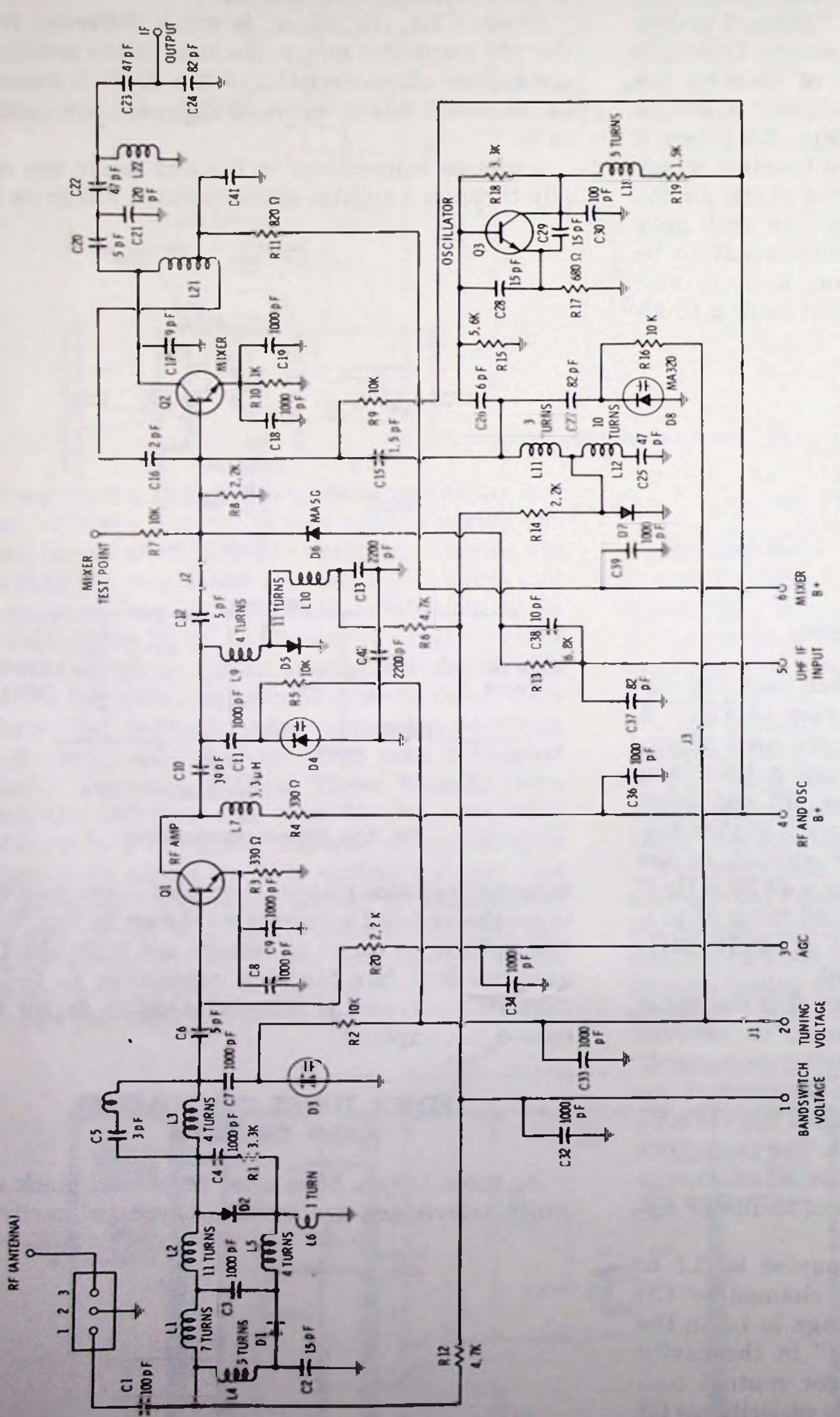
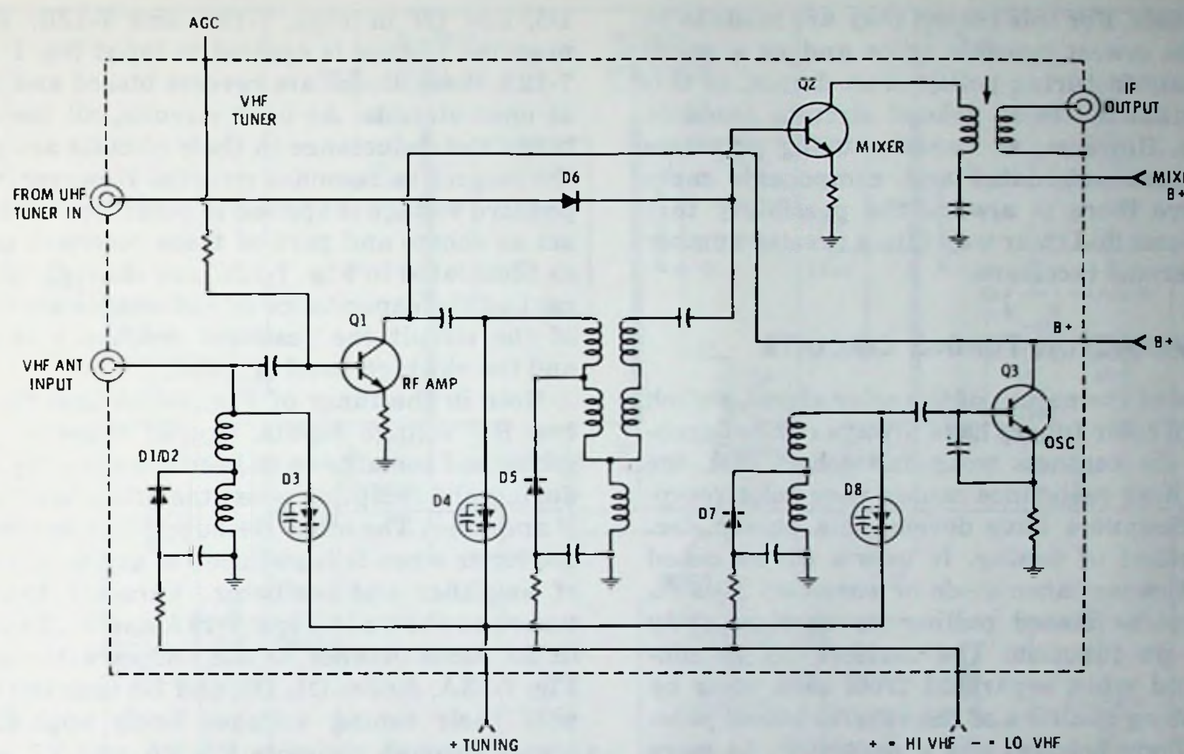


Fig. 7-11. Simplified varactor tuning circuit.

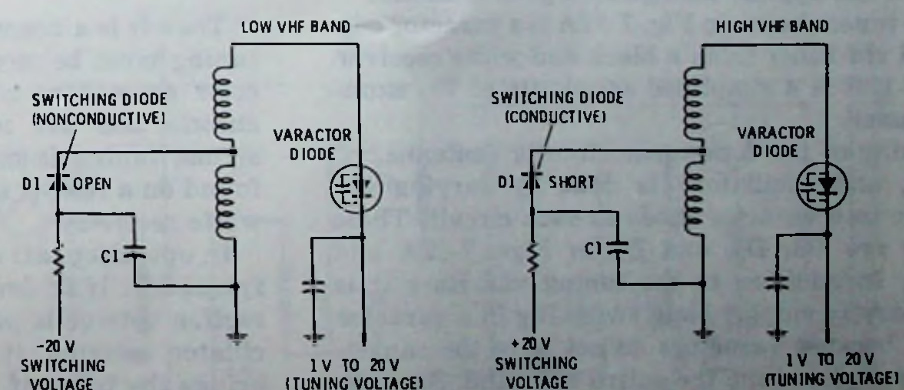


(A) Varactor tuned vhf tuner.

Fig. 7-12. Varactor tuners with



(B) Simplified varactor tuner.



(C) Tuning and switching diodes.

switching diodes. (*Courtesy Quasar Co.*)

"second" sets. For this reason they are made to be sold at the lowest possible price and as a result of this manufacturing policy most do not, at this time, contain the more refined circuits found in color sets. However, as manufacturing processes become more automated and components more inexpensive there is always the possibility that these systems find their way into a greater number of monochrome receivers.

VARACTOR TUNING CIRCUITS

Because of the nature of the color signal, switch contacts in color tuners have always created problems. As the contacts wear and collect dirt, the resulting high resistance causes poor color reception. So designers have developed a purely electronic method of tuning. It uses a device called a variable capacitance diode or *varactor*. This diode is reverse biased pulling its carriers away from the pn junction. The carriers act as conductors and when separated from each other by the insulating qualities of the reverse biased junction the diode behaves like a capacitor. As more reverse bias is applied to the diode, the carriers are pulled farther apart, and less capacitance is produced, and vice versa. Thus, a variable capacitor is provided when the diode is biased by a variable voltage supply.

Fig. 7-11 is a simplified *varactor* tuning circuit. In tuner use, as the channel selector is tuned, a different preselected voltage is applied to the diode—this causes it to tune the circuit to the channel selected. Fine tuning is the fine adjustment of the applied voltage by a potentiometer.

The tuner shown in Fig. 7-12A is a varactor controlled vhf tuner from a black and white receiver. Fig. 7-12B is a simplified schematic of the same-type tuner.

Tuning of the four tuner circuits (antenna, rf, mixer, and oscillator) is done by varying the voltage to a varactor diode in each circuit. These diodes are D3, D4, and D8 in Figs. 7-12A and 7-12B. In addition to the tuning varactors it is necessary to employ band switching in a varactor tuner, because varactors do not have the capacitance range to tune the entire vhf band. So additional inductance or capacitance is switched into the resonant circuits (Chapter 4) to make them resonant at the low vhf channel frequencies (Channels 2–6) and switched out of the circuits to make them resonant at the high vhf frequencies (Channels 7–13). To accomplish this additional switching diodes (not varactors) are used as shown in Fig. 7-12C. These diodes are D1, D2, D5, and D7 in Figs. 7-12A and 7-12B. When a negative voltage is applied to input No. 1 in Fig. 7-12A these diodes are reverse biased and become as open circuits. As open circuits, all the capacitance and inductance in their circuits are part of the respective resonant circuits. However, when a positive voltage is applied to point No. 1 the diodes act as shorts and part of these resonant circuits, as illustrated in Fig. 7-12C, are shorted out. With part of the capacitance or inductance shorted out of the circuit the resonant frequency is higher and the vhf high band is tuned.

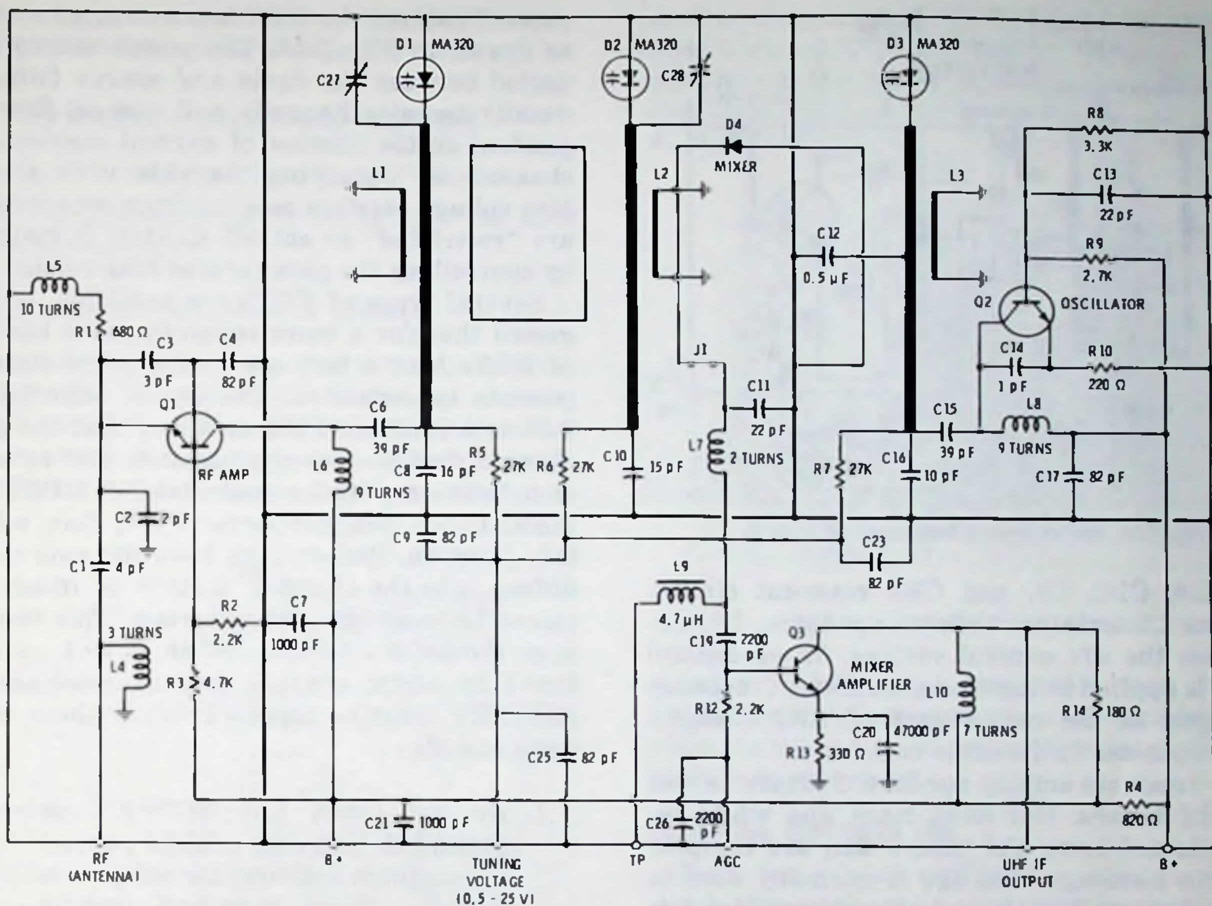
Note in the tuner of Fig. 7-12A that there are two B+ voltage inputs. One of these is for the mixer and remains *on* to keep the mixer operating during uhf reception when the mixer serves as an if amplifier. The other B+ supply is removed from the tuner when it is switched to uhf to disable the rf amplifier and oscillator. Varactor tuned uhf tuners as shown in Figs. 7-13A and 7-13B operate in the same manner as the vhf varactor unit. In Fig. 7-13A, diodes D1, D2, and D3 tune the system with their tuning voltages being applied from source through resistors R5, R6, and R7, and inductors L1, L2, and L3. No diode switches are necessary since the circuits used can operate over the entire uhf spectrum. The agc is applied to the mixer rather than the rf amplifier, but the operation is the same. The tuner shown in simplified form in Fig. 7-13B is similar to the tuner in Fig. 7-13A. However, in this tuner, the agc voltage is applied to the rf amplifier base.

AUTOMATIC FINE TUNING (AFT)

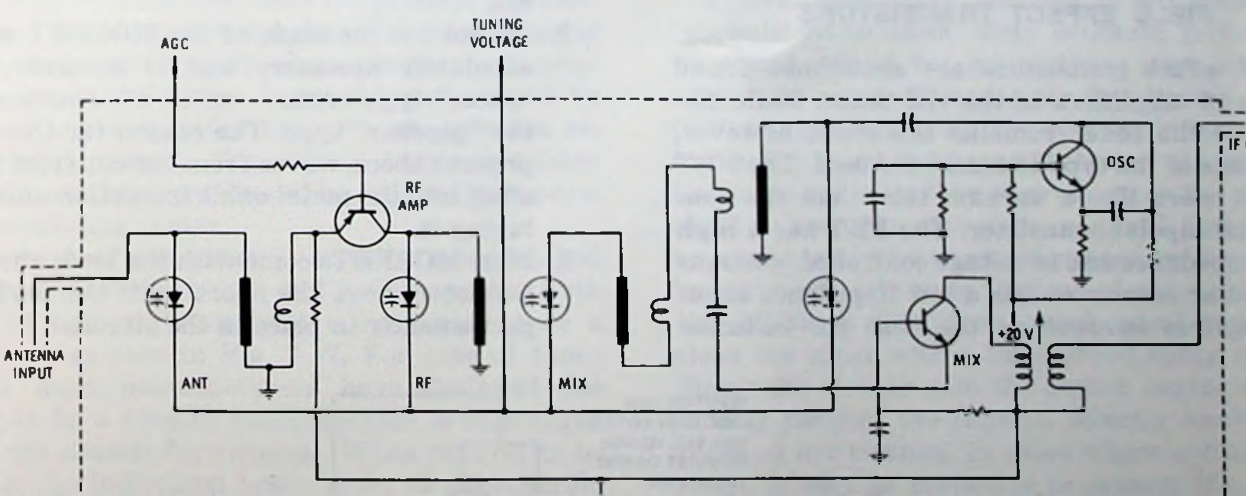
The aft is a necessity in color receivers because tuning must be more precise to correctly tune in color as well as sound and video. Since monochrome sets are not concerned with the color signal, tuning is not so critical. The aft, though found on a few, is not necessary on the black and white receiver.

In operation, aft circuits sense the tuner output frequency. If it deviates from 45.75 MHz a correction voltage is produced and applied to the oscillator causing it to change frequency. This brings the tuner if output frequency in line with the if amplifier tuning at 45.75 MHz. The system is reminiscent of the horizontal afc circuit from Chapter 4.

Though the circuit shown in Fig. 7-14 is of a uhf tuner, the manner in which aft is achieved is identical to that of the vhf tuner. The uhf tuner is used in this example because of its "uncluttered" nature. Varactor diode CR2 is connected



(A) Uhf varactor tuner.



(B) Simplified varactor uhf tuner.

Fig. 7-13. Varactor uhf tuners. (*Courtesy Quasar Co.*)

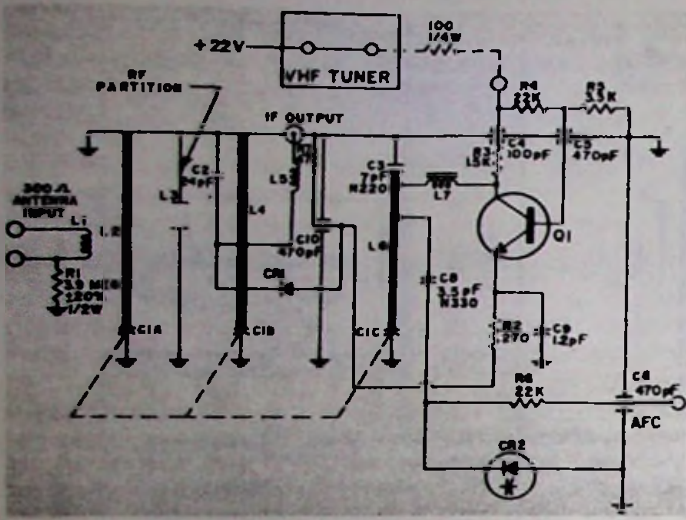


Fig. 7-14. Monochrome television aft circuit.

to the L6, C1C, C8, and CR2 resonant circuit. Capacitor C8 isolates the low impedance, L6, circuit from the afc control voltage. When control voltage is applied to the diode, oscillator frequency is changed as the capacitance of CR2 changes. Vhf aft operates in the same manner.

Color receivers employ agc on uhf tuners as well as on vhf tuners. But most black and white receivers do not have uhf tuners that are complex enough to have agc. The agc is normally used to control the amplification of the rf amplifier but can be used to control any amplifier, such as the mixer amplifier in Fig. 7-13A. Regardless of where agc is used its action is the same as explained previously for vhf tuners.

FIELD EFFECT TRANSISTORS

Field effect transistors are sometimes found used as rf amplifiers in the vhf tuner. Basic circuitry of the tuner remains the same, however, regardless of the type of transistor used. The FET behaves more like a vacuum tube than the conventional bipolar transistor. The FET has a high input impedance and is voltage controlled, whereas the bipolar transistor has a low impedance input and requires current on the base for collector current control. An FET is constructed somewhat as drawn in Fig. 7-15. The power source is connected between the drain and source (which can usually be interchanged) and current flow is dependent on the number of current carriers in the channel. By supplying the gate with a reverse bias voltage carriers moving from source to drain are "restricted" or cut off. Control is maintained by controlling the gate reverse bias voltage.

Several types of FETs are available. It is suggested that for a more comprehensive knowledge of FETs that a text concerning solid-state components be consulted. The device shown in Fig. 7-15 is a junction FET meaning that the gate to channel fusion creates a junction just as any fusion between p and n materials. A MOSFET or, Metal Oxide Semiconductor FET, does not have this junction. Rather than have the gate material diffuse into the channel, a layer of insulation is placed between the two materials. This insulation is on the order of "microns" thick and easily ruptured by static charges and over-voltage. If a MOSFET must be replaced follow these instructions exactly:

1. *Do not* touch the MOSFET unless well grounded. You may ground yourself through a 1 megohm resistor. *Do not ground yourself directly*—if you do so and come into contact with a hot chassis, severe shock can result. Failure to be grounded while handling a MOSFET may allow the static electrical build-up on your body to puncture the metal oxide insulation between the gate and channel.
2. Do not cut the leads of the MOSFET unless absolutely necessary and if necessary use "shear"-type cutters—most wire cutters are the "pincher" type. The reason for this is to prevent shock waves from the cut from traveling into the metal oxide insulation and rupturing it.
3. Most MOSFETs come with the leads shorted. Do not remove the short until the device is permanently in place in the circuit.

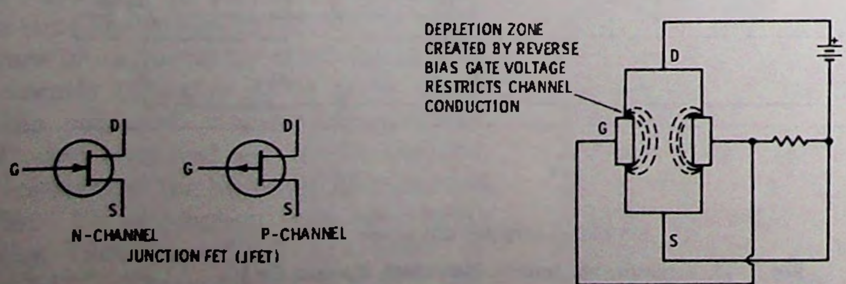


Fig. 7-15. Field effect transistor (FET).

4. *Do not* use a soldering *gun* on a MOSFET—always use a grounded soldering *iron.*

TROUBLESHOOTING VHF TUNERS

Symptoms caused by defective vhf tuners are:

1. Switch problems—dirty contacts, weak contact springs, etc.
2. Snow
3. Good raster—no sound or picture

Other circuits can cause the same symptoms, specifically the if amplifiers and the agc circuit. Before deciding that the tuner is faulty, adjust the agc control. If the picture comes back it was misadjusted. If the agc has no effect, return the control back to its original setting and substitute the tuner with a tuner substituter (Fig. 7-16) or an analyst with an if output. If the set produces a picture when a substitute tuner is used the tuner is most likely defective. Once the problem has been confined to the tuner it may be repaired or shipped to a tuner repair facility. Unless the proper equipment is available it is suggested that tuners be shipped to a rebuilding firm. For the average repair shop, anything other than a simple transistor or diode replacement should be left to the experts at a rebuilding center.

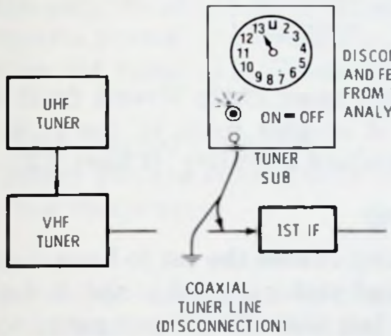


Fig. 7-16. Tuner substitution.

Removal of the tuner is usually accomplished by removal of the knobs and a few screws. Both the vhf and uhf units are often removed as a "module" as seen in Fig. 7-17. For ease of tuner repair most manufacturers have designed the tuner to be a plug-in module which is unplugged from the chassis for removal. When sent off to be rebuilt the individual tuner must be taken from the assembly. For the vhf tuner this requires taking antenna leads, B+, antenna, agc, if, uhf B+, and the uhf if link loose. The uhf tuner requires only that the antenna leads, B+, and uhf/vhf connecting link be taken off. Care should be exercised in de-soldering on the tuner. Feedthrough capacitors, such as C5 and C7 in Fig. 7-8, are easily broken or destroyed by excessive heat. Also, when removing a tuner *be sure to draw a diagram showing exactly how each wire was removed.* Failure to do this may cause a lot of unhappiness when the tuner is to be replaced and you've forgotten how it was wired.

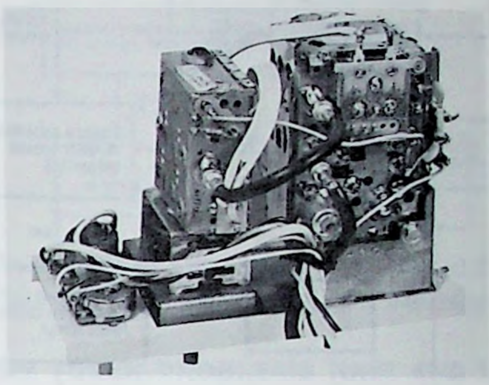


Fig. 7-17. Uhf/vhf tuner "module."

Poor Fine Tuning of Uhf

Poor fine tuning ability is usually caused by clutch slippage in the tuner drive system, and can be eliminated by cleaning and proper lubrication. Be careful *not* to lubricate any friction drive surfaces.

Mechanical Problems

Typical mechanical troubles in vhf tuners are intermittent contacts, dirty contacts, picture but no sound, sound but no picture, some channels cannot be received, and poor fine tuning. Intermittent and dirty contacts are usually manifested by having to set the tuner "between channels" or having to put some type of pressure on the selector shaft to make the set receive a signal. Picture but no sound, and vice versa, is caused in most cases by dirty contacts as is the loss of some channels. For all these defects the most usual cure is to clean the tuner with a commercial spray cleaner. Spray the cleaner onto the switch contacts while briskly turning the channel selector knob so all contacts are cleaned. In cases where contacts are worn, it may be necessary to remove the turret, "re-tension" the springs, and clean them with a pencil eraser. If this is done be careful that the many small coils do not become squeezed or stretched. Changing their shape in any way changes the tuning of that particular circuit.

Chart 7-1. Troubleshooting Snowy Picture

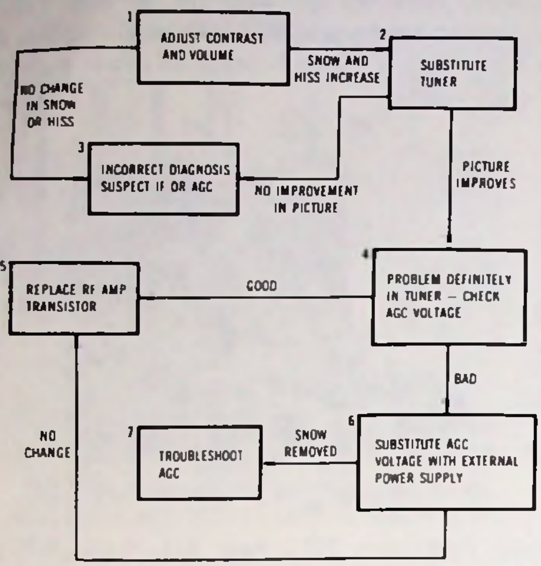
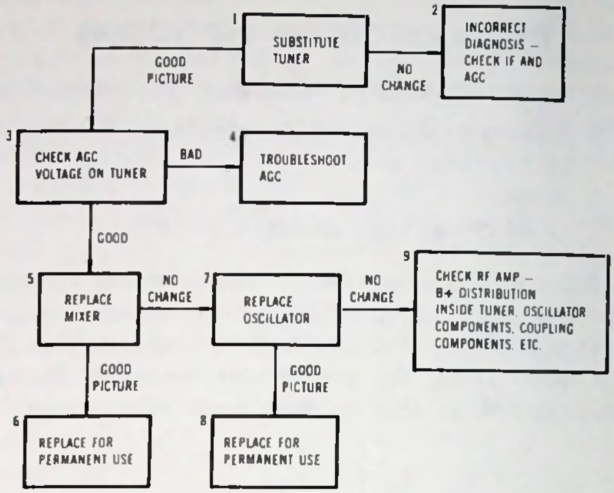


Chart 7-2. Troubleshooting No Picture or Sound—Raster Good



Snow

Snow on the screen is an indication that the mixer stage is working and that following circuits are also operating. If the contrast control is turned up the snow should increase (Chart 7-1). If the volume is increased atmospheric noise (hiss) should also increase. These tests indicate that the mixer and all subsequent stages are operating, and the most likely fault is a bad rf amplifier stage (if the antenna system is good!).

No Picture or Sound—Raster Good

This symptom usually indicates a defective oscillator or mixer (assuming the antenna system is good). If no noise is seen in the picture in the form of snow the most likely circuit fault is the mixer because it creates most of the snow produced by the receiver circuitry (Chart 7-2).

Poor Fine Tuning

Poor fine tuning causes the set to have distorted sound with a good picture, good sound and a poor picture, or may not have the proper range to tune the picture and sound for full fidelity. The cause may be slippage in the drive mechanism or a broken gear. A good visual inspection will normally locate the trouble. In some instances the slug screw in the end of the coil form is screwed out or the plastic threads strip or the form itself breaks. For these defects the tuner must be sent to a tuner rebuilder.

Chart 7-3. Dead UHF Tuner

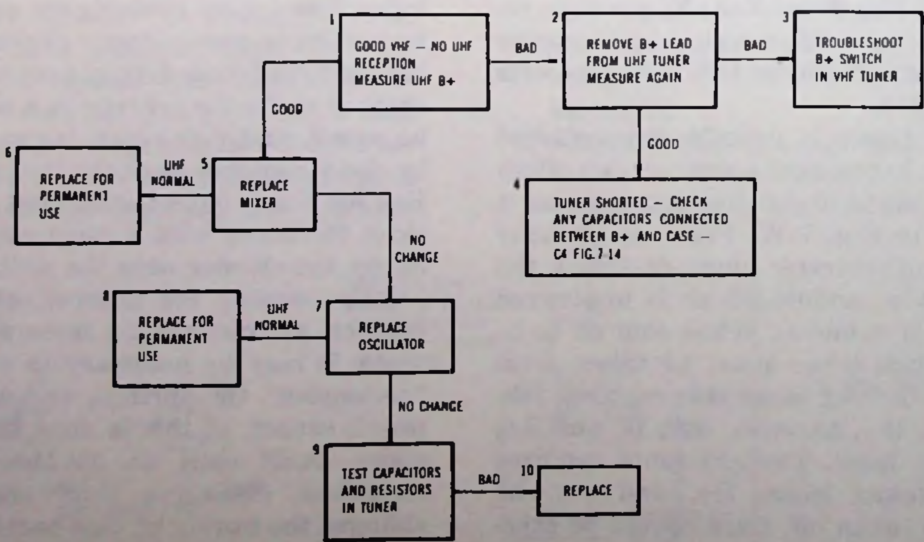
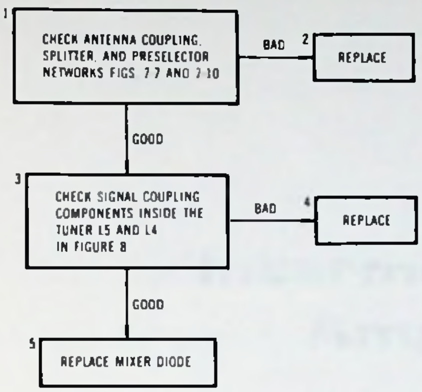


Chart 7-4. Snowy Picture



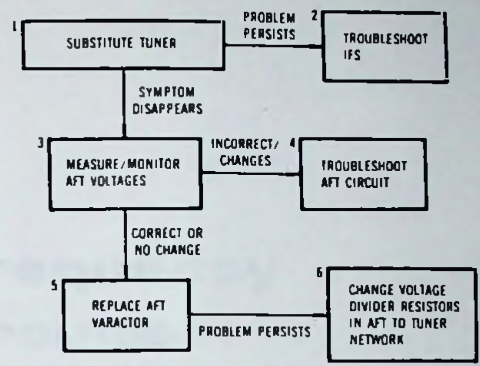
TROUBLESHOOTING UHF TUNERS

When only the uhf tuner is defective the set will continue its normal vhf operation. Symptoms of a defective uhf tuner are (Chart 7-3):

1. Dead—no uhf reception
2. Snowy picture (Chart 7-4)
3. Poor fine tuning

Note: Other symptoms that are the same as those encountered with the vhf tuner may be caused by the same type of defect. This is especially true in uhf tuners such as shown in Fig. 7-13. These tuners are identical to the vhf tuner in function, having an rf amplifier and agc.

Chart 7-5. Troubleshooting AFT Defects



OTHER TUNER PROBLEMS (UHF AND VHF)

Symptoms created by defects in aft circuits (Chart 7-5) are as follows:

1. Station won't fine tune
2. Station tuning "drifts"

If station drift is present in varactor tuners monitor the varactor tuning supply voltage. If it drifts check and replace any voltage regulation components (transistors and zeners) and series dropping resistors. If drift continues replace oscillator varactor diode.

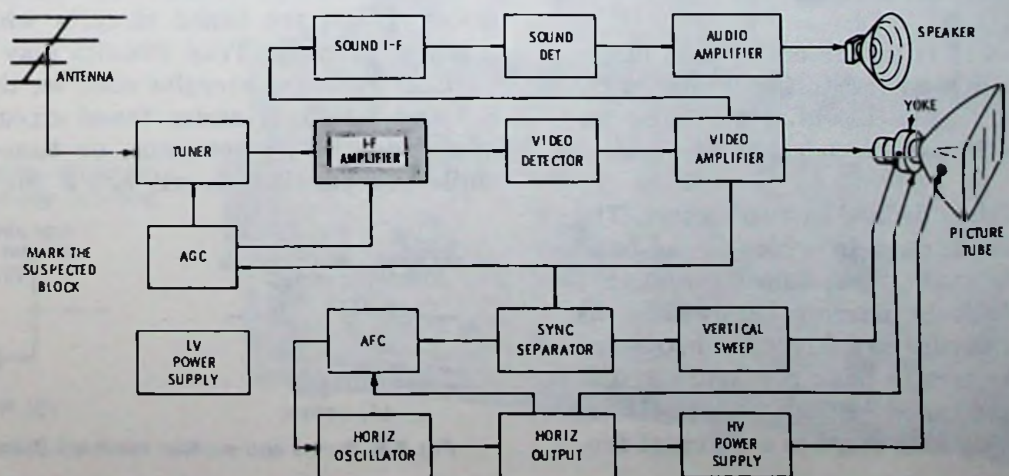
Chapter 8

Intermediate Frequency Amplifier Circuits

The intermediate frequency amplifier circuits are wide band, tuned circuits. This means that they are tuned to accept and amplify a band of frequencies. The actual bandwidth will vary depending on the class of receiver. The purpose of the if amplifiers is to produce a greatly amplified output signal identical to the input from the tuner mixer stage. This requires that they pass the entire band of usable frequencies including audio and video. The if's must also "trap out" unwanted frequencies such as the sound and video from adjacent channels, and after the sound is separated from the video, additional traps ensure that no sound information modulates the picture tube electron beam. If sound does get to the crt, an interference pattern such as that in Fig. 8-1 is produced. The if's are also gain controlled with their amplification automatically altered by the agc circuit. Fig. 8-2 shows the relationship of the if and agc circuits. If the incoming signal is strong, the agc circuit develops a voltage which decreases the if circuit gain. The opposite happens if the received signal level is low. In review, the if's do the following:

1. Amplify a selected band of frequencies including sound and video if carriers at 41.25 and 45.75 MHz, respectively.
2. "Trap" out unwanted frequencies such as adjacent channel sound and video, and any

Fig. 8-1. Sound modulated video.



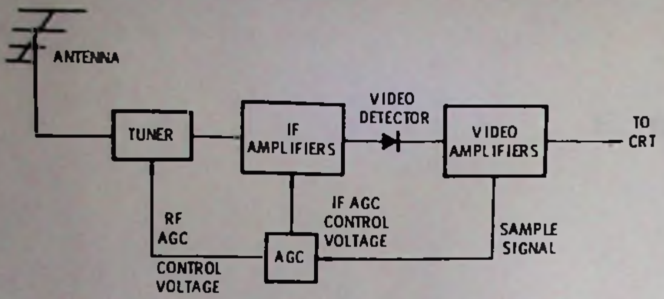


Fig. 8-2. Agc controls if amplification.

residual sound signal to keep it from interfering with the picture presentation.

3. Provide gain—controlled by the agc circuit.

BANDPASS

Fig. 8-3 shows the band of frequencies passed by the if circuitry referred to as the circuit *bandpass.* Note that like the tuner the if bandpass is broad, covering approximately 6 MHz. Because video signals extend only to about 3 MHz as illustrated in Fig. 8-3 it is not essential that monochrome if bandwidth extend to the limits of the 6 MHz bandwidth. It is essential for color receivers to do this, however—or color information would be lost.

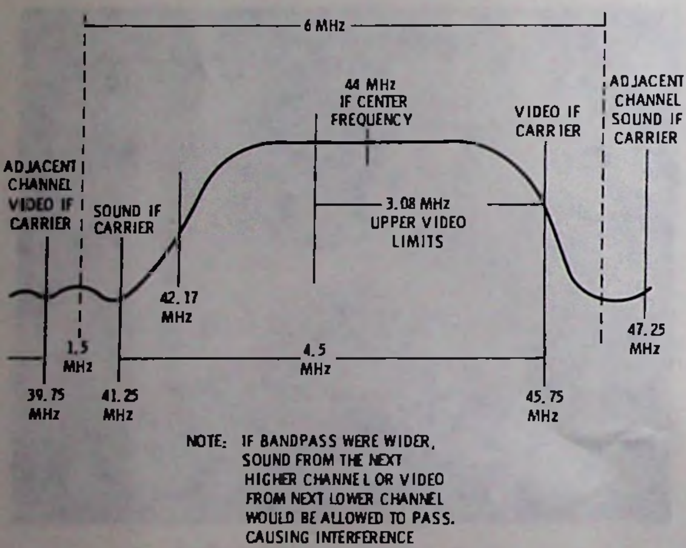


Fig. 8-3. If bandpass.

The if bandwidth is defined by two factors. The first factor is the manner in which broad-band tuned circuits are made. Most tuned (resonant) circuits have relatively narrow bandwidths as seen in Fig. 8-4. In order to achieve the necessary if bandwidth these narrow band resonant circuits are usually "stagger tuned." Stagger tuning is accomplished by tuning each stage to a different frequency so the resonant frequencies of each stage overlap as shown in Fig. 8-5A. The overlapping of tuned frequencies produces an overall circuit bandpass, as seen in Fig. 8-5B. This manner of tuning helps to define the limits of the bandpass.

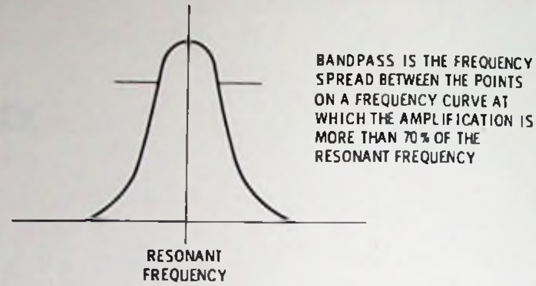
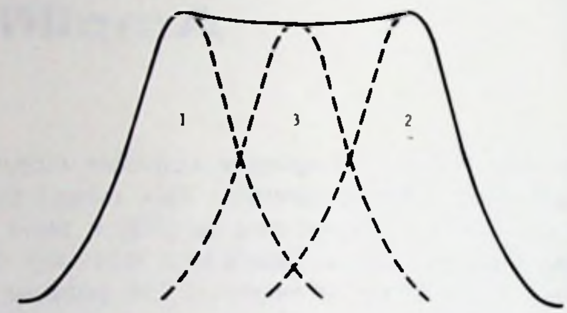
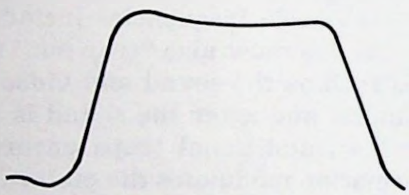


Fig. 8-4. Narrow bandwidth produced by most resonant circuits.



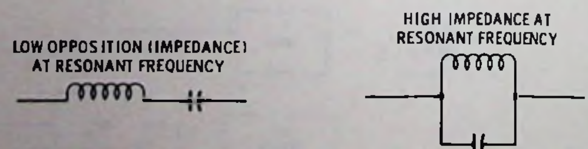
(A) Overlapping response curves of three stagger-tuned if circuits.



(B) Overall response curve of the three stagger-tuned if's in Fig. 8-5A.

Fig. 8-5. Stagger-tuned if's create a broad bandwidth.

The second way to limit the bandpass is to use traps. Traps are tuned circuits which are normally adjustable. Trap circuits may be series or parallel resonant circuits such as those in Figs. 8-6 and 8-10D. A series tuned circuit has a low impedance at its resonant, or tuned, frequency while the parallel circuit has a high impedance



(A) Series. (B) Parallel.

Fig. 8-6. Series and parallel resonant (tuned) circuits.

at its resonant frequency. The series circuit, then, will pass its resonant frequency and oppose all others. The parallel circuit has the opposite effect. The traps shown in Fig. 10D are good examples of this. The series circuit consisting of C1 and L1 is tuned to 39.75 MHz, the adjacent channel video if carrier. Being tuned to this frequency and being a series tuned circuit, the adjacent channel video if carrier is allowed to pass to ground while all other frequencies pass on into the if amplifiers. Note that the adjacent trap is tuned to 47.25 MHz, which is the adjacent channel sound if carrier.

A parallel tuned circuit is represented in Fig. 8-10D by L9 and C. This circuit is a trap to impede the 4.5 MHz sound if from advancing into the video circuits. Being a parallel resonant circuit, it passes all but its resonant frequency (4.5 MHz) on into the video circuitry, and thus traps out the sound.

The trap limits circuit bandpass when used as shown in Fig. 8-7. When used to limit bandwidth in this manner, the traps "suck out" unwanted frequencies such as the adjacent channel sound (47.25 MHz), adjacent channel video (39.75 MHz), and 4.5 MHz sound if signals which may be present. As mentioned, these traps are tunable.

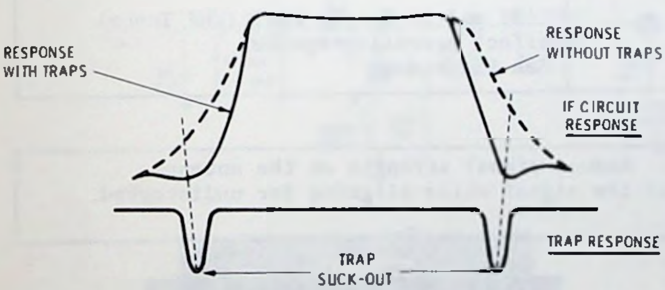


Fig. 8-7. Traps determine bandwidth.

When misaligned they can suck out part of the sound or picture information of the channel being received. Of course, they can also be mistuned so that adjacent channel sound, adjacent channel picture, and 4.5 MHz sound if causes interference.

ALIGNMENT

Alignment is the process of adjusting the traps and other tuned circuits in the if stages to pass the desired signals and reject unwanted ones. It is a process which is difficult to perform correctly and requires expensive precision equipment. The equipment used may be similar to that shown in Fig. 8-8 or may consist of more than one piece of equipment. It is beyond the scope of this book to go into detailed alignment procedures but a sample PHOTOFACT® alignment guide is printed in Fig. 8-9. This guide explains how the if traps and bandpass transformers are typically aligned (tuned) so that the correct bandwidth is achieved. A sweep generator must be used, with another generator used to provide "markers" or "blips" on the scope trace at critical frequencies. These blips can be seen on the scope traces in Fig. 8-9. By having these frequencies identified on the trace the technician can see if his curve includes the correct frequencies and if certain frequencies are amplified to the proper amplitude. A typical if response curve will look like the one in Fig. 8-9B. Notice the position of the various marker frequencies; they are explained in Fig. 8-3.

While on the subject of tuned circuits and alignment, it should be mentioned that the tuner link coupling the tuner with the if's is also tuned. If it must be replaced be sure to replace it with the same type of coax cable and use one of the same

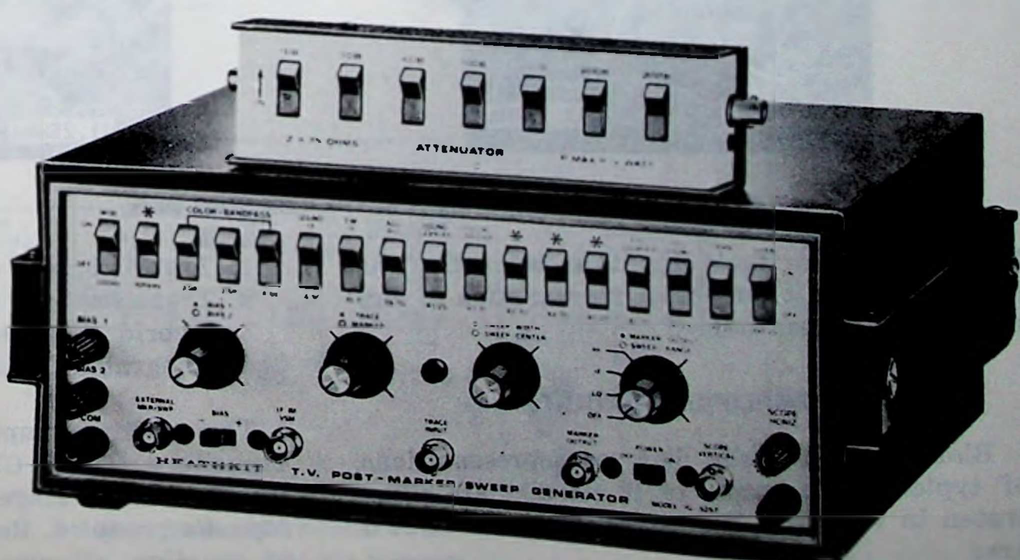


Fig. 8-8. Television alignment equipment. (*Courtesy Sencore, Inc.*)

TV ALIGNMENT INSTRUCTIONS

Use an isolation transformer, or observe polarity, and maintain line voltage at 120VAC.
Allow a 20-minute warm-up period for receiver and test equipment.

Suggested Alignment Tools:	GC ELECTRONICS
L101, L102, L103, L104, L106, L107, L108, L201, L202, IF Output Coil (VHF Tuner)	9296, 9297, 9300

PRELIMINARY INSTRUCTIONS

Set the channel selector to the highest unused channel. Set scope sweep to external. Connect scope vertical input to scope vertical input on sweep/marker generator. Connect scope external horizontal input to scope horizontal input on sweep/marker generator. Ground test equipment to TV chassis unless specified otherwise. Use only enough generator output to provide a usable indication.
Note: Response may vary slightly from that shown.
Connect a +6 volt bias to TP12.

VIDEO IF ALIGNMENT

DIRECT PROBE FROM SWEEP/MARKER GENERATOR	SWEEP GENERATOR OUTPUT	SWEEP GENERATOR FREQUENCY	MARKER GENERATOR FREQUENCY	REMARKS
To TP13	To TP on VHF tuner.	44MHz (10MHz Sweep)	41.25MHz 47.25MHz	Adjust L102 for MINIMUM. Adjust L103 for MINIMUM. See Fig.8-9A.
"	"	"	41.25MHz 42.17MHz 44.00MHz 45.75MHz 47.25MHz	Adjust L101, L104, L106, L107, L108 and IF Output Coil (VHF Tuner) for maximum gain and symmetry of response L104 and L106 affect 44.00MHz. L107 and L108 affect 42.17MHz and 45.75MHz. L101 and IF Output Coil (VHF Tuner) affect overall response. See Fig.8-9B.

SOUND IF ALIGNMENT

Tune in a station and adjust L202 for maximum sound. Reduce signal strength at the antenna terminals until distortion appears. Continue to reduce the signal while aligning for undistorted output by adjusting L201.

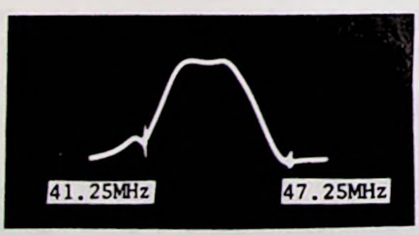


Fig. 8-9. A typical if alignment guide.

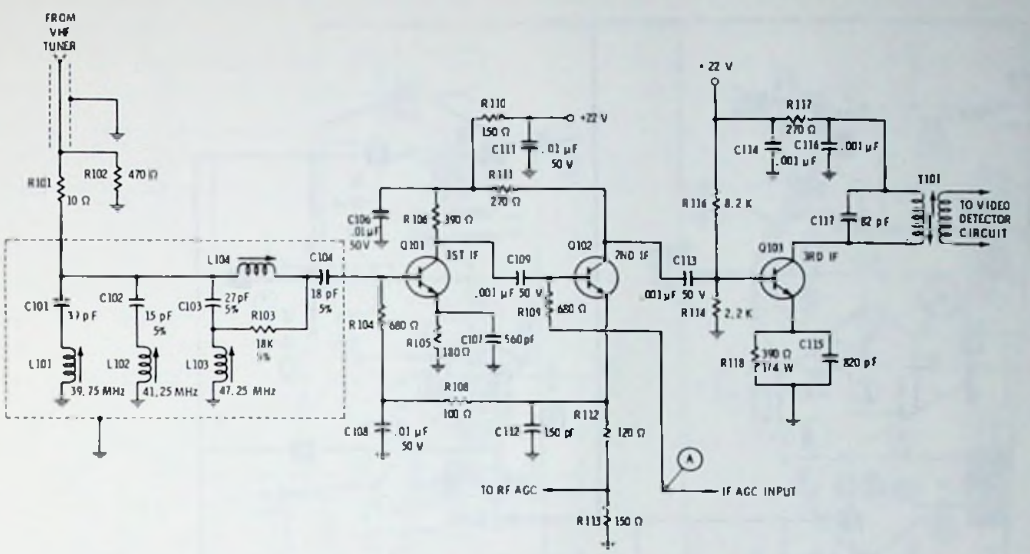
length. There are tuned circuits at each end of the link for tuning it for proper transmission of signal from the tuner to the if.

IF AMPLIFIER CIRCUITS

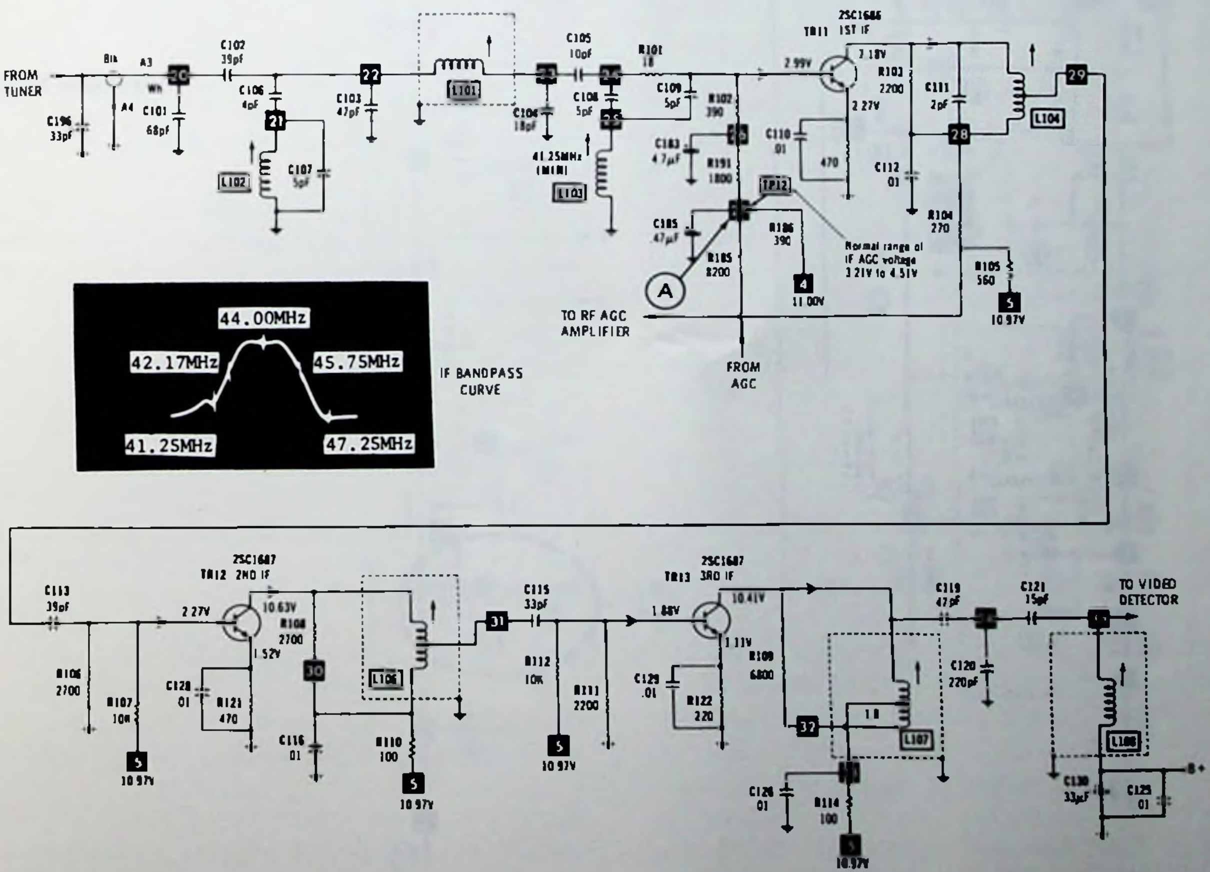
Block and schematic diagram representations of typical monochrome tv if circuits are illustrated in Fig. 8-10. The types of circuits shown are:

1. Transistorized, capacitor coupled
2. Transistorized, inductance coupled
3. Hybrid (transistor and IC)
4. Integrated Circuit

The capacitor coupled circuit of Fig. 8-10A uses capacitors (C104, C109, C113) to transfer the signal from one stage to the other, hence the term *capacitor coupled*. Because of this simple method of coupling, alignment (tuning) to the correct

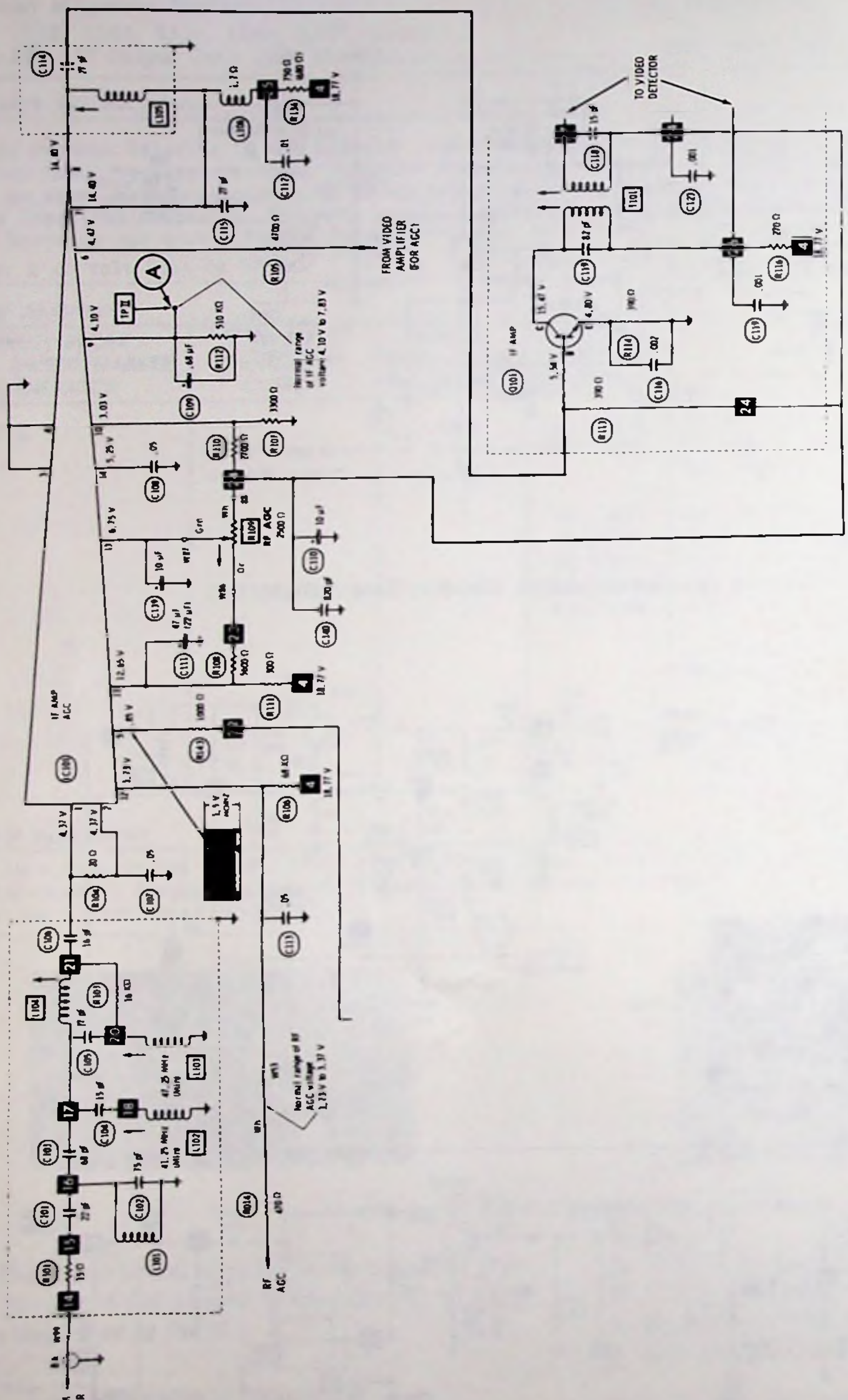


(A) Transistorized, capacitor coupled If's. (*Courtesy General Electric Co.*)



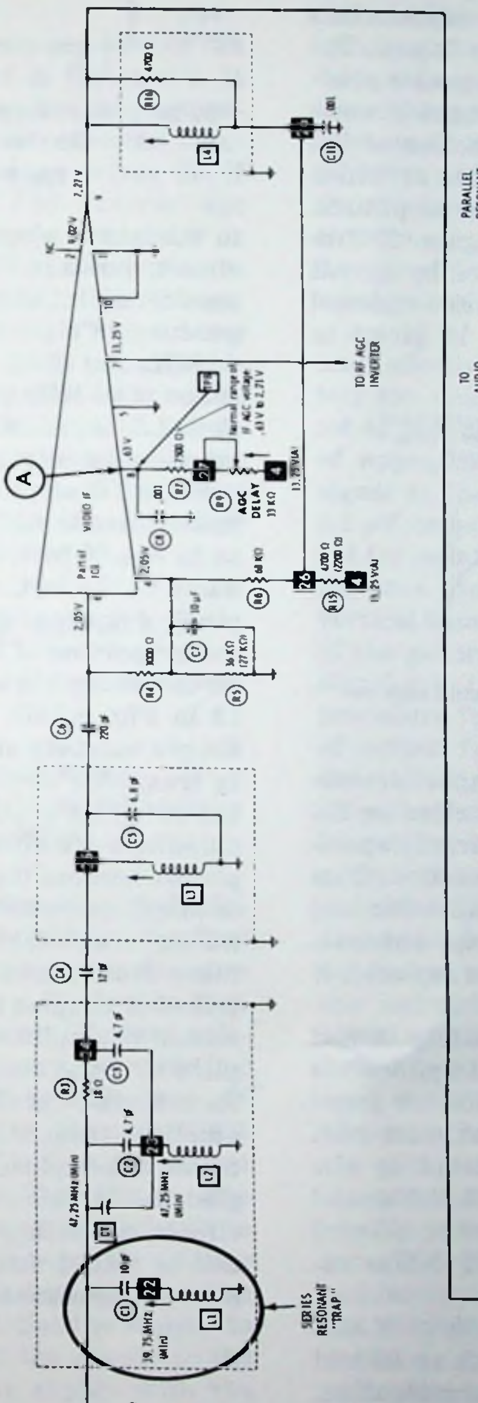
(B) Transistorized, inductance coupled if's.

Fig. 8-10. Typical if circuits.



(C) Hybrid if circuit.

Fig. 8-10. (continued)



(D) IC if circuit.

Typical if circuits.

frequencies is less complicated than most inductance coupled circuits. In this particular system tuned circuits are used only at the input and output of the if. There are three trap adjustments and one peaking adjustment at the input. The output transformer, T101, has two peaking adjustments. Peaking circuits are resonant circuits which, because of the regenerative action of the resonant circuit, cause the frequencies at which they are resonant to be increased in amplitude. Because of peaking circuits the higher if frequencies, which are usually attenuated by circuit capacitance to ground, are brought back to normal amplitude. An illustration of this is given in Fig. 8-11.

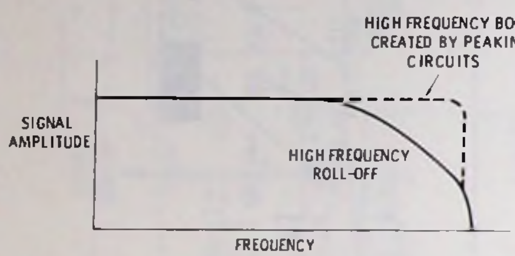


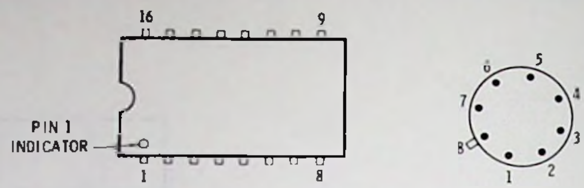
Fig. 8-11. Effects of peaking circuits on lowered high frequency response.

Another benefit from the use of capacitor coupling (sometimes called resistor-capacitor or RC coupling) is that the transistor internal capacitances have little effect on circuit operation. This eliminates the need for circuit neutralization and minimizes tuning shifts as bias voltage changes. It also means that when a transistor is replaced, if alignment is not generally required.

Inductance coupled circuits such as Fig. 8-10B use stagger tuning and each stage of amplification is tuned. In this circuit L102 and L103 are traps while other coils are adjusted for maximum gain and bandpass curve shape as indicated by the scope trace shown in Fig. 8-10B. Coils L104 and L106 are basically tuned to 44 MHz and L107 and L108 are tuned to 42.17 and 45.75 MHz, respectively.

Many present day receivers use hybrid if circuits as shown in Fig. 8-10C. Here both an IC and a discrete transistor are used for if amplification. Tuning of this circuit is done on the input, between the IC and transistor, and on the output. Stagger tuning is again employed with T101 and L104 tuned to 44 MHz and L105 tuned to 45.75 MHz. Coils L102 and L103 are traps and L104, L105, and T101 are adjusted for maximum gain and for curve shape.

More monochrome televisions are being found



(A) DIP (dual in-line plastic) case—top view.

(B) Round package (top view).

Fig. 8-12. IC pin designations.

to contain a single IC if amplifier circuit. The circuit shown in Fig. 8-10D is such a system. And even though it contains a single IC it is still stagger tuned. Coils L1 and L2 are the traps, L3 affects 44 MHz and 45.75 MHz, L4 affects bandpass curve shape at 44 MHz and L6 affects 42.17 and 44 MHz. Coils L3, L4, L5, and L6 are adjusted to give maximum gain and correct curve shape.

When IC amplifier circuits are drawn in schematic form the IC is usually shown as a triangle as in Fig. 8-10D. The input to the circuit is normally to the left, flat end of the triangle. This is pin 6 of the first portion of IC1 and pin 13 of the second portion of IC1. The outputs are to the right on the sharp point of the triangle or pins 9 and 19 in Fig. 8-10D. When looking at the IC itself, the pin numbers are counted as shown in Fig. 8-12. In transistor circuits the signal usually enters on the base and is taken out on the collector. The if amplifiers are almost always common emitter amplifiers because they produce the most voltage gain or amplification. In a circuit such as in Fig. 8-10A, the signal enters the base of Q101, is amplified, and taken from the collector of Q101. It is then transferred or coupled by C109 to the base of Q102. The second if amplifier, Q102, amplifies the signal applied to it and couples the amplified if signal from its collector via C113 to the base of the third if amplifier transistor, Q103. Final if signal amplification takes place in Q103 and the signal is coupled to the video detector stage via a final tuned circuit consisting of T101 and C117. The signal can be traced through any of the circuits in Fig. 8-10 in this manner.

IF AGC

Each of the circuits in Fig. 8-10 shows agc control. The agc control voltage is applied to the base of Q102 in Fig. 8-10A, to the base of TR11 in Fig. 8-10B, at pin 9 of IC101 in Fig. 8-10C, and is internally connected in IC1 in Fig. 8-10D. Note in Fig. 8-10D that the video signal used by the agc to determine signal strength is fed to pin 3 of IC1 and agc voltage is measured at pin 8. Yet there is no agc connection shown between the two sections of the IC. The if agc system is *inside* IC1 and not available to the technician except at the two points just mentioned.

The if agc operates in the same way as does the tuner rf agc that was explained in Chapter 7. It operates by driving the if transistor into saturation or toward cutoff. Either will cause the transistor to decrease gain. *Forward* agc drives the if transistor toward saturation and *reverse* agc drives it toward cutoff. If an npn transistor is used for the if amplifier, a positive going agc voltage applied to its base would produce forward agc. A negative going agc voltage applied to the same transistor base will produce reverse agc. This is so because an npn transistor requires a base voltage that is more positive than its emitter to conduct. A more negative voltage will turn off the transistor. A high positive base voltage will cause the transistor to saturate. The agc circuit will be presented in more detail in Chapter 10.

TROUBLESHOOTING THE IF AMPLIFIERS

Symptoms caused by defective if amplifiers are:

1. No picture—no sound
2. No picture—weak to normal sound
3. Weak picture—weak, normal, or no sound
4. Grainy picture—smeared picture

Tuner, agc, and if troubles are often indistinguishable. For a suspected if problem, the first order of troubleshooting is to determine for sure that the fault is in the if circuitry. To do this, first check tuner B+ and rf agc voltages. If these voltages are correct, substitute the tuner. Substituting the tuner is easy to do and takes little time. If the set returns to normal with the substitute tuner it has a tuner problem. If it does not return to normal the difficulty may be if or if agc. The next step is to reconnect the tuner and substitute if agc voltages. To do this use a variable voltage supply connected to the if agc bus such as the points labeled "A" in Fig. 8-10. Set the supply to zero and with the set off attach the supply to the agc bus line. *Do not* attach the supply with the set operating. To do so may cause damage to the if transistors. The correct sequence of steps is:

1. TV off, power supply off or set to zero volts.
2. Attach the supply to the agc bus.
3. Turn on the set.
4. Adjust the power supply voltage to the value called for on the schematic.

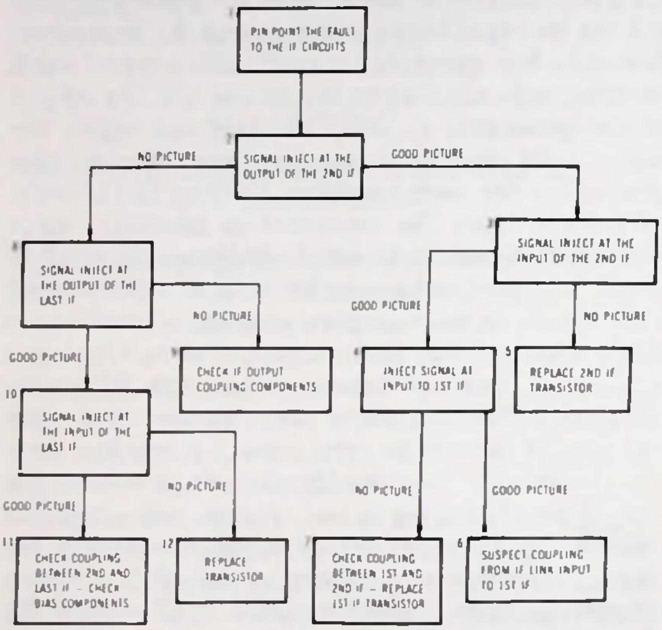
Now if the set operates normally the agc is defective—if it does not operate normally, the problem is in the if circuitry.

Troubleshooting can be done by oscilloscope or by signal injection with an analyst. To use the scope a special "detector" probe must be used. Even then, erroneous conclusions can be reached because of the high frequencies involved and the sensitive nature of the circuits. Signal injection is the preferred method of troubleshooting the if circuits. An analyst is best because of the picture produced on the screen, and is essential for troubleshooting some problems.

An af/rf signal generator can sometimes be used effectively if proper care is taken not to inject too much signal. With the signal generator set to produce square wave output at a frequency of approximately 100 kHz, begin injecting the signal at the output of the last if stage. Place a 0.1 μF capacitor in series with the generator output for isolation between the set and the generator. Advance the generator output until several dark vertical bars are seen on the screen. Cut the output of the generator to about one-half and inject the signal into the last if transistor base. Repeat this procedure for each amplifier. Cutting the amount of output from the generator is necessary each time the signal is injected. Another stage of if amplification has been included in the system and less signal is necessary to produce a good video presentation. Too much signal can overload the circuits or destroy transistors and ICs. This process is useful only when the symptom is a clear cut loss of picture or very weak picture. It allows the technician to identify the stage where the signal amplification is lost. It does not allow the technician to "see" where signal distortion occurs, since the only picture produced is a series of vertical bars. A bad transistor or IC is normally the cause of weak or no video and the problem stage can usually be found rather easily. Picture quality symptoms, such as smear or grainy picture, are more difficult to solve and a picture-producing analyst is a must. This technique will not work if the receiver uses a synchronous video detector.

Replace any components in the if circuits with exact replacement parts. General purpose devices do not always work in such exacting circuits. If such a device is used and the set still does not work, the technician does not know if his original diagnosis was correct or if another problem exists. With the correct replacement component, if the set does not work, it is known that another problem exists. Many times we make our own problems in this way. With an incorrect, nonoperating part in the set we begin to look for a second problem which really does not exist, thus wasting time and frustrating ourselves. *Do it right the first time!* If an exact replacement transistor cannot be found and a general purpose transistor must be used, do not substitute a metal can unit for a plastic case type—they quite often do not work because of the added capacitance due to the metal case. A typical symptom associated with replacing an if transistor with an incorrect substitute is a grainy picture. Grainy pictures can also be caused by incorrect bias on the transistor base and by misalignment. The following are troubleshooting guides for general if troubleshooting for common symptoms—refer to Chart 8-1.

Chart 8-1. No Picture—No Sound



(Chart assumes a typical three-stage if.)

No Picture—Weak to Normal Sound

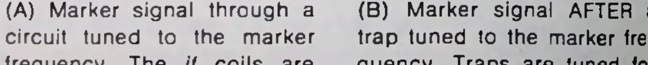
For this symptom, troubleshoot in the same manner as for no picture—no sound. It is often found that the sound signal will be nearly normal even with an if transistor out of the socket. It has been observed in the foregoing discussions that the sound signal receives almost no amplification in the if circuitry (see the curve in Fig. 8-3). The actual amplification is 10% or less of the amplification given to video if signals. But then little sound signal is necessary since the sound system employs its own if circuitry. Only enough sound if signal is necessary for beating against the video if to produce the 4.5 MHz sound if. Note in the if curve in Fig. 8-3 that the video and audio carriers are 4.5 MHz apart. When the two signals beat against each other the difference frequency of 4.5 MHz is selected as the sound if frequency. This signal is then applied to the sound if circuits and processed—more about this in Chapter 11.

Weak Picture—Weak to Normal Sound

This symptom is repaired in the same way as a no picture symptom except you will be looking for a partial loss of signal rather than a complete loss.

Grainy Picture—Smeared Picture

These symptoms are opposites. Grainy pictures are often caused by increased high frequency response (or loss of low frequency) while smeared pictures are caused by an increase in low frequency gain (or loss of high frequency). Both are caused by misalignment or defective components in the tuned circuits. Lowered gain sometimes causes excessive snow on strong stations which appears almost the same as a grainy picture. This is often caused by a defective transistor or bias resistor in the base circuit. *Note that alignment is rarely a problem;* but, for these symptoms it is advisable that the receiver be connected to an alignment set-up for analysis. When lashed to the alignment gear, if the video if carrier at 45.75 MHz is higher on the curve than shown in Fig. 8-9, the low frequencies are going to be emphasized; if it is lower on the curve than shown, the higher frequencies are going to be emphasized. Align the if's for best responses. If they cannot be properly aligned, a defect exists in the if circuitry causing a resonant frequency shift. Use the signal inject method to locate the defective circuit, use a modulated marker input as explained in the alignment equipment instruction manual. A modulated marker is a modulated signal corresponding to the resonant frequency of the stagger tuned stages. If the modulated marker frequency for one of these stages does not react as it should, or as the others, the stage tuned to that frequency is



(A) Marker signal through a circuit tuned to the marker frequency. The *if* coils are tuned for MAXIMUM marker signal amplitude output.

(B) Marker signal AFTER a trap tuned to the marker frequency. Traps are tuned for MINIMUM marker output.

Fig. 8-13. Modulated marker signal.

defective. The modulated marker produces a signal on the scope similar to that drawn in Fig. 8-13. Each if tuned circuit is tuned for maximum signal output while the traps are tuned for minimum signal level output at their respective frequencies. Test equipment manufacturers such as B&K-Precision (Dynascan) and Sencore have prepared excellent explanations of if circuits as well as how to use their alignment equipment for alignment and troubleshooting.

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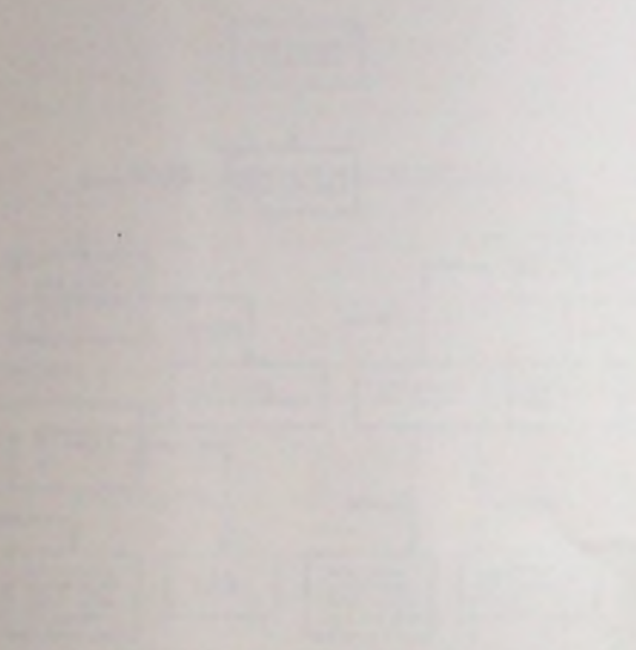

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Chapter 9

Video Circuits

There are three sections to the video handling circuits: the video detector, the video amplifiers, and the picture tube, sometimes called the cathode ray tube or crt.

VIDEO DETECTOR CIRCUITS

As it comes into the video detector, the composite video signal looks something like the drawing in Fig. 9-1. It is an am signal with a carrier frequency of 45.75 MHz. And, since it is an am signal it is symmetrical or identical above and below the zero amplitude line. Because of the mirror image signal with an average amplitude of zero, no picture would result if it were applied to the crt. Just as in am radio, one-half of this signal must be removed so the crt electron beam can be controlled. The diode was discussed in Chapter 3, where it was seen that it will conduct in only one direction. Thus, if we feed the composite video signal into a diode, one-half of the signal is not allowed to pass. This, in effect, cuts off either the positive-going or negative-going half of the signal, depending on which way the diode is placed in the circuit. A typical diode video detector circuit is shown in Fig. 9-2. Notice in this circuit that the top, or positive half, of the signal is blocked from passing into the video amplifiers. After further processing, the signal will have the correct polarity to control the electron beam when applied to the crt. The action of the picture tube will be explained in more detail later in this chapter.

The video detector is usually a germanium signal diode, but sometimes silicon is used—both in a glass envelope. It is normally found inside the last if amplifier transformer shield. The shield prevents harmonics produced by the detected video signal from being radiated and causing interference in the rf and if amplifiers. Sometimes the detector is a transistor which is biased off

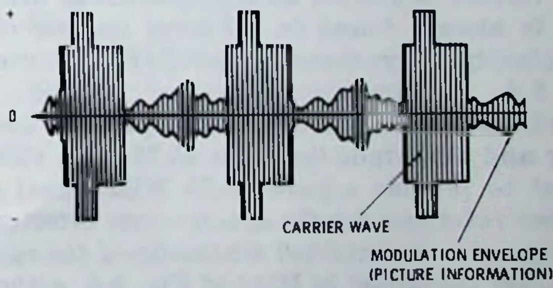
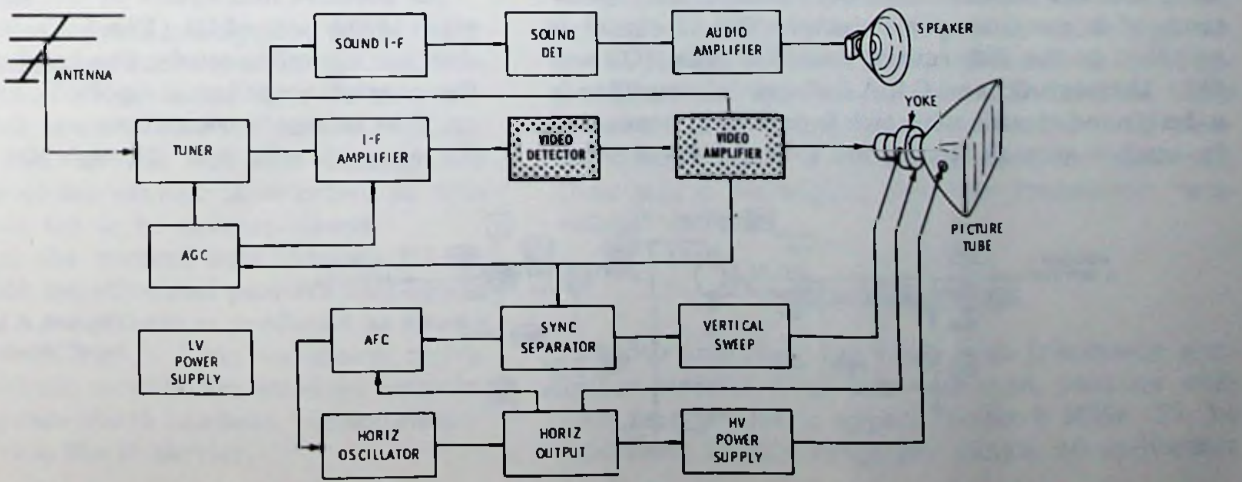


Fig. 9-1. Undetected if composite video signal.



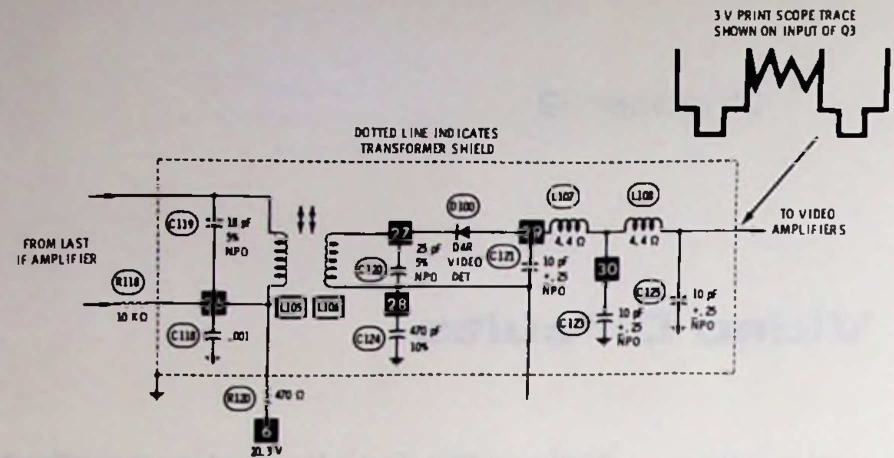


Fig. 9-2. A typical diode "envelope" video detector.

except upon the receipt of a signal, whereupon it turns on and conducts for one-half the signal. An example of a transistor detector is illustrated in Fig. 9-3. The base emitter junction serves as the detector diode junction and the rectified signal is amplified before departing the transistor. Another type of video detector will be found inside an IC when the if circuitry is integrated. Such a circuit is seen in Fig. 9-4. Detectors of the types just described are often referred to as envelope detectors.

Yet one other type of video detector may soon be in widespread use in monochrome television receivers. It is already used in many color sets. The circuit is known as a synchronous detector and is always found in IC form because of its complexity. A synchronous detector is pictured in Fig. 9-5.

In IC12, a carrier frequency amplifier is used to filter and amplitude-limit the 45.75 MHz video if signal to provide a pure 45.75 MHz signal as a carrier reference for the synchronous detector.

Fig. 9-6 is a simplified schematic of the carrier amplifier contained in IC12 of Fig. 9-5. Although this IC obviously cannot be repaired, the diagram will aid the reader in understanding the operation of a synchronous detector. The if signal is applied to the differential amplifier pair (Q2 and Q3) through Q1 and Q4. A differential amplifier is a balanced circuit with two inputs, and connected in such a way as to respond to the *difference* between the two input voltages, but effectively canceling *like* input voltages. The output load of this differential amplifier is a sharply tuned circuit consisting of L109 and C119, tuned to resonate to the 45.75 MHz picture carrier frequency. Diodes D1 and D2 act as clippers to limit the amplitude of the output signal. The output then is a nearly constant amplitude of 45.75 MHz signal. Note that two output signals are available. They are 180° out of phase, or of opposite polarity, being taken from opposite ends of the differential amplifier.

Fig. 9-7 shows the simplified schematic of the synchronous detector. Notice that it has three input signals. Two input signals are from the carrier reference amplifier just described, and the other is the if output signal.

Transistor Q7 is a constant current source. Transistors Q1 and Q2 form a differential amplifier, and Q3 through Q6 are if carrier frequency-operated switches. Note that the differential amplifier receives its input from the if amplifier, while the switches receive input signals from the carrier amplifier. Fig. 9-8 illustrates the input and output waveforms of the synchronous detector.

As positive half-cycles of the if signal are applied to the base of Q1 (Fig. 9-7), it increases conduction. Simultaneously, the in-phase input from the carrier amplifier is applied to Q3, turning it on. This causes increased current flow through R1. No current will flow through Q4 because it is

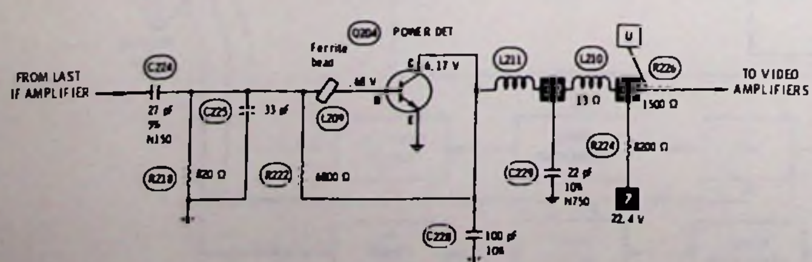


Fig. 9-3. A transistor "envelope" video detector circuit.

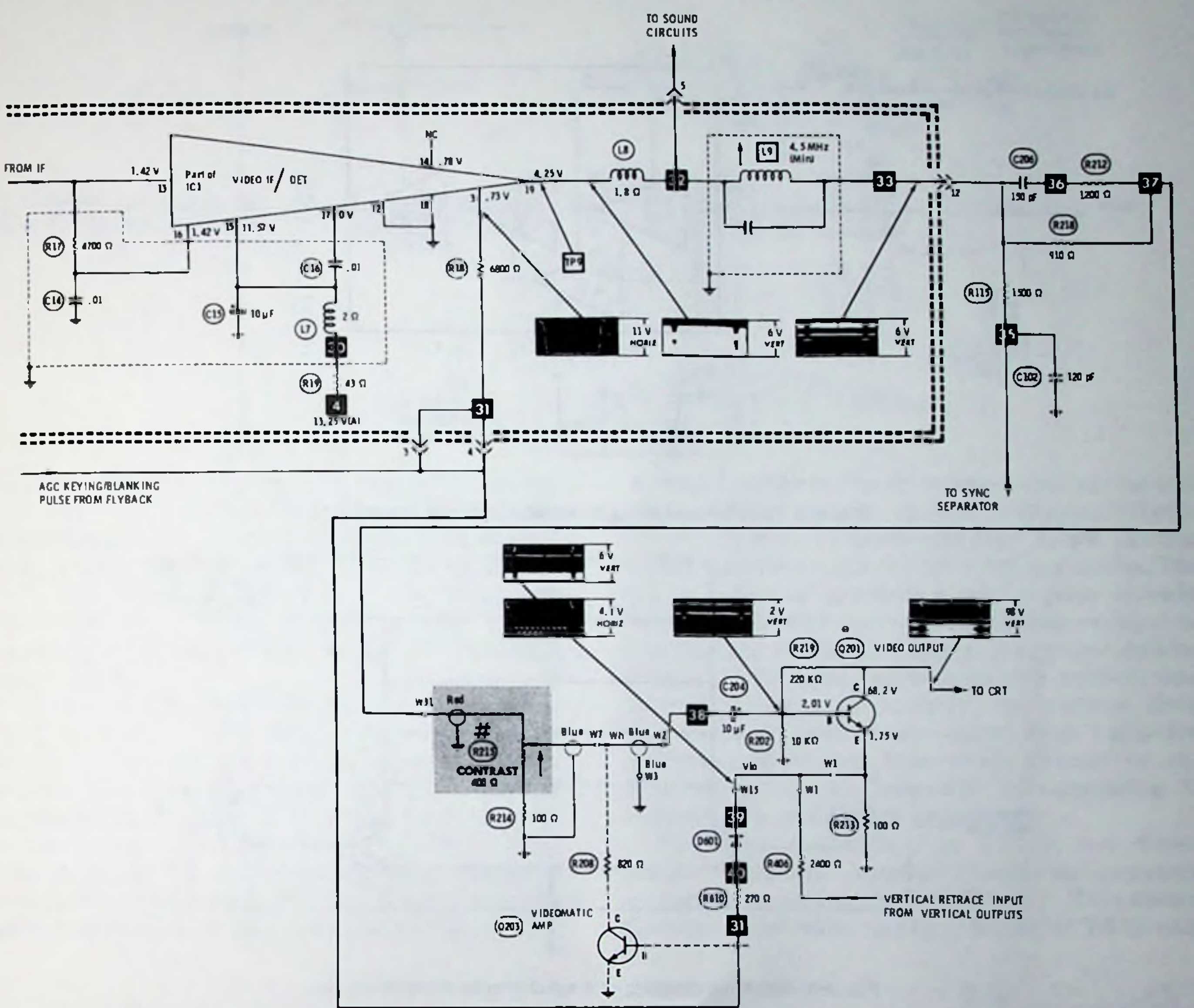


Fig. 9-4. Video detectors are often found in ICs.

switched off by the reverse-phase signal from the carrier amplifier.

When negative signals are applied to the base of Q1, it decreases conduction, causing Q2 to increase conduction. At the same time the reverse-phase carrier turns on Q4 and the current through R1 increases. No current will flow through Q3 because the in-phase carrier is negative at this time and causes Q3 to be reverse-biased.

As just seen, the current flow through R1 increased for *both* negative and positive half-cycles of the carrier. A waveform is produced as shown in Fig. 9-8, waveform D. This waveform represents the amplitude modulation envelope containing the intelligence which has been "demodulated" or extracted from the if carrier.

The synchronous detector is used because it provides an exceptionally linear detected video signal, and better immunity to noise pulses, which appear in the picture as snow. It also prevents false triggering of the sync circuits by interference. The receiver using a synchronous detector will perform much better in a high rf noise environment than will a set with a diode or transistor "envelope" detector.

VIDEO AMPLIFIERS

Video amplifiers are basic high frequency amplifier circuits. They are wideband, passing signals from 30 Hz to approximately 3 MHz. To be wideband in this frequency range, no inductive

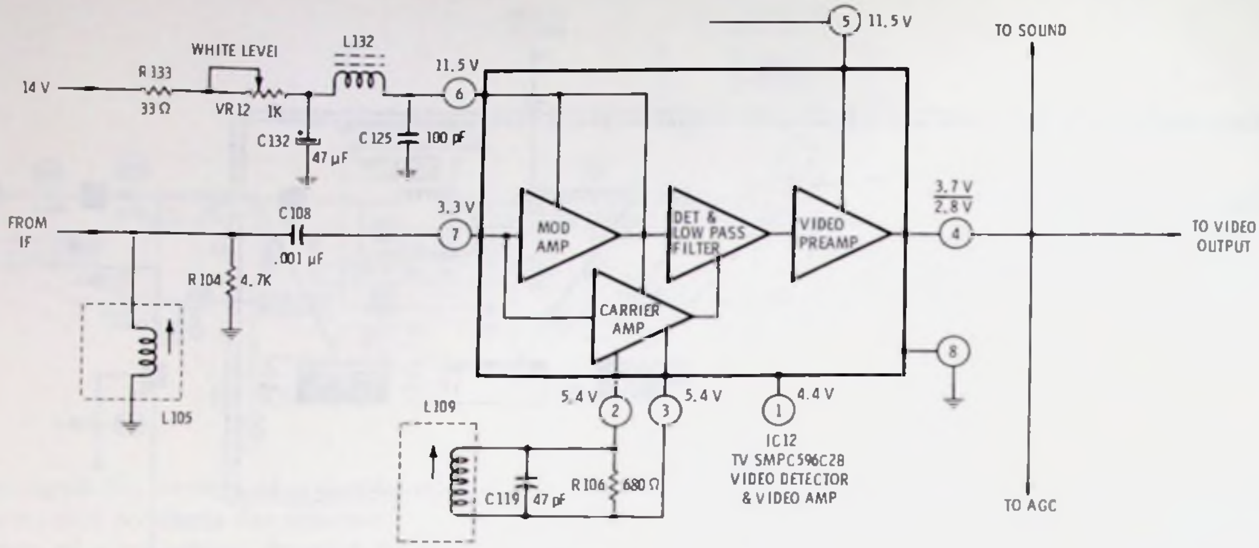


Fig. 9-5. Synchronous video detector. (*Courtesy Quasar Co.*)

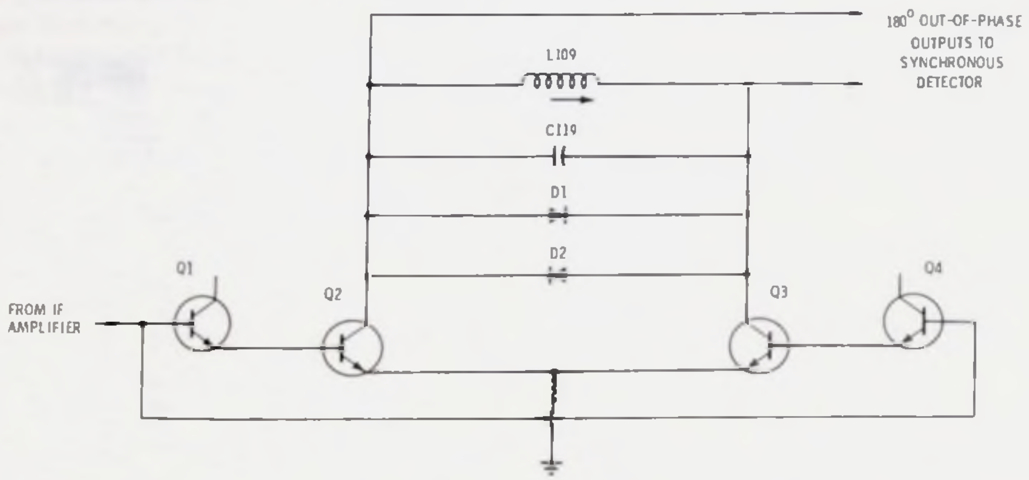


Fig. 9-6. Simplified diagram of a synchronous detector carrier.

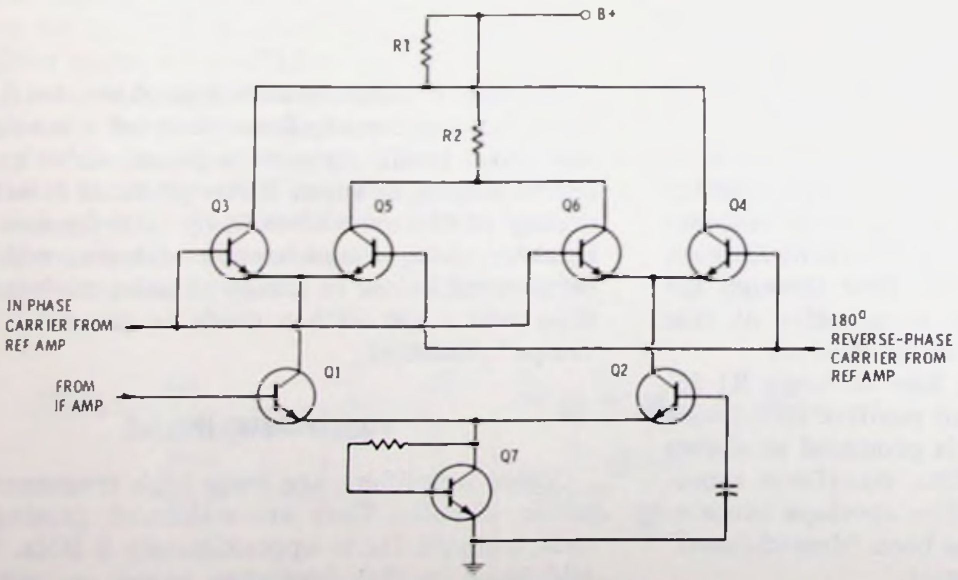


Fig. 9-7. Simplified diagram of the synchronous detector.

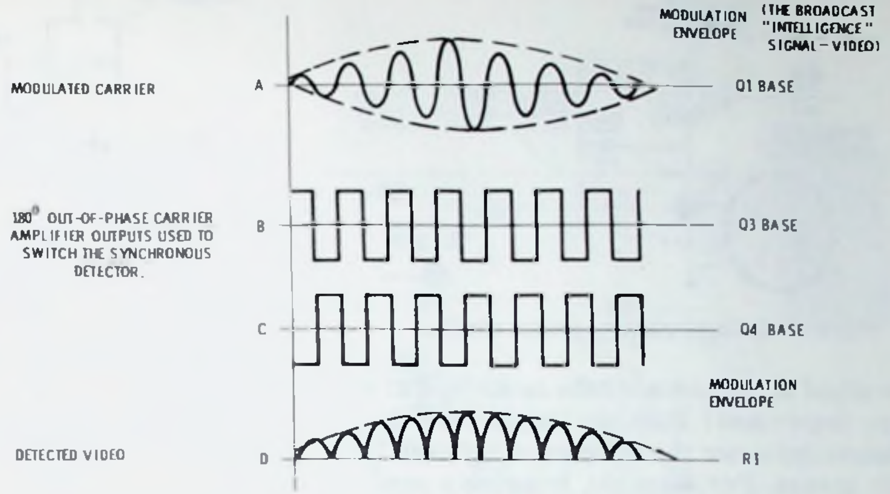


Fig. 9-8. Input and output signals of the synchronous detector.

coupling and little capacitive coupling can be used. The reactances of both inductors and capacitors change with applied signal frequency and would cause different amounts of amplification to result for different frequencies. Thus, video amplifiers are usually direct coupled. In Fig. 9-9 the hybrid IC-transistor video section is completely direct coupled.

Video is detected inside IC12 and coupled inside the IC to the first video amplification stage. From pin 4 of IC12, video is coupled via R141 and a peaking circuit consisting of L141 and R144 to the base of Q15. From Q15 to the crt, the signal is carried through D12, R145, and R603, with C146 shunting the signal around D12 and R145 to prevent signal degeneration. This allows the full signal level to be applied to the cathode of the crt, and yet allows the dc voltage level of the collector of Q15 to also be applied to the crt cathode. The action here is much like that of an emitter bypass capacitor (Fig. 9-10) in audio circuits. The bypass capacitor provides a low impedance path for the signal while causing the dc bias current to flow through the resistor to provide proper dc bias voltage. If the signal as well as bias current had to flow through the resistor, the voltage drop would change with every signal level variation and the emitter-base bias would change in the direction to cut the transistor *off*—resulting in lowered gain or signal degeneration.

The video circuit in Fig. 9-11 is not direct coupled. Note that capacitor C144 is not bypassed by resistance as was C146 in Fig. 9-9. This means that the dc potential on the collector of TR15 can-

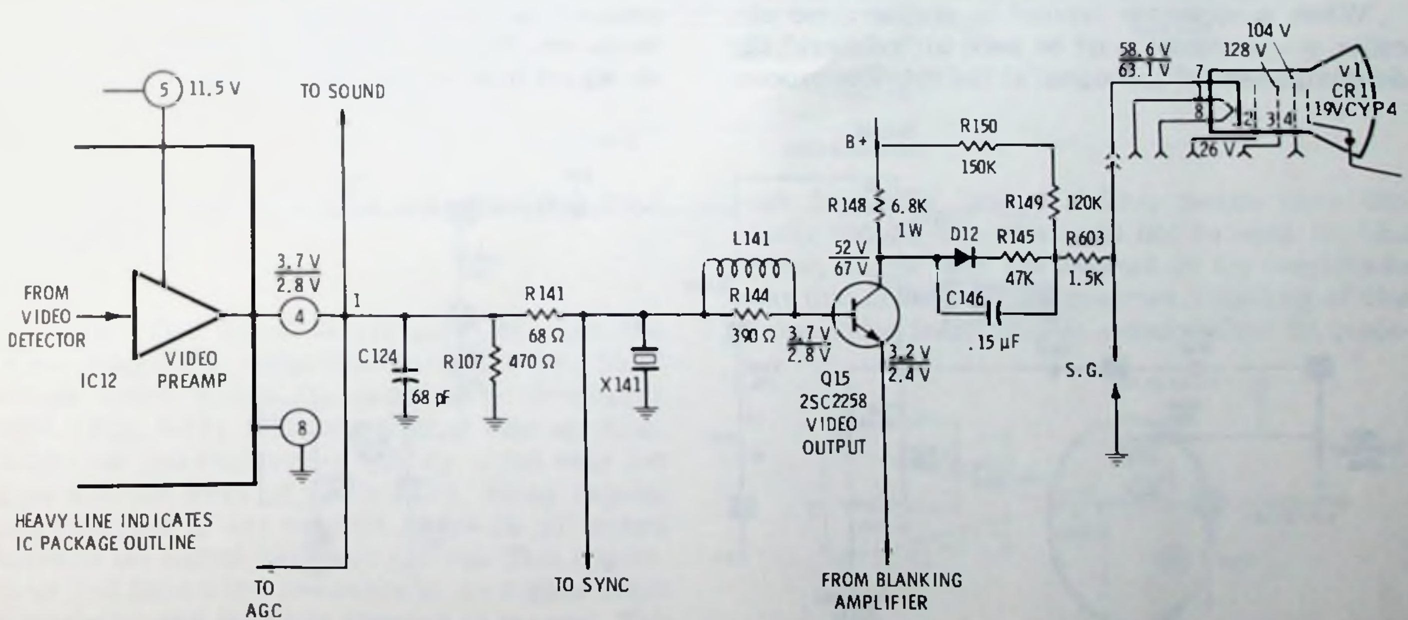


Fig. 9-9. A hybrid, direct coupled video system. (*Courtesy Quasar Co.*)

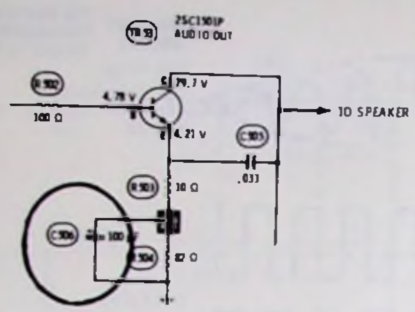
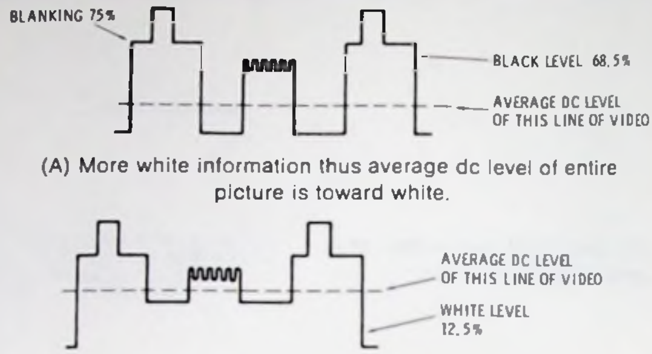


Fig. 9-10. Emitter bypass capacitor circuit.



(A) More white information thus average dc level of entire picture is toward white.

(B) Less white information and average dc level is closer to black.

Fig. 9-12. Signals have identical picture information but different brightness levels.

not be applied to the picture tube cathode. But why is this so important? Because the dc level in the video signal indicates the difference between light and dark scenes. For example, imagine a scene of a bright sunny day, then the same scene at night. The actual picture information may be identical but the level of picture brightness is different. Fig. 9-12 shows two signals of identical picture information but different brightness levels. By this figure it can be seen that the dc component of the signal determines the brightness level of the scene. By passing this brightness level dc component of the signal to the picture tube, the crt bias is changed and differing brightness levels result. But, this dc component of the signal cannot be passed from the video detector to the crt if there is no dc path. There will not be a dc path if a capacitor or transformer is used for signal coupling. For this reason, direct coupling is usually found in the video circuits.

DC Restoration

When a capacitor is used to couple video circuits, some means must be used to "reinsert" the dc component of the signal at the crt. The process of restoring the dc component to the crt circuit is called dc restoration. A diode circuit as seen in Fig. 9-13 is used to rectify the video signal and to produce a dc voltage proportional to the level of picture brightness. Other dc restoration circuits may include resistive voltage dividers as seen in Fig. 9-14. Here a particular percentage of the dc voltage level input divides across the resistors according to their values, while the ac or picture information is coupled to the crt through C132. In a series voltage divider such as this, the voltage drop across a resistor is directly proportional to the resistance. For example, if R137 and R139 are 20% of the resistance of the divider made of R137, R139, and R136, 20% of the applied voltage will appear across them at point K. Of course, with the capacitor having a low capacitive reactance at the video frequencies, very little signal is dropped across it and the complete video signal is applied to the crt. This dc potential, or a percentage of the dc signal level originating at the detector, is ap-

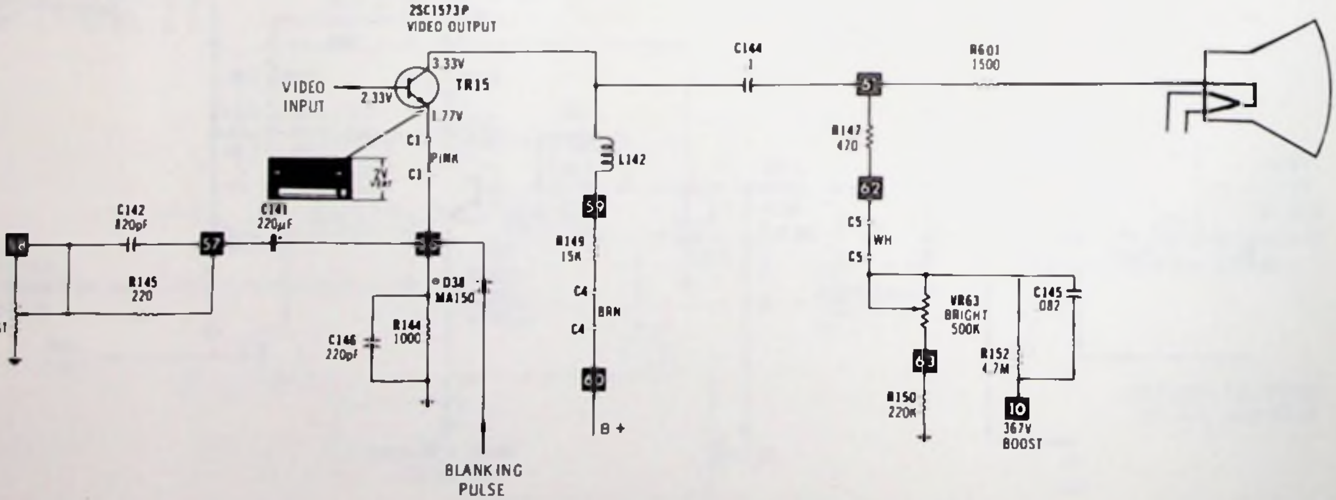


Fig. 9-11. An ac coupled video circuit. Unbypassed capacitor C144 causes the circuit not to be direct coupled.

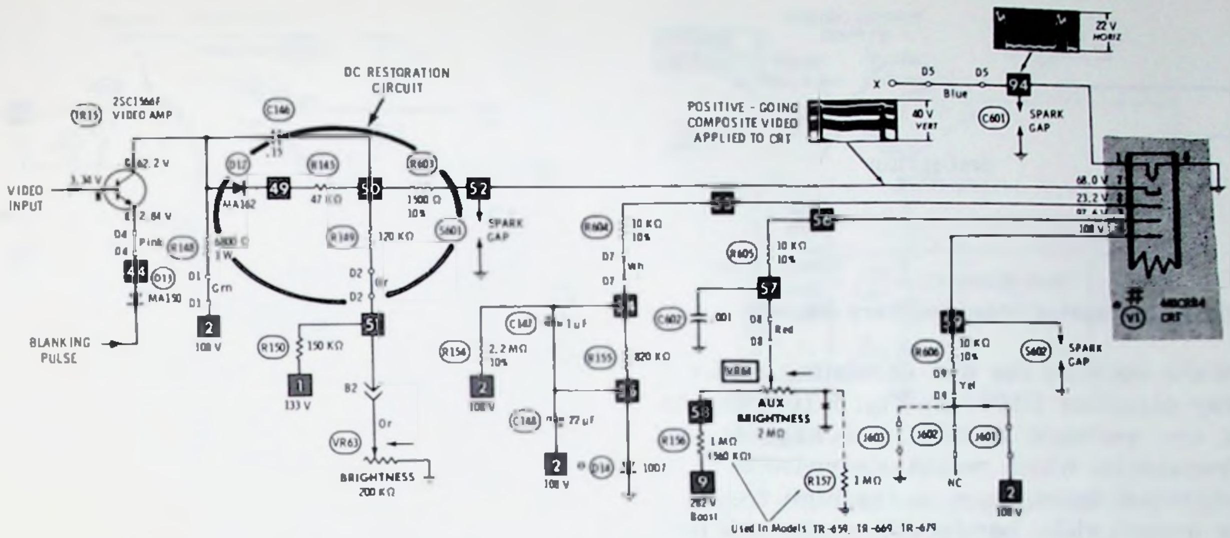


Fig. 9-13. Diode dc restoration circuit.

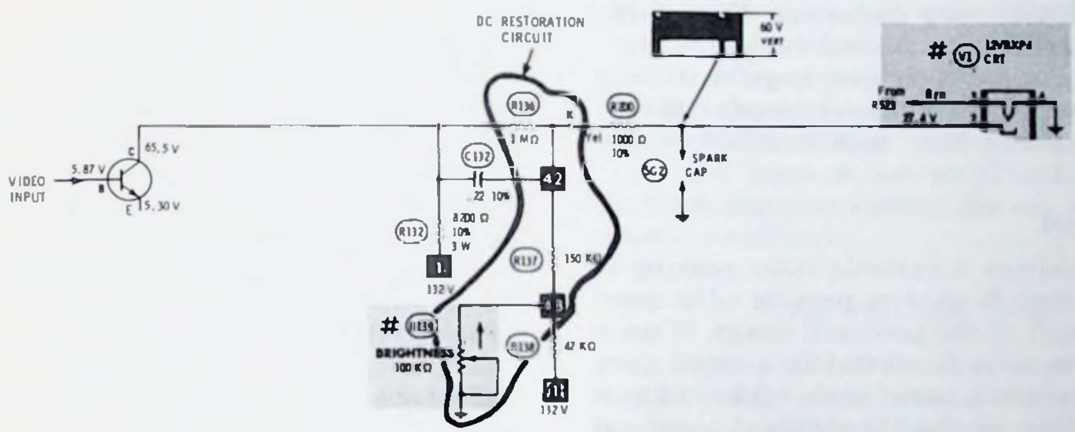


Fig. 9-14. Voltage divider dc restoration circuit.

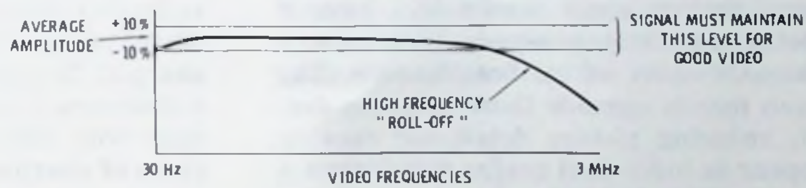


Fig. 9-15. Video amplification curve showing frequency response.

plied or "restored" to the crt for brightness level tracking.

Peaking

As the video signal is processed through the video amplifiers, amplification must be "flat" within ±10% across the entire video frequency band (Fig. 9-15) for good picture reproduction. Achieving this measure of quality is not easy for such a broad band of frequencies. Stray capacitance usually in the amount of 10–15 pF exists between the signal path and ground. This capacitance will have a low reactance to the higher video frequencies and they are shunted to ground. The result is a response as seen in Fig. 9-15. Note the high frequency "roll-off." This means that the higher video frequencies will not be seen on the screen, unless they are boosted to an amplitude near that of the lower frequencies. Boosting of the higher video frequencies is accomplished by peak-

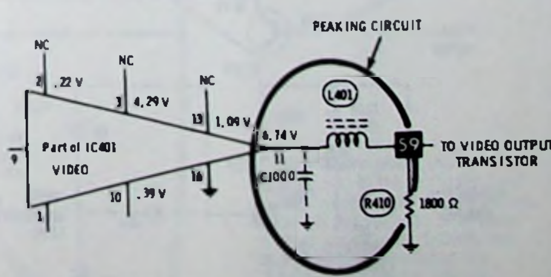


Fig. 9-16. A series video peaking circuit.

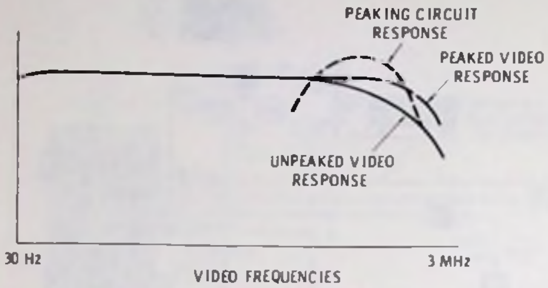


Fig. 9-17. "Boosted" video frequency response.

ing circuits such as the one consisting of L401 and stray capacitor C1000 in Fig. 9-16. Peaking circuits are resonant circuits, resonant at the video frequencies which would otherwise be lost. With additional boost given to the high frequencies, the overall video bandwidth might look like that shown in Fig. 9-17.

Peaking circuits may be series (Fig. 9-16), parallel (Fig. 9-18), or a combination of series and parallel (Fig. 9-19). In each case the inductor is resonant with the stray capacitance of the circuit as indicated in Figs. 9-16 and 9-18 by dotted lines.

Peaking Control

In some receivers a variable video peaking or sharpness control is used to provide adjustment to the "softness" of the produced image. When a large screen receiver is viewed in a small room the picture appears to have "grain." Since all televisions operating on the US standard broadcast system have the same number of scan lines, it is only natural that a small screen will have a sharper picture than a large screen. Both screens have the same number of picture elements. The larger screen merely spreads these elements farther apart, reducing picture detail and causing them to appear as individual grains rather than a

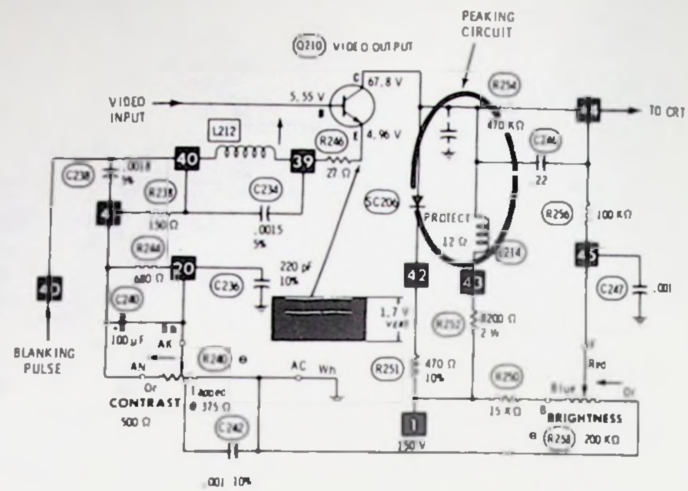


Fig. 9-18. A parallel video peaking circuit.

picture whose elements blend together. When the higher frequencies are lost, the grainy appearance of the picture is lessened and the picture appears softer. Also, if the picture has a noticeable amount of snow, snow being high frequency random noise, the video peaking control can cause it to be less objectionable.

The peaking control operates like the tone control on less expensive radios and phonographs. A variable resistor is placed in series with a capacitor as seen in Fig. 9-20. The capacitive reactance of the capacitor is such that the higher video frequencies are allowed to pass to ground if the resistance is set to a low value. Naturally, as the resistance is increased, less of the high video frequencies are passed to ground, and the picture is sharper. The peaking control is sometimes called a sharpness control and may be a switch arrangement with different capacitances for different degrees of sharpness of picture as seen in Fig. 9-21.

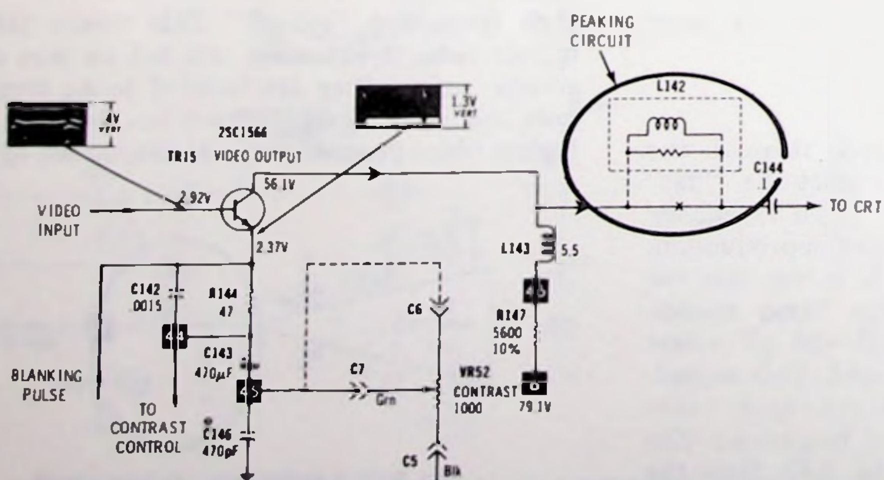


Fig. 9-19. A combination video peaking circuit.

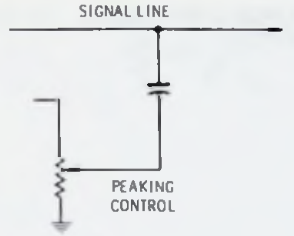


Fig. 9-20. A variable high frequency attenuator.

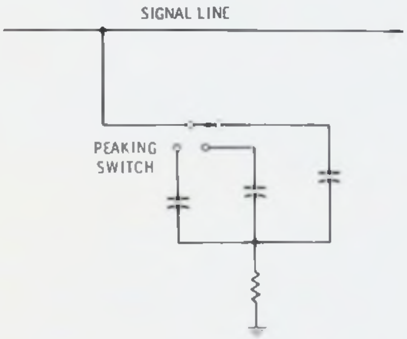


Fig. 9-21. A switched high frequency attenuator.

Contrast Control

Another control found in the video circuits is for contrast adjustment. Its purpose is to vary the amount of video signal that will be applied to the picture tube. It either controls the gain of one of the video amplifiers or operates like a radio volume control to vary the amount of signal applied to the video amplifiers. Fig. 9-22 illustrates a common type of contrast control. The control, VR52, varies the resistance to ground for signal passage but is isolated from the emitter of TR15 by C143. Because of this isolation, the dc bias of TR15 is changed little by varying VR52. But varying the resistance of VR52 does provide ac or signal degeneration. As was discussed earlier, concerning the emitter bypass capacitor, this ac path provides a low impedance circuit for signal currents. By increasing the impedance to the signal, degeneration occurs and there is less amplification by TR15, less video signal to control the crt, and thus less picture or contrast.

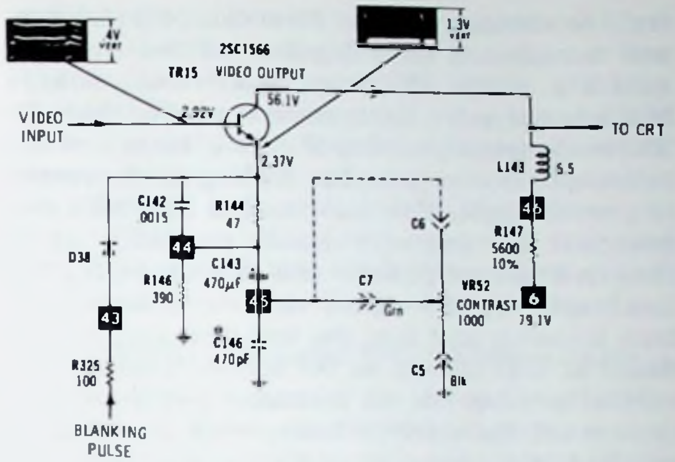
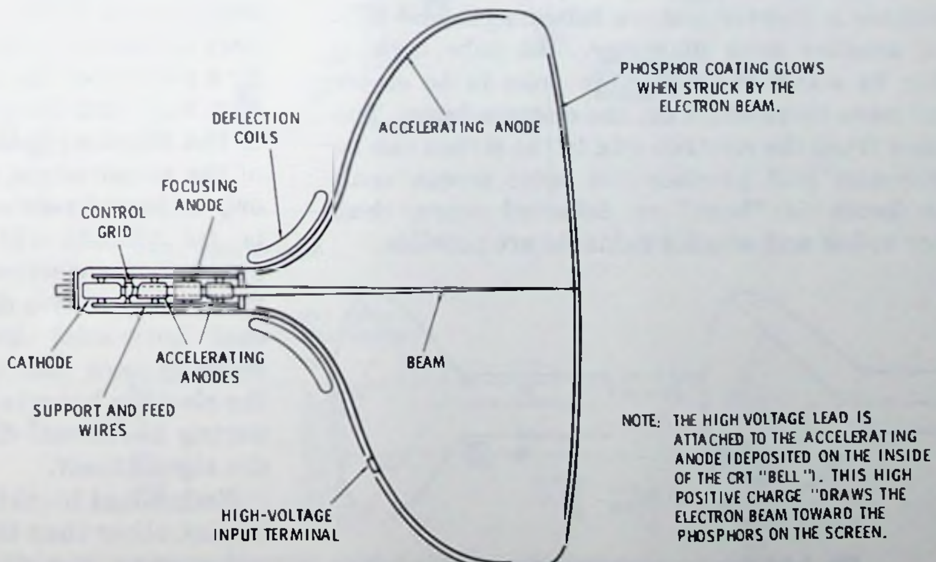


Fig. 9-22. Contrast control.

THE PICTURE TUBE

An explanation of the way in which the crt works will help explain how more video produces more contrast. The crt operates on the same principle as any other vacuum tube. It has a filament (heater) which heats when current flows through it, a cathode charged negatively to give off electrons when heated by the filament, grids to con-

Fig. 9-23. The monochrome picture tube.



trol the electron flow and form them into a beam, and a means of collecting the emitted electrons (see Fig. 9-23). The more negative the cathode is made the more electrons are emitted from it. These electrons are shaped into a beam and accelerated into the phosphor coating on the screen to produce light. Now look back at Fig. 9-13, and note that the composite video is positive going at the crt. The more positive (the same as saying the less negative) the signal, the less cathode electron emission and thus the less light that is produced at that instant on the screen. Since the crt control process has an incoming positive signal to turn off the electron beam, when *no* signal is received, the screen is at its whitest. Likewise, the screen can never get darker than when the crt is cut off. These two conditions (lack of signal and lack of power) represent white and black. If more video information is applied to the cathode, it becomes more positive and in some cases the beam is cut completely off to reproduce a dark image. The blanking pedestal is also used for this purpose as explained elsewhere in this text. With less video signal the beam will not be cut completely off and the resulting picture is lighter. Any signal level between the two extremes will produce a gray picture.

Various types of crt's are used in black and white receivers. Tubes are typed according to their size, measured diagonally from corner to corner, and by deflection angle. The number on most American made tubes indicates the size and type of phosphor. For example, a 12VAMP4 is a 12-inch tube with the common white P4 phosphor. Deflection angle is concerned with the angle the electron beam must be deflected by the yoke as seen in Fig. 9-24. With a higher angle of deflection also comes a shorter picture tube length and usually a smaller neck diameter. The tube neck is smaller to allow the deflection yoke to be closer to, and have more effect on, the electron beam. The distance from the electron gun to the screen can be shorter and still produce the same screen scan if the beam is "bent" or deflected more, thus shorter tubes and smaller cabinets are possible.

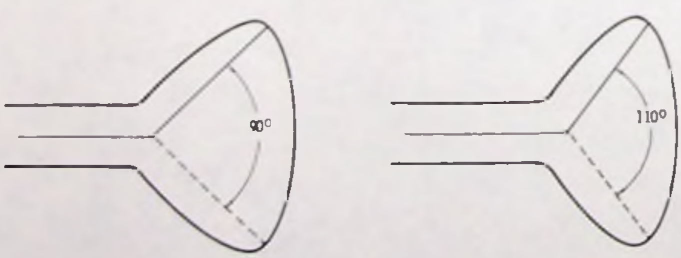


Fig. 9-24. Two crt deflection angles.

Brightness Control

The brightness control may either be used to cause the crt cathode to be more negative (for more brightness) or less negative (for less brightness). Or, it can be connected to the picture tube control grid where a more negative potential causes less brightness and less negative potential allows more electron beam current and thus more brightness. This action is a result of like charges repelling each other. If the grid is more negative, a greater repelling force is presented to the stream of electrons in the beam. Likewise, if it is less negative, less repelling force will be present and more beam current will be conducted to the crt face.

Blanking

The picture must be blanked out during horizontal flyback time and vertical retrace time. If the electron beam is not turned off during these times, bright white lines will appear superimposed over the picture as seen in Fig. 9-25. Blanking was

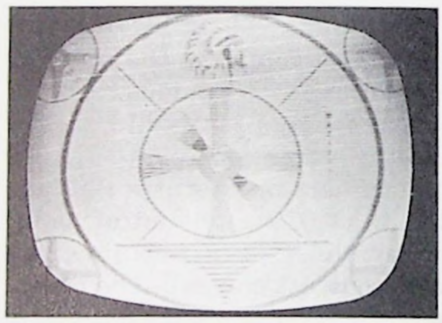


Fig. 9-25. Retrace lines.

discussed earlier in this text so a more thorough explanation of the idea of blanking is not necessary at this time. Blanking is accomplished in part by a portion of the composite video signal. Note in Fig. 9-26 that the most positive part of the signal is the blanking pulse (and sync pulse). At 75% of the amplitude of the blanking pulse, for a properly adjusted receiver, the crt will be cut off. That is, its cathode will be made positive enough to shut off the electron beam. And, as can be seen from our previous discussions, this occurs between each horizontal line of picture information and between each field of vertical information. Thus, the electron beam is cut off and the picture blanked during horizontal flyback and vertical retrace by the signal itself.

Redundant blanking is carried out by additional means, other than the blanking pedestal. Blanking pulses may be obtained from the horizontal and

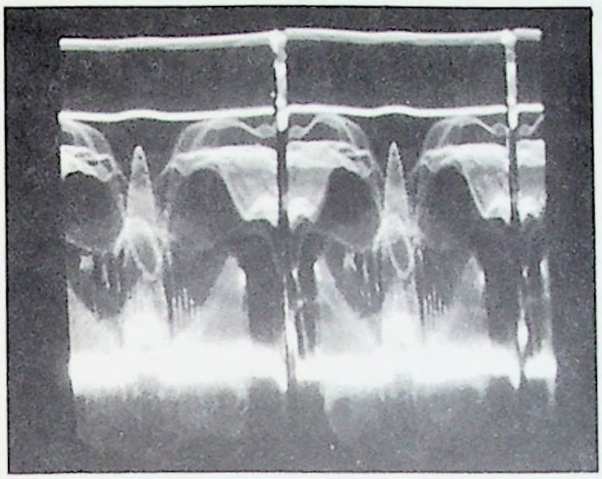


Fig. 9-26. Composite video signal.

vertical output circuits and applied to the crt control grid as shown in Fig. 9-27. Or, a blanking pulse may be linked to the video amplifiers in such a way as to cause the video output to cut off as the flyback pulse is produced in the horizontal output, or a vertical retrace pulse is created in the vertical output circuit. An example of this circuit is seen in Fig. 9-28. In most cases horizontal blanking is accomplished by linking the horizontal output transformer to the crt control grid and vertical blanking is performed by applying the vertical pulse to a video amplifier. In Fig. 9-29 vertical pulses from the vertical output, and horizontal pulses from the flyback transformer are both applied to the base of TR38, the blanking amplifier. These positive-going pulses cause TR38 to conduct and its emitter becomes more positive, reverse biasing D13. All video output current flows through D13, since it is in the emitter circuit of TR15, and if it is reverse-biased the video amplifier is cut off. The video is then blanked each time a horizontal or vertical pulse is produced.

Other Circuits Associated With the Video Chain

Other support circuits are often found in the video chain. These may include blanking amplifiers, brightness limiters, and trap circuits. Traps of some type are found in all video systems but brightness limiters and blanking amplifiers are not.

Traps

We discussed traps earlier in Chapter 8. They are resonant circuits used to pass an unwanted frequency to ground or block it from entering into circuits where it would interfere with other signals. Such is the case in the video-handling amplifiers. If sound if signals are allowed to beat with video signals an interference pattern like the one in Fig. 9-30 is produced. So sound if frequencies at 4.5 MHz must be blocked from enter-

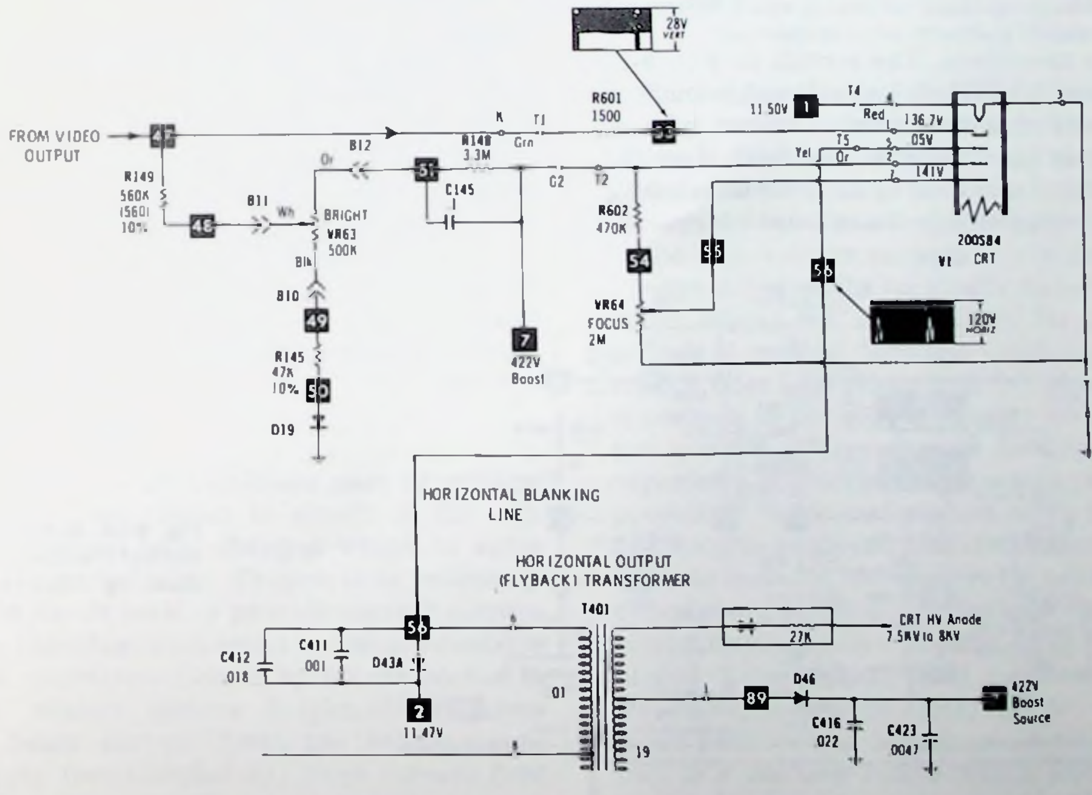


Fig. 9-27. Horizontal blanking applied directly to the crt.

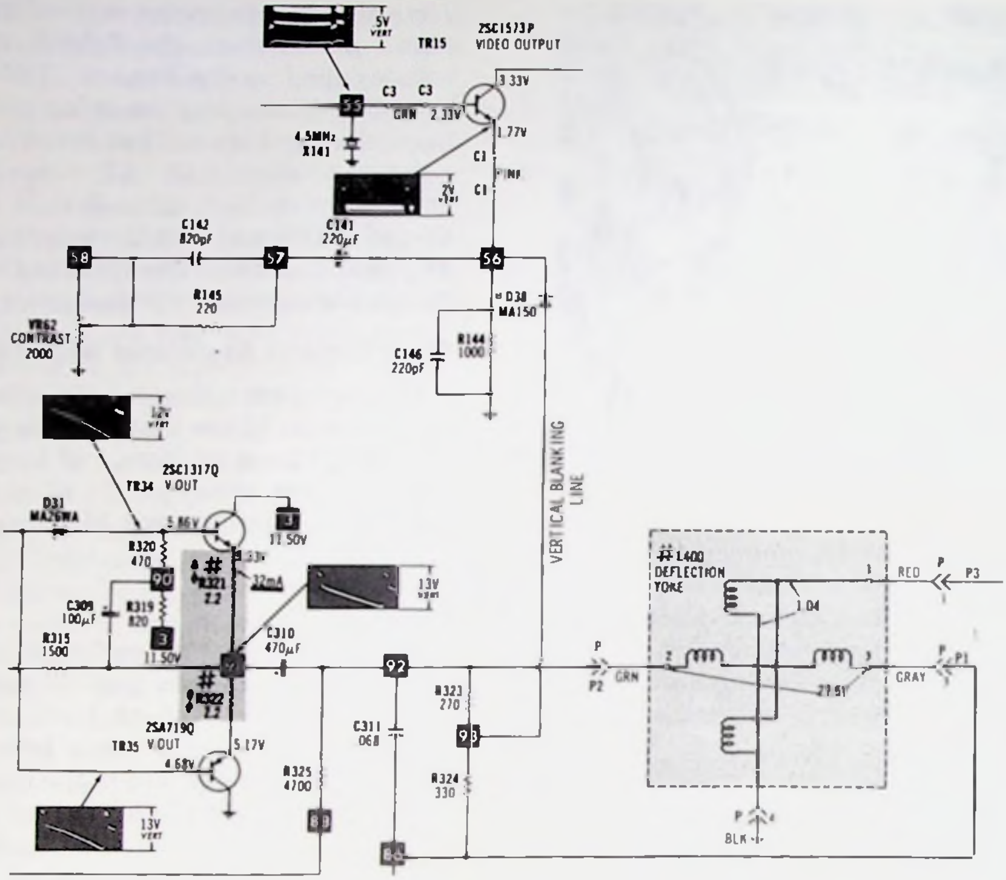


Fig. 9-28. Vertical blanking is accomplished here by applying the vertical retrace pulse to a video amplifier. Horizontal blanking is applied to the crt as in Fig. 9-27.

ing the video amplifiers. The circuit in Fig. 9-31 shows a typical 4.5 MHz trap as found in modern solid-state television receivers. Another type of 4.5 MHz trap is illustrated in Fig. 9-32. Here the trap makes use of a crystal or ceramic filter which exhibits low impedance to its resonant frequency of 4.5 MHz. Crystal X141A works in conjunction with the parallel resonant circuit of L141 and C140. The parallel resonant circuit is a high impedance path keeping 4.5 MHz sound if signals from the video amplifiers while X141A provides a low impedance path to ground for any sound if

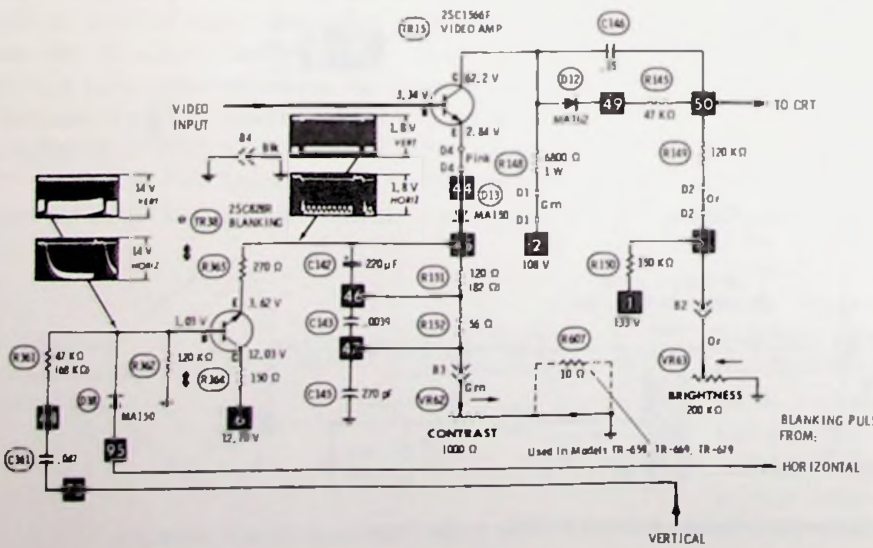


Fig. 9-29. Both horizontal and vertical blanking pulses are utilized by TR38 for blanking.

Fig. 9-30. When sound if signals beat with video signals a beat pattern such as this appears on the screen.

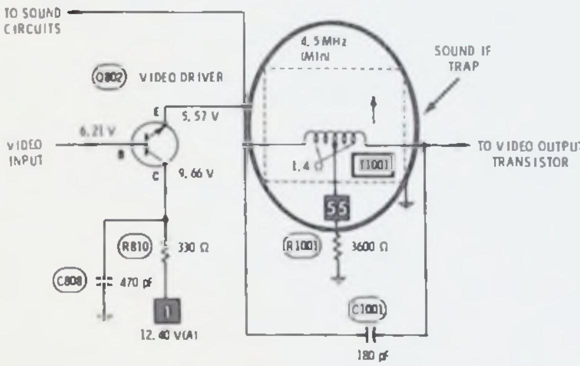


Fig. 9-31. Sound if frequencies are trapped out of the video circuit by trap circuits such as this.

signals reaching CircuiTrace 42. In many cases only the crystal filter is used as seen in Fig. 9-33. This reduces the need for a resonant circuit of capacitance and inductance and in most cases is adequate for good sound if trapping.

Naturally, a crystal filter is not tunable. Older resonant circuit-type filters were almost always adjustable and were tuned for minimum sound-picture interference.

Brightness Limiters

Direct-coupled video amplifiers pass dc voltage level changes from circuit to circuit to the crt, causing brightness level changes which in some cases may be undesirable. Though it is necessary to maintain the dc level to provide correct picture brightness tracking from scene to scene, *excessive* brightness sometimes caused by bright scenes is unwanted. Higher picture brightness requires more crt beam current from the high voltage power supply (see Chapter 5). More current flow in the high voltage circuits consequently means a

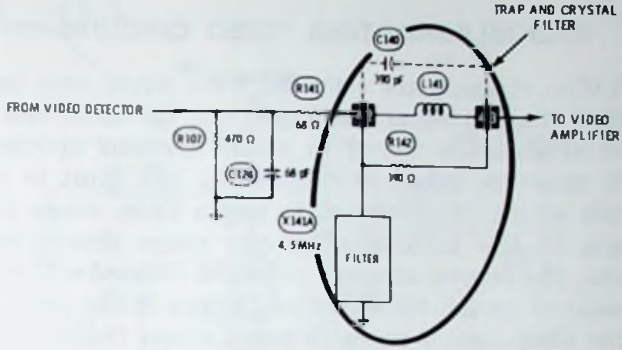


Fig. 9-32. Sound trap with crystal filter.

greater voltage drop is produced there, leaving less high voltage available for the crt. In a severe case of over-brightness the lowered high voltage can cause out-of-focus conditions and "blooming."

In sets with unregulated power supplies, changes in the ac source voltage cause dc supply output variations. These variations in turn cause brightness level changes to occur.

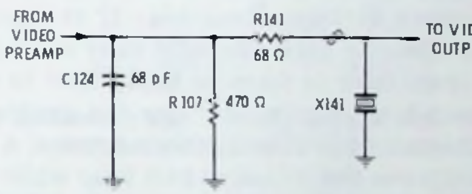


Fig. 9-33. A crystal filter for trapping sound if signals from the video circuits. (*Courtesy Quasar Co.*)

The brightness limiter circuit provides a solution for both the above problems. It senses the crt beam current and automatically holds it within predetermined limits. Transistor Q503 in Fig. 9-34 receives base bias from the ground return side of the high voltage secondary winding of TX502. Though noted on the schematic as being connected to B+ supply No. 1, the 15,734 Hz pulses are returned to ground through C523 and the power supply filter capacitor, both of which offer little opposition to the high frequency horizontal pulse, and a small voltage drop is developed across the capacitors. However, when excessive current is present in the transformer a more negative voltage drop is produced at CircuiTrace 105 causing Q503 to increase conduction. Its collector then becomes more positive and the emitter of Q801 becomes more positive causing Q801 to be reverse biased. Video output, Q801, decreases conduction, its collector voltage rises, the crt cathode goes more positive and brightness is reduced. The result is a limiting action which maintains a controlled brightness level and crt beam current.

TROUBLESHOOTING VIDEO CIRCUITS

Video circuits are serviced with equal ease by signal tracing or signal injection. In direct-coupled circuits as found in video systems special care must be taken in diagnosing the fault to a single stage. With direct dc paths from stage to stage, if the transistor in one stage shorts or opens, the improper stage voltages created will be measured on the following amplifiers in the chain. If the diagnosis is made in haste either transistor may be judged defective because of the incorrect voltages about it. A simple in-circuit method used to determine if a transistor is defective is often useful. Example: If a transistor's emitter-collector voltage is low (somewhat less than half of the supply voltage) the transistor is either shorted or being held in saturation by incorrect forward bias. To determine which, monitor the emitter-collector voltage and short the emitter and base together. If the transistor is good this should turn it off causing the emitter-collector voltage to rise to near source voltage. Example: If the emitter-collector voltage is high (usually near source voltage) the transistor is open or being held in cutoff by incorrect bias. Again, monitor the emitter-collector voltage, but in this instance connect a 100K resistor between the collector and base while monitoring the voltage. If the transistor is good it will be turned on and the emitter-collector voltage will drop to a lower value. *Do not short the collector to the base*—to do so may destroy the transistor.

With many new monochrome receivers the video amplifiers are emitter followers and no voltage gain or signal polarity inversion occurs in the individual emitter follower amplifier. It is important, when signal tracing with the oscilloscope, not to expect voltage gain or signal polarity inversion in such amplifier circuits. To do so will lead one to assume a fault when none exists.

One other troubleshooting consideration should be to analyze the various controls and control circuits associated with the video amplifiers. For example if the blanking transistor in Fig. 9-35 were to develop an emitter-collector short, its emitter voltage would be felt on the collector, and further, on the emitter of Q803 cutting it off. The result would be no video—a classical video problem, but the defect is not in the video amplifiers. It is usually best to test these associated circuits first by measuring their voltages and input and output waveforms, making sure the circuit is operating properly before doing more extensive troubleshooting.

The following troubleshooting charts are helpful in servicing the more common video problems. Video circuit fault symptoms include:

1. No video—good raster
2. Weak video
3. Excessive contrast

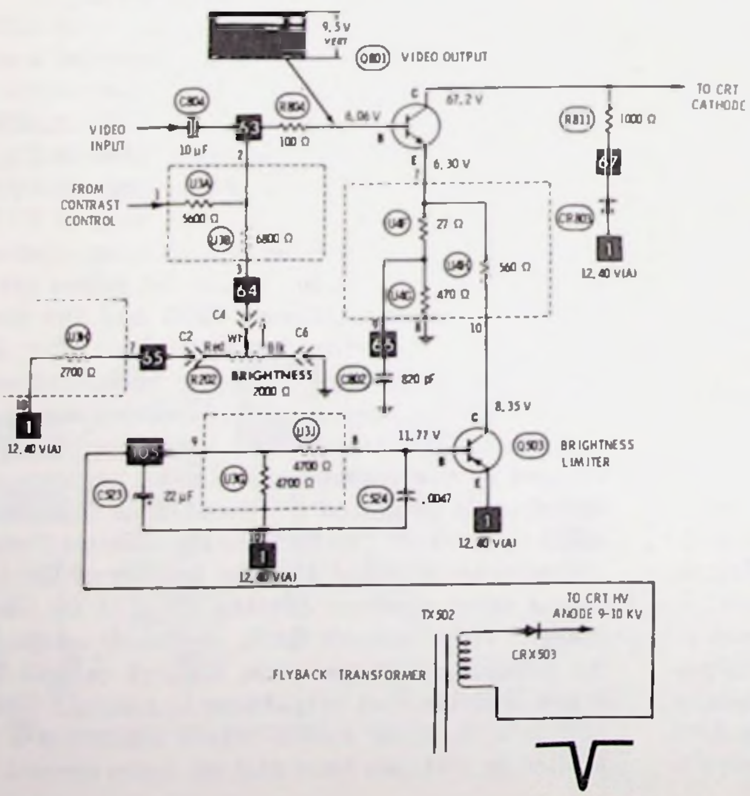


Fig. 9-34. Brightness limiter circuit.

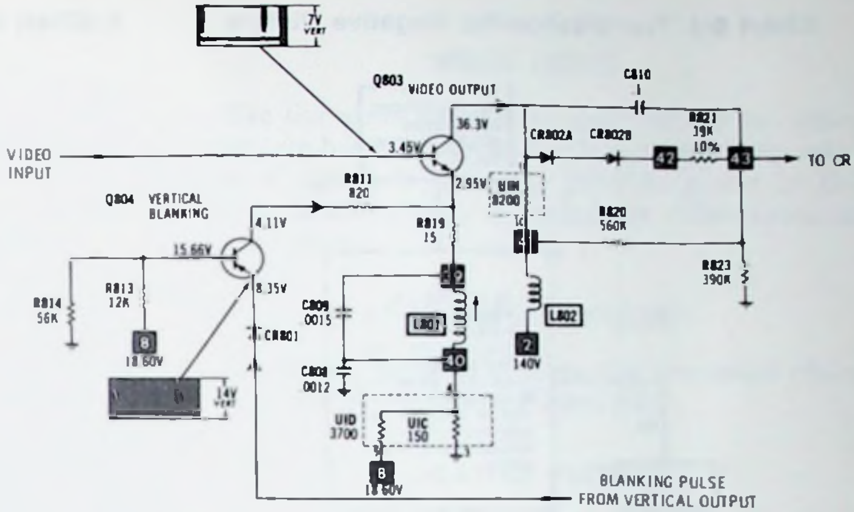


Fig. 9-35. Blanking circuit.

Chart 9-1. Troubleshooting IF and AGC Problems

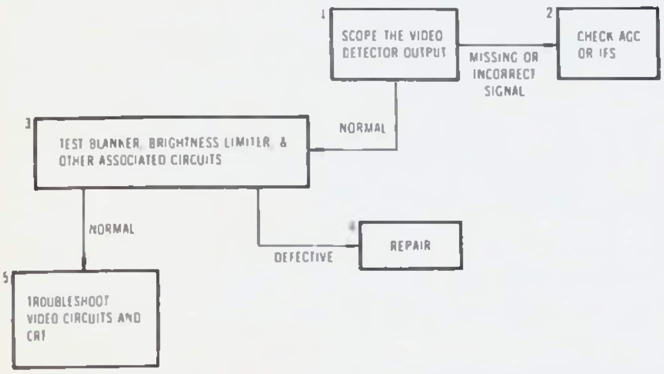
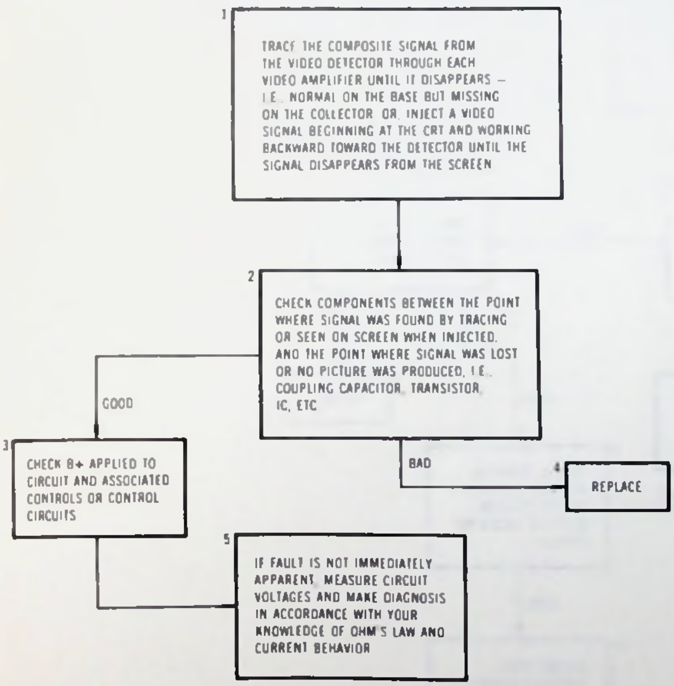


Chart 9-2. No Video—Good Raster



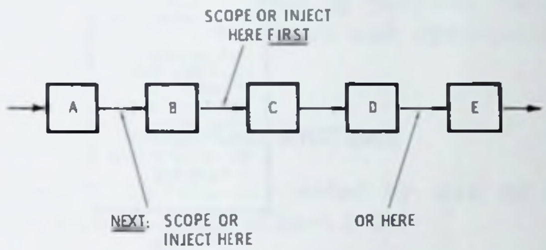
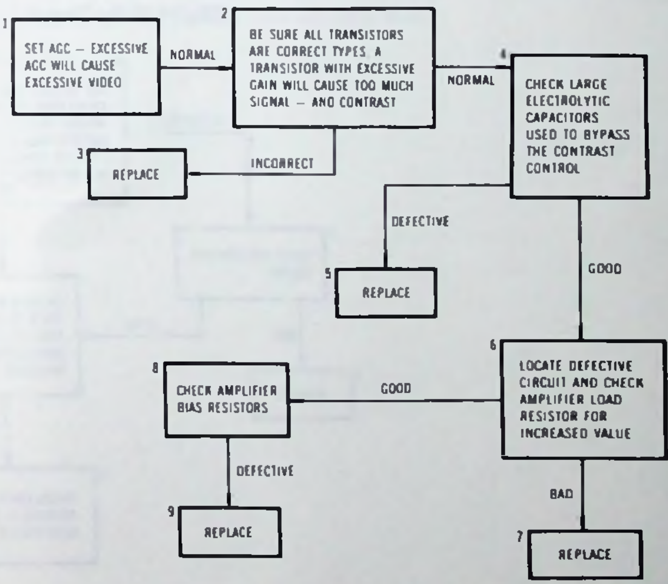


Fig. 9-36. Effective signal tracing or signal injection makes use of the "divide-and-conquer" method.

Chart 9-3. Troubleshooting Excessive Contrast



4. Negative picture
5. Smeared picture
6. Retrace lines

Tests to limit the problem to the video circuits should be preliminary to any video circuit trou-

Chart 9-4. Troubleshooting Negative Picture

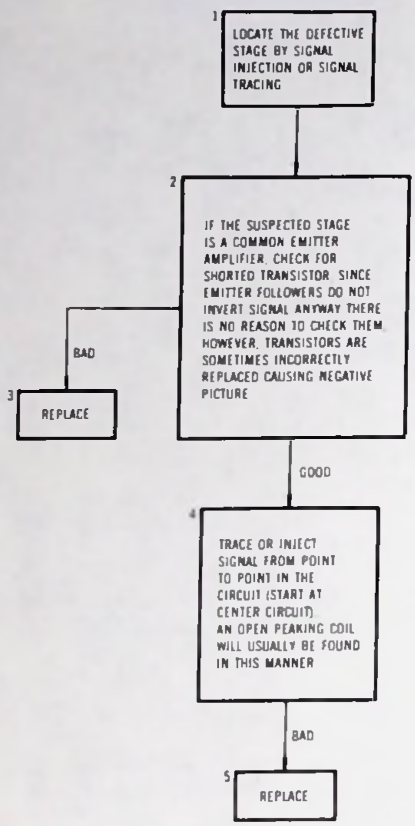
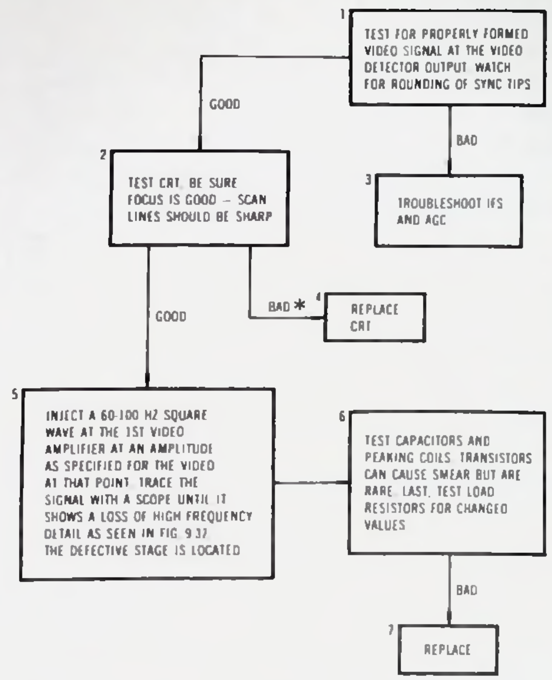


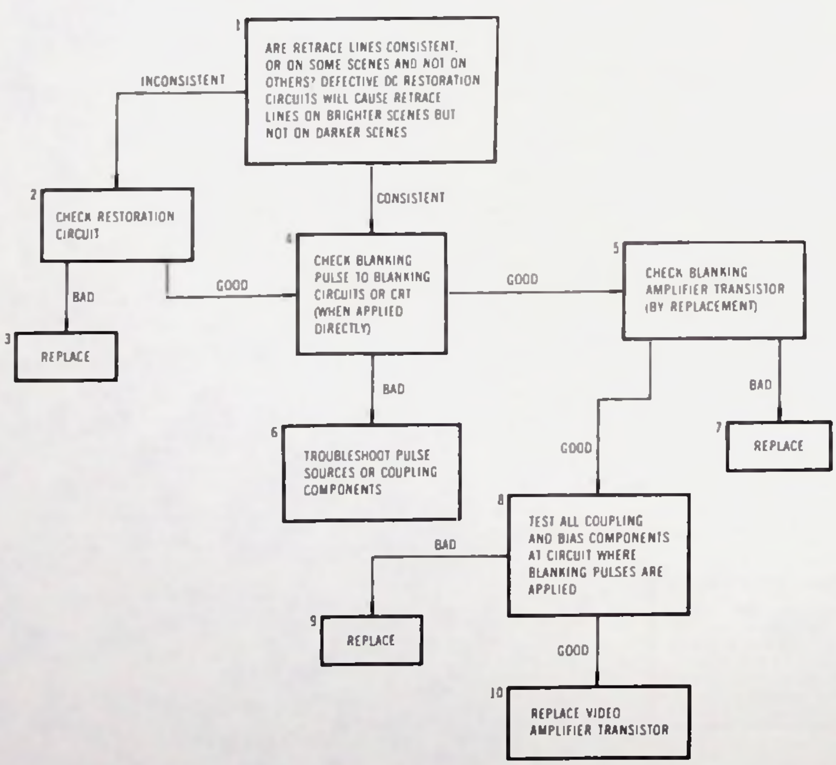
Chart 9-5. Troubleshooting Smeared Picture



* A CRT BAD ENOUGH TO CAUSE PICTURE SMEAR WILL ALSO CAUSE PICTURE HIGHLIGHTS (SUCH AS AROUND NOSE AND CHEEKBONES, ON THE FACE) TO APPEAR CHAULKY IN APPEARANCE. CONTRAST WILL ALSO BE WEAK.

bleshooting. Sometimes if or agc problems can cause similar symptoms and must be eliminated as

Chart 9-6. Troubleshooting Retrace Lines



possible causes of the symptom (Charts 9-1 and 9-2).

Video circuit troubleshooting presents an opportunity for the technician to perform signal injection and signal tracing techniques. Efficient use of either technique will allow the technician to rapidly determine the cause of circuit failure. Efficient use dictates that the least time and effort be put into the performing of these tests. To save time and effort inject or trace the signal at the center of the circuitry in question. In Fig. 9-36 the center circuit is in block C. Note that if the signal is scoped or injected here half the circuit will be eliminated as being at fault. For example, when signal injecting, if circuits in blocks C, D, and E are operating, a picture will be seen on the screen indicating that the fault must be in the circuits in blocks A or B. Now, if the last half of the suspected circuitry is proved to be operating normally you would next trace or inject at the center of the remaining circuits and so on until the specifically defective circuit is located.

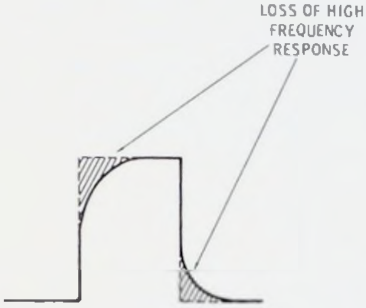


Fig. 9-37. A square wave signal can be used to indicate loss of high frequency response in the video amplifiers.

WEAK VIDEO

Use the same method as used for the *no video* symptom but look for partial loss rather than total loss of signal. Be sure the problem is not in the agc or if circuits by checking the video detector output signal.

EXCESSIVE CONTRAST

Excessive contrast is caused by too much video signal reaching the crt (Chart 9-3).

NEGATIVE PICTURE

The negative picture symptom is caused by signal inversion often created by shorted common emitter connected transistors and open peaking coils (Chart 9-4).

SMEARED PICTURE

A smeared picture is created by lack of high frequency video detail (Chart 9-5).

RETRACE LINES

Common defects that cause visible retrace lines are open coupling circuits, defective transistor, and defective ICs (see Chart 9-6).

Chapter 10

AGC Circuits

The fundamentals of agc circuit action are simple. Referring to the block diagram in Fig. 10-1, a sample of the incoming signal is taken from the video amplifiers, changed into a dc voltage representative of the signal level, and applied to the if and rf amplifiers for the purpose of controlling their gain. When the received signal is strong the gain of the if and rf amplifiers is turned down. The opposite occurs when the received signal is weak. The result is a picture signal of relatively constant strength.

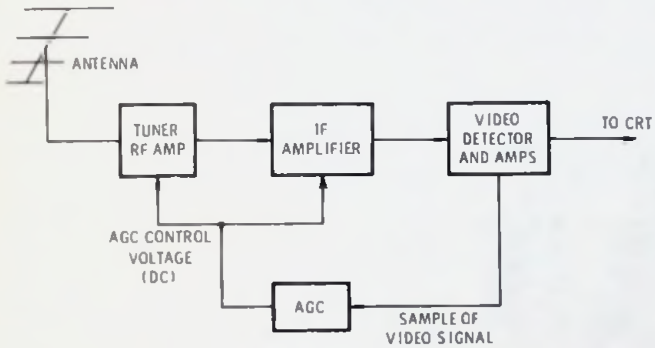


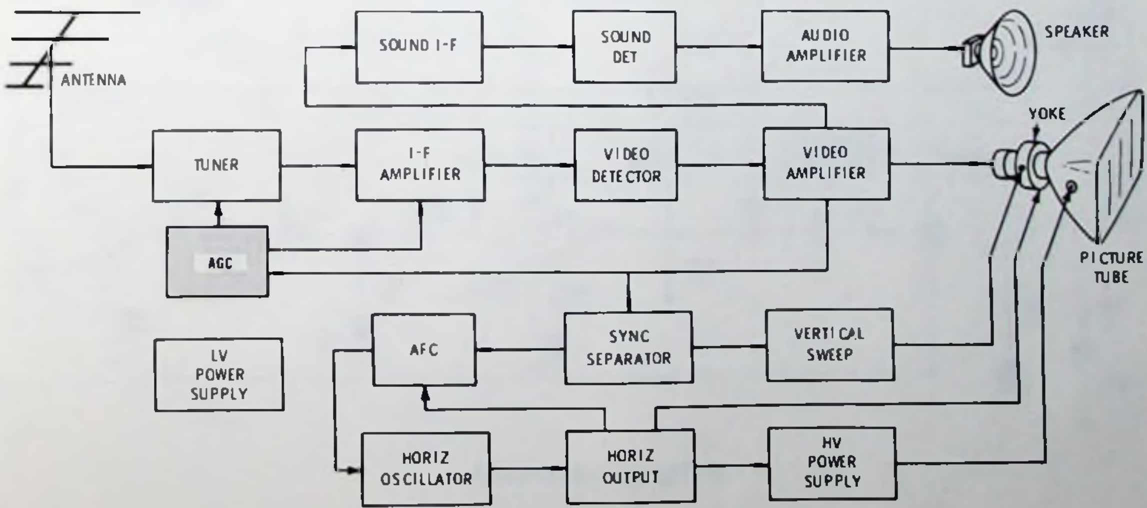
Fig. 10-1. Agc functional block diagram.

AGC TYPES

Two primary types of agc circuits are found in typical monochrome receivers. Forward agc is achieved by using the agc control voltage to forward bias the if and rf transistors into near saturation, where their gain decreases. Reverse agc is achieved by using the control voltage to reverse bias the if and rf transistors, cutting them near off and reducing their gain. Either type of agc may be *keyed* or *unkeyed* though most sets in use today use keyed systems.

KEYED AGC

Fig. 10-2 shows a keyed (sometimes referred to as "gated") agc circuit block diagram. By referring to an agc circuit as being keyed we mean that it is turned on, or "keyed" on, only during horizontal flyback time. The reasons for this is twofold. One, if the agc were allowed to operate continuously it could attempt to sense the amplitude of noise or the always changing video, resulting in rf and if amplifiers trying to change con-



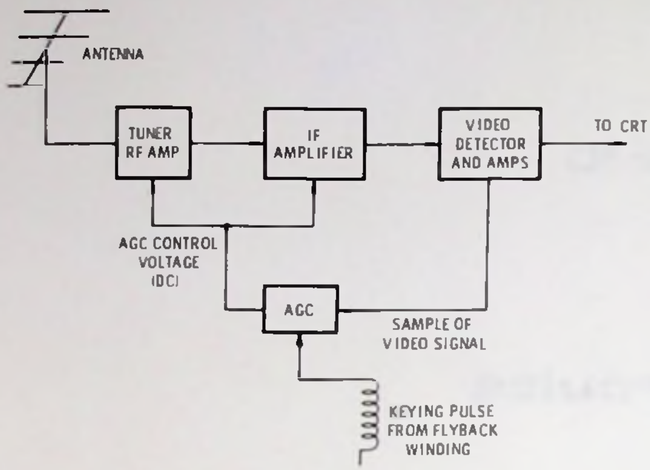


Fig. 10-2. Keyed agc block diagram.

duction erratically. The second reason is that by operating only during flyback time the agc circuit is on during horizontal sync/blanking pulse time. The blanking pedestal/sync pulse of any given signal is always the same amplitude line after line and changes only as the signal strength changes. So by using the blanking pedestal/sync pulse as an indicator of signal strength a constant agc output that varies only with signal strength is maintained.

The circuit of Fig. 10-2 is easily recognized as a keyed-type agc because it has a direct connection to a winding on the flyback transformer.

A discrete transistor keyed agc is illustrated in Fig. 10-3. Video input to the agc is taken from the collector of the first video amplifier and coupled to Q402, the agc gate. The horizontal pulse utilized for keying comes from a winding on the flyback; a typical arrangement though it is sometimes taken from other points in the horizontal circuitry. Negative going sync pulses are applied to the base of Q402 and negative going keying pulses are coupled to the collector. These polarities are just right for the pnp transistor, Q402. That is, a negative signal is necessary on both the base and collector of a pnp to cause it to conduct. For this reason the pnp agc gate transistor conducts *only* when both negative signals are present. The circuit is considered to be keyed on as the collector receives the negative horizontal keying pulse.

When Q402 conducts, the resistance between the emitter and collector drops to a very low value causing the collector to go toward positive. The positive going output can now be passed on to Q405 through diodes CR403 and CR402. Notice that CR402 blocks the negative going keying pulse from Q405, the agc amplifier. As the positive agc pulse moves to Q405 it is amplified and a portion of its output is used for rf amplifier agc control. Part of the output from Q405 is further amplified

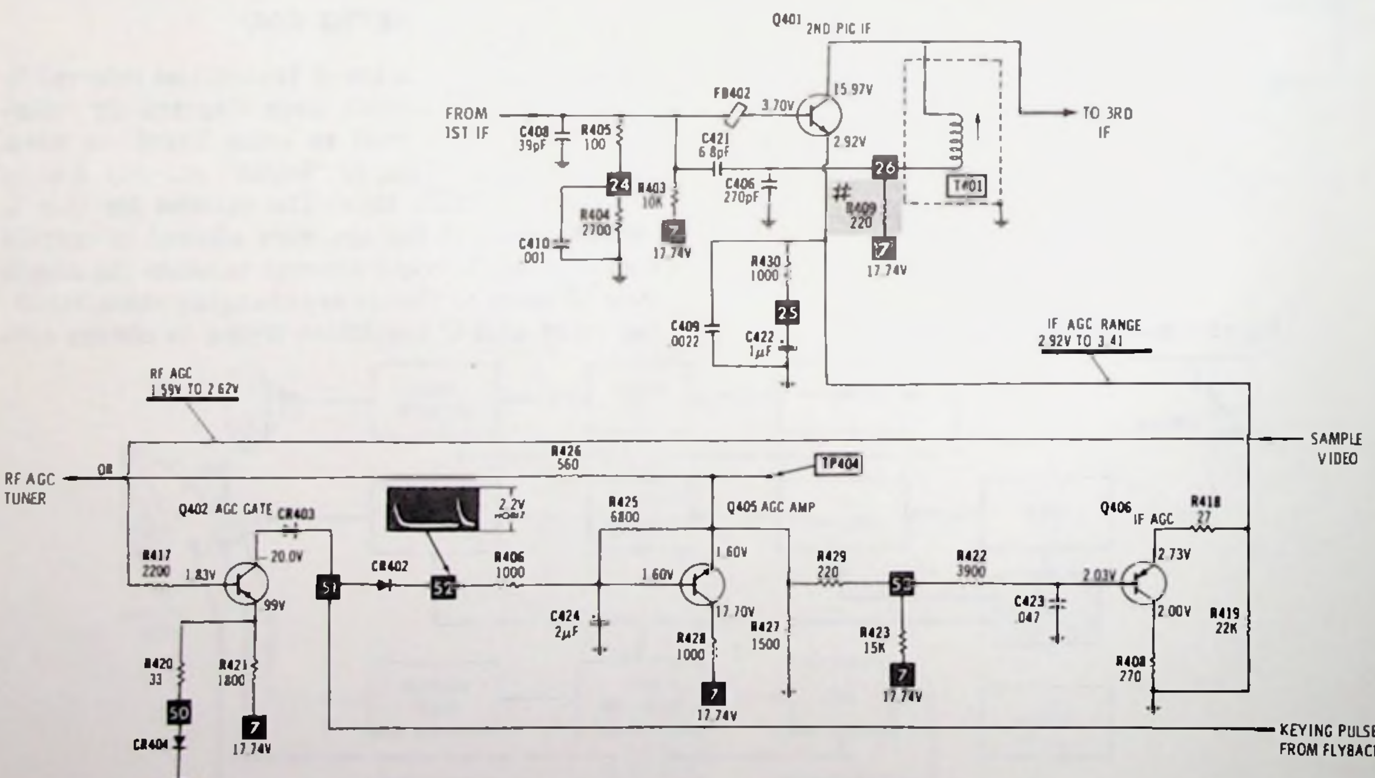


Fig. 10-3. Keyed agc.

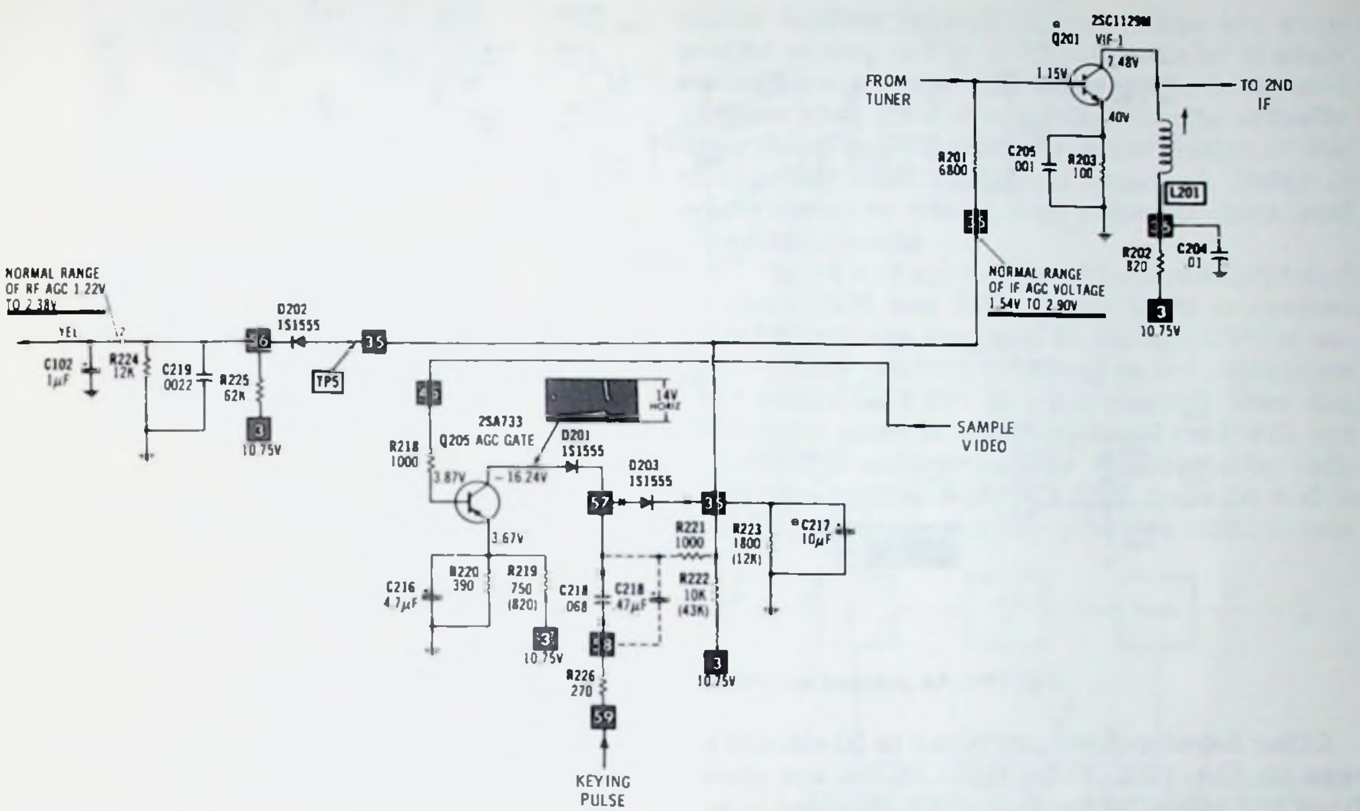


Fig. 10-4. A single transistor keyed agc circuit.

by Q406 and used to control the amplification of the second if amplifier.

If transistor Q401 is an npn but receives a positive agc voltage on its emitter, it must be using reverse agc to turn off the if amplifier. Likewise, it would be using forward agc if the agc voltage were negative and causing Q401 to be turned on.

A single transistor agc circuit is shown in Fig. 10-4. Its operation is identical to that of Fig. 10-3 except only one transistor is used.

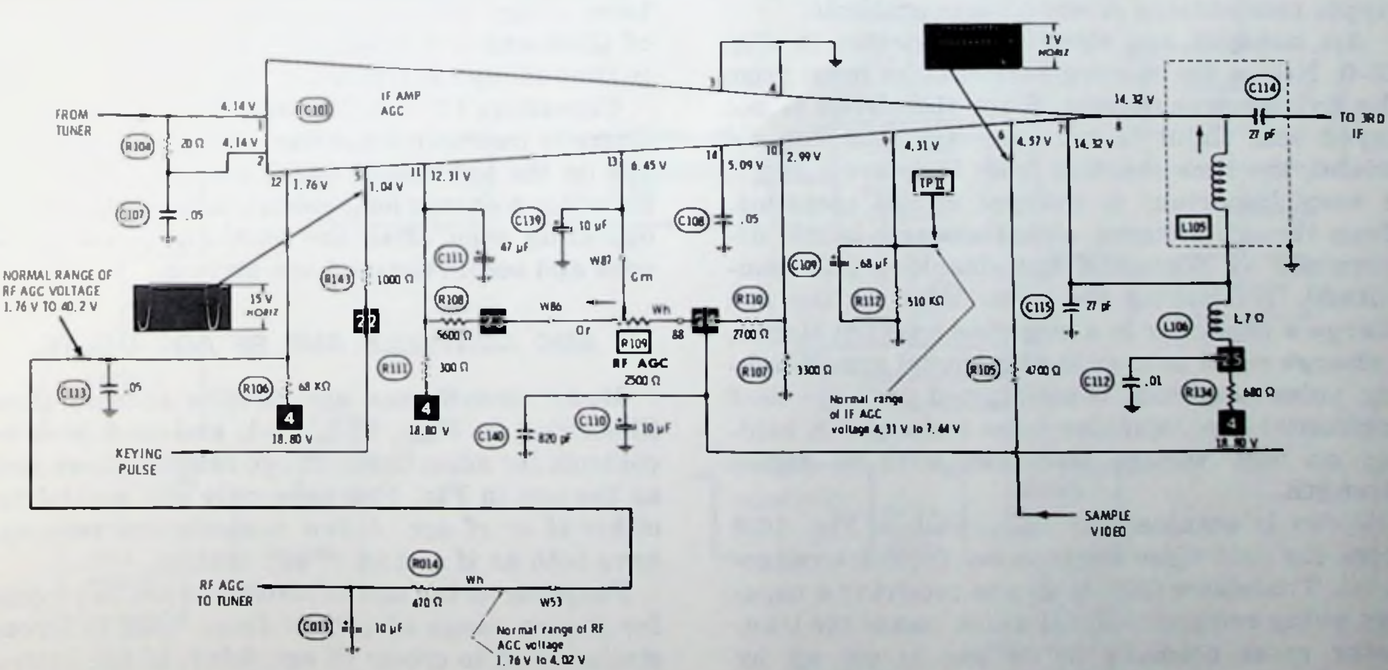


Fig. 10-5. IC agc circuit.

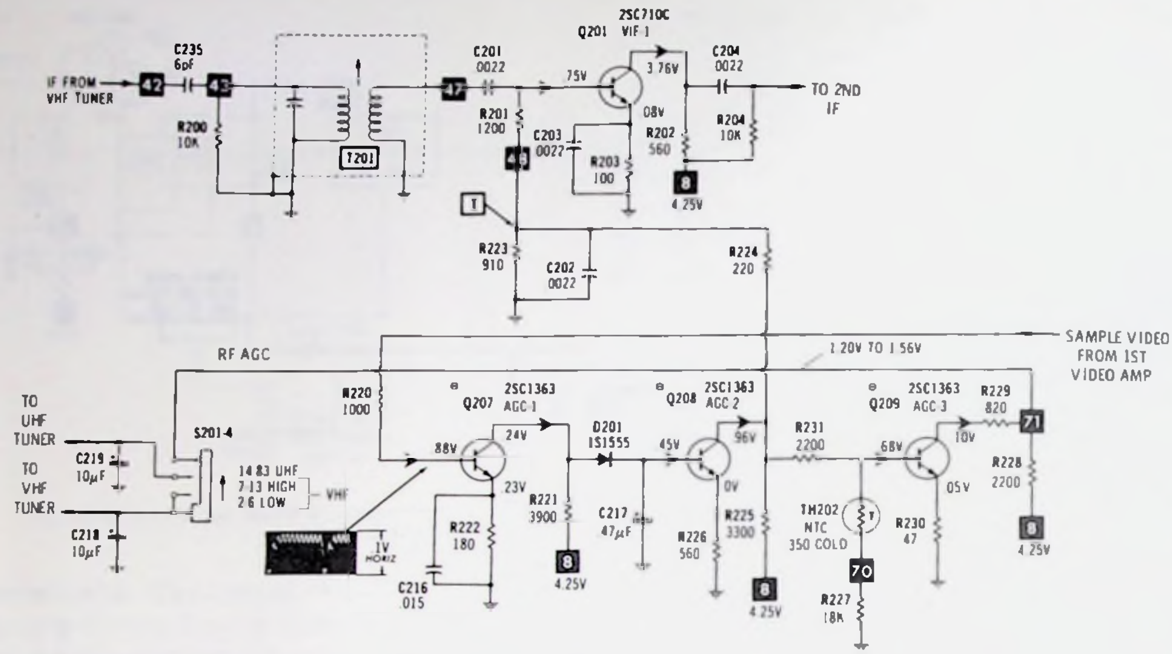


Fig. 10-6. An unkeyed agc circuit—note the absence of keying pulse input.

Other keyed systems are found in IC circuits as seen in Fig. 10-5. Video input to the agc comes from the output of the first video amplifier to pin 6 of IC101. The keying pulse is taken from a flyback winding and coupled to pin 5 of the IC. The rf agc output is from pin 12 of IC101 where it is filtered by C013. Filtering is essential in all agc circuits for if any pulses or ripple were applied to the if or rf amplifiers on the agc line, the circuit amplification would attempt to change at the ripple rate causing severe picture problems.

An unkeyed agc circuit is illustrated in Fig. 10-6. Notice the missing keying pulse input from the flyback transformer. Since the circuit is not keyed this input is not necessary. But our old friend, the time constant from Chapters 4 and 6, is very important to unkeyed circuit operation. Even though unkeyed, signal strength is still determined by horizontal sync/blanking pulse amplitude. By having the video input to the agc charge a capacitor in a long time constant circuit, a charge equal to near the horizontal sync/blanking pulse amplitude is maintained until the next horizontal sync/blanking pulse recharges it, holding an agc voltage level indicative of signal strength.

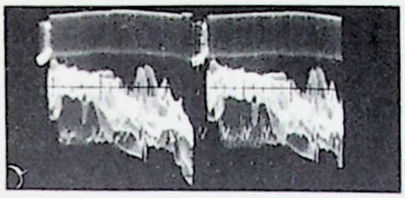
Video is obtained for the circuit in Fig. 10-6 from the first video amplifier—a typical arrangement. Transistor Q207 is an npn receiving a negative going composite signal which means the transistor must normally be *on* and is cut *off* by incoming horizontal sync tip and blanking pedestals. As the emitter-collector voltage rises because of cutoff, a positive going signal is transferred through D201 to Q208. A positive signal on the base of Q208 causes a negative going output signal on the collector of this common emitter amplifier. Thus, a negative agc signal is applied to the base of Q209, another common emitter agc amplifier. Its output will be positive since common emitters invert the signal from input to output. The positive agc output from Q209 is used for tuner rf agc. The if agc is taken from the collector of Q208 and is a negative signal level to be used to turn off npn if transistor Q201.

Capacitors C217, C218, and C219 serve as agc filters to maintain a constant unvarying agc voltage on the agc output bus. Capacitor C217 must maintain a charge long enough to keep the system operating even after the blanking pedestal has gone and before the next one arrives.

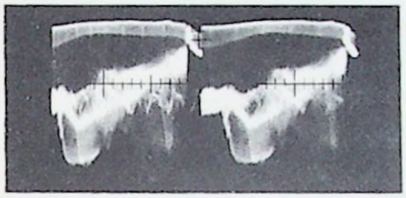
AGC CONTROLS AND RF AGC DELAY

Many monochrome agc circuits such as those illustrated in Figs. 10-3, 10-4, and 10-6 have no controls for adjustment of agc range. Others such as the one in Fig. 10-5 have only one control for either if or rf agc. A few monochrome receivers have both an if and an rf agc control.

Purposes of the agc adjustments are to provide for proper range of control from weak to strong stations and to create rf agc delay. If agc control range is set incorrectly, weak signals may have



(A) Normal signal.



(B) Compressed sync pulses.

Fig. 10-7. Compressed sync pulses are caused by overloading amplifier circuits.

excessive snow, or strong signals may cause overload. It is important that both extremes of signal level be controlled so neither of these conditions prevails. The agc delay allows the rf amplifier to operate at maximum amplification until a signal is received that is strong enough to cause rf amplifier overload. When an amplifier circuit overloads, the incoming signal is large enough to begin to saturate, or sometimes cut off, the rf amplifier transistor. In an overload condition video information is distorted and sync pulse tips are compressed as seen in Fig. 10-7. The result of rf overloading is a picture with bends, audio hum, and unstable sync. The rf agc delay circuits actually delay the effect of limiting the amplification of the rf amplifier until overload is imminent. Delay is accomplished by diodes, high value resistors, and transistor circuits.

In Fig. 10-4 rf agc is delayed by diode D202 and resistors R225 and R224. Diode D202 is reverse biased by voltage produced by voltage divider action of R225 and R224. As long as the voltage on the cathode of D202 is more positive than the anode, the diode is reversed biased and will not conduct. The cathode voltage is produced by voltage division across R224 and R225 from ground to the 10.75 V source. Anode voltage on D202 is pro-

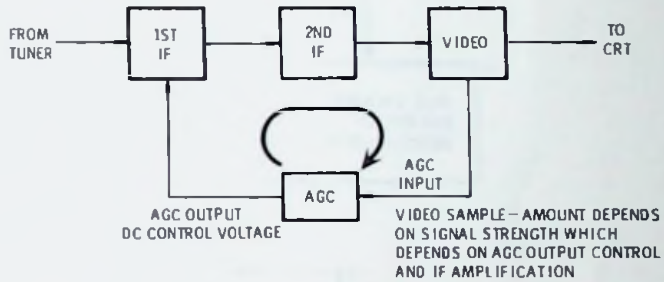


Fig. 10-8. The agc loop (showing if agc only).

Chart 10-1. Diagnosis of an AGC Symptom

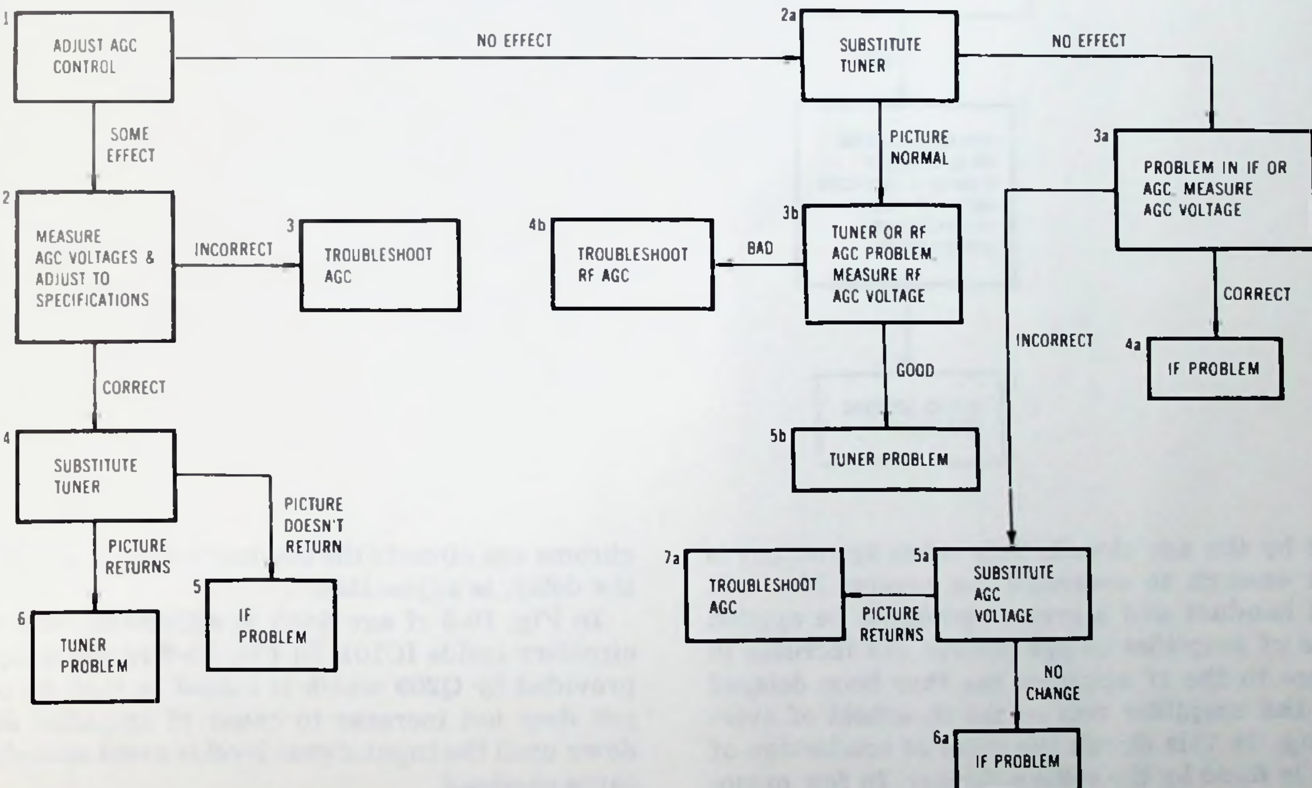
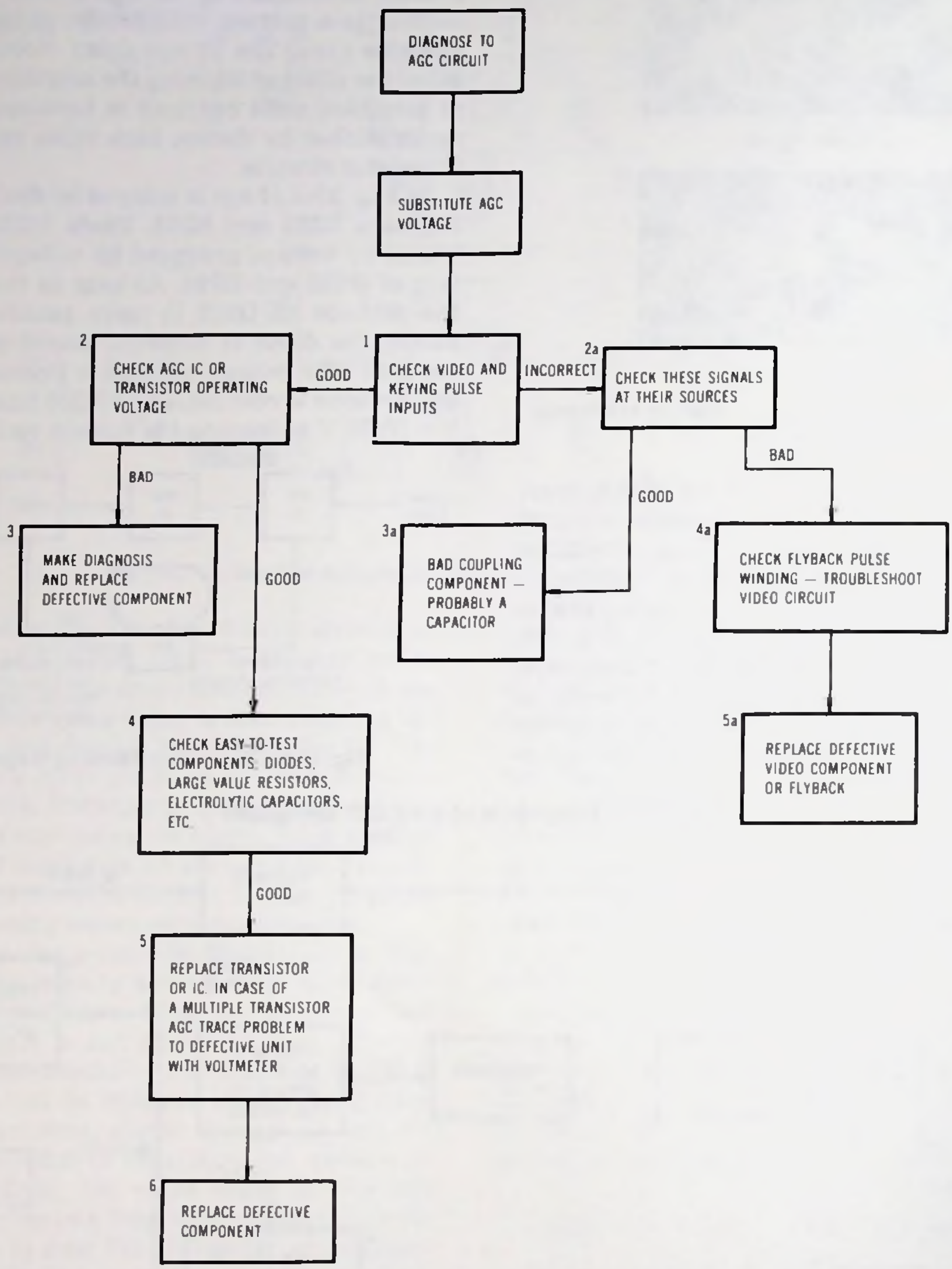


Chart 10-2. Troubleshooting Chart for All AGC Symptoms



vided by the agc circuit. Only when agc output is great enough to overcome the reverse bias will D202 conduct and a greater potential be applied to the rf amplifier as agc control. An increase in voltage to the rf amplifier has thus been delayed until the amplifier was on the threshold of overloading. In this circuit the point of conduction of D202 is fixed by the voltage divider. In few monochrome agc circuits the conduction point, and thus the delay, is adjustable.

In Fig. 10-5 rf agc delay is adjustable with the circuitry inside IC101. In Fig. 10-6 rf agc delay is provided by Q209 which is biased so that its output does not increase to cause rf amplifier shut down until the input signal level is great enough to cause overload.

TROUBLESHOOTING AGC CIRCUITS

The agc circuit, with the rf, if, and video circuits, forms a *loop* circuit (see Fig. 10-8). A loop circuit is one which exhibits control over itself by having its input control its output and eventually its own input. In Fig. 10-8, agc input controls agc output which then controls if signal gain and thus the agc's own input.

Several loop circuits can be found in the monochrome receiver including horizontal apc. By their very nature loops are difficult to service. In fact in order to effectively troubleshoot the loop, it must be broken. The loop can be broken by removing its input, its output, or by overriding its control voltage output with another power source. Removal of inputs and outputs is simply a matter of disconnection. Overriding the control voltage output is accomplished by connecting an adjustable power source to the agc output and adjusting the supply output to the normal agc voltage specified on the technical literature.

Symptoms caused by defective agc circuits are:

1. No video, no audio, lighted raster
2. Weak video
3. Video overload with buzz in the sound

Diagnosing these symptoms to the agc circuitry usually requires the use of test equipment because both the tuner and the if's produce the same symptoms. Step number *one* then is to limit the problem to the agc circuits (see Charts 10-1 and 10-2).

Chapter 11

Sound Circuits

Audio circuits amplify the 4.5 MHz fm audio if, detect it to extract the intelligence, amplify that intelligence and reproduce it via a loudspeaker. Earlier in Chapter 7 you learned that the sound carrier and video carrier are always 4.5 MHz apart. It is from this relationship that the 4.5 MHz sound if is derived. As all incoming signals go through the video detector, these two carriers—41.25 MHz sound if and 45.75 MHz video if carriers—beat together because of the nonlinear nature of the detector diode. A tuned circuit extracts the difference between these two frequencies or 4.5 MHz, and traps keep it from entering the final video stages to prevent audio interference on the picture. Because of the manner of producing the sound if frequency the sound is almost always split from the other signals after the video detector. Note the sound takeoff point, and tuned circuit trap in Fig. 11-1. It is expected, however, that as synchronous video detectors (Chapter 9) begin to see more use, a different sound takeoff point may be used. Synchronous detectors are more linear than diode detectors so the picture and sound if carriers are not as likely to beat together.

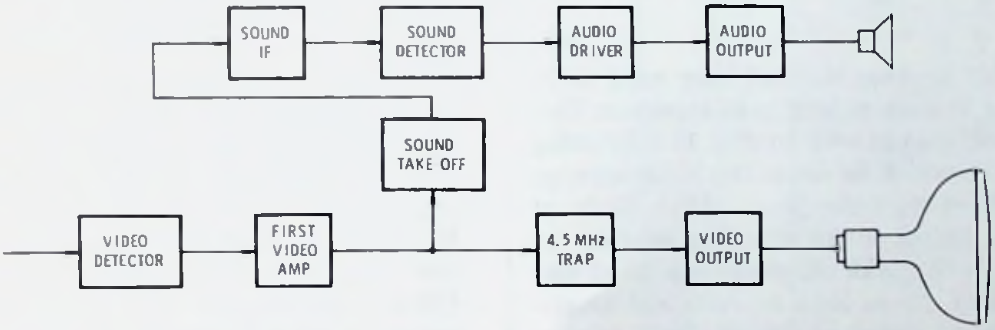
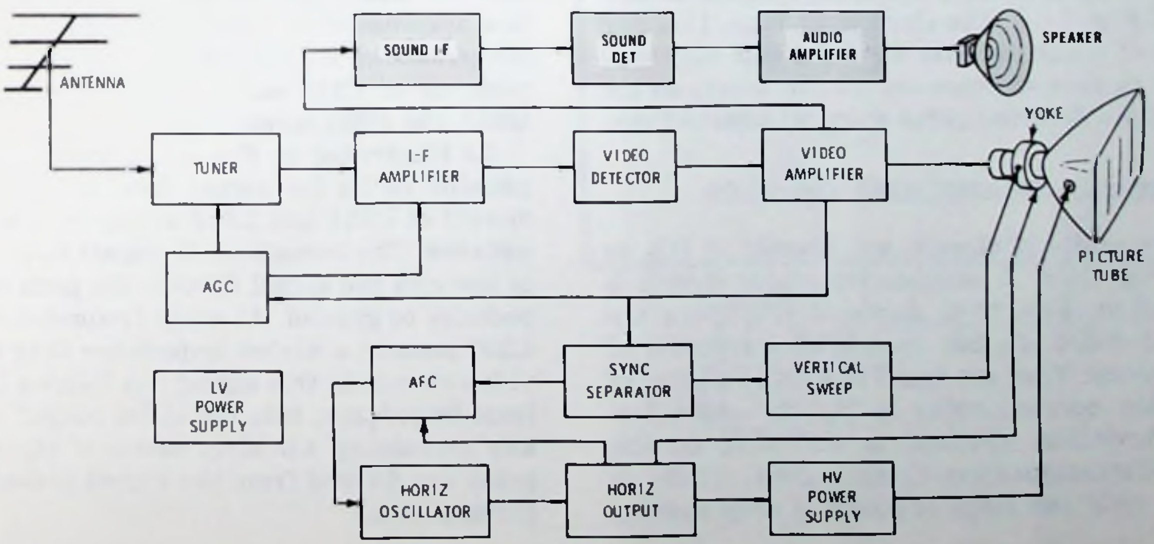


Fig. 11-1. A functional block diagram of the sound system showing sound takeoff and trap locations.



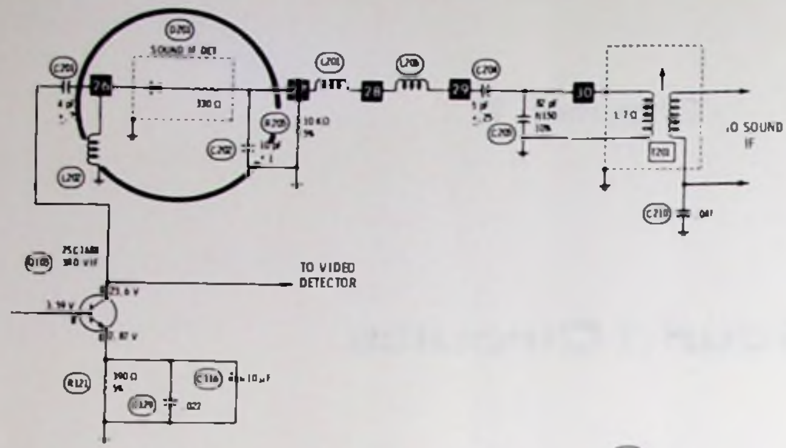


Fig. 11-2. Diode sound detector used when sound signal is taken before the video detector.

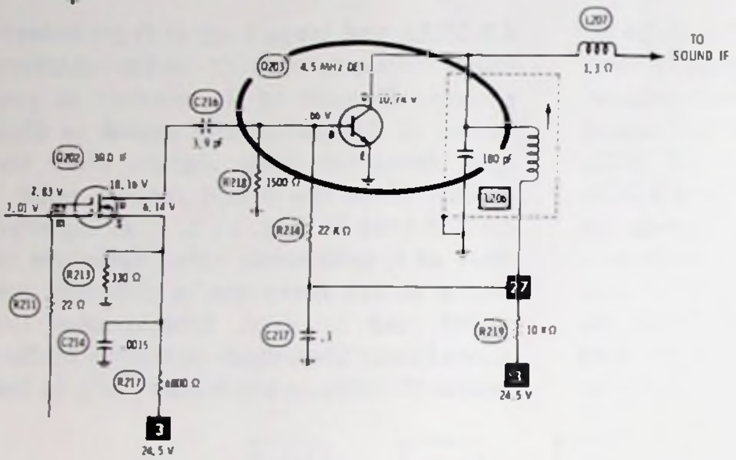


Fig. 11-3. Transistor sound detector used when sound signal is taken before the video detector.

This means that another method may need to be found to get the two signals to beat together. This is easily accomplished as seen in Fig. 11-2 by using an extra diode in which to cause the heterodyning (mixing together) to take place. This diode of course must be placed in the circuit ahead of the video detector so the take off point can be at any place in the video if's as long as sufficient amplification is available. Other means of signal mixing can be used, such as the nonlinear transistor amplifier of Fig. 11-3. The circuits in Figs. 11-2 and 11-3 are of color receiver circuitry but may well be found in monochrome sets in the future as the synchronous detector gains more widespread use.

SOUND IF AMPLIFIER CIRCUITS

Today's audio if circuits are usually in ICs as seen in Fig. 11-4. A discrete transistor circuit is illustrated in Fig. 11-5. Audio if amplifiers are similar to video if's but operate at a fraction of the frequency. They are tuned to a narrow band of frequencies corresponding to the fm audio frequency deviation (limited to ±25 kHz by the Federal Communication Commission). There is normally only one stage of sound if amplification as no more amplification is necessary to produce a good volume output. In Fig. 11-5 T202 is the sound takeoff transformer. It passes the 4.5 MHz sound if while rejecting all other frequencies. Video is separated from audio in the first video amplifier by taking the video signal from the emitter and the audio from the collector of Q205—capacitor C214 and inductor L207 form a series resonant sound if trap tuned to 4.5 MHz—thus allowing the 4.5 MHz signal to go to ground through the low impedance of C214 and L207 at resonance. *Nonresonant* frequencies encounter the high impedance of C214 and L207 and must proceed to Q401, the video output.

As illustrated in Fig. 11-6, these circuits form parallel paths for signal flow with the resonant circuit of C214 and L207 acting as a variable impedance. The impedance to signal flow of 4.5 MHz is low and the signal follows the path of least impedance to ground. At other frequencies C214 and L207 present a higher impedance than that of the video circuit so this signal too follows the path of least impedance, into the video output circuit. So, any remaining 4.5 MHz sound if signals at this point are filtered from the signal presented to the picture tube.

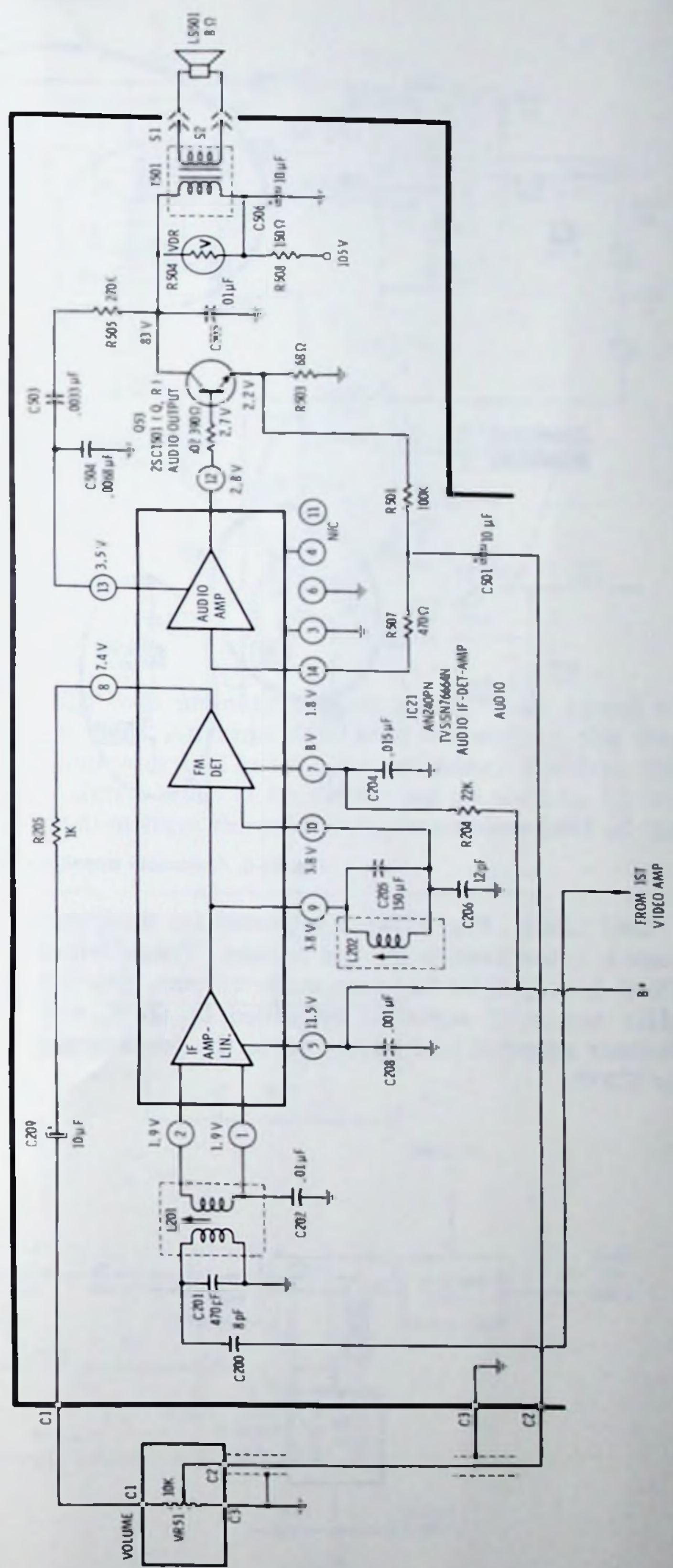


Fig. 11-4. Some sound ICs contain the if amplifier, limiter, detector, and part or all of the audio amplification circuits. (*Courtesy Quasar Co.*)

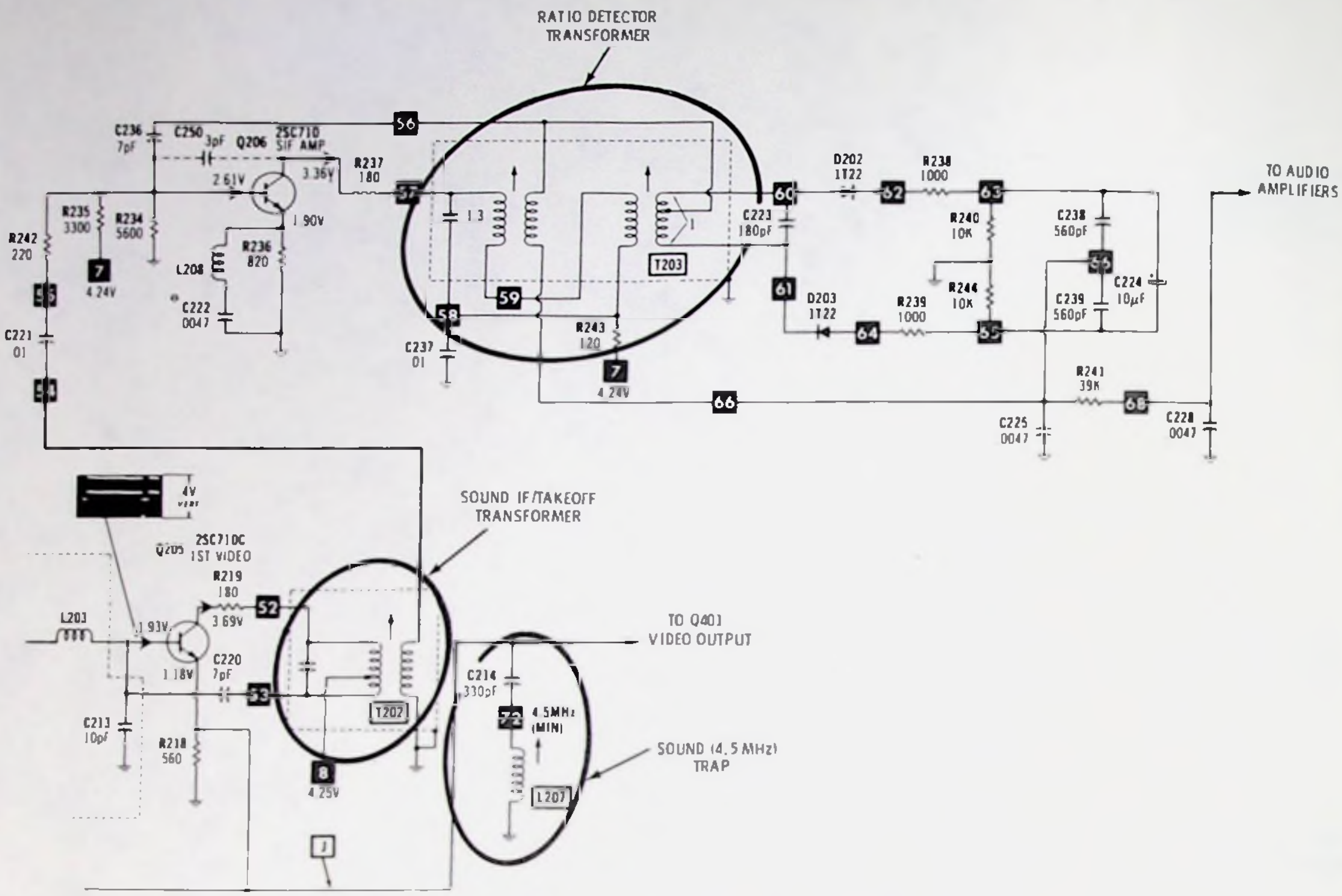


Fig. 11-5. A discrete transistor sound if with diode ratio detector.

Coil L207 (Fig. 11-5) is adjusted for minimum sound interference on the screen. Transformer T202 is adjusted for maximum volume. The 4.5 MHz sound if signal is amplified by Q206, and further selected and passed on to the fm detector by T203.

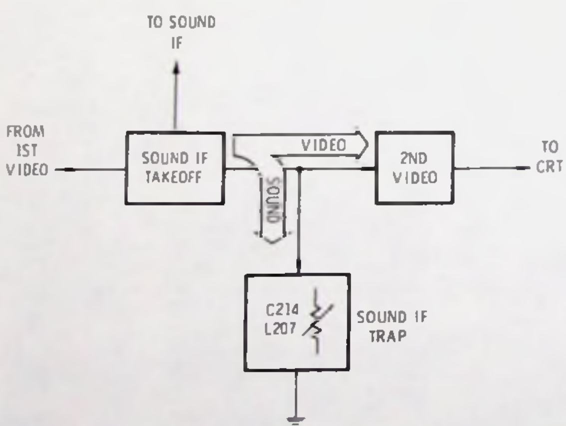


Fig. 11-6. This sound trap is in parallel with the video circuit; any 4.5 MHz sound signal left after takeoff is shunted to ground.

In the IC circuit of Fig. 11-7 sound if is also taken from the first video amplifier. A sound trap consisting of a parallel resonant circuit of L109, C125 and C127 provides high impedance to the resonant 4.5 MHz while allowing all other frequencies to pass through for picture production. Transformer T300 couples the 4.5 MHz signal into pins 1 and 2 of IC301, the sound if amplifier and detector. Adjustments are identical to those of the discrete circuit explained above.

FM DETECTOR CIRCUITS

Following the if is the fm detector, also usually found in an IC as Fig. 11-4 shows. A discrete component detector is illustrated in Fig. 11-5. The normal fm audio detector is either a ratio detector or a discriminator which causes the shifting frequency to be changed to a varying voltage level that is amplified and applied to the speaker.

The ratio detector and discriminator appear very much alike at first glance but upon further examination several differences can be observed. First, note the direction of diode placement, then

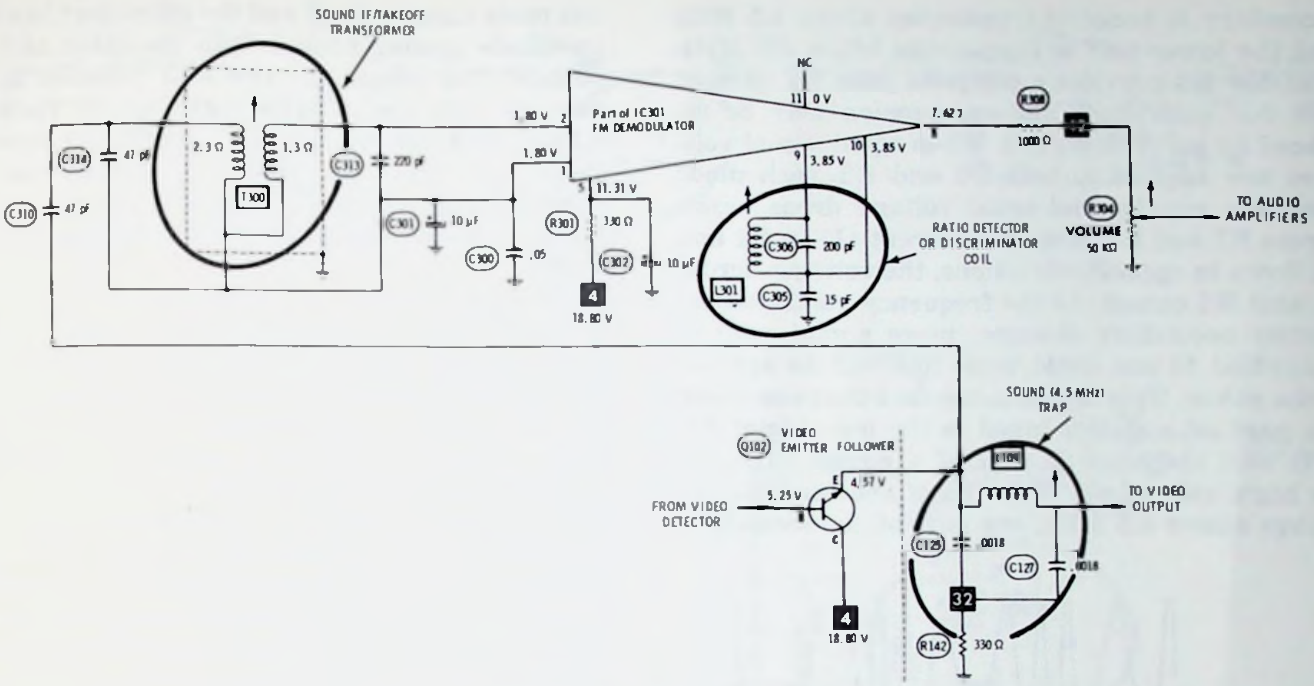
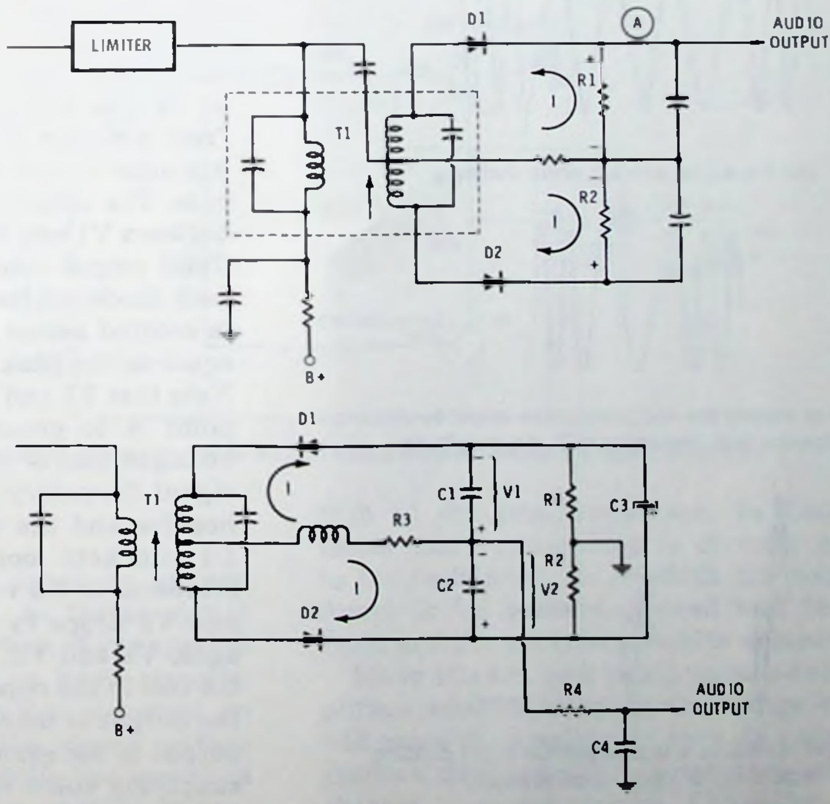


Fig. 11-7. An IC sound if circuit.

the connection of load resistors and capacitors, input transformers, signal output connection, and the presence of stabilizing capacitor C3 in Fig. 11-8B.

In Fig. 11-8A, T1 is a double-tuned transformer with both primary and secondary coils tuned to 4.5 MHz. An important note concerning the discriminator coil is that the secondary receives the if signal input at its center tap as well as by induction from the primary so the upper half of the

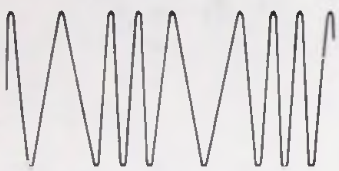


(A) Discriminator.

(B) Ratio detector.

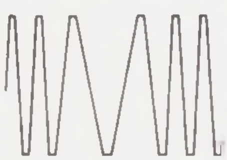
Fig. 11-8. Fm detector circuits.

secondary is tuned to frequencies above 4.5 MHz and the lower half to frequencies below 4.5 MHz. Resistor R3 provides a complete path for current flow for each diode and on occasion may be replaced by an rf choke coil. When equal signal voltages are applied to both D1 and D2, each diode conducts equally and equal voltage drops result across R1 and R2. Since the current (I) in D1 and D2 flows in opposite directions, the voltages across R1 and R2 cancel. As the frequency on the transformer secondary changes, more signal voltage is applied to one diode while less will be applied to the other. This is due to the fact that one diode is a part of a circuit tuned to the low side of 4.5 MHz and the other is part of a circuit tuned to the high side of 4.5 MHz. So if the incoming if swings above 4.5 MHz, one part of the secondary

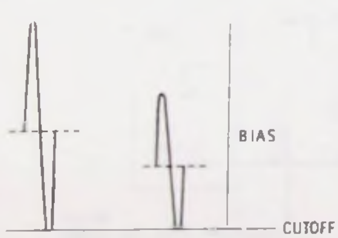


(A) Fm signal.

(B) Fm signal with am noise pulses.



(C) Clipped or limited fm—no intelligence is lost by clipping. Intelligence is in frequency shift, not amplitude.



(D) Clipper maintains a bias to provide slight clipping regardless of input signal strength.

Fig. 11-9. Fm clipping action.

has more signal output and the other part has less, one diode conducts more than the other and the voltage drop across the two load resistors is unbalanced. By the polarity markings on resistors R1 and R2 it can be seen that current flow through these resistors is in opposite directions and the voltage drop across the combination at output point A is the result of these opposing voltage drops.

The ratio detector is often used as an fm detector because it is insensitive to fm signal amplitude changes caused by electrical interference. Because of this insensitivity a limiter stage does not precede the ratio detector. In other fm detector circuits a limiter is usually necessary to "clip" the fm signal (see Fig. 11-9) so no static interference is allowed to disrupt the audio signal. Such a limiter circuit may be a special amplifier circuit or be incorporated into the if amplifier. In either case the amplifier is controlled by the signal, much like the sync separator in Chapter 6, to develop a bias which changes with input signal strength. Signal level is kept at a constant amplitude, with the signal tips and thus any am interference clipped as seen in Fig. 11-9.

A ratio detector can be seen in Fig. 11-8B. Like the discriminator both primary and secondary of T1 are tuned to resonate at the 4.5 MHz sound if frequency. Diodes D1 and D2 are in series, with one of the diodes being reversed from that in the discriminator. By being in series, stabilizing capacitor C3 will charge to the diode output voltages of V1 *plus* V2. In order to keep the ratio detector from reacting to amplitude modulation, this voltage must be stabilized so as not to vary at an audio rate. The output is obtained only when the ratio between V1 and V2 changes at the output, point A. Total output voltage across C3 remains fixed. As each diode conducts, a rectified voltage, V1 or V2, is created across C1 or C2 that is approximately equal to the peak value of the incoming if signal. Note that V1 and V2 have opposite polarities from point A to ground. At 4.5 MHz these opposite voltages cancel and there is no output. As the signal frequency changes one diode will conduct heavier and the other will conduct less. Assume D1 conducts more, the voltage drop across V1 increases to 0.5 volt. Conversely, D2 conducts less and V2 drops by 0.5 volt. The two rectified voltages, V1 and V2, produce an identical change of 0.5 volt in the opposite directions at point A. Since the output is taken from this point the amount of output is the same as though only one diode were supplying audio voltage corresponding to the frequency variations in the fm signal.

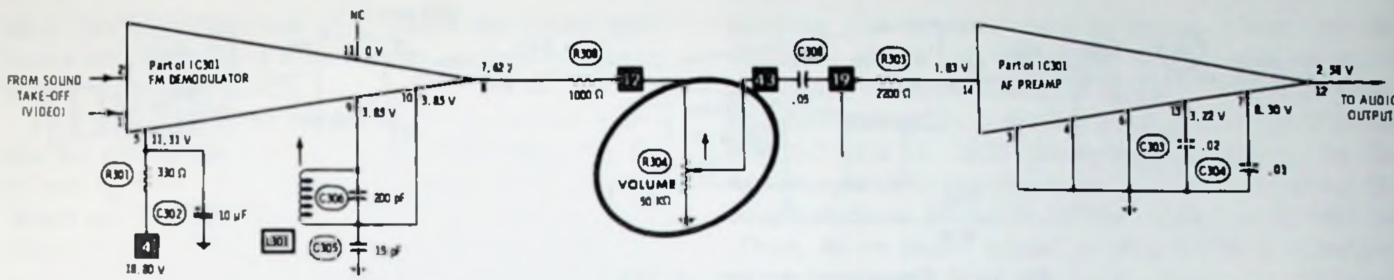


Fig. 11-10. Ac volume control circuit.

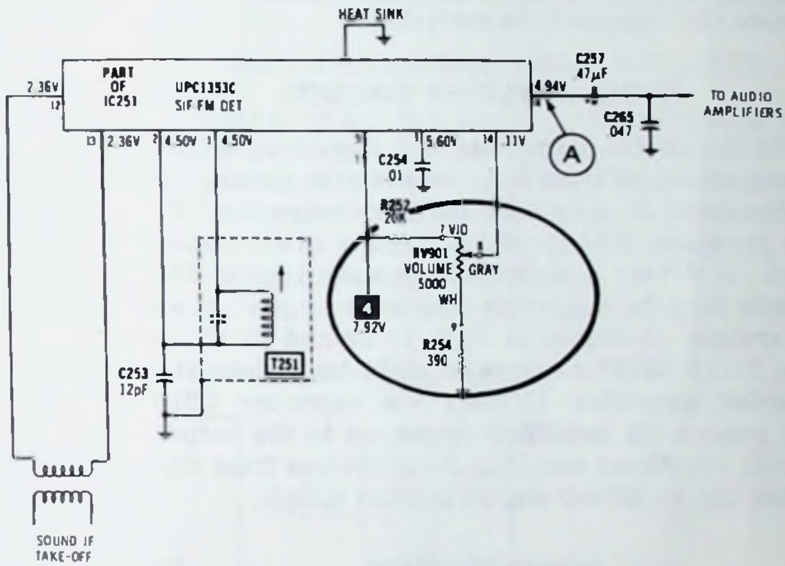


Fig. 11-11. Dc volume control circuit.

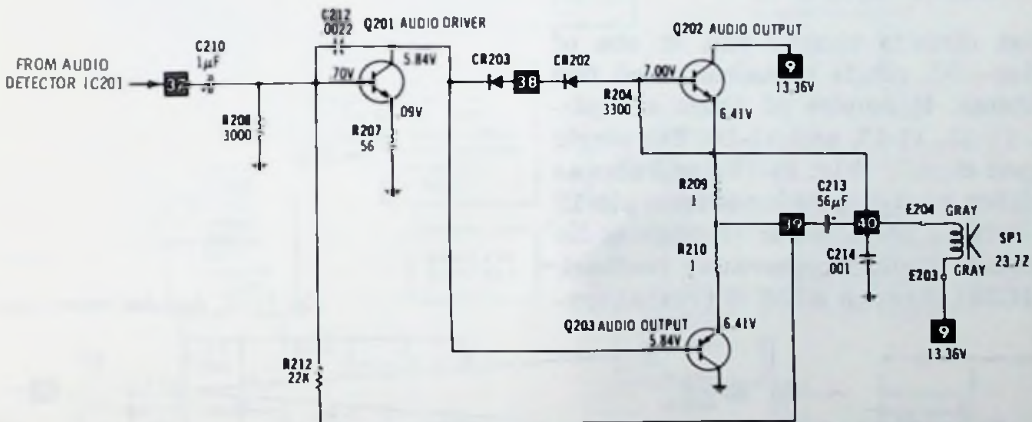


Fig. 11-12. Complementary-symmetry audio output with a discrete transistor driver amplifier.

CONTROLS

Volume controls are usually simple ac voltage dividers as seen in Fig. 11-10. As the ac signal is put across the control any portion of the applied signal can be chosen for use in later circuits. For instance, if the lower section (ground to slider) of R304 is 10K and the upper section (slider to *CircuiTrace* 42) is 40K, the signal is being taken from the 10K portion of R304 or one-fifth of the total resistance. In Chapter 2 we found that voltage drop is directly proportional to the resistance. So one-fifth the total signal is found to be between ground and the slider of R304 and the set is at one-fifth volume.

Many ICs are now using voltage-controlled amplifiers where a varying dc voltage on an input will cause the amplifier to vary its gain. Fig. 11-11 shows a circuit which is sometimes used in monochrome tv sound circuits. Changing the voltage

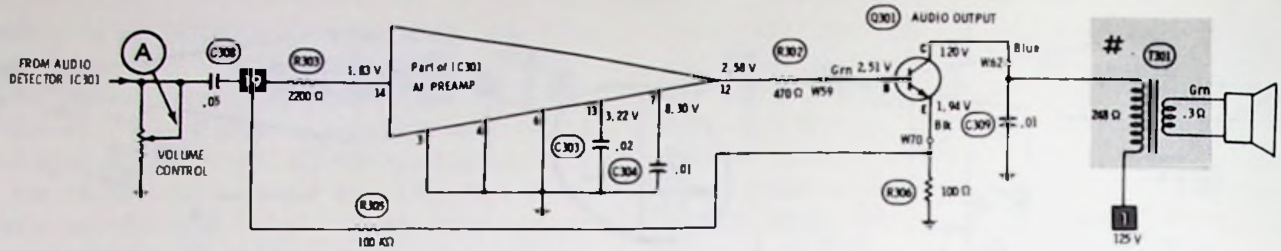


Fig. 11-13. Single transistor audio output with an IC driver amplifier.

applied to the IC via dc voltage divider RV901 causes the volume to be controlled.

AUDIO AMPLIFIER CIRCUITS

Once the fm signal has had the audio intelligence removed from it by the detector circuit, the audio must be amplified and then reproduced by the speaker. Two amplifier circuits are normally used—a driver and the audio output circuit. The driver may be a discrete transistor or part of an IC system as shown in Figs. 11-12 and 11-13. In Fig. 11-12, Q201 receives an audio input from the detector/amplifier (IC201) via capacitor C210 and passes its amplified output on to the output circuit via direct coupling. As is obvious from this figure the amplifier circuit is quite simple.

AUDIO OUTPUTS

Audio output circuits usually fall in one of three categories—IC, single transistor, and two transistor systems. Examples of these are pictured in Figs. 11-12, 11-13, and 11-14. The single transistor output circuit (Fig. 11-13) operates as a Class A amplifier receiving its input from pin 12 of IC301 and driving the speaker through audio output transformer T301. Degenerative feedback is supplied to IC301 through R305 to prevent system oscillation. The speaker is driven directly by IC1 through coupling capacitor C18 in the IC circuit of Fig. 11-14. Where a coupling or output transformer is used the purpose is to match the output impedance of the transistor or IC to the low impedance of the speaker. Speakers being constructed as they are (see Fig. 11-15) are low impedance devices. If enough wire were used in the voice coil windings to make it a high imped-

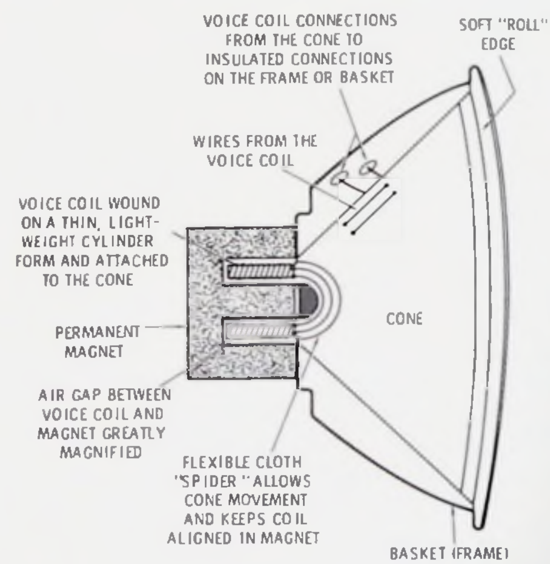


Fig. 11-15. Speaker construction.

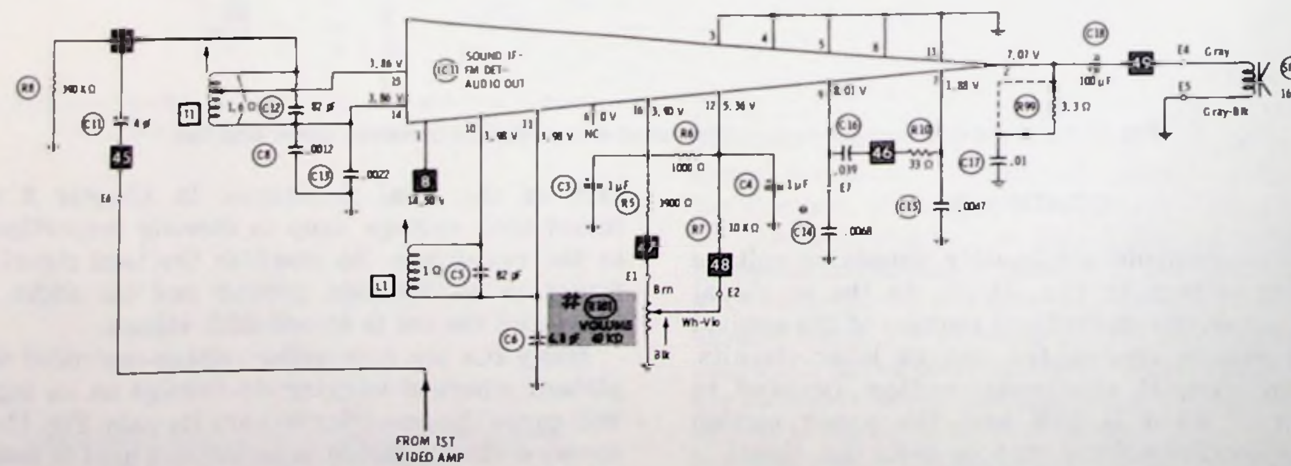


Fig. 11-14. A single IC audio system.

ance device, the voice coil would be bulky and heavy and would not move easily enough to create sound with good fidelity.

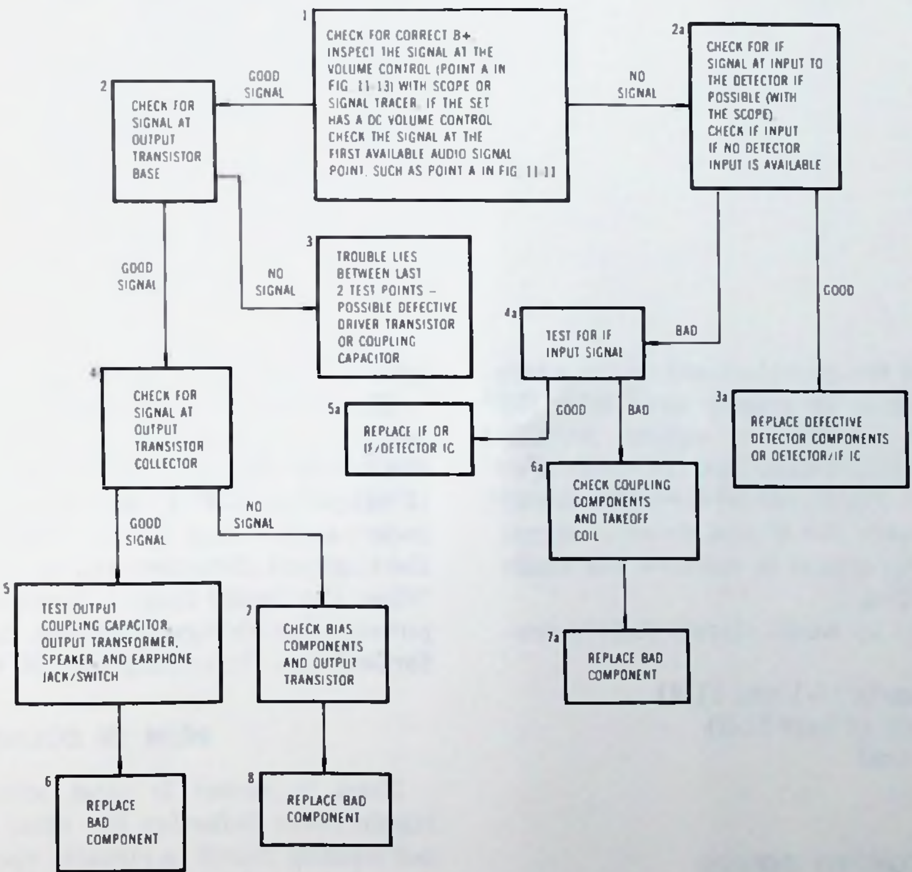
In Fig. 11-12, transistors Q202 and Q203 operate as a complementary pair (see Chapter 6) driven by Q201 the common emitter audio driver. When an npn and a pnp transistor are connected thusly they make up a complementary-symmetry push-pull amplifier. Transistors Q202 and Q203 form a voltage divider from the positive 13.36 V source to ground so approximately one-half of this supply voltage can be measured at *CircuiTrace* 39 when no signal is applied to the circuit. Capacitor C213, being essentially in parallel with Q203, is charged to the same voltage. When a negative signal appears at the collector of Q201, the bases of both Q202 and Q203 are also negative. Transistor Q203 will conduct, being a pnp and requiring a negative base, but Q202, an npn, will not conduct. At this time capacitor C213 will charge from ground through Q203, R210, and the speaker causing the speaker cone to move. Next as the collector signal of transistor Q201 goes positive the bases of Q202 and Q203 are positive and Q202 conducts allowing a discharge path for C213 from the left end of C213 through R209, Q202, to the speaker, and to the right end of C213, causing the speaker cone to move in the opposite direction. Thus, as an audio signal is coupled to the output circuit, charge and discharge currents through C213 and the speaker are switched producing speaker cone movement and audio reproduction.

TROUBLESHOOTING AUDIO CIRCUITS

Because of the low signal levels involved, few sound problems are found other than with the output transistor. Of course this is consistent with our component failure analysis in that the output transistor is often the only active device in the circuit, and the only power device.

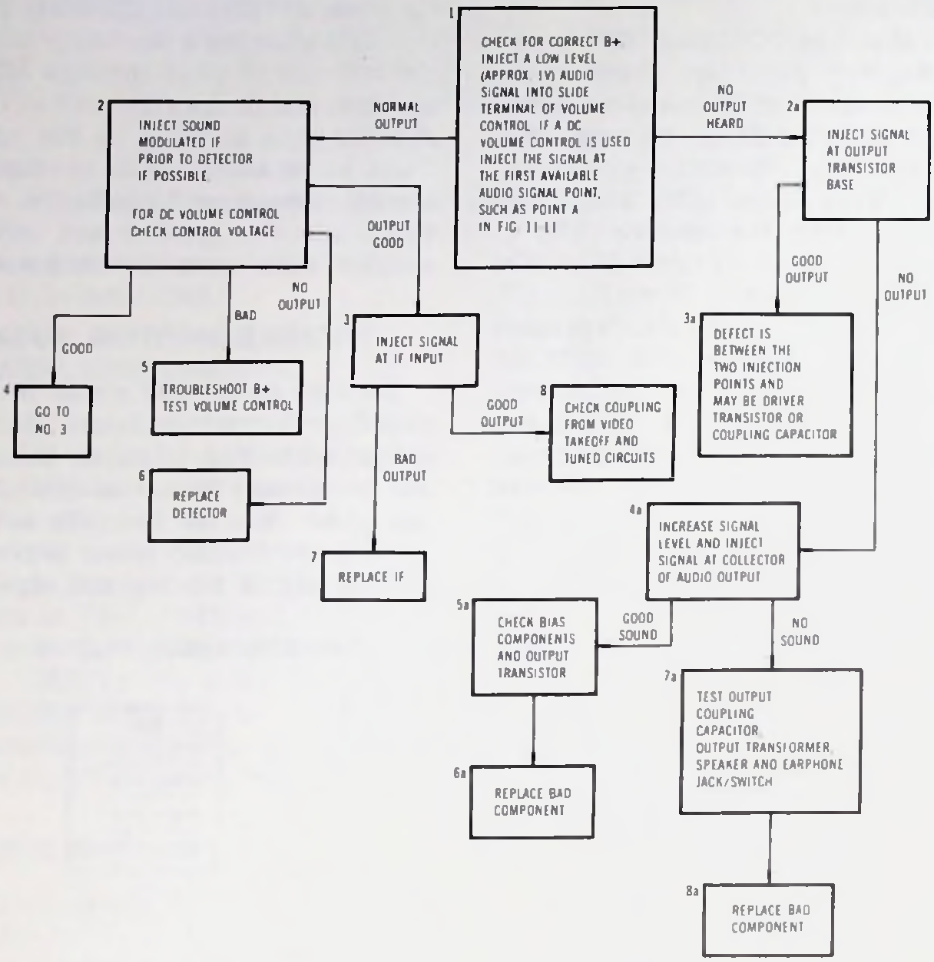
Both signal tracing and signal injection tech-

Chart 11-1. No Sound—Signal Tracing Troubleshooting Method



The no sound symptom is most often caused by defective ICs, defective transistors, and open coupling capacitors. Test B+ first. If there is no B+, troubleshoot source; if B+ is low, remove audio output transistor and check voltage again. If it is normal, a problem may exist in the amplifier which loads the B+ supply. If there is no change with the transistor removed, troubleshoot the voltage source.

Chart 11-2. No Sound—Signal Injection Troubleshooting Method



niques can be used for troubleshooting the audio system. Signal tracing is usually done with the oscilloscope up to the detector output. At this point an audio signal tracer can be used. For signal injection, an fm signal of 4.5 MHz center frequency is necessary for if and detector signal injection. Any audio signal is suitable for audio circuit signal injection.

Symptoms caused by audio circuit failure are:

1. No sound (Charts 11-1 and 11-2)
2. Distorted sound (Chart 11-3)
3. Hum in the sound
4. Low volume

DISTORTED SOUND

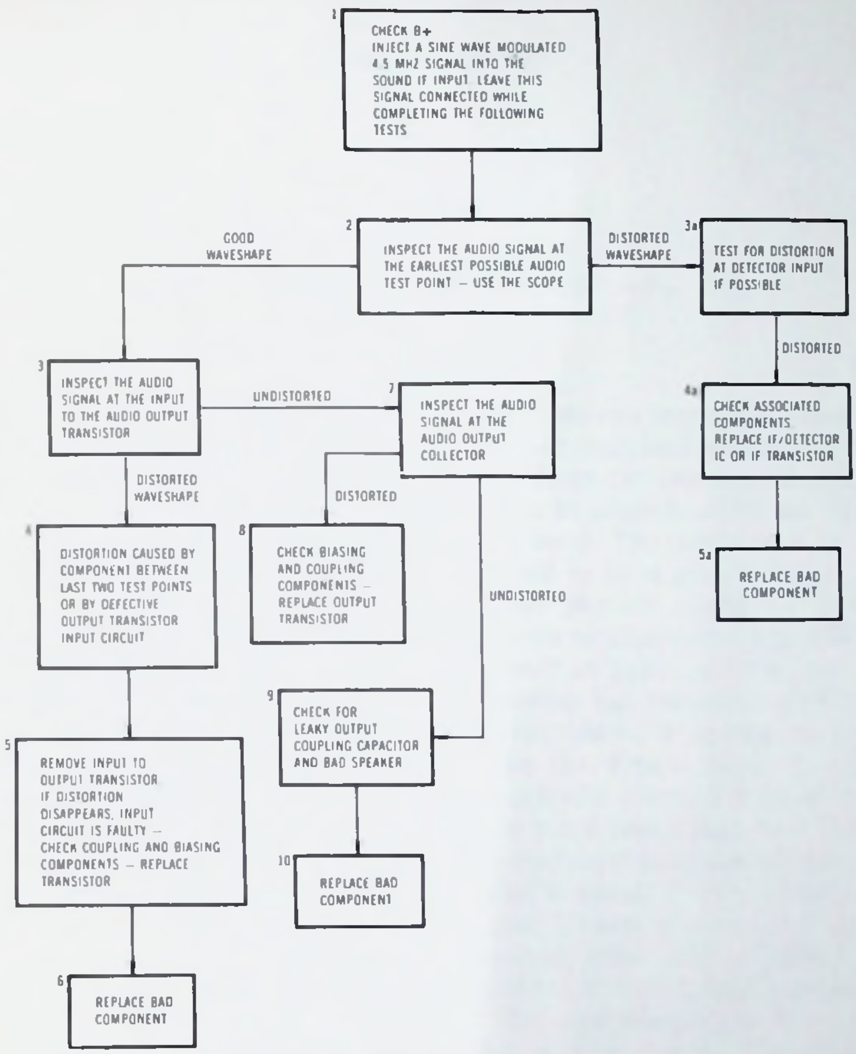
Distorted audio is caused by defective transistors (especially one of a complementary pair), leaky coupling capacitors, changed value bias and load resistors, and out of alignment systems.

Signal injection or signal tracing can be used but in some cases neither is effective in locating the source of minor distortion. For this reason it is suggested that a pure sine wave signal be injected and a scope used to trace that signal. Even the slightest distortion can be detected in this way. When the faulty stage is located, check bias components for change in values, coupling capacitors for leakage, then change the IC or transistor.

HUM IN SOUND

Hum in sound is most often caused by B+ ripple from defective B+ filter capacitors and is not usually found in circuits operating from horizontal output derived power sources. Derived power source ripple frequency is 15,750 Hz so even if a filter capacitor is leaky, the ripple frequency is too high to be considered hum.

Chart 11-3. Distorted Sound



LOW VOLUME

Follow the same steps as for *no sound* but watch for lowered signal level rather than for complete loss. Most likely defects are leaky coupling capacitors and faulty transistors or ICs, but bias and load resistors, if changed in value, can cause lowered stage gain and low volume.

Chapter 12

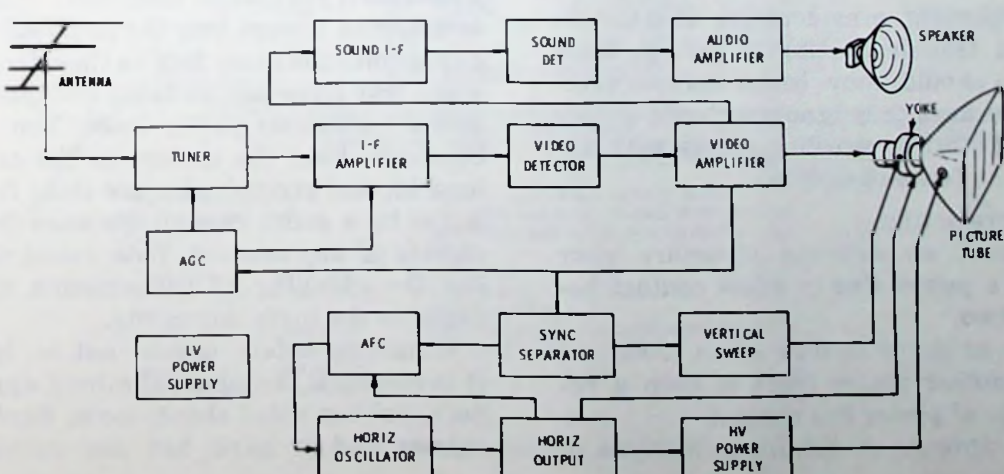
Antennas

Without a good input signal the television is of little use. The key to good tv reception and picture reproduction is the antenna system. The type of antenna system necessary depends on several factors including distance from the station, terrain, number of stations to be received, and locally produced interference.

Most sets will produce a picture of sufficient contrast with a very poor signal yet the quality of the picture may be bad due to excessive snow or ghosts. Snow on the receiver screen is due to low signal level and a high noise level, commonly referred to as a low signal to noise ratio. The signal must be of an amplitude such that it "overrides" the noise, somewhat like speaking louder to be heard in a noisy room. The signal level necessary to produce a noise-free picture will vary slightly from set to set but a signal of 600 μV (microvolts or millionths of a volt) should usually produce reasonable picture quality. Cable companies normally strive for about 1000 μV of signal at the set. No differentiation is made between monochrome and color signal requirements since a signal strong enough to produce a good noise free black and white picture should also produce a good color picture in modern receivers.

Ghosts are caused by poor reception and inadequately designed antenna systems. When two signals from the same source arrive at the same antenna at slightly different times, two pictures are produced. The secondary or weaker signal is referred to as a ghost. Fig. 12-1 illustrates how a ghost picture might be formed. A radio wave travels at approximately 985 feet per microsecond (speed of light) so if a bounce wave reaching the antenna has traveled 1000 feet further than the direct wave, it arrives a full microsecond later than the direct wave. A microsecond (one millionth of a second) may not sound like much time but when translated into the distance of electron beam travel across a 13-inch tv screen it will produce a ghost ¼ inch offset from the regular picture. Ghosts can usually be eliminated by good lead-in wire and a highly directional antenna pointed in the right direction.

In most areas near a tv station an outdoor antenna is not needed. The transmitted waves can be picked up by the uhf "loop" or built-in vhf "rabbit ears." In remote areas, however, an outside antenna is a must. In a single family dwelling the antenna system may be very simple, consisting of an antenna, lead-in wire, and perhaps a rotor. For



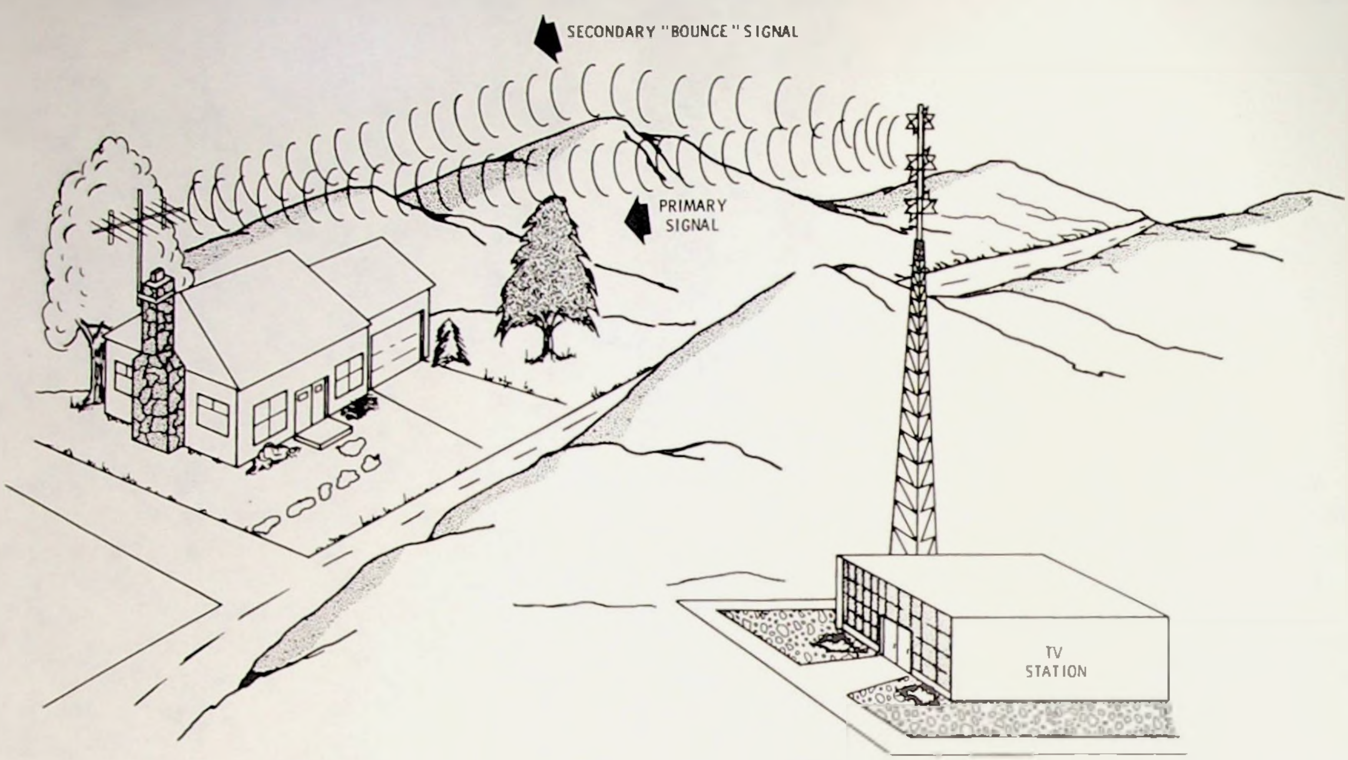


Fig. 12-1. Two signals, one delayed slightly, cause ghosting.

the apartment house, motel, or school, a larger more complex system must be provided.

In this chapter we discuss antenna theory, general information, system installation, and safety. Only a minimum of antenna theory is presented due to space requirements and the complexity of the subject. If further theory is desired, numerous texts are available. One of the most complete textbooks on antenna theory is the American Radio Relay League's *The A.R.R.L. Antenna Book*. One of the best industry produced texts is Channel Master's *MATV Systems Planning Manual*.

ANTENNA SAFETY

The most important consideration in antenna installation and troubleshooting is *safety*. Each year people who should know better become careless—and die, because they ignore antenna safety guidelines. The rules for working safely with antenna systems are few and simple:

1. Think before acting.
2. Do not erect an antenna structure near enough to a power line to allow contact between the two.
3. Do not try to throw lead-in wires from one point to another where there is even a remote chance of power line contact.
4. Ground all antenna structures properly.
5. Safety check receivers for power line leakage to the antenna.
6. Use standard antenna system connectors and equipment.
7. Use proper climbing equipment (ladders, supports, etc.).
8. Dress correctly—hard hat, rubber sole "gripper" shoes, etc.
9. Obtain help to handle heavy or hard to manage equipment.

The biggest hazard in installing antennas is from coming in contact with the power mains or ac distribution lines. Many people are injured or killed each year when they raise or lower antennas or antenna towers into the ac power wires. Others experience the same fate as they drop, throw, or in some way have lead-in cable and ladders come into contact with the power lines. You cannot be too cautious. Plan the system so the antenna, tower, lead in, and ground wire are clear from the power wires by a great enough distance that there is *no chance* of any contact. This would also apply during the carrying of the antenna system components to the installation site.

Climbing safety should not be ignored either. It is essential that good climbing apparel be worn. Soft, rubber soled shoes, loose, flexible pants and shirts, and a hard hat are required. Ladders should be constructed of a nonconductive material, such as wood. If an aluminum ladder must be used it should *never* be placed so that it could contact power lines in the event it slides or falls. On high chimneys where a chimney mount is being used, a smart installer will use pole climbing gear similar to that used by telephone and power linemen.

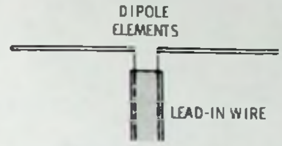


Fig. 12-3. A simple dipole.

SMALL SCALE ANTENNA SYSTEMS

An antenna installation for the single family residence is shown in Fig. 12-2. Make note of the terminology applied to the various parts of the system. Portions of this small scale system will be discussed in the following pages. Then attention will be focused on small scale antenna system installation and troubleshooting.

Antenna Theory

The dipole antenna is used as a basis for study of more elaborate antenna types. It consists of two wires or metal rods mounted in line with each other but not making contact. Fig. 12-3 shows the dipole in simple form. All antennas are considered to be a signal source or "generator" having an impedance as illustrated in Fig. 12-4. The gen-

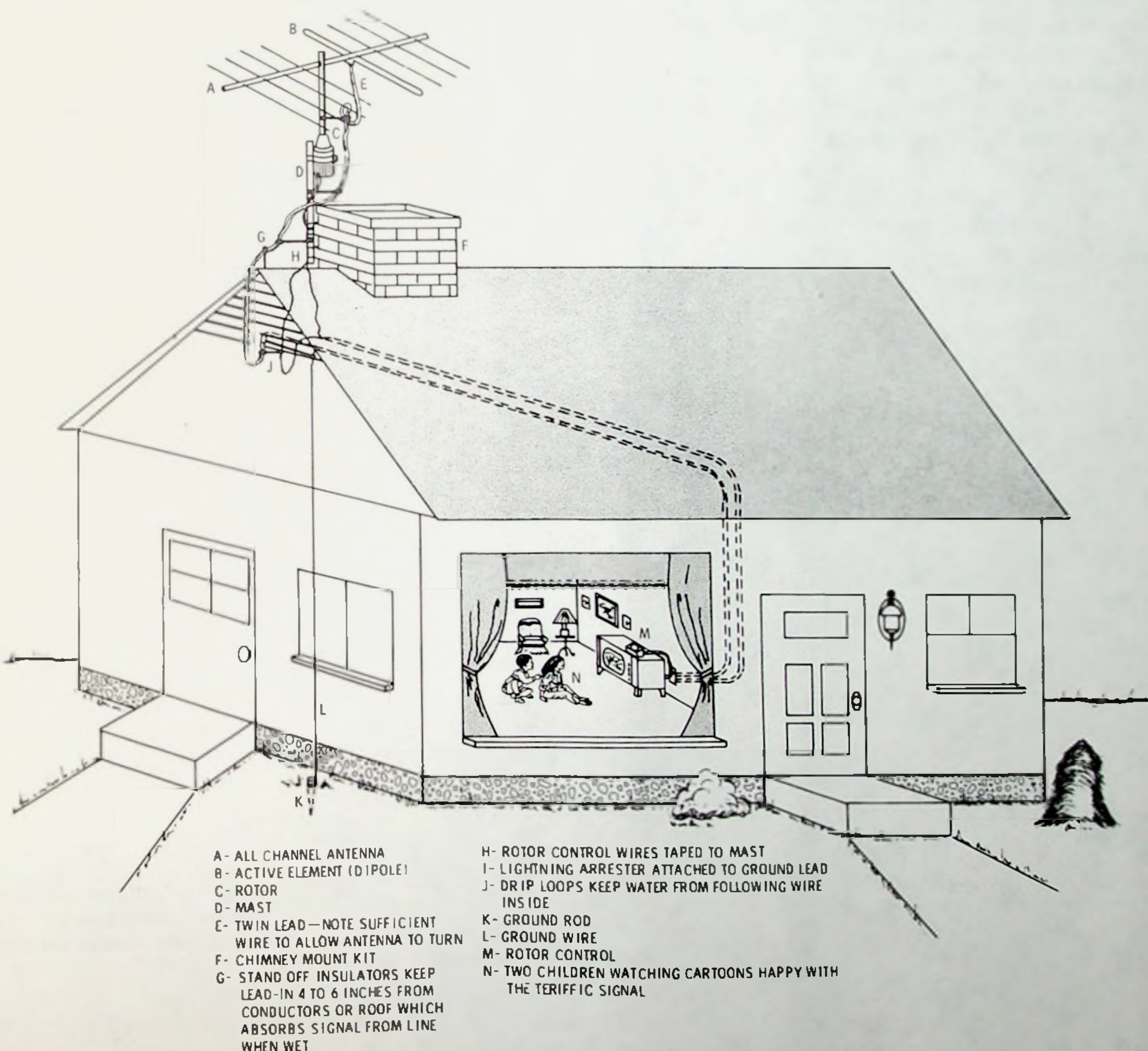


Fig. 12-2. A single dwelling antenna system.

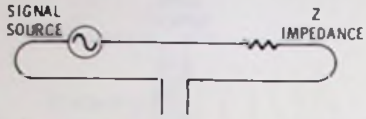


Fig. 12-4. All antennas are considered to be a signal source with an impedance.

erator is in reality the received signal created by the broadcast signal (magnetic field). The impedance depends on the type and design of the antenna and varies with the physical length of the antenna in proportion to the wavelength of the signal being received.

Signal wavelength is illustrated in Fig. 12-5 as the distance between points of a wave that have the same polarity and amplitude. Notice that as the antenna current is maximum, a maximum number of magnetic lines of force are created and their numbers gradually decrease as antenna current decreases. Put in terms of travel distance, at the speed of light, the higher the frequency the closer together in space are the points of maximum magnetic flux so the wavelength is short, hence the term shortwave. Likewise, the lower the frequency the further apart are these points and the wavelength is longer. The wavelength in meters can be calculated by dividing the speed of light in meters by the frequency. For example a frequency of 60 MHz has the wavelength of 5 meters, or roughly 16.4 feet.

$$\lambda = \frac{300,000,000}{f}$$

where,
λ is wavelength in meters,
f is frequency in hertz.

or

$$\lambda = \frac{300}{f}$$

where,
f is frequency in megahertz.

Wavelength is of the utmost importance in antenna design. As the magnetic field crosses an antenna, currents are induced which duplicate the broadcast antenna current and they distribute themselves along the antenna according to the densities of the magnetic field as seen in Fig. 12-6. In Fig. 12-6 antenna currents are represented by a sine wave showing their distribution on the antenna. The current must be minimum at the end of the conductor. Because the antenna is a resonant circuit, its output is greatest when it is resonant with the received signal. The resonant frequency

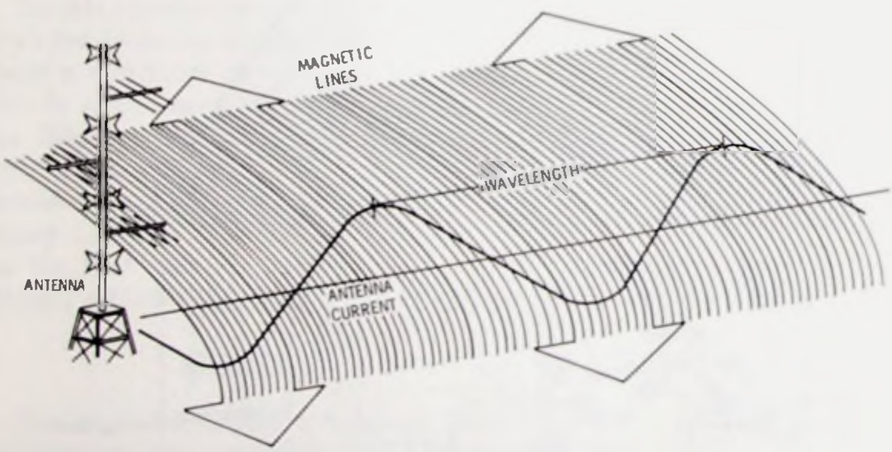


Fig. 12-5. Wavelength is the distance between points of equal amplitude at same polarity.

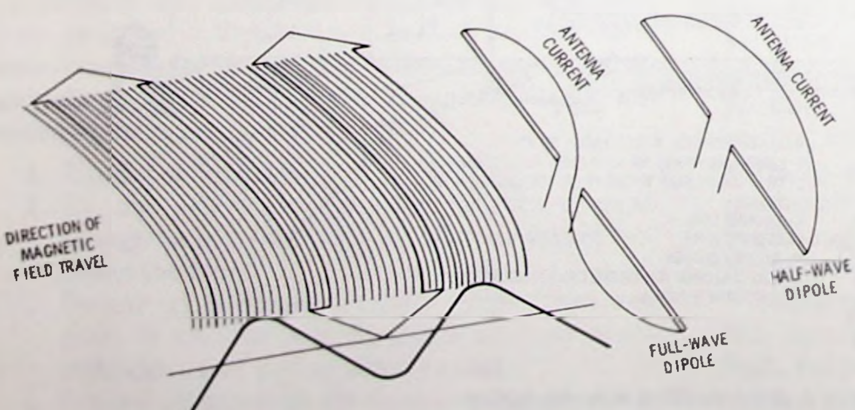


Fig. 12-6. Currents are created in the antenna as the magnetic field cuts across the antenna.

of the antenna is almost wholly determined by the length of the dipole. However, because of capacitance which alters antenna current distribution, the antenna must be shortened by about 6% in order to be resonant. The resulting formula for half-wave antenna calculations reflecting this 6% change is:

$$\lambda = \frac{462}{f}$$

where,
  λ is wavelength in feet,
  f is frequency in megahertz.

Because current is maximum at the center terminal of the half-wave dipole, according to Ohm's law the impedance must be minimum. The impedance of the half-wave dipole is approximately 72 ohms. As antenna length is changed and the signal take-off point changes relative to the current distribution, antenna impedance changes. Because the current distribution on the full-wave dipole is such that the current is minimum at the signal take-off points (see Fig. 12-6) impedance is maximum at approximately 5000 ohms.

Though the antenna has been explained to this point as being a signal source with an impedance, it is sometimes more advantageous to consider it as a series resonant circuit. Fig. 12-7 shows the equivalent circuit of the dipole with its inductance, capacitance, and resistance. The values of inductance and capacitance are such that the antenna is always resonant at the frequency for which it is approximately one-half wavelength long.

The most common tv antenna type is the folded dipole shown in Fig. 12-8A. It has essentially the same characteristics as the simple dipole. It has the same outside length, the same resonant frequency, and the same pick-up pattern as shown in Fig. 12-8B. But two considerations make the folded dipole more useful for tv uses. It has a higher impedance (300 ohms) and a broader frequency response which is better for picking up a 6 MHz wide channel bandwidth.

To the folded dipole "active" or "driven" element, parasitic elements are added as seen in Fig. 12-9. Parasitic elements improve the antenna performance but are not physically connected to the active element. Directors are placed in front of the active element. As they have currents induced on them by the arriving signal, the magnetic field about each director is such that they are slightly out of phase and add to the signal as it reaches the active element. This causes more signal to be available from the dipole than would be possible without the directors. The antenna is now considered to have a "gain" because it has more output than the dipole alone.

When a reflector is added, its placement and length is such that its magnetic field tends to cancel out any signal coming from the rear of the antenna. So an antenna with directors and a reflector will have gain on signals it is pointed toward, and very little signal reception from the rear and sides. By adding reflectors and directors and by changing spacing and length of the antenna elements, broadband antennas can be designed to cover all tv channels.

As you have previously learned, impedances must be matched to get maximum transfer of power from one circuit to another. Considering

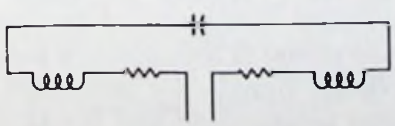
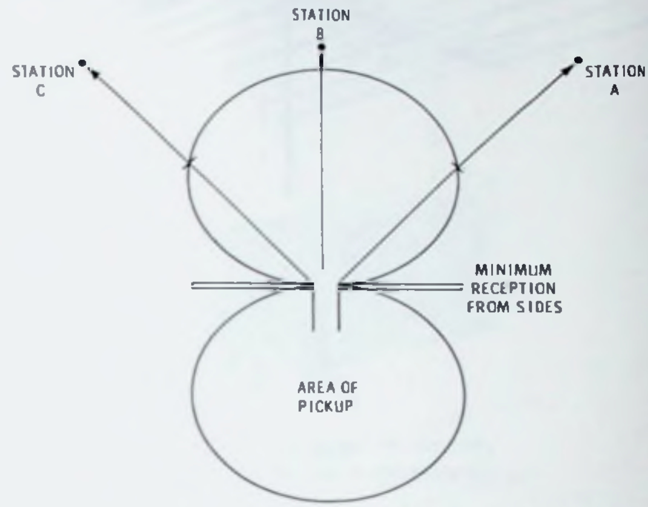


Fig. 12-7. Equivalent circuit of a dipole antenna.

(A) Folded dipole.



(B) Dipoles pick up equally well on each broadside. Best reception on station B, worst on station A.

Fig. 12-8. Folded dipole and pickup pattern.

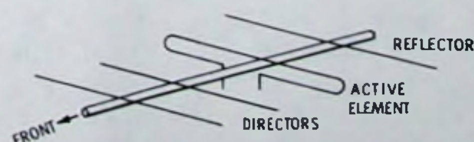
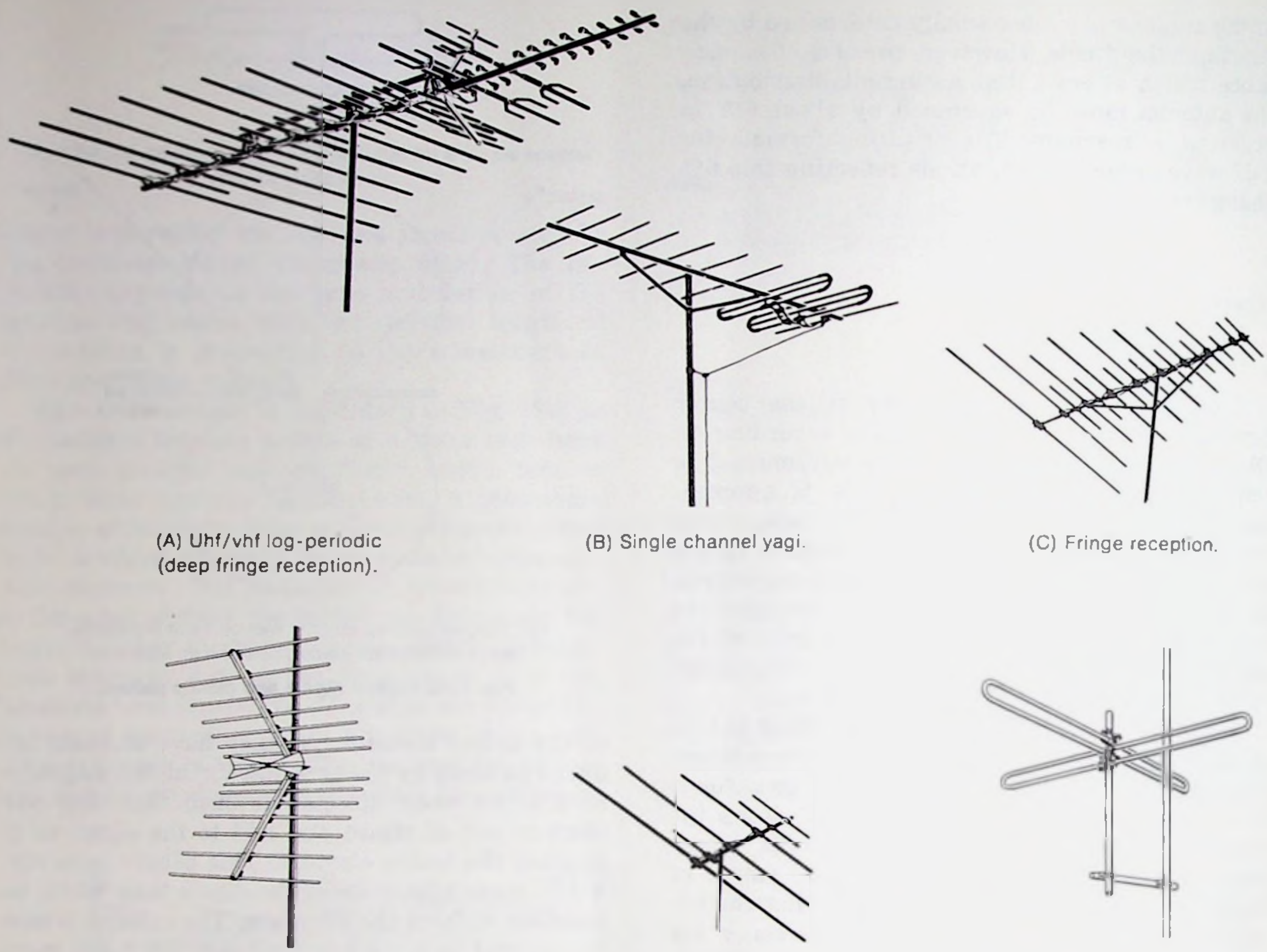


Fig. 12-9. Addition of directors and reflectors make antenna more sensitive and directional.



(A) Uhf/vhf log-periodic (deep fringe reception).

(B) Single channel yagi.

(C) Fringe reception.

(D) Uhf corner reflector.

(E) Local reception.

(F) Fm.

Fig. 12-10. Common antenna types. ***(Courtesy Channel Master Corp.)***

the extremely small signal available at the antenna, it is obvious that the entire system, antenna, lead-in, and tv must be well matched in order not to loose signal. A 300-ohm folded dipole matches well with readily available 300-ohm twin lead which in turn matches the common 300-ohm receiver input. For matching 300-ohm antennas to other types of wire, special matching transformers are necessary. Wire types and characteristics will be covered later in this chapter.

The greater the number of elements the antenna has, the more gain, directivity, and front to back rejection ratio it will have. Antenna manufacturers classify reception areas as local, fringe, and deep fringe or some variation of these. Fig. 12-10 gives an illustration of the antennas used for each signal classification. Notice that the greater the distance from the station the larger the antenna necessary. There is no substitute for mass of metal for good reception. As described previously, when the magnetic field broadcast by the station cuts across the antenna elements, a small current is produced in the antenna. The varying magnetic field produces a current in the antenna that is identical to the current in the broadcast antenna which created the magnetic field. More metal for the field to cut across means more current induced. Just as in transformers when more turns are added to the secondary coil, more voltage output is obtained.

Because of this principle of magnetic field cutting across mass, antenna orientation is important. Signals are broadcast polarized in a horizontal or vertical direction, or in some cases a portion of the signal is broadcast in both polarizations. Television signals are broadcast primarily via horizontal polarization and for this reason tv antennas are oriented horizontally. Most inter-

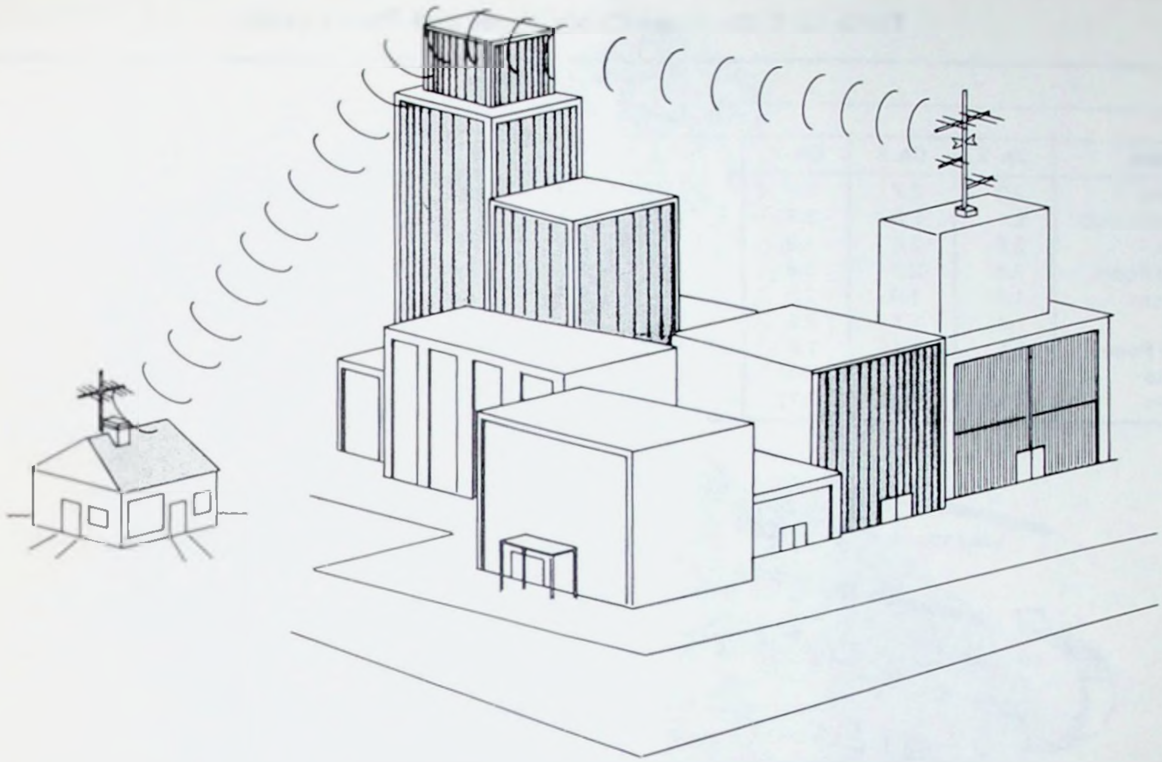


Fig. 12-11. Sometimes the primary signal is blocked out and the antenna must be pointed at a strong secondary signal.

ference is radiated by vertical polarization so by broadcasting in a horizontal plane, most interference is kept to a minimum. The receiving antenna must be "pointed" at the broadcast station or the signal to be received. In cases where "bounce" signals and multipath reception is common, the antenna may have to be oriented toward the strongest signal or toward the bounce location. An example might be such as seen in Fig. 12-11 where the antenna is pointed toward a nearby building in order to receive any signal at all. Remember in such a situation, the more antenna elements, the more directional the receiving pattern, and the greater the rejection of signals from the sides and the rear of the antenna.

Lead-In Wire

Most home use antennas have 300-ohm impedance outputs so for low signal loss, correct impedance matching is a must. The most commonly used lead-in line is the 300-ohm twin lead shown in Fig. 12-12. Lead-in wire is classed according to manufacturer's type, such as twin lead, coaxial, ladder, etc. Each type is further classed according to its characteristic impedance and the insulation materials used. The term impedance has been explained and lab exercises performed in the SAM. In wire the term "characteristic" impedance is used. If wire is viewed in relation to its effect on

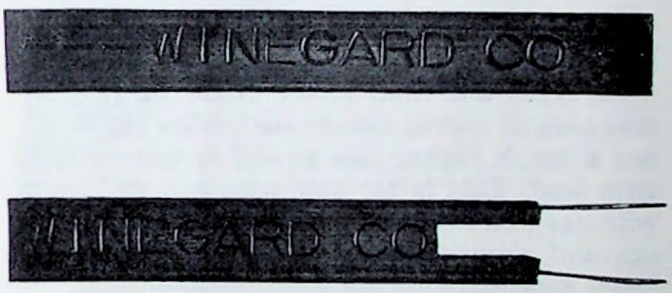


Fig. 12-12. Twin lead wire.

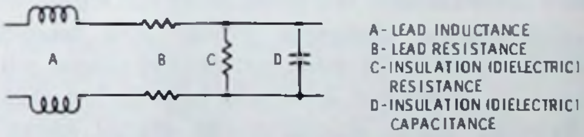


Fig. 12-13. Wire has resistance, capacitance, and inductance which affects its use at high frequencies.

signal currents it must appear as seen in Fig. 12-13, as having inductance, capacitance and resistance along its entire length. When this LRC is mathematically combined it is referred to as the characteristic impedance. Regardless of the length of wire the *relationship* of L, R, and C to each other is constant so the impedance is constant no matter what the length of the wire. It is a characteristic of the wire type, size, insulation, and spacing and is thus called the "characteristic" impedance.

Table 12-1. Common Cable Types and Their Losses											
Cable Characteristics											
Nominal Attenuation dB per 100 Feet											
Cable	Ch. 2	Ch. 6	Ch. 7	Ch. 13	Ch. 20	Ch. 30	Ch. 40	Ch. 50	Ch. 60	Ch. 70	Ch. 83
Color Duct	2.3	2.7	3.8	4.2	6.5	7.0	7.5	7.8	8.0	8.4	9.0
Foam Color Duct	2.1	2.5	3.3	3.8	5.9	6.3	6.7	7.0	7.3	7.7	8.0
RG 59/U	2.6	3.5	4.9	5.4	8.3	8.8	9.2	9.7	10.3	11.0	11.9
RG 59/U Foam	2.3	2.7	3.8	4.2	6.2	6.6	6.8	7.1	7.3	7.7	8.0
RG 6 Foam	1.7	1.9	2.8	3.0	4.8	5.2	5.6	5.9	6.2	6.5	6.8
RG 11/U	1.4	1.7	2.2	3.2	5.1	5.3	5.5	5.7	6.1	6.2	6.8
RG 11/U Foam	1.1	1.4	1.6	2.3	3.9	4.0	4.1	4.2	4.4	4.6	4.9
.412 Cable	.74	1.0	1.4	1.5	2.5	2.6	2.7	2.9	3.1	3.3	3.5
.500 Cable	.52	.67	.72	1.1	1.5	1.8	2.1	2.4	2.7	3.0	3.1

Courtesy Channel Master Corp.

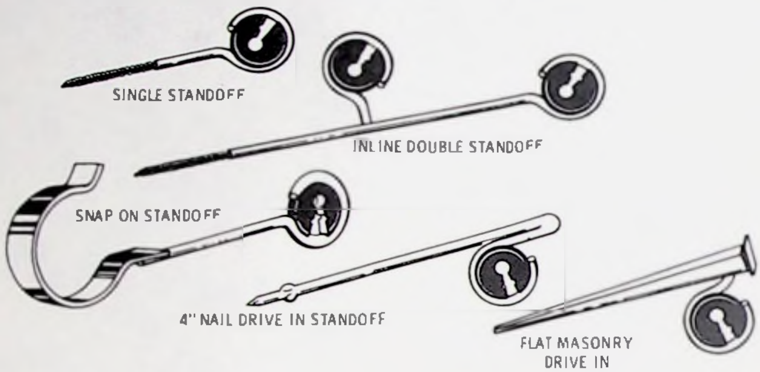


Fig. 12-14. Lead-in and standoff insulators hold the lead-in away from materials which absorb or re-radiate signals.

Some wire types have advantages over others for particular uses. Table 12-1 shows common cable types and their losses. Notice in this table that coaxial (often called coax) cable (RG 59/U) has a much higher loss at uhf frequencies than twin lead. This is for new wire and will change with age and deterioration. Twin lead cracks with age and absorbs moisture causing much higher losses especially during damp weather.

Coax is much better than twin lead in areas where interference is a problem or the signal must be distributed alongside power and telephone lines. Because of its construction, the shield, which is usually grounded, conducts interfering signals to ground while shielding the signal carrying inner wire. Twin lead provides little protection against interference but has lower losses at high frequencies. More care must be taken in routing twin lead. Because of the lack of shield, if the wire is laid on a large mass of metal such as guttering, aluminum siding, etc., signal is absorbed from the lead in and signal loss results. Interference can also be the result of this as the metal also absorbs signals and re-radiates them to cause interference in the lead in (see Fig. 12-14).

Most household installations requiring a short lead in to one or two sets will use twin lead. Twin lead with its 300-ohm impedance can be connected directly to the receiver and the antenna, but 75-ohm coax requires matching transformers as seen in Fig. 12-15. Use of twin lead presents another advantage over coax in that it is easily connected. Coax requires special connectors as shown in Fig. 12-16, but twin lead requires only stripping and wrapping around a screw terminal.

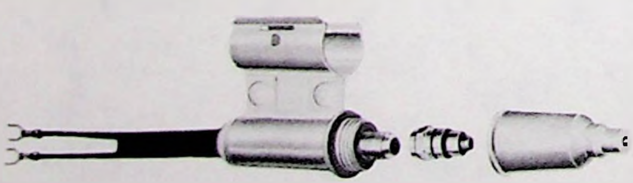


Fig. 12-15. Antenna matching transformer (balun). (*Courtesy Winegard Co.*)

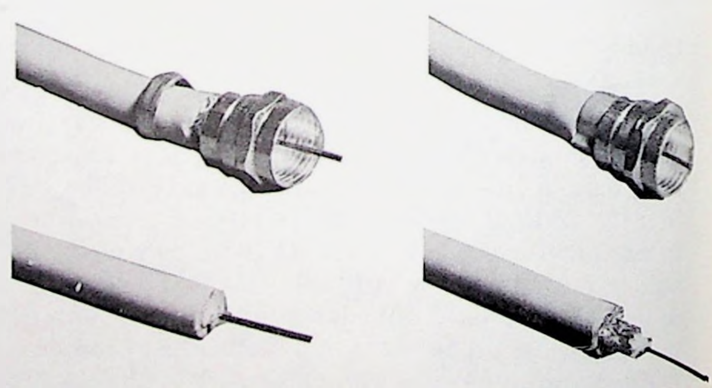


Fig. 12-16. RG-59 cable and F connector. (*Courtesy Winegard Co.*)

Fig. 12-17. Field-strength meter. (*Courtesy Blonder-Tongue Laboratories, Inc.*)

A word about purchasing lead-in wire. Do not buy "bargain basement" wire. It may be coax or twin lead but with cheap wire, impedances change with insulation imperfections and the shield may be sparsely woven. In many cheaper twin lead wire brands, there will be a big difference in the wire resistance due to the reduced number of strands of wire in the cheaper lead in.

Signal Strength

It is necessary to have some idea of the signal strength available at the antenna before much time and money is expended in putting in a system to find that it doesn't work. A field-strength meter (Fig. 12-17) connected to a test antenna will indicate how much signal is available. In mountainous regions or in cities, a portable tv is helpful because it gives an indication of quality of picture as well as signal strength indication. A field strength meter may indicate good signal strength but cannot differentiate between a strong primary signal and several weak "bounce" signals which would appear as ghosts on the tv.

In most suburban areas, neighborhood signals can be expected to be similar but in rural areas they vary widely. For assurance of a working system, anywhere, the signals should be measured before planning the system.

When possible the same antenna should be used for signal tests as will be used in the installation. If this is not possible, use an antenna with a known gain figure. Then the expected signal level can be determined for the antenna to be used. The signal levels found at different heights and locations in the area should be recorded. The antenna location can then be determined as that with the best overall signal levels.

The Decibel (dB)

Signal levels are measured in microvolts but because of the difficulty in doing calculations with the 6 and 7 digit numbers, most antenna calculations are made in decibels. The bel is a unit of measure of power related to sound production and named for Alexander Graham Bell, inventor of the telephone. The decibel is equal to 1/10 of a bel. Decibels are logarithmic *ratios* and as such they are added and subtracted instead of divided and multiplied. In almost all antenna installations because of the use of decibels, mathematics is kept to the addition and subtraction of one and two digit numbers.

The mathematical formula for the decibel used in antenna work is:

$$dB = 20 \log_{10} \frac{E1}{E2}$$

You will probably find little use for the formula since most people use prepared tables such as the one in Table 12-2.

It was mentioned that the dB is a ratio—as such it has no absolute value. Think of it as a rubber rule—it merely indicates the relationship of a measurement to a preestablished reference level. The reference level for antenna measurements is a standard of 1000 μV. Because of the logarithmic nature of the dB, the relationships are NOT linear. For example 10 dB is not twice as much as 5 dB. A signal level of 5 dB is equal to 1800 μV and a 10-dB level is equal to 3200 μV. Chart 12-1 gives some examples of how different dB levels relate to each other. Note that the reference level used in antenna calculations is 1000 μV *across 75 ohms of impedance.* With this reference, 0 dB equals 1000 μV across 75 ohms. A signal of less than 1000 μV will be given as a *negative* dB number. The 1000-μV and 75-ohm figures were chosen because in earlier times 1000 μV was the signal level thought necessary to provide a good picture and the sets often used 75-ohm inputs. We still try to have 1000 μV of signal and many manufacturers are putting 75-ohm connectors on the set along with the 300-ohm connectors. Use of 75-ohm inputs allows the set to be used directly on cable systems. The following are examples of the use of dB measurements:

Chart 12-1. Typical dB/μV Comparisons

10 dB = 3.2	× reference level of 1000 μV = 3200 μV	
20 dB = 10	× reference level of 1000 μV = 10,000 μV	
30 dB = 32	× reference level of 1000 μV = 32,000 μV	
40 dB = 100	× reference level of 1000 μV = 100,000 μV	
60 dB = 1000	× reference level of 1000 μV = 1,000,000 μV	

Table 12-2. dBmV Versus Microvolts

dBmV	uV	dBmV	uV	dBmV	uV
−40	10	0	1,000	40	100,000
−39	11	1	1,100	41	110,000
−38	13	2	1,300	42	130,000
−37	14	3	1,400	43	140,000
−36	16	4	1,600	44	160,000
−35	18	5	1,800	45	180,000
−34	20	6	2,000	46	200,000
−33	22	7	2,200	47	220,000
−32	25	8	2,500	48	250,000
−31	28	9	2,800	49	280,000
−30	32	10	3,200	50	320,000
−29	36	11	3,600	51	360,000
−28	40	12	4,000	52	400,000
−27	45	13	4,500	53	450,000
−26	50	14	5,000	54	500,000
−25	56	15	5,600	55	560,000
−24	63	16	6,300	56	630,000
−23	70	17	7,000	57	700,000
−22	80	18	8,000	58	800,000
−21	90	19	9,000	59	900,000
−20	100	20	10,000	60	1.0 volt
−19	110	21	11,000	61	1.1
−18	130	22	13,000	62	1.3
−17	140	23	14,000	63	1.4
−16	160	24	16,000	64	1.6
−15	180	25	18,000	65	1.8
−14	200	26	20,000	66	2.0
−13	220	27	22,000	67	2.2
−12	250	28	25,000	68	2.5
−11	280	29	28,000	69	2.8
−10	320	30	32,000	70	3.2
−9	360	31	36,000	71	3.6
−8	400	32	40,000	72	4.0
−7	450	33	45,000	73	4.5
−6	500	34	50,000	74	5.0
−5	560	35	56,000	75	5.6
−4	630	36	63,000	76	6.3
−3	700	37	70,000	77	7.0
−2	800	38	80,000	78	8.0
−1	900	39	90,000	79	9.0
−0	1,000	40	100,000	80	10.0

1. A known antenna with a 6 dB gain is being used to make preliminary signal tests.
2. The antenna to be installed will have a 12 dB gain.
3. The field-strength meter shows an output of −8 dB or 400 μV from the test antenna (see Table 12-2).

What will be the signal strength output from the new antenna?

1. It has a 6 dB gain over the test antenna.

new antenna	12 dB	
test antenna	6 dB	
difference	6 dB	more gain with the new antenna

2. With the 6 dB gain added to the −8 dB of the test antenna a signal strength of −2 dB should result. A signal strength of −2 dB equals 800 μV of signal, enough to give a good picture though not up to standard. If more signal is needed a higher gain antenna or an amplifier could be used.

Antenna Amplifiers

When the signal is weak special low noise preamplifiers are mounted on the antenna (see Fig. 12-18) to boost the signal level. A power supply comes with the amplifier and is often mounted on the rear of the receiver. It supplies dc to the preamp through the lead-in wire.

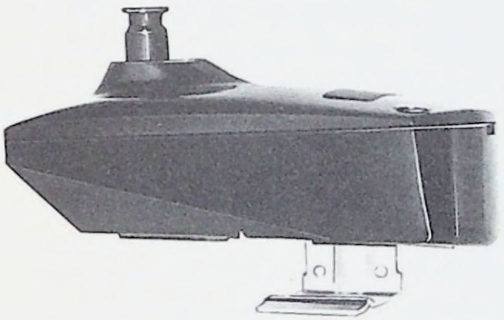


Fig. 12-18. Antenna preamplifier. (*Courtesy Winegard Co.*)

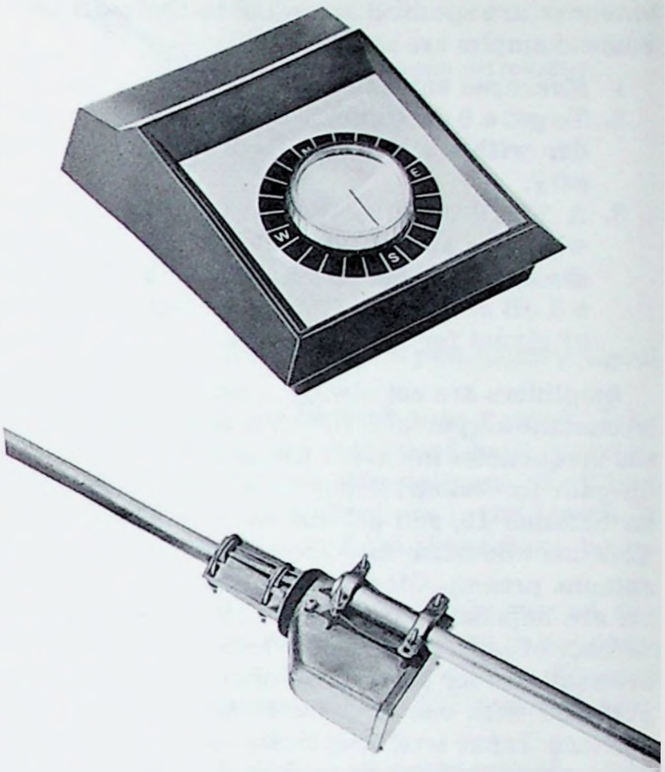


Fig. 12-19. Antenna rotator. (*Courtesy Channel Master Corp.*)

When the signal survey has been made with a field-strength meter and a portable tv, and the available signal is still less than required for a good picture, an amplifier should be chosen which can provide the necessary gain. Amplifiers like

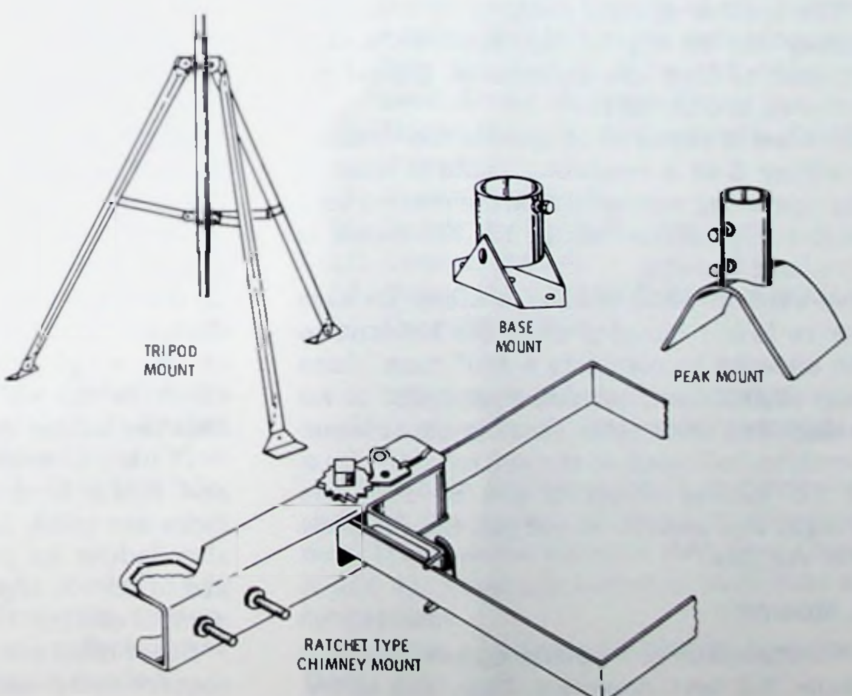


Fig. 12-20. Antenna mounting kits.

antennas are specified according to their dB gain. Some examples are as follows:

1. Measured antenna output, −7 dB or 450 μV.
2. To get a 0 dB signal to the receiver an amplifier with a minimum of 7 dB gain is necessary.
3. A 10 dB amplifier can be purchased which will give an output of 3 dB (−7 dB from the antenna plus 10 dB amplifier gain equals a 3 dB output) or 1400 μV of signal—plenty of signal for a good picture.

Amplifiers are not always capable of providing a constant output level for all channels because of the frequencies involved. An amplifier with a 10 dB gain on Channel 2 may have only a 9 dB gain on Channel 13, and a 7 dB gain on Channel 83. This must be taken into account when buying the antenna preamp. Other things necessary to watch for are impedance, maximum input level, and the number of sets which can be connected. Amplifiers are available for use with 75-ohm or 300-ohm outputs and with one or more receiver output connections. Input level specifications are important if the amplifier must be used where a strong local signal can be received. If the local signal is greater in amplitude than the amplifier can handle, the signal will be distorted on that channel.

Antenna Rotators

In locations where signals arrive from several directions a rotator is used to point the all-channel antenna toward the incoming signal to be received. The rotator system consists of a control unit usually set on top of the receiver, and a geared motor to turn the antenna. A typical rotator is shown in Fig. 12-19.

Special wire is required to operate the rotator. Usually either 3 or 4 conductor cable is used to carry the operating current from the control unit to the motor. Operating voltage for the motor is normally about 28 volts.

Observe caution when wiring rotators. Be sure enough wire is left hanging from the antenna to allow the antenna to complete a 360° turn. Once the rotator is installed, set the rotator dial to an identifiable point, i.e., north. Then set the antenna in the direction indicated on the control dial. Use a compass for setting direction and be sure the antenna mast and mounts do not pull the compass off its true reading.

Antenna Mounting

The antenna needs to be above all surrounding obstructions for best reception. They are often mounted on towers, chimneys, roof peaks, the eve of the house, and in the attic. Mounting kits are available for about any place an antenna can be mounted. A selection of mounting brackets is shown in Fig. 12-20.

When using any mounting system use common sense and caution. For a mount that bolts down to the roof, a good quality silicon or latex caulk should be used to ensure against leaks. In locations where high winds are likely, use a low-mass antenna and guy wires. Chimney mounts must not be used on old, deteriorated chimneys. All clamps must be tight so the antenna cannot move. Antennas should not be mounted over metal roofs or in attics where foil-backed insulation or aluminum siding has been used. The presence of such large amounts of metal makes clean signal pickup difficult because of signal absorption and reflection.

Antennas and masts are often hard to manage because of their size. It is advisable to have help in installing antennas of a size or weight that would be difficult for one person to handle easily. Make sure all clamps and brackets are tight before raising the antenna. Coat all connections and clamp screws with a clear plastic spray such as Krylon to prevent corrosion and rust. Then, when the antenna is ready to erect, set the mast to the base and attach two opposite guy wires to their roof anchors. Now, with a helper on one of the remaining two guy wires the two installers can easily pull the antenna into position. These two guy wires are anchored and all guy wires adjusted for a vertical antenna.

If ladders are involved, and they usually are, be sure to use proper safety precautions. A nonconductive ladder is preferred but if an aluminum ladder is used make sure it cannot come in contact with any electrical wiring. The base of the ladder should be placed a distance equal to one-third of the ladder height from the wall. For example, if you have an 18 foot ladder, its base should be placed 6 feet from the wall it is leaning against. If the ladder is pulled from the wall a greater distance than this, it may bend or break because of the weight distribution. If it is placed much closer to the wall than this, there is a possibility that the ladder may topple over backwards.

If an extension ladder is used, keep the rope and pulley in good condition and make sure the locks are solid. Do not attempt to raise an extension ladder by yourself. Even aluminum ladders are often too top-heavy for this and you can lose control easily.

Since most antennas are mounted on the roof or require some walking on the roof it is good to be aware of the dangers and rules of working on roofs. Avoid working on steep roofs without anchoring or safety lines. Don't attempt to work on steep roofs unaided. Hook a ladder over the roof peak so you can work on the ladder, or if possible slant the ladder from the ground so that it is laying on the roof and then work on the ladder. A few don'ts are listed as follows:

1. Don't leave tools lying on the roof—you might step on them and slip.
2. Don't make any sudden moves—if you drop a tool, don't try to catch it.
3. Stay off slate and wood shingle roofs—both are easily damaged and you will have the repair bill to pay.
4. Walk carefully on all types of roofs. Abuse of any roof will cause it to leak and the customer to be very dissatisfied.
5. Don't work close to the edge of the roof.

Grounding and Lightning Protection

All antenna masts should be grounded in the same way as the home electrical system. Use a UL approved ground rod long enough to reach underground moisture—this length will vary greatly from one part of the country to another, so check local electrical requirements. Drive the ground rod into the ground so 6 inches of it remains above the surface. A ground clamp purchased with the rod is used to clamp the large gauge (usually No. 10) wire to the ground rod. The other end of the ground wire is clamped securely to the antenna mast.

The antenna lead in should have a lightning arrester placed between the antenna and the receiver. The lightning arrester provides a spark gap path to ground for high voltages. When a lightning arrester such as seen in Fig. 12-21 is used, lightning is passed to ground via the spark gap between the antenna lead in and ground as the high voltage lightning or static build-up occurs on the line.

Installing the Small System

A well planned antenna system is installed more quickly, easily, and works better after installation than the haphazard installation. Take time to plan so time and effort are not wasted—work safely. A sample plan follows:

1. Determine the type of antenna needed. Take into account the distance from the station, the directivity needed for reduction of ghosts, and the amount of gain needed.

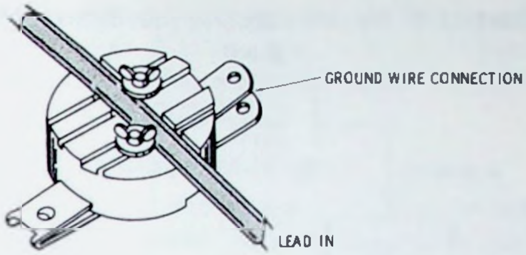


Fig. 12-21. One type of twin lead lightning arrestor.

All these are based on a preliminary signal survey.

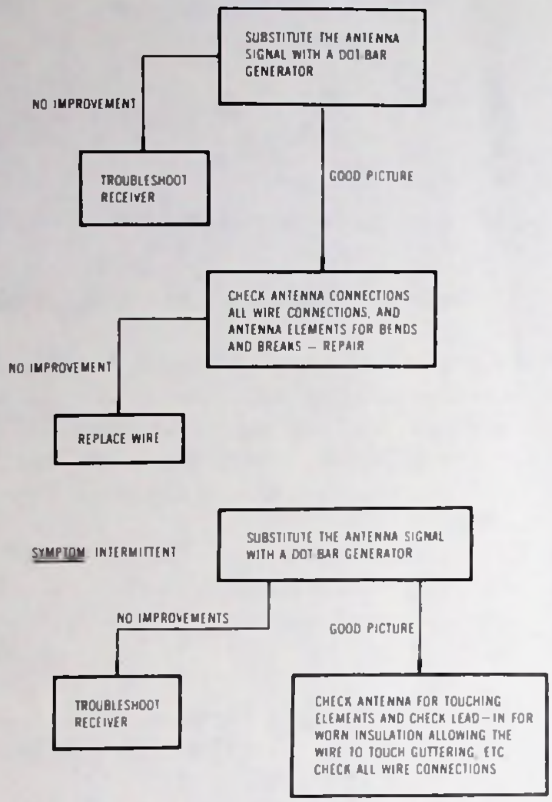
2. Determine the type of wire needed. Take into account the amount of local interference possibilities, the environment of lead in (near power wires, etc.), the length of lead in needed, and the channels to be received.
3. Locate antenna placement. Survey of signal will give some indication as to best location. Observe chimney condition. Observe use of aluminum siding, foil backed insulation, etc.
4. Determine the type of mount needed—it depends on where the antenna is to be located.
5. Determine the location of television receivers.
6. Determine the shortest path for the lead-in wire. Watch for metal (plumbing, guttering, power and telephone lines, aluminum siding, foil backed insulation, etc.). Use feedthrough bushings for feeding wire through walls. Use stand-off insulation for routing lead in around guttering, etc.
7. Run the lead-in wire and rotor wire, if used. Solder all connections.
8. Mount the mast and antenna. Install rotor if used.
9. *Ground the mast.*
10. Install the lightning arrester.
11. Connect the set.
12. Orient the antenna for best signal and align the rotor if used.

TROUBLESHOOTING THE SINGLE DWELLING ANTENNA SYSTEM

The single dwelling system is simple—troubleshoot it via logical elimination, eliminating the most troublesome elements first (see Charts 12-2, 3, and 4). These are normally amplifiers and poor connections.

Common symptoms created by antenna system faults are:

Chart 12-2. Troubleshooting the Unamplified System



Symptoms: Snow, ghosts, weak reception

1. Snow
2. Ghosts
3. Intermittents
4. Weak reception

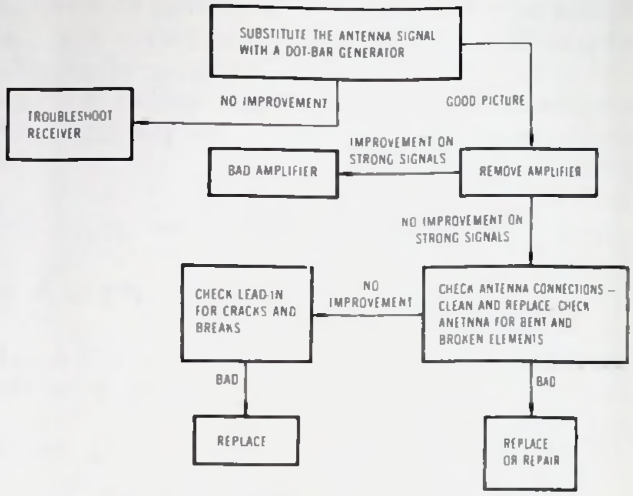
MASTER ANTENNA TELEVISION (MATV)

The MATV systems provide good quality tv signals to the occupants of apartment houses, hotels, motels, schools, and businesses where individual antennas would not be possible for each unit. The MATV systems may be very complex and must be carefully planned to provide the quality of signal demanded by the tv systems in use today. It is basically a system of cables and special equipment used to process and distribute the antenna signal for use by many receivers.

The Head End

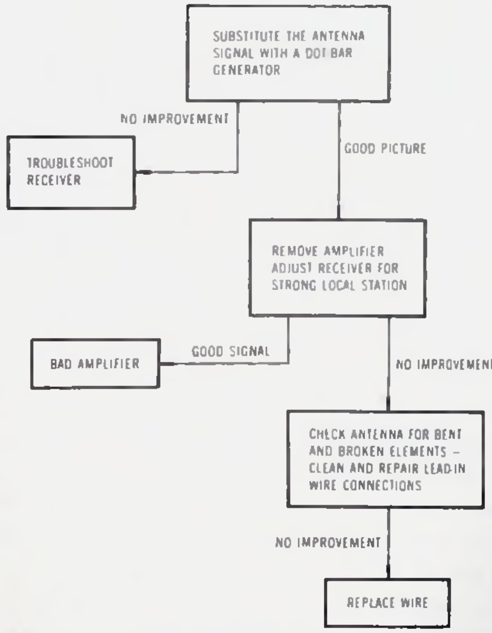
Technicians usually refer to the antenna and signal processing equipment as the "head end" of the system. Signals here may be changed to the frequency of another channel by a process called "converting" and undesirable signals may be trapped and filtered, while desired signals are amplified and distributed.

Chart 12-3. Troubleshooting the System With Antenna Amplifiers



Symptoms: Weak reception, snow, ghosts

Chart 12-4. Troubleshooting the System With Antenna Amplifiers



Symptom: Intermittent

Antennas must be chosen as for small single dwellings. Remember now that a rotor cannot be used and unless all the channels to be received come from the same direction, an all channel antenna cannot be used. Antennas cut for single channels are most often used for MATV systems because they have more gain than all channel antennas. They can also be stacked as shown in Fig. 12-22, for even more gain. Stacked antennas should be spaced as illustrated in Fig. 12-22 so the signals from both antennas travel the same distance before combining. By traveling the same

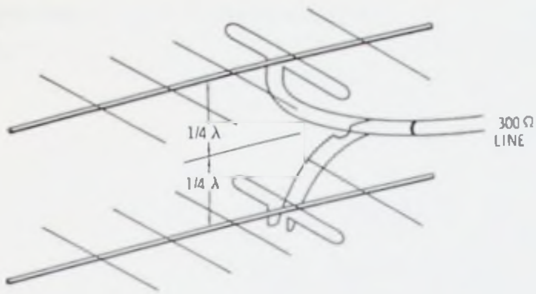


Fig. 12-22. Vertically stacked antennas.

distance the signals are in phase and add, creating an additional gain of up to twice the gain of a single antenna. Antennas may be stacked side by side or vertically. Vertical stacking sharpens directivity in the vertical plane and so reduces noise pickup from sources below the antenna.

Preamplifiers

As with single dwelling systems, if the signal is too weak to provide an acceptable picture it may be preamplified. Preamplification can take place on a single antenna or more than one antenna in a multiantenna system. A typical commercial preamp is shown in Fig. 12-23.

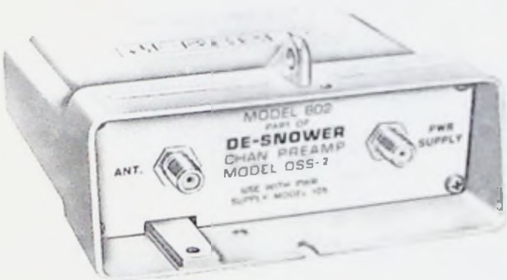


Fig. 12-23. MATV single channel antenna preamp. (*Courtesy Jerrold Electronics Corp.*)

The following four characteristics should be examined when choosing a preamp:

1. Is it intended for use with vhf and uhf, vhf or uhf only, and does it have fm traps to eliminate fm interference.
2. Preamp gain must be chosen to provide adequate signal to the system.
3. Input capability of the preamp is given in μV and is important where both high and low level signals will be amplified. The high level local signal must not overload the system so the higher the input capability the better. An overloaded input causes severe signal distortion.
4. All preamps have noise figures which indicate the amount of noise (picture snow) the amplifier creates. Of course, the lower, the better, which means a large *negative* dB number.

Signal Processing and Mixing

Signal processing equipment must be used to sort the good signals from the bad, eliminate interference, mix signals, convert them to different frequencies, and attenuate (make smaller) them. The equipment used may consist of filters, traps, mixers, converters, and attenuators.

Filters and Traps

Filters and traps are used to eliminate interfering signals such as fm stations and various other broadcast and industrial rf sources. The packaging of a trap circuit may take any form, from a sealed box with input and output connectors to a unit with dials for trap band width adjustments as seen in Fig. 12-24.

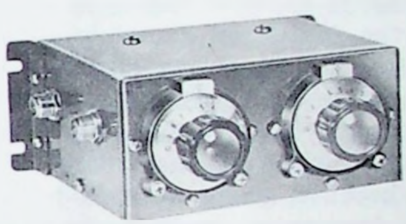


Fig. 12-24. Adjustable trap. (*Courtesy Channel Master Corp.*)

Mixers

Where individual single channel antennas are used, mixing is usually required. Remember that the total resistance or impedance of a group of parallel connected components is a function of $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots + \frac{1}{R_n}$. When antennas are connected in parallel the impedance of the system drops accordingly, antenna to line mismatch occurs, and signal loss results. By using a mixer (see Fig. 12-25) several antennas can be fed into the mixer, the system impedance is unchanged, and all the channels come out on one line for common amplification and distribution.

Converters

Converters work like the tv tuner. They beat the incoming channel against a local oscillator to create a difference signal at a frequency of another tv channel. They are most often used to convert a uhf channel down to an unused vhf channel for distribution as a lower loss, low frequency

Fig. 12-25. Antenna signal mixer. (*Courtesy Channel Master Corp.*)

signal. Also, where adjacent channels may cause interference one of the channels may be converted to a nonadjacent channel before distribution.

Attenuators

Wide variations in signal levels usually exist from channel to channel. For equal quality on all channels, the individual signal levels should be balanced to prevent strong signals from overriding the weaker signals. An attenuator (Fig. 12-26) can be fixed or variable and can be used to attenuate a single channel or the entire band. However, because attenuators drop the output level of all frequencies by the same amount, if a single channel is to be attenuated, it must be separated from the nonattenuated signals.

DISTRIBUTION SYSTEM

When the head end has been designed, installed, and the levels of each channel equalized, it is time to design the distribution system. Once the signal out of the head end has been checked and when the system losses have been calculated, the distribution amplifier can be selected. Following a description of distribution system equipment will be an analysis of a typical MATV system illustrating how to determine system losses.

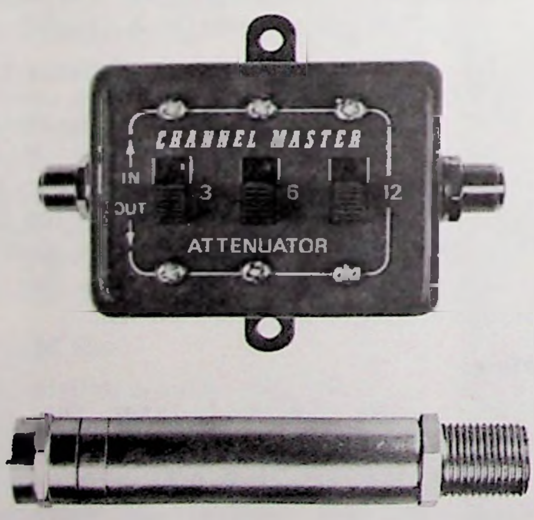


Fig. 12-26. Signal attenuator. (*Courtesy Channel Master Corp.*)

Distribution Amplifiers

The purpose of the distribution amplifier is to boost the head end signal enough to overcome system losses and to provide a minimum of 0 dB (1000 μV) per receiver operated from the system. In order to choose a distribution amplifier the technician must consider the channels to be received, the loss of the system to be fed with the signal, gain of the amplifier, and the available input signal. A distribution amplifier is pictured in Fig. 12-27.

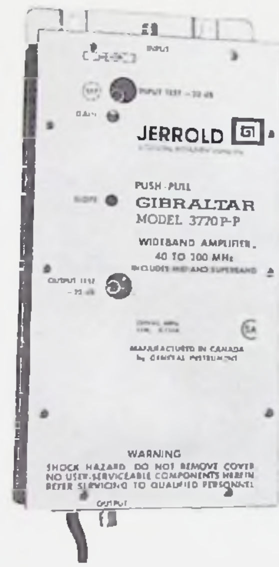


Fig. 12-27. A distribution amplifier. (*Courtesy Jerrold Electronics Corp.*)

Either broadband or single channel amplifiers may be chosen. Single channel amplifiers are often used when adjacent channels are involved. If adjacent channels are to be received, each channel must be filtered to prevent interaction. To achieve this, single channel amplifiers are required. If adjacent channel reception is not intended, a broadband amplifier can be used. Broadband amplifiers may be purchased for vhf and fm, uhf, or combined vhf, uhf, and fm.

Single channel amplifiers have the advantage of providing complete control over each individual channel and some have agc while others have manual gain controls. The loss of a single channel doesn't wipe out the entire system—a definite plus. These advantages make the single channel amplifier much preferred over broadband amplifiers for all larger MATV systems. In addition they may have other important features such as attenuator, gain, and tilt controls. The attenuator can reduce the input by a specified amount across the entire bandwidth of the unit. If the amplifier input signal is 12 dB and the amplifier cannot accept over 8 dB without overloading, the attenuator can reduce that signal to a usable level.

Gain controls are used to adjust the output level of the amplifier to match it to the system loss. Most amplifiers will provide a gain control for each band (vhf lo, vhf hi, and uhf) for more flexibility.

Tilt controls "tilt" the amplifier characteristic to give more amplification at one end of the band and less at the other end. Usually, less amplification is necessary at the low frequency end of the band than at the high frequency end. The reason is that the distribution system has more loss in the cable at the higher frequencies so the higher frequencies need more amplification.

Other Distribution Equipment

The MATV systems use 75-ohm coaxial cable to distribute the signal. Most installations use cable designated RG-59 and "F" connectors (Fig. 12-28). Where longer runs of cable are needed, larger lower-loss cable is used. Typical cable desig-

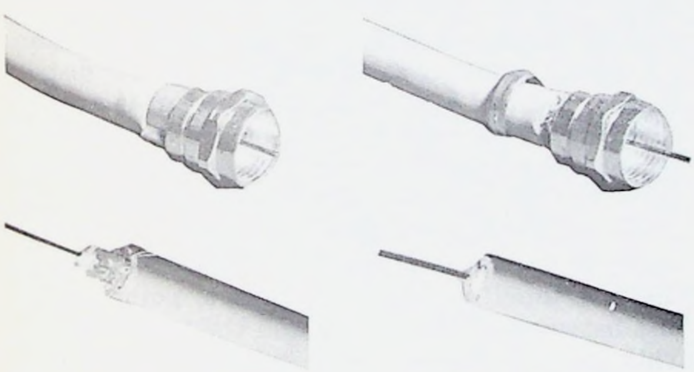


Fig. 12-28. RG-59 cable and F connector. (*Courtesy Blonder-Tongue Laboratories, Inc.*)

nations for such "long run" uses are RG-11U, 0.412 or 0.500. These cables have solid aluminum shields and foam insulation, making them suitable for outside and underground use. Special, larger connectors are used with these cables. Table 12-1 gives the loss of distribution cables per 100 feet. Cable loss must be taken into consideration when planning the distribution system.

Splitters

Sometimes it is necessary to "split" the signal into more than one distribution line. The line splitter accomplishes this objective. They may be purchased according to the number of outputs available. Two, three, or four way splitters may be purchased. A two way splitter is shown in Fig. 12-29.

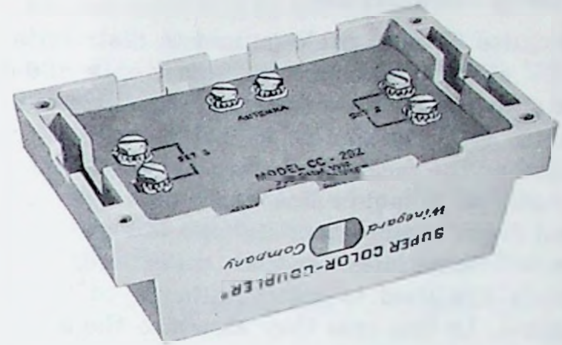


Fig. 12-29. A two way splitter. (*Courtesy Winegard Co.*)

Tapoffs

A tapoff is used to deliver signal to individual receivers from the distribution line. They take enough signal from the line to operate the set, pass the larger part of the signal down the line and provide isolation between sets. If isolation were not provided, local oscillator signals from one set could possibly feed back into the line to other sets creating interference.

Two types of tapoffs are generally available: the wall tap and the line tap. Wall taps are placed in the wall, like an ac outlet, in standard electrical boxes. They are available with 300- or 75-ohm outputs.

Line tapoffs are used to provide an output from a central trunk line as might be found running down a long hallway in schools, motels, etc. They provide low loss to signals passing on down the trunk line, with a high degree of receiver isolation from the line. The ac and dc voltages will pass through a line tapoff from trunk line input to output but not to the receiver output. By passing ac/dc voltages, control voltages can be put on the

Fig. 12-30. A line tapoff. (*Courtesy Channel Master Corp.*)

trunk line to operate in-line signal boosting amplifiers. A line tapoff is shown in Fig. 12-30.

Matching Transformers

Because 75-ohm cable is used to distribute the MATV signal and many tv's accept only 300-ohm inputs an impedance matching transformer must be used. It is recommended that the transformer be used at the receiver antenna terminals because a length of 300-ohm line could pick up enough signal from strong local stations to create interference. Sometimes, special waterproof transformers are used to match antenna to line impedances. In this case they attach to the antenna at the dipole terminals.

Some matching transformers, like the one in Fig. 12-31, provide the additional function of band splitter. It accepts all channels at its input and provides outputs for vhf, uhf, and sometimes fm. They can be purchased with either 75- or 300-ohm input impedance.

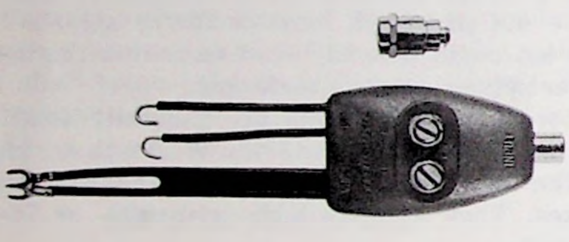


Fig. 12-31. Matching transformer. (*Courtesy Channel Master Corp.*)

Terminators

Each unused output on an antenna system should be terminated in the characteristic impedance of the transmission line or tapoff. If the line isn't terminated, signal coming to that point is not used, and is reflected back into the system causing ghosts as the reflected signal arrives at the tv later than the primary signal. Terminators are resistors often encased in an "F" plug as seen in Fig. 12-32.

Fig. 12-32. A 75-ohm terminator. (*Courtesy Channel Master Corp.*)

Designing the Distribution System

Now that the major pieces of equipment and their uses have been discussed we are ready to design an MATV system. The distribution system is designed before the amplifier is chosen because the distribution system losses, in part, determine the amplifier requirements. Step No. 1 in designing the system is to find where each tv signal outlet is to be placed. Obtain a blueprint or a sketch of the building layout and mark the outlets and distribution amplifier locations.

Cable Loss—Determine from the building plans the best way to run the distribution lines. Cable runs should be as short as possible, avoid zigzags, loops, and use the least amount of equipment possible to cut down on signal losses. Every piece of cable has a loss—determine cable loss for the highest frequency used. Always figure vhf systems at Channel 13 loss. See Table 12-1 for cable loss figures.

Splitter Loss—When splitters are used the signal output will be less than its input. For a two way splitter the signal loss per output leg will be about 3.5 dB less than that of the feed line. As an example, assume that a two way splitter has an input of 26 dB. It will supply about 22.5 dB to each output. This reflects a 3.5 dB loss per branch.

Isolation Loss—Each tapoff reduces the signal taken from the line by an amount specified as "isolation" loss to keep the tuner local oscillator of one set from interfering with another set. For example, if there is an 18 dB signal on the distribution line, and a 17 dB isolation tapoff is used to take part of that signal for use by a receiver, the signal available for that set would be 1 dB. The 17 dB is referred to as tapoff isolation loss.

Since this is not actually a signal loss on the trunk line it is not counted as a system loss until the last tapoff on the line. At this point it is a loss between the trunk line and the tapoff output. This loss must be replaced by amplification provided by the distribution amplifier. Normal tapoff isolation values are 23 dB, 17 dB, and 12 dB.

Insertion Loss—All tapoffs create a small loss on the trunk line as signal flows through the tapoff. This loss is referred to as feedthrough or insertion loss because it is a loss caused by inserting the tapoff. When calculating total system loss, the insertion losses of each tapoff are added to determine the total system insertion loss. As a rule the higher the value of tapoff isolation used, the lower the insertion loss per tapoff.

A SAMPLE SYSTEM

At this point a sample vhf MATV system will be designed, step by step. Fig. 12-33 shows a simple diagram of a two-branch, nine-terminal

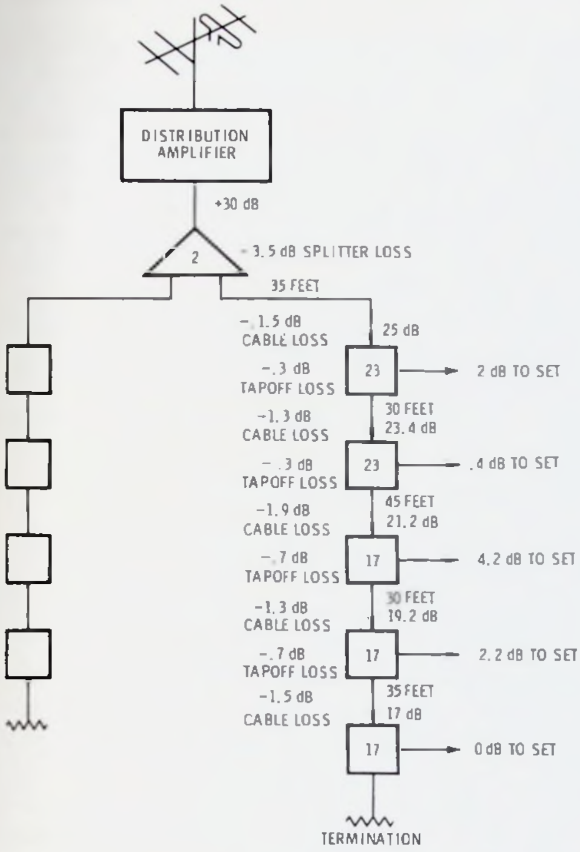


Fig. 12-33. A sample diagram of a two-branch, nine-terminal MATV system.

system as might be used in a small motel or apartment building. The MATV symbols are illustrated in Fig. 12-34. Refer to Fig. 12-33 while following the system design explanation. Figures are given for the largest branch line.

1. Cable loss (RG-59 U foam) 175 feet of cable at a loss of 4.2 dB/100 feet . . . . 7.9 dB loss
2. Splitter loss—two way splitter . . . . 3.5 dB loss
3. Insertion loss. The longest trunk line is always used for the basis of MATV calculations so our system will be based on the line with five tapoffs.
   At this time our losses are *estimates* so an *average* isolation loss tapoff will be specified. Of the three isolation values available the 17 dB unit is the *average* unit. It has an insertion loss of 0.7 dB per unit. Five units at 0.7 dB loss each give a total loss of 3.5 dB. . . . . 3.5 dB loss
4. Isolation loss. Each tapoff causes some loss on the trunk line as the signal passes through it. Because the lowest isolation value available for wall tapoffs is 12 dB we must have a minimum of 12 dB of signal remaining at the input of the last tapoff. Branch loss is 12 dB. . . . . 12.0 dB loss

Total system loss . . . . . 26.9 dB

We must have a minimum of 27 dB of signal from the head end to overcome system losses and allow each set to have a minimum of 0 dB of signal. A distribution amplifier of this amount of gain must be specified if the antenna system delivers 0 dB of signal to the amplifier. If more signal is provided by the antenna, less must be provided by the amplifier and vice versa. For instance, if the antenna system has an output of 2 dB the amplifier would need only a 25 dB gain. However, many MATV designers suggest over specifying the amplifier by 6 dB for safety. If this were the case, instead of using a 27 dB amplifier, a 33 dB amplifier would be used. Naturally, the amplifier with a gain figure nearest the gain needed would be purchased.

When head end requirements are resolved, isolation values for each tapoff must be determined. Each set should have a minimum of 1000 μV of signal input (0 dB). To achieve this and keep insertion losses to a minimum the highest possible isolation value is used. We have already mentioned the 3 common isolation values as being 23, 17, and 12 dB. An example of using the greatest isolation value possible is: If the input signal is 17 dB, a 17 dB isolation tapoff can be used and the receiver will still have its 0 dB signal input. If the signal level dropped below 17 dB, an isolation value of 12 would be necessary. A typical receiver can handle a signal level of up to 48 dB or 250,000 μV, or more, before the tuner overloads.

In the example in Fig. 12-33, the amplifier supplies 30 dB to the splitter which then delivers 26.5 dB of signal to each branch line. In our example the line from the antenna to the amplifier and from the amplifier to the splitter is so short that cable loss is negligible. In some cases this may not be the case and the loss would have to be calculated.

In order to reach the first tapoff, 1.5 dB of signal is lost in the cable. A 25 dB signal reaches the

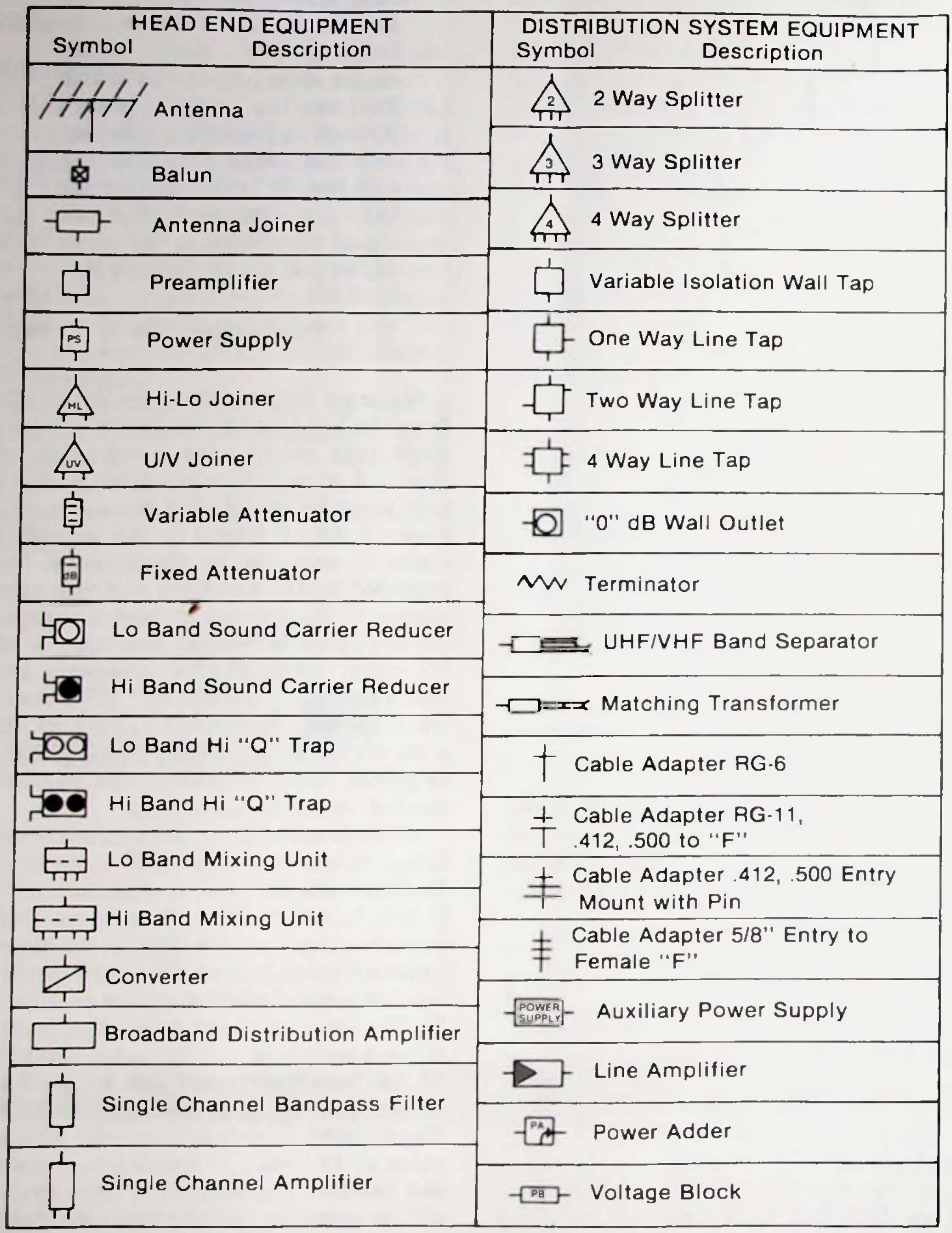


Fig. 12-34. MATV symbols.

first tapoff. With 25 dB at the tapoff an isolation value of 23 dB can be used, allowing 2 dB or 1300 μV of signal to reach the set. The tapoff has an insertion loss of 0.3 dB and the following 30 feet of cable has a 1.3 dB loss so tapoff No. 2 receives 23.4 dB of input. Again an isolation value of 23 dB can be used and the receiver will be supplied 0.4 dB of signal—0.4 dB greater than the required 0 dB. Only 21.2 dB of signal reaches tapoff No. 3 so a 17 dB isolation unit must be used. This gives the set a 4.2 dB signal input. The 17 dB tapoff has an insertion loss of 0.7 dB. After insertion and cable losses of 2 dB, tapoff No. 4 has an input of 19.2 dB and delivers an output of 2.2 dB. Again a 17 dB isolation value can be used. Cable and insertion losses leave a 17 dB input to the last tapoff, delivering a 0 dB signal to the last set. Because this is the last tapoff a 75 ohm terminator resistor must be used if the tapoff is not self-terminating, as some are.

The second branch line of the system will be calculated in the same manner. It is much simpler if the branch lines can be balanced as closely as possible. Remember that the system is designed around the branch with the largest loss.

INSTALLATION

The MATV installation requirements are basically the same as for the single residency home. Heavier duty equipment must be used for durability. Special commercial grade antennas and mountings are required but installation methods are the same. Care must be taken in preparing the coax and fittings. Bad connections can cause ghosts, intermittents, and snow. Use a crimping tool as pictured in Fig. 12-35 to make sure all connections are well made. Be sure the antenna structure is correctly grounded and lightning arresters are inserted in the coax near the antenna. Coaxial lightning arresters may be difficult to find in some locations, but are readily available through ham radio equipment dealers.

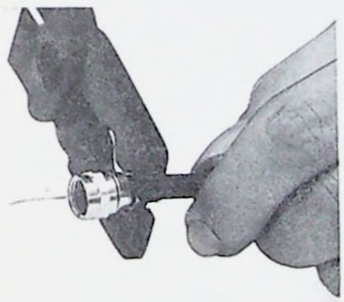


Fig. 12-35. Coax crimping tool. (*Courtesy Winegard Co.*)

TROUBLESHOOTING MATV SYSTEMS

Problems most often encountered in MATV systems are:

1. Cross modulation interference
2. Overmodulation distortion
3. Adjacent channel interference
4. Co-channel interference
5. Power line interference
6. Ghosting

Cross modulation

Cross modulation occurs in amplifiers when an input signal exceeds the maximum input rating of the amplifier. Where overloading occurs, two channels beat together and both pictures can often be seen at the same time. It is sometimes identified as the windshield wiper effect and will occasionally produce a negative picture (see Fig. 12-36).

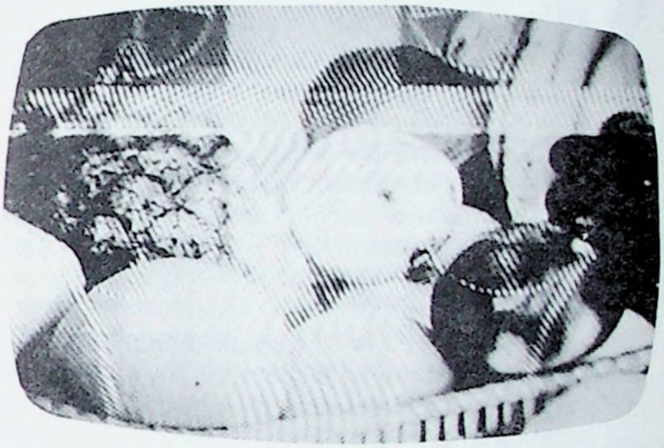


Fig. 12-36. Cross modulation interference.

Overmodulation

Overmodulation occurs in single-channel amplifiers. The symptom is similar to agc failure in the receiver, with the picture going dark, having excessive contrast, and loosing sync. Overmodulation distortion can be eliminated or reduced by reducing the amount of input signal via the use of attenuators. It does not occur in multichannel amplifiers because cross modulation would be a problem long before the signal level was sufficient to cause overmodulation.

Adjacent Channel Interference

A herringbone interference pattern is caused by adjacent channel interference (see Fig. 12-37). When a channel next to another channel is strong enough, it will override the weaker channel causing adjacent channel interference. All succeeding channels are adjacent with the exception of 4 and 5, and 6 and 7. A 4 MHz guard band lies between Channels 4 and 5. Channel 6 has an upper frequency of 88 MHz and Channel 7 does not begin until 174 MHz with various emergency, business, amateur, and the commercial fm band falling between them.

Adjacent channel interference can be elimi-

Fig. 12-37. Adjacent channel interference.

nated by increasing the weak channel or attenuating the strong channel. Tunable traps may also be used to attenuate the picture or sound carrier of the interfering channel.

Co-Channel Interference

When two stations on the same channel are received simultaneously both pictures can be seen on the screen. This co-channel interference can be eliminated or minimized by using more directional antennas or by antenna stacking.

Power Line Interference

The buzzing and crackling of power line interference is caused by antennas being located too near high tension power lines, pick up on twin lead, and faulty power line equipment. Locate antennas as far from power lines as possible, ground the system, use shortest possible lengths of twin lead, and if problems are worse in wet weather call the power company. In damp weather moisture accumulates in cracked power line insulators and the interference worsens. Replacement of the insulators by the power company should eliminate the problem.

Ghosts

Ghosts are caused by poor insulation, multipath reception at the antenna, or secondary pickup by the receiver or down lead. Ghosts are of two varieties—leading or trailing. Trailing ghosts are most common and are caused by receiving a secondary or bounce signal slightly *later* than the main signal. Leading ghosts are less common and are caused by pickup of strong local signals by the wire that connects the tuner to the antenna. This signal is displayed a microsecond or so before the antenna signal. The result is a leading ghost. To cure the leading ghost problem, shield the short connecting length of wire between the tuner and the antenna connectors. Use the shortest possible length of twin lead between the wall tapoff and the antenna connectors. If possible use coax and connect a balun or matching transformer as close as possible to the antenna terminals.

Trailing ghosts are either antenna orientation problems, lack of line termination, or poor connections. Poor connections will cause an impedance mismatch and signal reflections. Check for correct antenna direction, terminations at unused outlets, and poor connections.

Chapter 13

Interference

Interference with picture or sound reproduction in a television receiver is caused by frequencies falling within the television receiving frequencies or by other frequencies of high enough amplitude to cause overriding of the television circuits.

The most up-to-date and comprehensive material on television interference was published recently by the Electronic Industries Association. This material is reprinted in part in the following pages.

The television electronics technician will find some areas are susceptible to moderate or even severe television interference (tvi). The following are typical causes of television interference:

Medical diathermy and X-ray equipment.
Industrial rf heating equipment.
Amateur radio transmitters.
Police radio communications.
Fm broadcast transmitters.
CB radio transmitters.
Electrical appliances.
Automobile ignition noise.
Neon signs.
Static from electrical storms.
Radio paging stations.
Short-wave radio transmitters.

All of the preceding are capable of originating signals which may fall in or near the frequency range of the television receiver, causing disruption of the picture or sound. (It is not possible to design a television receiver to reject unwanted signals at frequencies within tv channels.) In addition to the above, front-end overload can occur from strong signals in the 0-54–MHz range, causing interference to the picture or sound.

RECEIVER CONSIDERATIONS

Before taking steps to reduce or minimize forms of interference in the ways outlined in following pages, always make certain that there is no malfunctioning circuitry in the receiver itself. An open coil within the antenna matching transformer can produce a snowy picture and make a receiver susceptible to interference. Check for an open matching transformer or open transmission line by simply sliding a hand along the transmission line while observing the effect on the picture. If the picture changes considerably as the hand is moved, the line or antenna is probably open.

Interference can also be caused if the agc circuits are functioning improperly. For example, if the rf bias becomes too high and the if bias becomes too low due to a divider network changing in value the picture can become excessively snowy and be subject to rf beat interference.

Alignment of a receiver must also be correct if interference is to be minimized. The sound trap and adjacent channel traps must be tuned properly and the overall alignment must be correct.

The technique of dealing with television interference is an expansive subject. Modern receivers have been designed to greatly minimize problems of interference. Still, a technician should be prepared to deal with interference promptly in instances when it does show up.

Shields

Don't get careless about reinstalling tube shields and other shields properly after servicing a receiver. Such carelessness has been known to result in cases of interference beats in the picture, if oscillation, degraded picture, distorted sound, and critical fine tuning. Proper placement of tube shields on the tubes in the tuner unit, picture if, and sound if sections of the receiver is particularly important. Check the grounding spring to ensure good contact between the tube shield and the chassis. Always make certain that all shields placed over tubes and components are properly installed and grounded.

IDENTIFICATION OF INTERFERENCE

Since the majority of interference problems involve the customer's location and/or locally generated interference which affects the equipment while in the customer's home, there is little use in attempting to cure the problem without first calling at the customer's home and investigating first hand. Attempts to obtain the necessary information from the customer by phone are unlikely to be successful due to the technical nature of the details which must be investigated.

There is no basis for the assumption that the absence of interference in a given piece of equipment makes that equipment better. Tvi happens in the best of families, and we mean the best. Equipment with the highest sensitivity and gain are better prospects for tvi than inexpensive low-gain equipment.

First, of course, it must be determined that it is not an internal defect of the television equipment that causes the problem. Tvi may originate inside the television equipment. Once it has been determined that the equipment is not at fault, the following information should be obtained by checking the equipment and questioning the customer. Following is a checklist of questions that should lead the technician to understand the basic characteristics of the interference:

1. What does the interference look like?
   ______a. Beat pattern.
   ______b. Venetian blinds.
   ______c. Windshield wiper.
   ______d. Vertical black bars.
   ______e. Horizontal black bars.
   ______f. Picture blacks out.
2. Can you hear the interference in the loud-______speaker?
   ______a. Does it sound garbled?
   ______b. Is it music?
   ______c. Is it an intelligible voice?
3. Is it from a commercial fm station, CB amateur radio station, or from other com-______munication system?
4. Do you know the call letters of the sta-______tion?
5. Do you know the location of interference, ______how far away, same house, next door, etc? (Interference produced by CB or ham equipment owned by a relative of the complaining customer in the same house has been known to have happened.)
6. Are there specific times of the day or night ______when the interference is noticed?
7. Do you know the broadcast frequency of ______the interfering station?
8. On what channels can the interference be ______seen?
9. Does the interference come and go or is it ______on continuously?
10. Does the interference disappear when the ______antenna is disconnected?
11. Can the interference pattern be tuned with ______the fine tuning control?
12. When moving the set to a different room of the home (or a different place in the same room) are there changes in the intensity of the interference, or, possibly, does the in-______terference disappear?
13. Is the same interference found on other television receivers in the home or in the ______neighbor's home?
14. Does adjusting the antenna affect the in-______terference?
15. Does dressing antenna transmission line ______affect the interference?
16. Does the interference disappear when a ______different ac outlet is used?
17. Does the interference disappear after all the lights in the customer's home are ______turned off?
18. Can the interference be heard on a por-______table radio? If it can be heard, carry the radio from room to room to determine where the interference is the loudest. If there are electrically operated devices in the room turn them off one at a time.

Do not promise the customer a complete cure to his problem. In some cases only a reduction of the interference may be possible, and reducing the problem is better than no solution at all. Make the customer aware of the fact that this problem is unique and cannot be duplicated in the shop.

SOLUTIONS

Most interference problems can be solved by eliminating the source of the interference signal. Others, however, must be filtered out at the receiver. These interference signals can usually be eliminated by the use of commercially available traps and filters as discussed in Chapter 12. Where no available trap or filter will work, or the correct unit is not available, traps can be constructed by the technician. The subject of trap construction is too involved for this text but is included in Advanced Color Television Servicing available from the Howard W. Sams & Co., Inc.

CITIZENS BAND TRANSMITTER HARMONIC RADIATION

Diagnosis

Citizens band harmonic radiation interference pattern or garbled sound on television Channels 2, 5, 6, 9, and 10 may be caused by the second, third, fourth, and seventh harmonic of a Class-D Citizens' Radio Service transmitter operating on frequencies in the 26.96 MHz to 27.41 MHz band.

Identification

Harmonic radiation interference (Fig. 13-1) may be identified as a "beat pattern" and/or "garbled sound" on Channels 2, 5, 6, 9, and 10. The interference may appear on one or more of these channels, depending on the proximity of the transmitter during transmission.

Fig. 13-1. CB transmitter harmonic radiation.

Elimination

CB harmonics radiated at the transmitter cannot be suppressed at the tv receiver, since they occur at tv frequencies. If the CB transmitter is available, the technician, with the cooperation of the CB operator, may make brief tests in the "transmit" and "receive" positions with a low-pass filter in and out to determine if the transmitter is radiating harmonics into the antenna transmission line. Low-pass filters are available for the suppression of harmonics at the transmitter.

CITIZENS BAND, TV RF TUNER OVERLOAD

Diagnosis

Interference patterns, garbled sound, or picture blackouts, on all television channels, may be caused by overload conditions in the tv rf tuner, resulting in harmonic responses, or spurious responses in the tv rf amplifier or mixer stage.

Identification

The picture may black out, or interference patterns and/or garbled sound may be present on all channels to a varying degree (Fig. 13-2).

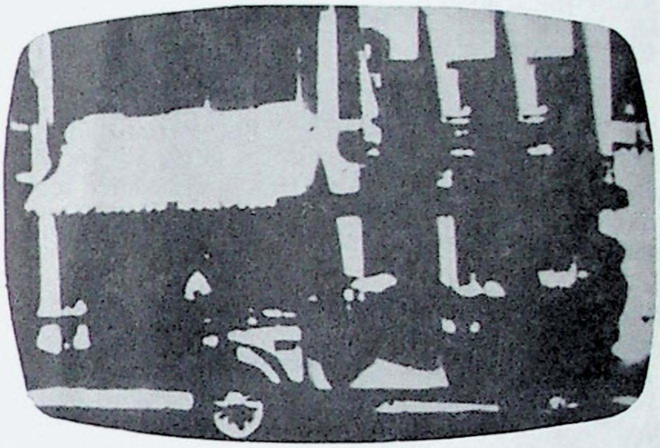


Fig. 13-2. CB, tv tuner overload.

Elimination

1. Check the tv antenna installation and determine if antenna system components and connections are good.
2. Check the lead-in wire; if it is too long remove excessive length.
3. Determine if interference is caused by direct pickup by chassis. Disconnect antenna leads for this test.
4. Install a 75-ohm or 300-ohm high-pass filter to the tv antenna terminals. In strong signal areas it may be desirable to install an attenuator pad in series with the filter to reduce front-end overload.
5. When a booster or a broadband distribution amplifier system is used, strong nearby sources of interference may overload the amplifier. In such cases the filter should be installed at the input of the amplifier and, if needed, at the antenna terminals of each tv receiver.

AMATEUR TRANSMITTER FUNDAMENTAL AND HARMONIC RADIATION

Diagnosis

There are primarily two types of amateur installations utilizing the 3.5 to 4.0, 7.0 to 7.3, 14.0 to 14.35, 21.0 to 21.45, 28.0 to 29.7, and 50 to 54 MHz ham band frequencies. These are the amplitude modulated carrier (am) and single-sideband suppressed carrier (ssb) transmitters. Both generate the same type interference beat when modulation takes place. The suppressed carrier transmitter produces no interference problems during the nonmodulation times, while the am carrier transmitter can produce an interference pattern while the transmit switch is closed.

Identification

The modulated carrier interference patterns from 14, 21, and 28 MHz may look like a series of fine vertical lines tilted slightly (Fig. 13-3). The suppressed carrier transmitter interference looks like bursts of interference, varying in width at an audio rate.

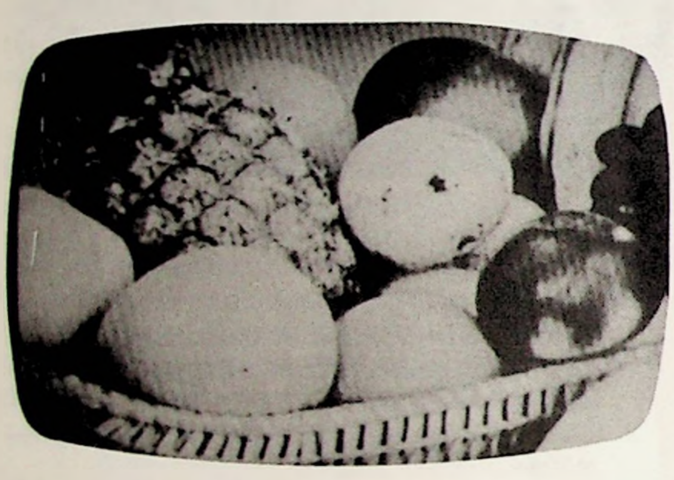


Fig. 13-3. Amateur transmitter radiation interference.

Elimination

1. Install a 75-ohm or 300-ohm high-pass filter to the tv antenna terminals. High-pass filters are commercially available and are designed to attenuate any signal falling in the 0-52–MHz range, which may be causing television interference.
2. Fixed-tuned traps or tunable traps can also be used to effectively reduce tvi.
3. High-pass filters, fixed-tuned traps or tunable traps may also be used when the problem has been diagnosed as front-end overload. This is a condition where an undesired signal from a transmitter reaches the tv rf and mixer stages of the tuner and generates harmonics which are not harmonically related to the transmitting frequency. Also under certain conditions picture and/or sound or a combination of both types may be fed back to the input circuits of the receiver and create interference.

AM BROADCAST

Diagnosis

The resulting interference pattern has a constant characteristic which looks like a cw beat pattern having vertical lines slightly tilted, or it may have an X or diamondlike shaped pattern throughout the picture.

Identification

The beat pattern (Fig. 13-4) will vary with the interference frequency and is related to the horizontal systems in the tv.

Fine tuning will not change its intensity or frequency; however, the contrast control will make the intensity change.

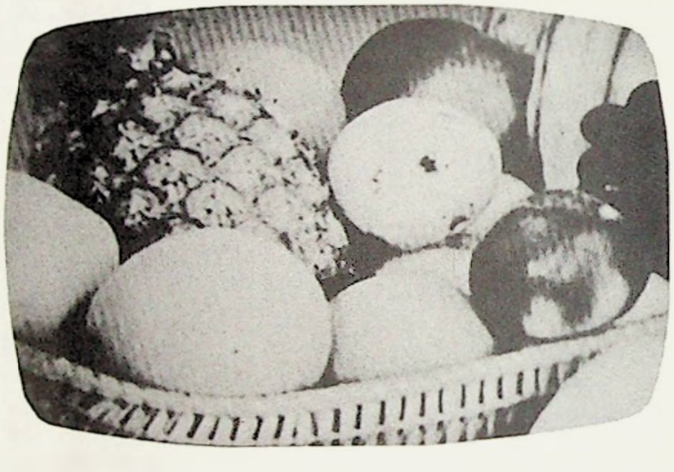


Fig. 13-4. Interference from am broadcast.

Elimination

Install a 10-pF to 100-pF capacitor in series with each side of the antenna lead. Use only UL-approved components suitable for antenna isolation applications.

40-MHz FM TRANSMITTER RADIATION

Diagnosis

The resulting beat in the picture is related to the fm carrier and the modulating frequency. The carrier frequency location near the picture if carrier, as well as its strength, will determine its severity, and the modulation of the carrier will show as a fine or coarse grain pattern. The determining factors being fine grain is a higher modulating frequency and a coarse grain, the lower modulating frequency. No modulation produces a vertical pattern tilted slightly.

Identification

Isolation of the tuner from the antenna will tell whether the interference enters through the tuner or through the if system.

Should the interfering pattern disappear (Fig. 13-5), the results are from either direct channel

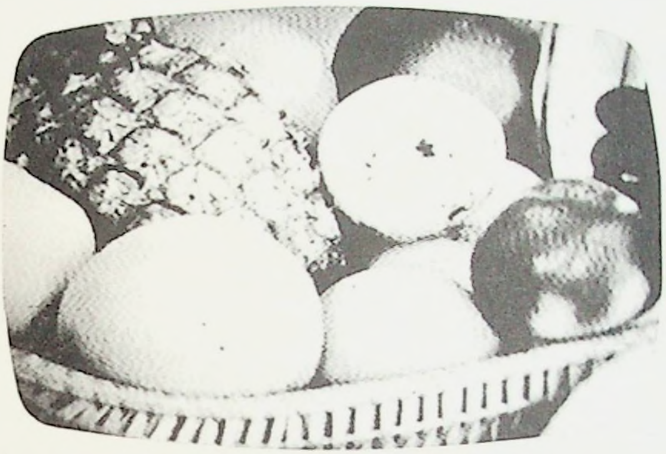


Fig. 13-5. Interference from 40-MHz fm transmitter.

response or 40-MHz signal spray from the antenna wire going from the antenna block to tuner.

Elimination

1. Install a 40-MHz antenna trap to the tv antenna terminals. Tune the trap to the tvi frequency. To avoid shock hazard, install the filter and/or attenuator pad outside the cabinet of the set as close as possible to the antenna terminals.
2. Separate the uhf and vhf antenna transmission lines and leads to minimize the tvi.

FM RECEIVER OSCILLATOR HARMONIC RADIATION

Diagnosis

In an fm receiver the local oscillator operates above the fm incoming signal by 10.7 MHz. The second harmonic of the local fm oscillator falls into high band Channels 11, 12, and 13, producing a beat pattern looking like diagonal lines slightly changing their angle due to oscillator instability. For example, when the fm receiver is tuned to a 90-MHz incoming signal, the fm local oscillator will oscillate at 100.7 MHz. The second harmonic of the fm local oscillator will fall at 201.4 MHz, in the range of Channel 11 (198-204 MHz).

Identification

Should the interference pattern (Fig. 13-6) come and go, the fm listener is returning to an-

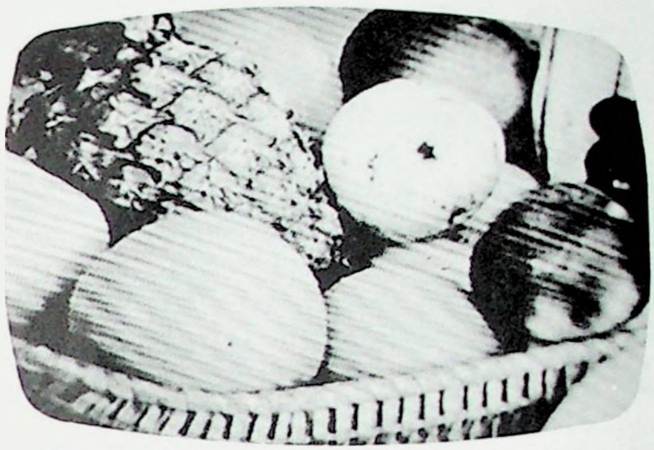


Fig. 13-6. Interference caused by fm receiver oscillator.

other station. Check by using an fm radio in close proximity to the tv antenna. Tune in the fm station to the lower end of the fm band and note similarity in patterns.

Elimination

1. If the interference is identified with an fm receiver located in the same home, turn off the fm receiver.
2. Install a fixed tuned trap or tunable trap to the tv antenna terminals or lead-in wires close to the antenna terminals. To avoid shock hazard, install the filter and/or attenuator pad outside the cabinet of the set as close as possible to the antenna terminals.
3. Install separate fm/tv antennas if a common antenna is used.

CO-CHANNEL INTERFERENCE

Diagnosis

The resulting interference pattern that develops when two channels on the same frequency interfere with one another produces two noticeable conditions: (1) Venetian blinds (mild). (2) Windshield wiper (severe). The horizontal and/or vertical blanking interval floats through the picture on the selected channel.

Identification

Co-channel interference (Fig. 13-7) can become severe enough that the interfering channel will synchronize with and become the prime picture. At this point, picture viewing is impossible.

Usually the interference is the result of ionosphere reflection, which is most noticeable in warmer weather or where the receiver is located midway between two co-channel stations.

Fig. 13-7. Co-channel interference.

Fig. 13-8. Adjacent sound interference.

Elimination

1. Improve antenna orientation to reject co-channel signals.
2. Wait until the ionosphere shifts to change the reflection angle into the signal area. The time of the day or night influences the ionized layers, causing them to shift their altitude and change their electron density.
3. Use an antenna which provides a large front-to-back ratio, which rejects the undesired signal.

ADJACENT SOUND INTERFERENCE

Diagnosis

The resulting interference can develop from the stronger lower adjacent channel sound carrier and the desired channel picture carrier beating causing a grainy picture.

Identification

The modulation on the lower channel carrier can be verified by using a second tv set tuned to the lower adjacent channel and viewing the interference on the desired channel. As the audio modulation changes the grainy beat pattern will have a corresponding change (Fig. 13-8).

For receivers with afc or aft, if the interference can be tuned out by fine tuning with aft off, and comes back with aft on, misalignment is indicated.

Elimination

1. Install a channel attenuator tuned to the strong lower adjacent channel.
2. Install a fixed tuned or tunable trap to the antenna terminals on back of the tv set, tuned to the lower adjacent sound carrier. To avoid shock hazard, install the filter and/or attenuator pad outside the cabinet of the set as close as possible to the antenna terminals.

CROSS-MODULATION INTERFERENCE

Diagnosis

The resulting interference is usually from two tv signals and can develop several ways, but always with at least one exceptionally strong signal.

In addition, an fm signal can cross-modulate with a tv channel.

Identification

The cross-modulation pattern (Fig. 13-9) looks like one television picture riding through the other (severe). An example is a strong Channel 6 on a distant weaker Channel 5. Usually the interfering picture will not lock in, but moves through the selected channel picture. A mild case in cross-modulation will produce a streaky picture.

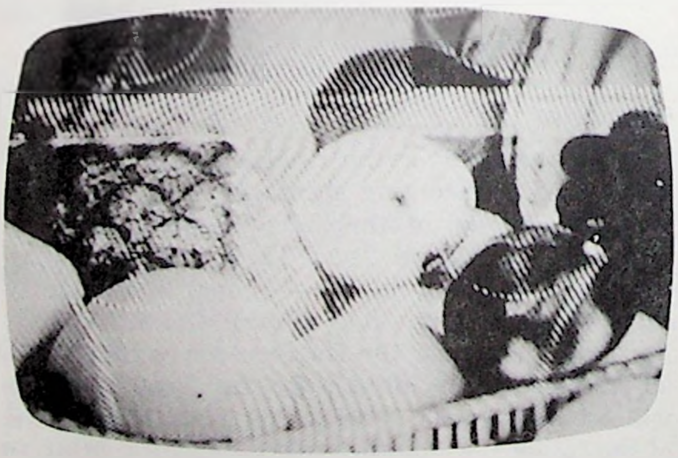


Fig. 13-9. Cross-modulation interference.

Elimination

Install a channel attenuator to the antenna terminals on the back of the television receiver, tuned to the strong interfering channel, or install a fixed tuned stub trap or tunable stub trap.

The amount of strong signal attenuation necessary on the strong channel will usually not affect its picture, but will improve the signal ratio for the weaker channel.

FM BROADCAST 88 TO 108 MHz INTERFERENCE

Diagnosis

The modulated fm carrier produces a grainy looking beat pattern that shifts with the modulating frequency—low frequency modulation, large grain; high frequency modulation, fine grain.

Identification

Fm interference (Fig. 13-10) is most often observed on Channels 5 and 6, but can also occur on other channels. Fine tuning will affect the pattern intensity somewhat and not the frequency. Contrast control affects the pattern intensity.

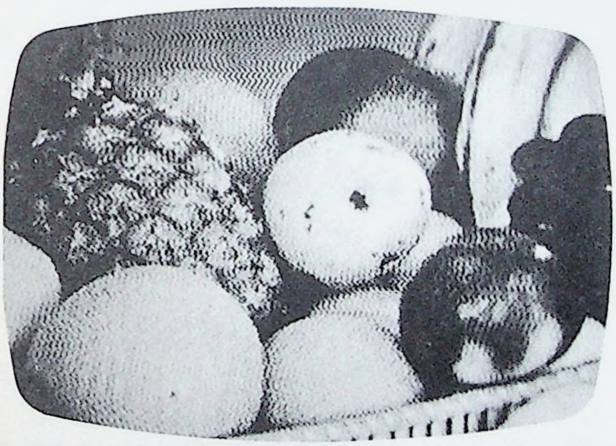


Fig. 13-10. Fm broadcast interference.

Elimination

Use fm tunable traps or fixed tuned traps for the interfering fm frequency. To avoid shock hazard, install the filter and/or attenuator pad outside the cabinet of the set as close as possible to the antenna terminals.

DIMMER SWITCH RADIATION CAUSED BY SCRs OR TRIACs

Diagnosis

This interference pattern is generated by the dimmer switch turn-on transient, when it is set for low levels of illumination.

Identification

Turning off the dimmer switch or turning it full on identifies the interference source, when the interference disappears (Fig. 13-11).

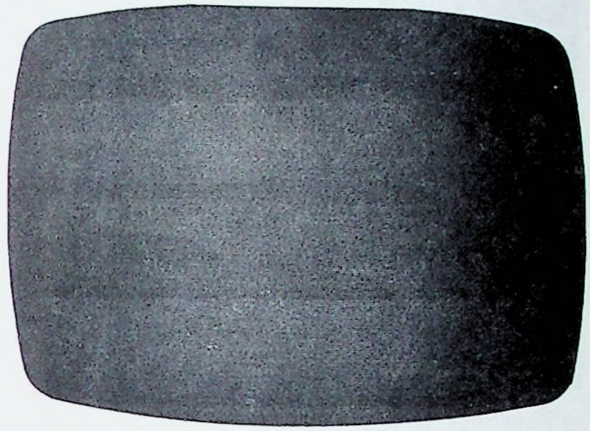


Fig. 13-11. Dimmer switch radiation interference.

Elimination

Suggest replacement of the unit causing interference with a newer-type dimmer switch designed to be free of interference radiation. Consult national and local electrical codes before replacing the dimmer switch, or contact a licensed electrician.

COMMUTATOR INTERFERENCE

Diagnosis

This noise pattern has a constant repetition rate, causing vertical roll and heavy horizontal noise bars.

Identification

Commutator motors are the cause due to the momentary short between the commutator bars by the brushes. As the brushes leave the shorted bars position, an arc develops, radiating to the antenna and conducting through the power line (Fig. 13-12).

Elimination

Install an ac line filter capable of handling the tv chassis current requirement. Use only UL-approved filters. The filter should be installed outside the cabinet of the tv set in accordance with manufacturers' instruction and national and local electrical codes. To avoid shock hazard install the ac line filter outside the tv cabinet.

Fig. 13-12. Commutator interference.

SLIP-RING NOISE INTERFERENCE

Diagnosis

This noise pattern is seen as long streaks in the picture, randomly occurring during dc motor operation.

Identification

Slip ring contact variation increases and decreases as brush pressure increases and decreases on the ring due to wear particles slipping between the ring and brush. This shows up as interference shown in Fig. 13-13.

Fig. 13-13. Slip-ring noise interference.

Elimination

1. Interference from dc motors caused by arcing between the brushes and ring, which is transmitted through the power line may be minimized by using an ac line filter. Use only UL approved filters which are capable of handling the tv chassis current requirements. The filter should be installed outside the cabinet of the tv set in accordance to manufacturers' instructions and national and local electrical codes.
2. In severe cases where the interference is radiated, it may be difficult to resolve. In such cases we suggest referring the customer to the equipment manufacturer for advice.

MERCURY-VAPOR RECTIFIER RADIATION

Diagnosis

This pattern is generated by a constant repetition rate from a commercial/industrial electrical mercury arc.

Identification

This type interference (Fig. 13-14) is transmitted by power line conduction from the source, usually a mercury vapor rectifier or similar-type rectifier. Its fundamental frequency can be from 60 Hz to 360 Hz depending on the number of phases and rectifiers.

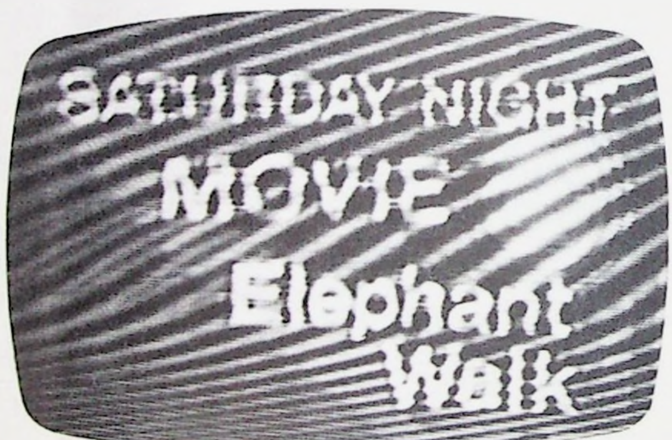


Fig. 13-14. Mercury-vapor rectifier radiation.

Elimination

Install an ac line filter capable of handling the current used by the tv set. Use only UL-approved filters. The filter should be installed outside the cabinet of the tv set in accordance with the manufacturers' instructions, and national and local electrical codes.

DIATHERMY RF HEATING

Diagnosis

The usual diathermy pattern appears as a band of elongated S's across the face of the picture tube, which may roll vertically up or down through the picture.

As a matter of interest, it should be noted that this peculiar pattern arises from simultaneous am and fm modulation. Am modulation in a diathermy machine of the order of 5% will create patterns of this nature.

Identification

Many technicians consider diathermy interference (Fig. 13-15) as another kind of man-made noise. However, a diathermy unit is a form of rf generator for which frequencies have been assigned. The center frequency of the bands set aside for diathermy and rf heating are: 13.66 MHz, 27.32 MHz, and 40.98 MHz. The 27.32-MHz frequency band is the widest of the three and the most frequently used in recent years.

Fig. 13-15. Interference due to diathermy.

Elimination

Locate the source, inquire about the frequency, select a suitable high-pass filter within the frequency range of the diathermy or rf heating unit and install the filter to the antenna terminals on back of the tv set. Seventy-five ohm or 300 ohm high-pass filters are commercially available and are designed to attenuate any signals falling in the range of 0-52 MHz.

AUTOMOBILE IGNITION INTERFERENCE

Diagnosis

The resulting interference is generated from an automobile ignition system. Older models of some make cars are a common source of tvi. In recent years car manufacturers have recognized the need for reducing tvi and added suppressors to the ignition system which virtually eliminates ignition interference.

Identification

A series of broken horizontal lines across the picture (Fig. 13-16) and a sharp popping sound in the audio.

Fig. 13-16. Automobile ignition interference.

Elimination

1. If the source can be located, suggest to the owner of the automobile: "Ignition maintenance or the installation of resistor-type spark plugs."
2. If the source cannot be located and an outside tv antenna is used, try replacing the transmission line from the tv antenna with a shielded type. Relocate antenna away from traffic to reduce the effect.

FLUORESCENT LIGHTS

Diagnosis

The resulting pattern may be caused by some fluorescent fixtures.

Identification

Short bursts of dashes across the picture (Fig. 13-17). Short bursts of noise or a continuous buzz may also be heard in the speaker. Usually this type of interference is also heard on am radio.

Elimination

1. Locate the source. Look for a flashing fluorescent lamp. Replace lamp and/or starter. If source cannot be located, use am portable radio to help locate source.
2. Install an ac line filter capable of handling the current used by the tv set. Use only UL-approved filters. The filter should be installed outside the cabinet of the tv set in accordance

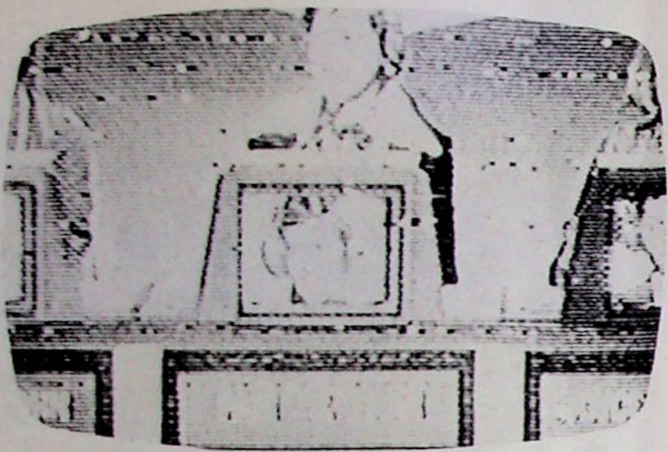


Fig. 13-17. Interference from fluorescent lights.

with manufacturers' instructions, and national and local electrical codes.

UNIVERSAL MOTOR NOISE

Diagnosis

Many fractional horsepower motors are series-wound "universal" motors, so named because of their ability to operate directly from ac or dc power sources. Motors of this type and their control systems occasionally cause tvi.

Identification

Horizontal bands, also accompanied by a whining noise in the audio (Fig. 13-18).

Fig. 13-18. Interference from a universal motor.

Elimination

1. Install an ac line filter capable of handling the current used by the tv set. Use only UL-approved filters. The filter should be installed outside the cabinet of the tv set in accordance with manufacturers' instructions, and national and local electrical codes.
2. The control systems for universal motors usually consist of SCRs and/or triacs. These devices may cause rfi associated with the switching action of triacs, which may be high frequency energy radiated through the air or it may be carried through the ac power line. Some ac line filters added to the universal motor control circuit may resolve the rfi problem. Consult the equipment manufacturer for details.

CHANNEL 8 TWEET INTERFERENCE

Diagnosis

The resulting interference is developed in any of the second detectors, such as the video detector, sound detector, and afc diodes. The 4th harmonic of 45.75 MHz (183 MHz) produces a beat located in the center of the Channel 8 response curve.

Identification

Look for a swirling "S" beat pattern that has horizontal bands several times throughout the raster (Fig. 13-19). Fine tuning will affect the intensity and frequency with afc off. The afc "on" holds the beat stationary with the horizontal band obvious. The afc "off" permits the pattern to move. Moving the antenna lead near the video detector will increase the interference.

Fig. 13-19. Channel 8 tweet interference.

Elimination

1. Check the antenna for balance.
2. Separate the uhf-vhf tuner leads.
3. Keep antenna wire away from the set.
4. Check for bad ground connection and missing shields around the video detector, sound detector, and afc diodes. Dress components to reduce interference.

HORIZONTAL INTERFERENCE

Diagnosis

The resulting interference pattern resembling "barkhausen" and "snivets" may be caused by a quadrupler retrace diode, trace SCR or a regulator clamp diode in the horizontal circuitry of a television receiver.

Identification

Usually evident on relatively weak station signals:

1. The interference (Fig. 13-20) caused by the quadrupler and retrace diode usually appears on the left side of the picture tube screen, in the form of a jagged vertical line (sometimes bowed).

Fig. 13-20. Horizontal interference.

2. The interference caused by the regulator clamp diode usually appears near the center of the picture tube screen, in the form of jagged bowed vertical lines.
3. The interference caused by the trace SCR usually appears at the center or the right side of the picture tube screen, in the form of a jagged vertical line.

Elimination

Replace one of the above components as related to the specific interference problem.

HIGH FREQUENCY TRANSISTOR RADIATION

Diagnosis

This vertical interference pattern moves back and forth and may vary from vertical to horizontal. It is the result of either or both the sync separator transistor or agc gate transistor turning on and off, creating the rf transient.

Identification

The interference (Fig. 13-21) is produced in one set and transmitted to others. Usually it is not visible on the set generating the condition. Placing a finger on either transistor reduces the condition.

Fig. 13-21. High frequency transistor radiation.

Elimination

Place a ferrite bead on each transistor lead or install a 100- to 150-pF capacitor from collector to base.

LOW FREQUENCY TRANSISTOR RADIATION

Diagnosis

Horizontal pattern approximately 4 inches wide with heavier portion at lower third. Result of low frequency oscillation from a vertical output transistor.

Identification

The interference (Fig. 13-22) is produced in one set and may be transmitted to others. It is visible on the set generating the condition.

Elimination

Solder a 0.01-μF capacitor from collector to base of the transistor. Use only UL-approved components suitable for the application.

ZENER NOISE INTERFERENCE

Diagnosis

Check all zener diodes by bypassing each one with a 0.01 μF capacitor. The one that produced the masking noise will be neutralized.

Fig. 13-22. Low frequency transistor radiation.

Identification

The noise transmission looks like fine snow on the picture tube and masks the picture with a grainy appearance (Fig. 13-23).

Elimination

Solder a 0.01-μF capacitor across the offending zener. Use only UL-approved components suitable for this application.

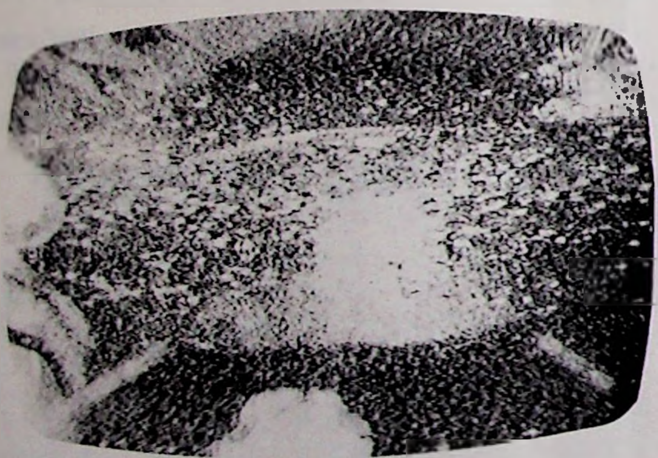


Fig. 13-23. Zener noise interference.

MOIRE

Diagnosis

The spot size of the electron beam on some color picture tubes is smaller than other types of the same screen size. This helps produce sharp, clear pictures. Moiré is usually seen on small areas of the picture tube.

Identification

The scanning lines of the raster are small enough so that they can "beat" with the horizontal rows of slots, or holes in the aperture mask. This "beat" can produce intensity modulation that produces weaving lines called moiré (Fig. 13-24). The "beat" will depend upon the vertical spacing of the mask aperture and the scanning-line spacing. The pattern sometimes changes with picture content.

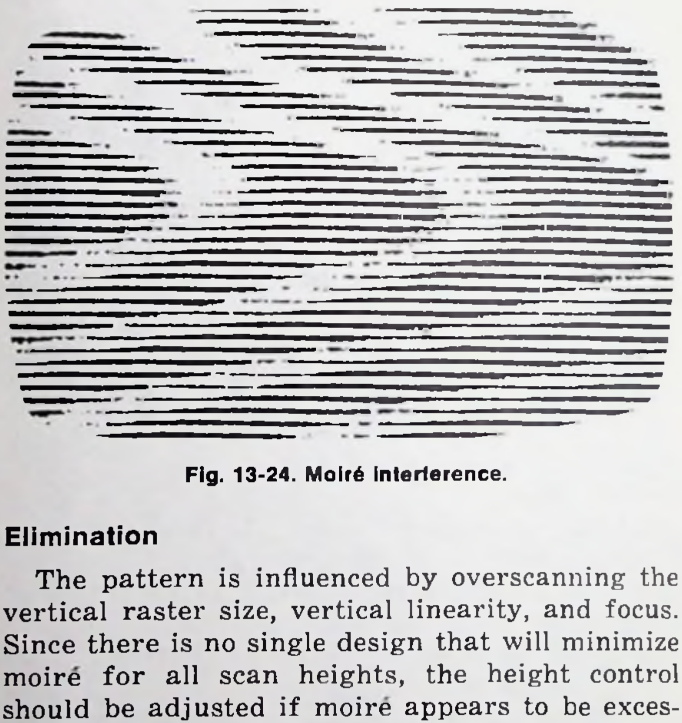


Fig. 13-24. Moiré interference.

Elimination

The pattern is influenced by overscanning the vertical raster size, vertical linearity, and focus. Since there is no single design that will minimize moiré for all scan heights, the height control should be adjusted if moiré appears to be excessive. Setting the focus control for good highlight focus will moderate any tendency to moiré at the edges. Slight defocusing may reduce the problem.

Chapter 14

Customer Relations

The primary purpose of any business is to satisfy the customer. By properly attending to this task the business owner and employees are rewarded by incomes to support their families. Dissatisfied customers are a direct cause of loss of income to the company. The *U.S. News & World Report* magazine reported from a survey in 1974 that 68% of the people who stopped doing business with a company did so because of company or employee indifference to the needs of the customer. People in the service industry *must* be good customer relations people if their businesses are to be successful. The customer's satisfaction is the most dominant factor in providing for future business. And though there is no hard and fast rule of obtaining customer satisfaction, there are methods and procedures of dealing with the customer which will help build good customer relations.

Customers have certain expectations concerning any product or service they purchase. For the money paid, they have a right to expect the following:

1. A knowledgeable, competent technician.
2. A courteous and polite individual with whom to do business.
3. A cheerful technician who sincerely wants to help the customer.
4. An honest person willing to do everything possible to satisfy the customer's need.
5. An individual with a positive and capable attitude.

It has been said that the technician must first repair the customer and then repair the television. The customer does not often realize how technical and complex the television set really is. As a result, customers often think that they are overcharged for work performed on the set. This probably would not be true if the technician would take the time to practice good customer relations concepts (Fig. 14-1)—tell them about the repair, reassure them of the quality of the set, find out what bothers the customers about their set, and work toward helping them build a more positive attitude toward service and the product. Also, if customers seem interested, explain to them in simple, layman's terms about the complexity of the device.

To make this type of favorable impression on customers, the requirements of a technician should include the following:

1. Professionalism and technical ability.
2. Social skill—getting along with people.
3. Neat appearance.
4. Honesty.
5. Reliability in approach to work.
6. Ability to maintain quality standards of work.
7. Ability to plan and organize.
8. Sensitivity to customer needs.
9. Ability to assess an on-site situation.
10. Ability to communicate verbally.
11. Resourcefulness.
12. Self-motivation.
13. Present and promote company image.

It is important, too, that the lack of almost any one of these traits can cause an otherwise successful businessman to only be a potential success. Why a "potential" success rather than a failure? Because everyone has the opportunity to seek self-improvement. Indeed, self-improvement takes will power and self-discipline but it can be done, if the desire is present. Thus, even those who don't have will power and self-discipline are potential, it's just a matter of if and when they decide to put effort into character and personality development. This kind of personal development can be accomplished by the individual through introspection and awareness. Sometimes the individual realizes something is wrong but doesn't know what. In this instance a professional counselor can help

Fig. 14-1. Good customer relations depend on a foundation of sound principles.

determine the direction needed by the individual. The counselor can look at personality traits from a more impersonal and unbiased viewpoint than the individual, his family, or friends. Habits such as neatness, planning, organization, and communications can be learned through practice. Help is also available in these areas if desired. Training in grooming, dress, speech, and organization is available in nearly every community. But, again, the point is that technicians must recognize the need for help in their business and their desire to succeed must be strong enough to motivate them to improve.

Some abilities which need to be learned and which will have a profound impact on the manner in which the technician handles complaints and day-to-day dealings with the public are interpersonal relationships (Fig. 14-2). Primarily the technician must do the following:

1. Show concern—not insincere concern but real concern for the customer.
2. Establish relevant facts concerning the problem.
3. Discuss the proposed action.

Fig. 14-2. Organization makes everything easier.

4. Obtain an agreement.
5. Close the deal.

SHOWING CONCERN

The technician must listen to customers to establish a rapport with them, and interpret customers' needs. When a customer calls with questions about repairs, this is a need for the set to be repaired. If the customer says, "How fast can you get to it?" there may be a need for immediate service. The technician must listen to the customer and interpret what is really being said. Be patient, especially if a complaint is involved. By allowing customers to talk, they will often answer many of their own questions and open lines of communication with you. Don't get upset when a complaint is made. Anger breeds anger—your anger will fuel the customer's anger (Fig. 14-3).

The term "probing" is often used to describe a technique used to deal with people to find out what their needs really are. Probing questions are open-ended questions which cannot be answered by a "yes" or "no." Probing questions demand an answer. With these questions the customer is kept busy thinking of answers. The questions should cause the customer to reach conclusions that are a moderating influence. An example is as follows:

Mr. Jones: This set is no good! I was right in the middle of the Monday night ball game and it went out. I knew I was being taken when I bought the thing. It cost me a fortune, but the salesman talked me into buying it.

What is this customer really saying? This person is apparently irate at having the ball game interrupted and is having second thoughts about the cost of the tv. Now that the set has failed, frustration leads the owner to proclaim that it is no good. What does the technician say in response?

Fig. 14-3. Anger has no place in customer relations.

Technician: Well, Mr. Jones, I would have to say that you do have a very fine set here. We haven't had many problems with this model. Oh, no doubt it cost a bit more, but you have automatic color control, the deluxe cabinet, which I might add looks terrific with this paneling, and the set has total remote control. Say, how much do you watch this set—three or four hours a day?

Mr. Jones: Oh yeah, I guess about four or maybe even five hours a day.

Technician: Well, how long have you had the set, it looks like it has been well kept?

Mr. Jones: Oh, we've had this set for six years this coming May.

Technician: That's about 5½ years. What other troubles have you had with it?

Mr. Jones: Well, actually, this is only the second time it's had any trouble. The first time it just needed some adjusting.

Technician: That's a good record. If you watch this set for 4 hours a day, that's 28 hours a week or 112 hours a month. Do you realize that you've watched this set for over 7000 hours? That's the equivalent of almost a full year of nonstop operation.

Mr. Jones: You know, I'd never thought of it that way before. I guess I got a darn good deal on this set—it's always had a beautiful picture. I can even pick up Channel 9, too. To tell you the truth, my neighbor is a little envious because I can get the Braves' games and he can't.

Technician: I've located the trouble in the set. I'll have that same beautiful picture you're accustomed to, in just a few minutes.

Notice that through open-ended questioning the technician found that the customer had had almost no trouble from the set. At the end, the customer had been offered sympathy, comforted, reassured, and led to see that the company's product was good.

ESTABLISH THE FACTS

The technique of probing is as valid here as it was in the previous example. Probing is not only a tool for mediating complaints. Use probing to find the history of the set, its difficulty, how it has been treated, etc. The *facts* are always useful. But you have to dig for them. The customer is not a technician and does not automatically know what you need to know in order to effectively repair the set.

Establishing some facts can be accomplished by telephone during the first contact with the customer. These facts will help the technician to know what parts and equipment to take on the service call. And remember, the first impression is the most lasting. Be sure the customer's first impression is positive. This is just as important in telephone contacts as in personal contacts. What the customer sees or hears will affect his attitude toward the entire customer/service relationship. If the technician does not have a professional appearance (Fig. 14-4) or doesn't sound knowledgeable over the phone, the customer may wonder if the workmanship will be professional. As a consequence the customer may be more critical of the work performed, and a call-back results. Call-backs cost the servicer since the technician cannot charge for the same service a second time and

Fig. 14-4. The technician should be neat and well groomed.

must use valuable productive time. Customers will willingly pay what they think the technician is worth, and their idea of worth is often based on how the technician looks and acts. Fewer complaints will be heard about service cost, if technicians look like they deserve the rates of professionals.

DISCUSS THE PROPOSED ACTION

A discussion of the action to be taken is important for all service actions, complaints, or routine service. Customers have a right to know what the situation is—to know the probable trouble, cost, alternatives, length of time required to repair the set, etc. In fact, some states have enacted laws that require the technician to supply customers with written estimates and other important information. By discussing these routine matters, customers are made aware of your concern for their needs.

If the set must be taken into the shop for repair, approach the customer in a positive way. Don't say, "I can't fix it here," or "I don't have the correct equipment with me." The customer will say, "Why not? You're in the business." Instead, tell the customer that in order to do the best possible repair and the critical adjustments needed to return the set to its original condition, the set must be taken into the shop. Be positive!

In case of a complaint, use probing questions, reassurance, and genuine concern in the problem to arrive at a plan of action agreeable to the company and the customer.

OBTAIN AN AGREEMENT

When the proposed action has been discussed, an agreement must be obtained. Ask customers to explain their views on proposed agreements, then restate them. This method is often used to lead customers to close deals and is known as directive questioning. By *directive questioning*, customers are directed toward a suitable conclusion. The technique is used in both sales and mediation of disputes. Such questions as "then you agree that . . . ?" or, "you said you liked . . . " are directive questions which focus customers' attention on the *positive areas of common agreement.* By doing this, the objections are broken down bit by bit. Many times customers will say, "Well, I like this part of the deal, but . . . ." At this point the directive question should focus on the part that customers like. The positive is accented and the negative (those parts of the deal not liked) is minimized and soon the deal is closed or an agreement is reached.

If there is a disagreement concerning the proposed action, use the techniques already explained, to overcome the opposition or to moderate the customer's position. Ask yourself, "Have I satisfied the customer?" But, be aware that the agreement may not be profitable this time, but the satisfaction of customers probably will pay benefits in return business or as they tell their neighbors about your service.

CLOSE THE DEAL

Reflection is the repeating of what customers have just said, but in different words. It encourages customers to be more expressive and allows the technician to show an understanding of the customers' points of view. It presents a climate for agreement, for when people hear their own ideas stated back to them, they may see the need to modify their ideas. Reflection of the same ideas back to customers makes them feel that they have sympathy and concern. An example of reflection follows:

Fig. 14-5. Never ridicule the customer's set.

Customer: This set has been a lemon.
Technician: This set has given you a lot of trouble (Fig. 14-5)?

Note that the technician changed the statement into a question to probe the customer, yet the customer's idea was repeated. Reflection is a good technique to use on the "stubbornly irritated."

Complete the repair; allow the customer to operate the set to see that the repair has been satisfactorily made. Clearly itemize the charges on the bill. Again, be positive. Keep away from statements such as "replaced defective transistor." The customer is wondering what a defective transistor was doing in the television. Simply state that a transistor was replaced and give the customer the old transistor. If any explanation is necessary, explain that components in the tv are like parts in a car, and that they sometimes fail while in use and must be replaced.

Reassure the customer of the quality of the repair, the tv set, and your company. Show concern that the failure occurred and wish the customer well. Show genuine gratitude for the business and remember to ask if anything else needs repairing. Remind the customer of other services, such as antenna installation, microwave oven repair, burglar alarm, and smoke detection system repairs. Business is business and it doesn't hurt to ask for it. Even if nothing else needs repair at the time, this customer will remember the good service and the fact that you can repair microwave ovens, as well as televisions.

CUSTOMER DISSATISFACTION

The five major causes of customer dissatisfaction are as follows:

1. Treatment by the service staff.
2. Quality of the technical service.
3. Speed of the repair.
4. Cost of the repair.
5. Quality of the appliance being repaired.

All of these causes can be minimized or resolved by applying the techniques already discussed. Remember that a lost customer is lost *income*. In order to maintain the income, the customer *must* be satisfied. The better the customer is known, the greater is the chance of customer satisfaction. The technician should show concern and interest. Each customer may well represent hundreds or even thousands of dollars in future business if his or her business can be retained and revitalized. We need to learn about customer needs, doubts, expectations, and objections.

IT IS EASY TO LOSE A CUSTOMER

It is easy to lose a customer but very, very hard to regain one. This is why so much effort must go into retaining a customer. Eleven ways we lose customers are as follows:

1. Lack of knowledge of how to explain products, company policies, etc.
2. Poor workmanship.
3. Lack of rapport with the customer.
4. The human desire to "win the argument" rather than mediate it.
5. Neglect of the customer.
6. Lack of interest in the customer and the company.
7. Being a "know-it-all," a loud-mouth, or not talking at all.
8. Finding fault with the product.
9. Indecision on how to interact with the customer.
10. Being unreliable.
11. Sloppy appearance.

Note that the ways we lose customers are the opposites of the qualities needed to keep customers. Customer relations become very simple—do what is right and the wrongs are taken care of. Put another way, if we accent the positive, the negative is cancelled.

Only a few of the fundamentals of good public relations have been covered. Public relations is a complete topic in itself and limiting such a study to a few short pages is like trying to run Niagara Falls through a 1-inch pipe. However, the basis for further study has been laid—the fundamentals have been presented. Each of the basic elements listed can be pursued individually. For example, professionalism and technical ability—just what constitutes professionalism and at what level do we assume reasonable technical ability? It is this type of question that should lead the inquiring technician to learn more by reading professional journals, trade magazines, and textbooks. Also, it may lead to involvement with trade associations and certification groups.

If more information is desired concerning customer relations the following groups may be contacted:

The Electronic Industries Association
National Electronic Service Dealers Association
International Society of Certified Electronic Technicians

Individual manufacturers occasionally produce material on a variety of subjects, customer relations included.

Good customer relations is good business and *pays* dividends.

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