# Pin Point TV TROUBLES IN 10 MINUTES

## Check Charts

**New TV Trouble-Shooting Technique . . .**
***The World's Fastest!***

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# PIN-POINT TV TROUBLES IN 10 MINUTES

## ABOUT THE AUTHOR

Mr. Harold P. Manly

Mr. Harold P. Manly has been one of our authors for over 25 years. He has a rare quality of being able to explain in words of one syllable the most complicated of electronics subjects.

Since 1925 Mr. Manly has written eleven home study courses for private schools: three on radio and television, one on industrial electronics and others on practical electricity, automotive, refrigeration and aircraft instruments.

He has written dozens of technical books on all types of electronics subjects. Among the outstanding he has written for Coyne have been the CYCLOPEDIA OF TELEVISION SERVICING, APPLIED PRACTICAL TELEVISION-RADIO (a 5 volume set of reference books), INDUSTRIAL ELECTRONICS, TV-RADIO HANDBOOK, and the COYNE TECHNICAL DICTIONARY.

With privately owned laboratory facilities in which he makes actual tests on every circuit used in any book he writes Mr. Manly has acted as a Consultant for many leading radio and TV companies.

The system outlined in this book Pin-Point TV Troubles in 10 Minutes represents one of Mr. Manly's greatest contributions to the TV field. The methods he recommends have been the basis for material he has developed for some of the outstanding radio and TV books and courses in the country.

We feel it would be indeed difficult to find a man better qualified than Harold P. Manly to prepare a book on television trouble shooting. An examination of this book would be the best evidence of the reason for such outstanding confidence in an author.

Ray Snyder, *General Manager*
Educational Book Publishing Co.
Coyne Electrical School
Chicago 12, Illinois

# PIN - POINT

# TV TROUBLES

# in

# 10 MINUTES

A Practical, Quick answer, REFERENCE book

on TV Trouble Shooting for Servicemen.

*Published by*

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COYNE ELECTRICAL SCHOOL
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# PIN-POINT TV TROUBLES in 10 MINUTES

# A SYSTEM FOR LOCATING TELEVISION RECEIVER TROUBLES

THIS BOOK is based on seventy kinds of faulty pictures. It covers approximately 700 troubles which may cause the faulty pictures. Cross references, whose use is explained on a following page, allow rapid location of the most probable reasons for each picture symptom.

Accompanying the tables of symptoms and causes are explanations of circuits and designs used in the majority of all television receivers produced since 1953. These explanations clarify the use of the tables. Illustrated and described are methods for checking performance of various parts or components. Also included are precautions to be observed when making tests and replacements, and, in general, the bits of practical information needed while locating and correcting receiver troubles.

The book deals only with trouble location and correction, not with principles and theory. It is assumed that the user understands proper adjustment of all the usual operator's controls and chassis controls, also the use of common service instruments. Instructions are included for some of the more troublesome service adjustments.

Obviously, it is impossible in any book to deal with every intricate trouble which may occur. However, this system will care for the great majority of difficulties, both simple and complex which daily confront the service technician.

# CONTENTS


| SECTION | | |
|---|---|---|
| | A System | V |
| | How to Use | VII |
| | Picture Symptoms | IX |
| | Picture Patterns | XI |
| A | Systematic Trouble Shooting | 1 |
| 1 | Antenna | 8 |
| 2 | Tuner | 12 |
| 3 | Intermediate-frequency (I-F) Amplifier | 27 |
| 4 | Video Detector | 36 |
| 5 | Automatic Gain Control (AGC) | 41 |
| 6 | Video Amplifier | 53 |
| 7 | Picture Tube Input | 67 |
| 8 | The Picture Tube | 83 |
| 9 | The Sync Section | 98 |
| 10 | Vertical Sweep | 127 |
| 11 | Horizontal Sweep | 160 |
| 12-16 | Deflection and High Voltage | 210 |
| 12 | Horizontal Deflection | 216 |
| 13 | Boosted B-voltage | 247 |
| 14 | High Voltage Section | 252 |
| 15 | Vertical Deflection | 267 |
| 16 | Deflecting Yoke | 275 |
| 17 | Low-voltage Power Supply | 277 |
| 18 | Television Sound | 301 |
| | Indexes | 328 |

# HOW TO USE THIS SYSTEM

**1.** In the following list of picture symptoms find the one that is marring picture reproduction.

**2.** Opposite that symptom are numbers of all pages on which are listed probable causes for the existing picture symptom. Numbers in heavy type refer to the page or pages listing most of the probable faults. Refer to these pages first. Use the other tables later, if necessary.

**3.** At the top of the table on a selected page find the name of the existing picture symptom. Underneath that symptom are reference dots. Opposite the dots, in the left-hand column, are receiver faults which may cause the trouble.

**4.** The faults listed in each table are numbered, beginning at 1 for each section of the book. Methods of correcting most of the faults need no explanation. For instance, if a capacitor is leaky or shorted it should be replaced, if a voltage is too high it should be lowered, etc.

*There are, however, certain faults which require specialized methods for correction or whose location is made easier by additional checks and tests.* For faults of this class there are explanations and suggested procedures in numbered paragraphs which precede or follow the tables in the same section of the book. The numbers of these paragraphs correspond to numbers of the faults in the tables. Numbered paragraphs are included *only* for faults requiring special instructions, *not for all of the faults listed in the tables.*

At the beginning of each section in this book are diagrams, illustrations and brief descriptions of designs and components considered in that section. Should you be in doubt as to the part of a circuit in which will be found some fault listed in a table, refer to these preliminary explanations.

Here also, will be found information on circuit peculiarities, on methods for improving performance, making service adjustments, connecting test instruments, checking various components and making many more or less routine tests. The best way to show you how this book will cut your TV trouble shooting time is to take you through an actual case step by step checking out the trouble with this system.

For this example turn to page headed "Picture Symptoms—Trouble Tables." Let's take the very first picture symptom — BAND or BAR Bright, bottom. This describes a problem of a bright band at the bottom of the viewing tube. You will note that the Trouble Tables at right, show that trouble shooting tables for this trouble are to be found on pages 157-158 and 159. On page 157 you will find a check chart with a reference to "bright bar, bottom," in the first column. Glancing down this column you note a dot at "Cathode heater, leak" in the output tube. This tells you that such a condition can cause a bright bar at the bottom of the tube. On the bottom line of page 157 you note that a grid resistor which is "too small" can also cause this trouble.

Continuing on page 158 you will note that a peaking resistor that is "too great" could cause this trouble. On Chart 159, page 159, it is indicated that this condition could be also caused by "too little resistance" in the Linearity control.

Any of the aforementioned conditions, which you can easily check, could cause a bright bar at the bottom of the picture.

With that sample procedure it is easy to understand how much time can be saved through this new system of TV troubles location. Over 70 picture symptoms can be checked in exactly the same way we have taken you through the sample case. As an added aid to the serviceman we include several dozen actual picture patterns. You will find these in a section following picture symptoms. We do this in every case where we feel the *Picture Symptom* as described may not be quite clear to the serviceman unless he *sees an actual photo of the picture trouble.* There are many of the Picture Symptoms such as Band, dark, bottom, Width lacking, etc. that require no picture illustration. *We only include picture patterns on troubles that we feel require them.*

The last section of the book covers sound problems in TV receivers. We confidently feel that when you acquaint yourself with the system covered in this book you can Pin-Point TV Troubles in 10 minutes as the name of the book implies.

Ray Snyder, General Manager
Educational Book Publishing Division
Coyne Electrical School
Chicago 12, Ill.

| PICTURE SYMPTOMS | TROUBLE TABLES (Page numbers) |
|---|---|
| BAND OR BAR | |
| Bright, bottom | 157, 158-159 |
| Bright, top | 80, **158**, 273-274 |
| Dark, top | 79-80 |
| Dark, vertical | 251 |
| Dark-bright alternating, vertical. See Ringing. | |
| BARS, HUM | 28, 39, 49, 57, **292** |
| BARS, SOUND | 15, **28**, 57 292 |
| Bas-relief, See Negative Pictures | |
| BENDING, TOP. see also Pulling. | 28, 57, **59**, 124 194, 196-197, 199 |
| BLOOMING | 85, **261-262**, 290 |
| Bright bar, bottom. See Band Or Bar, Bright, Bottom. | |
| Bright bar, top. See Band Or Bar, Bright, Top. | |
| Bright line, horizontal. See Line, Horizontal, One | |
| Bright line, vertical, See Line, Bright, Vertical. | |
| Bright spot only. See Spot Only, Bright. | |
| BRIGHTNESS CONTROL POOR | 77, 85 |
| BRIGHTNESS EXCESSIVE | 28, 77, **79-80**, **81**, 85, 197, 206. 251 |
| BRIGHTNESS LACKING | 15, 28, 77, 81, 85, 97, 194-195, 197, 200, 202-204, 205, 206, 225, 251, **261-262**, 273. 290. 292 |
| CENTERING DIFFICULT | **97**, 225, 276 |
| Compressed, bottom, See Linearity Poor, Vertical, Bottom. | |
| Compressed, top. See Linearity Poor, Vertical, Top | |
| CONTRAST EXCESSIVE | 8, 28, 49, 57-58, **59**, 81 |
| CONTRAST LACKING | 8, 15, 28, 39, 49, 57, **59-60**, **77**, 81, 85, 292 |
| CONTRAST VARIES | 49 |
| Dark band, top. See Band Or Bar, Dark, Top. | |
| Dark band, vertical. See Band Or Bar, Dark, Vertical. | |
| Dark line, vertical. See Line, Dark, Vertical. | |

| | |
|---|---|
| DARK MOMENTARILY | 49 |
| DARK. No raster or pictures. | 77, 81, 85, 97, 194-195, 196-197, 199-201, **202-204**, 205-106, 225, 235, 244-245, 251, 260, 261-162, 264, 273, **290-291** |
| DEFINITION POOR. See also Fuzzy Pictures. | 8, 15, 28, 39, 49, **57-58, 59-60,** 81, 85, 97 |
| Detail lacking. See Definition Poor, also Fuzzy Pictures. | |
| FLASHES | 15, 260, **264** |
| FLICKERING | 49 |
| FOCUS POOR | 85, 97, 251, **261-262**, 276, 292 |
| FOLD, HORIZONTAL. Center or side. | 124, 194-195, **196-197, 199-201,** 202, 204, 205, 225, 235, 244, 251 |
| FOLD, HORIZONTAL. Shadowy. | 194-195, 196-197, 199, 202-204 |
| FOLD, VERTICAL. See also Band Or Bar, Bright, Top. | 154-155, 156-157, 158 |
| FUZZY PICTURES | 195, 196-197, 200-201, 204, 205-206, 273-274 |
| GHOSTS | 8 |
| GRAINY PICTURES | 39, **58** |
| HEIGHT EXCESSIVE. See also Size Excessive. | 154-155, 156-157, 158-159 |
| HEIGHT LACKING. See also Size Lacking. | 154-155, 156-157, 158-159, 251, 273 |
| HEIGHT VARIES | 157 |
| Horizontal fold. See Fold, Horizontal | |
| Horizontal line. See Line, Horizontal, One. | |
| Horizontal sync faulty. See Sync, Horizontal. | |
| Hum bars. See Bars, Hum. | |
| INTERFERENCE PATTERN | 28, 39 |
| INTERLACE POOR. See also Fold, Vertical | 154 |
| ION BURN | 97 |
| JITTER, HORIZONTAL | 15, 57, 194-195, 196, 199, 202, 235, **264** |
| Keystoning. See Wedge Shaped. | |
| LINE, BRIGHT, VERTICAL | 197, **205-206**, 225, 235, 244-245 |
| LINE, DARK, VERTICAL | 205-206,235 |
| LINE, HORIZONTAL, ONE | 154-155, 156-157, 158, 159, 251, 273-274 |
| LINES, HORIZONTAL, MANY | 158 |

| | |
|---|---|
| LINEARITY POOR, HORIZONTAL | **205-206**, 225, 235, 244 |
| LINEARITY POOR, HORIZONTAL AND VERTICAL | 85 |
| LINEARITY POOR, VERTICAL. Bottom. | 155, 156, **158** |
| LINEARITY POOR, VERTICAL. Top | 155, 156-157, **158-159**, 251, 273-274 |
| MULTIPLE IMAGES | 15, 28, 39, **57**, **59** |
| NEGATIVE PICTURES | 57, 59 |
| NOISE IN PICTURES. See also Flashes, Grainy Pictures, and Speckling. | 15 |
| OVERLAPPING. See Fold. | |
| PAIRING. See Interlace Poor | |
| PULLING. See also Bending | 124 |
| Raster lacking. See Dark, No Raster. | |
| RASTER ONLY. No Pictures | 8, 15, 28, 39, 49, **57-58**, **59-60**, 77, 81, 85, 273, 292 |
| Resolution poor. See Definition Poor. | |
| RETRACE LINES APPEAR | 77, **79-80**, **81**, 273-274 |
| REVERSED, LEFT-RIGHT | **244**, 276 |
| REVERSED, TOP-BOTTOM | **273**, 276 |
| RINGING | 225, **235**, 244 |
| Ripples, See Wavy | |
| Rolling, vertical. See Sync, Vertical Absent. | |
| SHADOWING | 97 |
| SIZE EXCESSIVE (Height and width) See also Blooming. | **260**, 261-262 |
| SIZE LACKING (Height and width) | 85, 235, **290** |
| SKEW OR TILT | **97**, 276 |
| SMEARING | 15, 28, 39, 49, 57, **59-60**, 124 |
| SNOW | 8, 15, 49, 264 |
| Sound bars. See Bars, Sound. | |
| SPECKLING. See also Grainy Pictures. | 28, 225, 260, **264** |
| Split pictures. See Sync, Horizontal, Split. | |

| | |
|---|---|
| SPOT ONLY, BRIGHT | 276 |
| Streaking. See Smearing, also Speckling. | |
| Stretched, bottom or top. See Linearity Poor, Vertical. | |
| SYNC, HORIZONTAL AND VERTICAL. Absent or critical. | 15, 28, 39, 49, 57, 59-60, 81, 124, 251, 264 |
| SYNC, HORIZONTAL. Absent | 194-195, 196-197, 199-201, 202-204, 205 |
| SYNC, HORIZONTAL. Critical | 194-195, 196-197, 199-201, 202-203, 225, 235, 251 |
| SYNC, HORIZONTAL. Split left-right. | 124, 194-195, 196, 199, 202-203 |
| SYNC, VERTICAL. Absent or critical. | 154-155, 156-157, 158-159, 251, 292 |
| SYNC, VERTICAL. Split top-bottom. | 156-157, 158-159 |
| TEAR OUT | 57, 124, 264 |
| Tilt. See Skew Or Tilt. | |
| Trailers. See Smearing. | |
| Vertical fold. See Fold, Vertical. | |
| Vertical line. See Line, Bright, Vertical. | |
| Vertical sync. See Sync, Vertical | |
| Vertical waves. See Wavy, Vertical. | |
| WAVY, HORIZONTAL | 244, 274 |
| WAVY, VERTICAL | **124,** 196-197, 199, 202, 205, 274, 276, 292 |
| Weak pictures. See Contrast Lacking. | |
| WEDGE SHAPED | 244-245, 273-274, 276 |
| WIDTH EXCESSIVE. See also Size Excessive. | 201, 202, 204, 206, **225** |
| WIDTH LACKING. See also Size Lacking. | 194, 196, 200, 203, **205-206,** 225, 235, 244-245, 251 |


## VOLTAGE SYMPTOMS

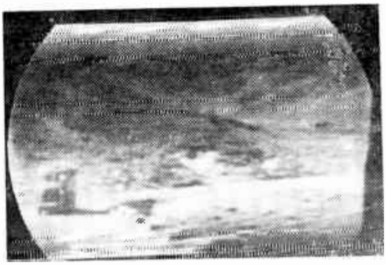

| | |
|---|---|
| ANODE VOLTAGE. Low-zero. | 225, 235, 244-245, 260, **261-262,** 264 |
| ANODE VOLTAGE. High. | 235, 244 |
| AUTOMATIC GAIN CONTROL | 50-51 |
| BOOST VOLTAGE. Low-zero. | 235, 251 |
| B-VOLTAGE. Low. | 290 |
| B-VOLTAGE. Zero | 291 |
| CORONA OR ARCING | 225, 260, **264** |
| RIPPLE OR HUM VOLTAGE | 292 |

# PICTURE PATTERN SECTION

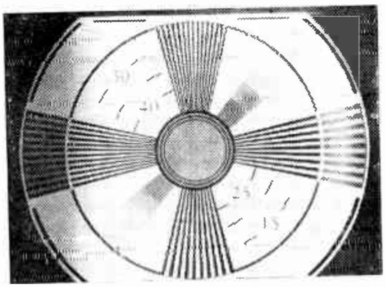
This section illustrates most of the TV troubles covered in this book. The caption under the picture pattern correspond to the description given in the previous section "Picture Symptoms". This section is arranged alphabetically by name of the TV trouble.

Band or bar, bright, bottom.
157-158-159

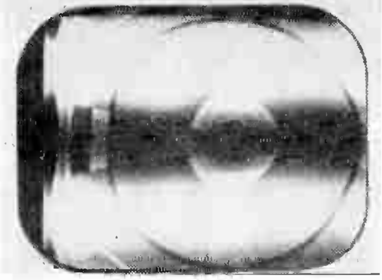
Band or bar, dark, top.
79-80



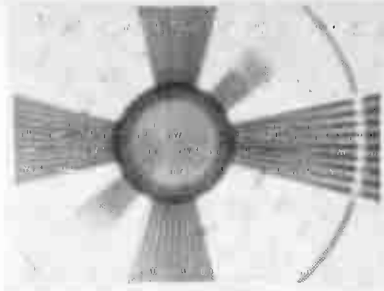
Band or bar, bright, top.
80, **158**, 273-274



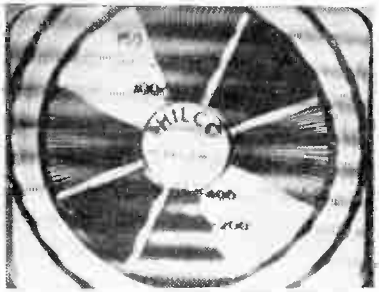
Band or bar, dark vertical.
251



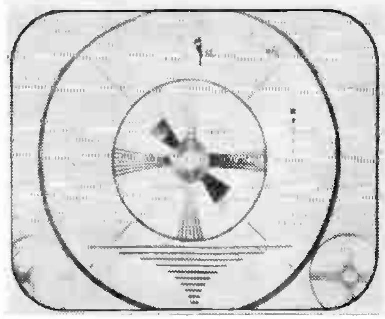
Bars, hum.
28, 39, 49, 57, **292**



Blooming.
85, **261-262,** 290

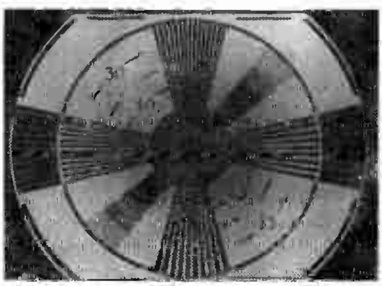


Bars, sound.
15, **28,** 57, 292

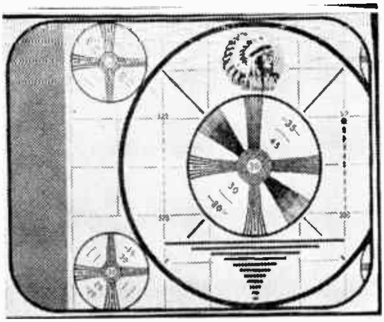


Brightness excessive.
28, 77, **79-80,** 85, 197, 206, 251

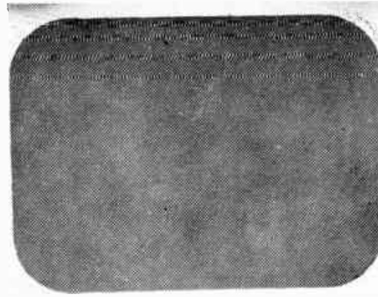
Bending, top.
28, 57, **59,** 124, 194,
196-197, 199



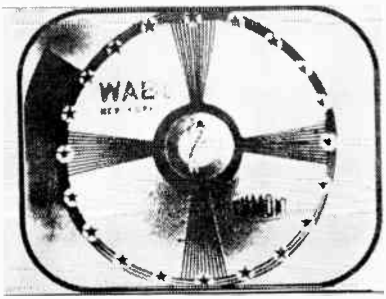
Brightness lacking
15, 28, 77, 81, 85, 97, 194-195,
197, 200, 202-204, 205-106,
225, 251, **261-262,** 273, 290,
292



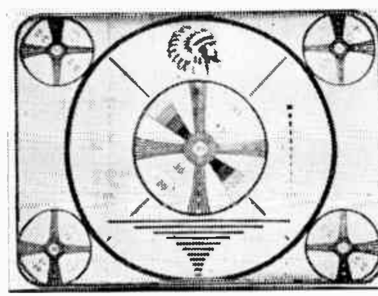
Centering difficult.
**97,** 225, 276



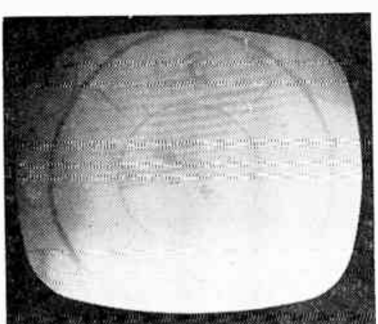
Dark, no raster or pictures.
77, 81, 85, 97, 194-195, 196-197, 199-201, **202-204,** 205-206, 225, 235, 244-245, 251, 260, 261, 262, 264, 273, **290-291**



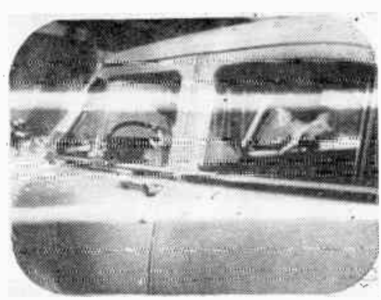
Contrast excessive.
8, 28, 49, 57-58, **59,** 81



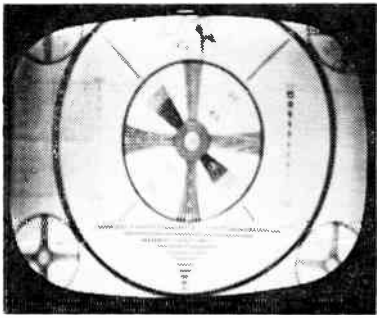
Definition poor.
8, 15, 28, 39, 49, **57-58, 59-60,** 81, 85, 97



Contrast lacking.
8, 15, 28, 39, 49, 57, **59-60,** 77, 81, 85, 292

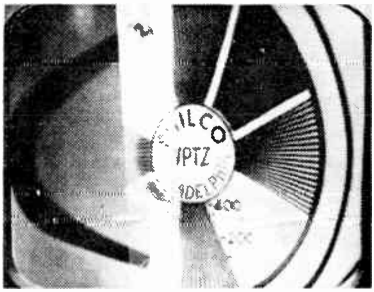


Flashes.
15, 260, **264**



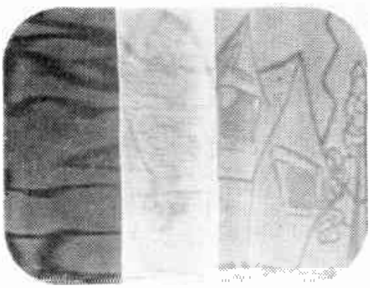
Focus poor.
85, 97, 251, **261-262,** 276, 292

Fold, vertical.
154-155, 156-157, 158

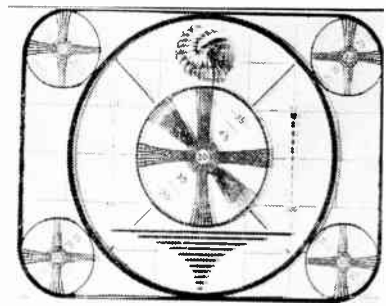


Fold, horizontal, center.
124, 194-195, **196-197, 199-201,** 202, 204, 205, 225, 235, 244, 251

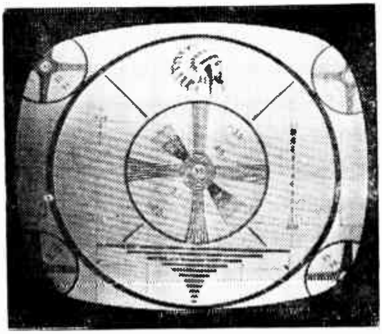
Fuzzy pictures.
195, 196-197, 200-201, 204, 205-206, 273-274



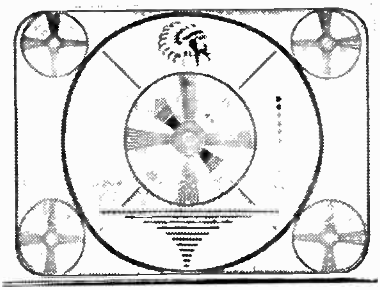
Fold, horizontal, shadowy.
194-195, 196-197, 199, 202-204



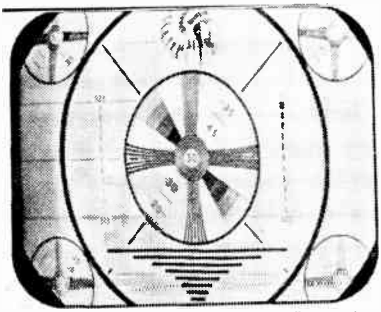
Ghosts.
**8**



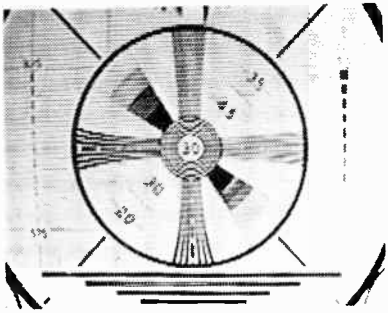
Grainy pictures.
39, **58**



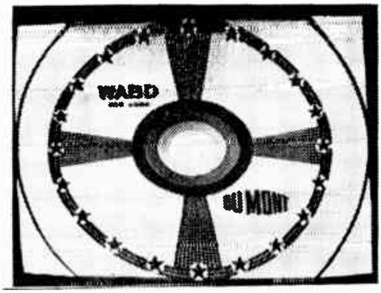
Interference pattern.
28, 39



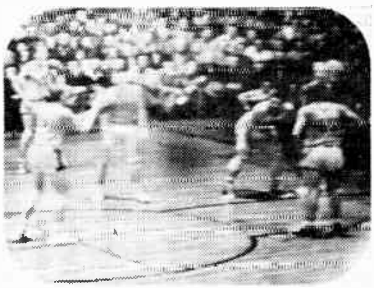
Height excessive
154-155, 156-157, 158-159,



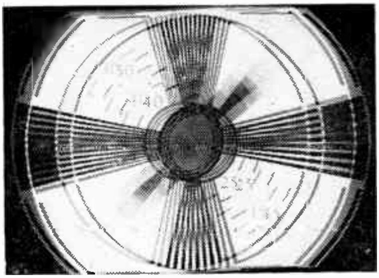
Interlace poor.
154



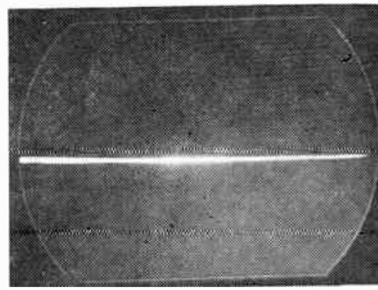

Height lacking.
154-155, 156-157, 158-159,
251, 273



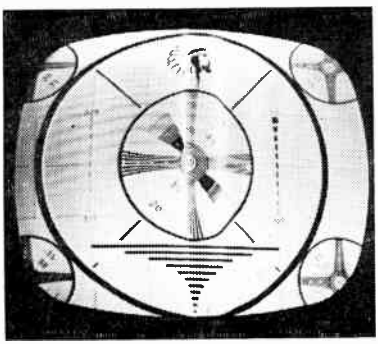
Ion burn.
97



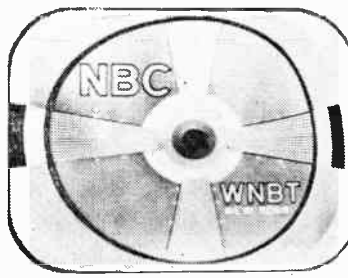
Jitter, horizontal.
15, 57, 194-195, 196, 199, 202, 235, **264**



Line, horizontal, one.
154-155, 156-157, 158, 159, 251, 273-274

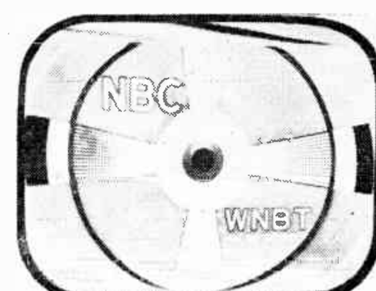


Line, bright, vertical.
197, **205-206,** 225, 235, 244-245, 205, 206, 235

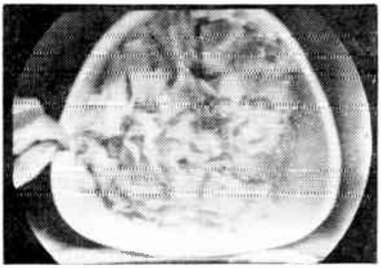



Linearity poor, horizontal.
**205-206,** 225, 235, 244

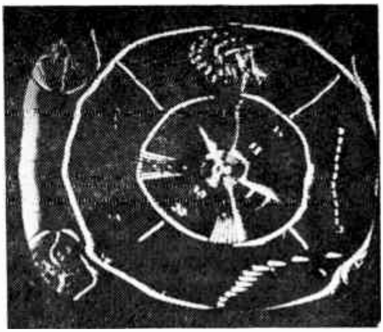
Line, dark, vertical.
205-206, 235



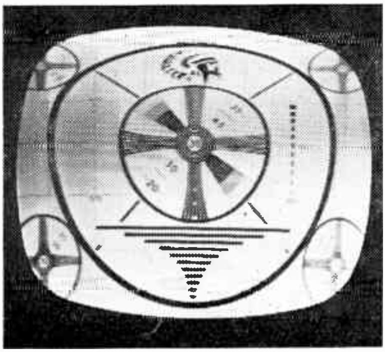

Linearity poor, horizontal and vertical.
85



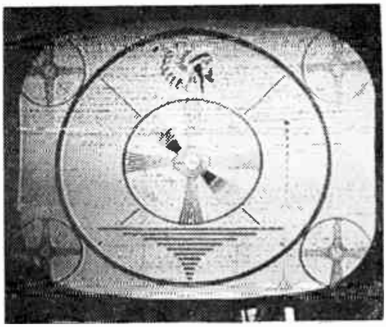
Linearity poor, vertical, bottom.
155, 156, **158**



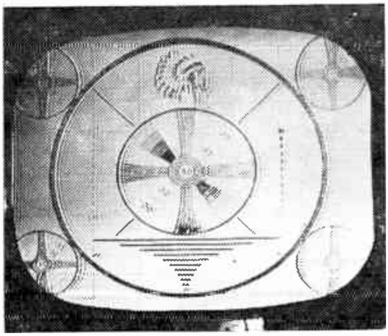
Negative pictures.
57, 59



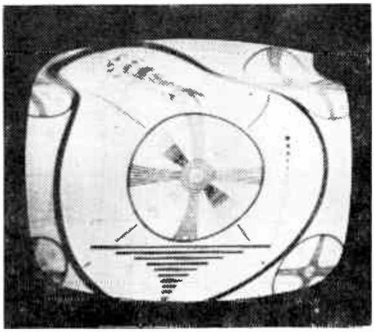
Linearity poor, vertical, top.
155-156, 157, **158-159,** 251, 273-274



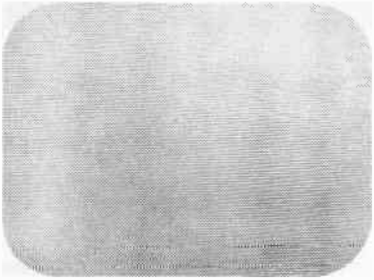
Noise in pictures.
15



Multiple images.
15, 28, 39, **57, 59**

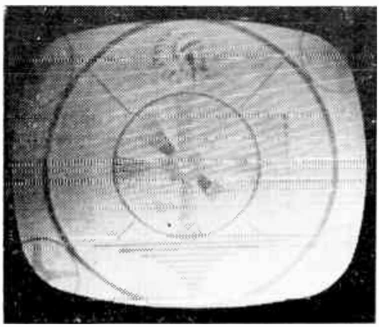


Pulling.
124

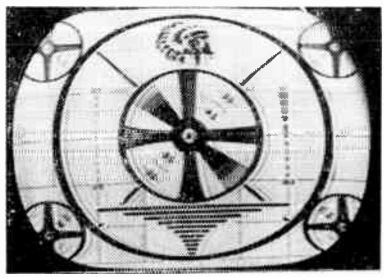


Raster only, no pictures.
8, 15, 28, 39, 49, **57-58, 59-60,** 77, 81, 85, 273, 292

Reversed, top-bottom.
**273,** 276

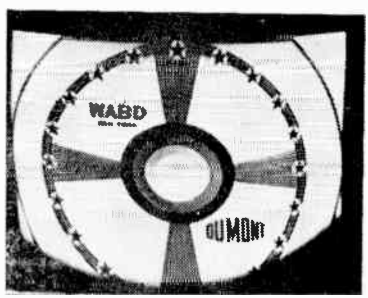


Retrace lines appear.
77, **79-80, 81,** 273-274

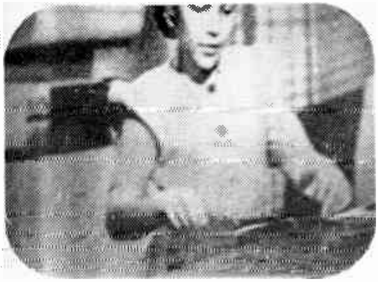


Ringing.
225, **235,** 244

Reversed, left-right.
**244,** 276

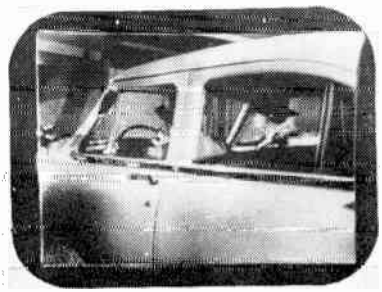



Shadowing
97



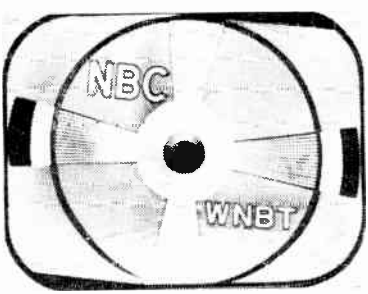
Size excessive, height-width.
**260,** 235, 262

Smearing.
15, 28, 39, 49, 57, **59-60,** 124



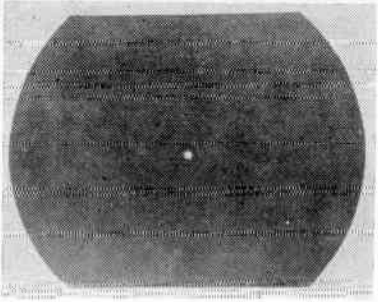
Size lacking, height-width
85, 235, **290**

Snow
8, 15, 49, 264

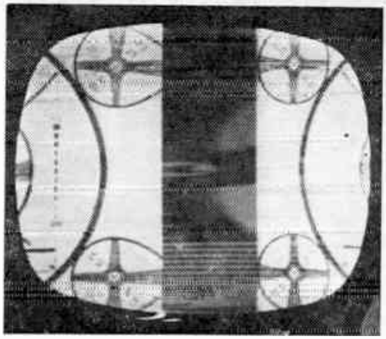



Skew or tilt.
**97,** 276

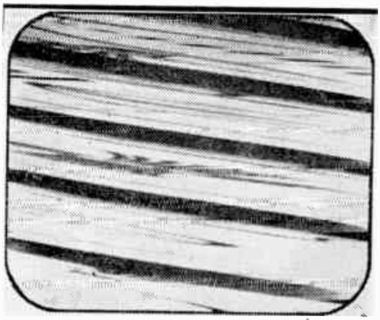
Speckling.
28, 225, 260, **264**



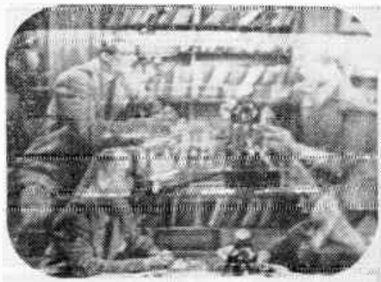
Spot only, bright.
276



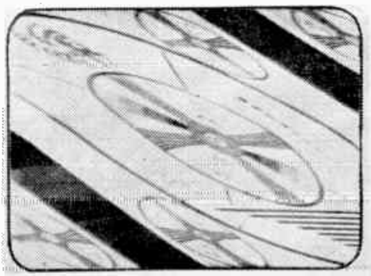
Sync, horizontal, split left-right.
124, 194-195, 196, 199, 202-203



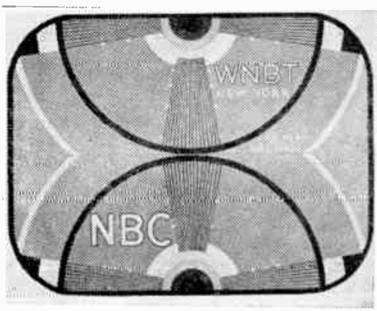
Sync, horizontal, absent.
15, 28, 39, 49, 57, 59, 60,
81, 124, 251, 264



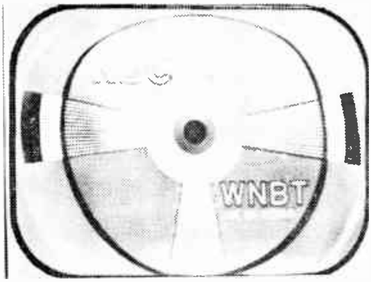
Sync, vertical, absent or critical.
154-155, 156-157, 158-159,
251, 292



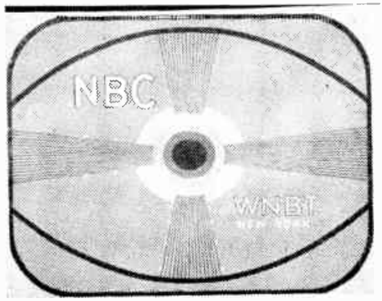
Sync, horizontal, critical.
194-195, 196-197, 199-201, 202,
203, 225, **235, 251**



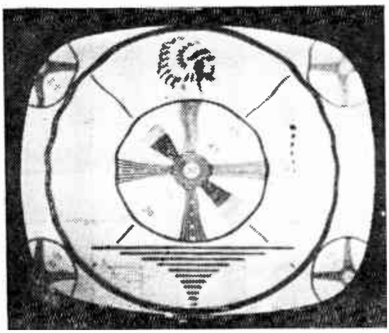

Sync, vertical, split top-bottom.
156-157, 158-159



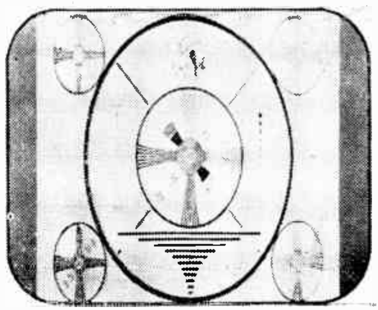

Tear out.
57, 124, 264



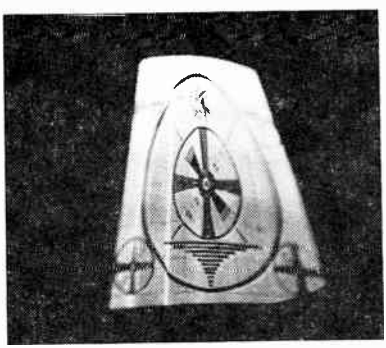

Width excessive.
201-202, 204, 206, **225**



Wavy, vertical.
**124,** 196-197, 199, 202, 205, 274, 276, 292



Width lacking.
194, 196, 200, 203, **205-206,** 225, 235, 244-245, 251



Wedge shaped.
244-245, 273-274, 276

# SECTION A

## SYSTEMATIC TROUBLE SHOOTING

Locating TV troubles could be almost a pleasure if some single test or observation would eliminate half the possibilities, if a second test could eliminate half of those remaining, and so on until you spotted one small section as containing the culprit. Then simple checks on a few parts and connections would pin point the needed adjustment or replacement. It would be as easy as pictured by Fig. 1.

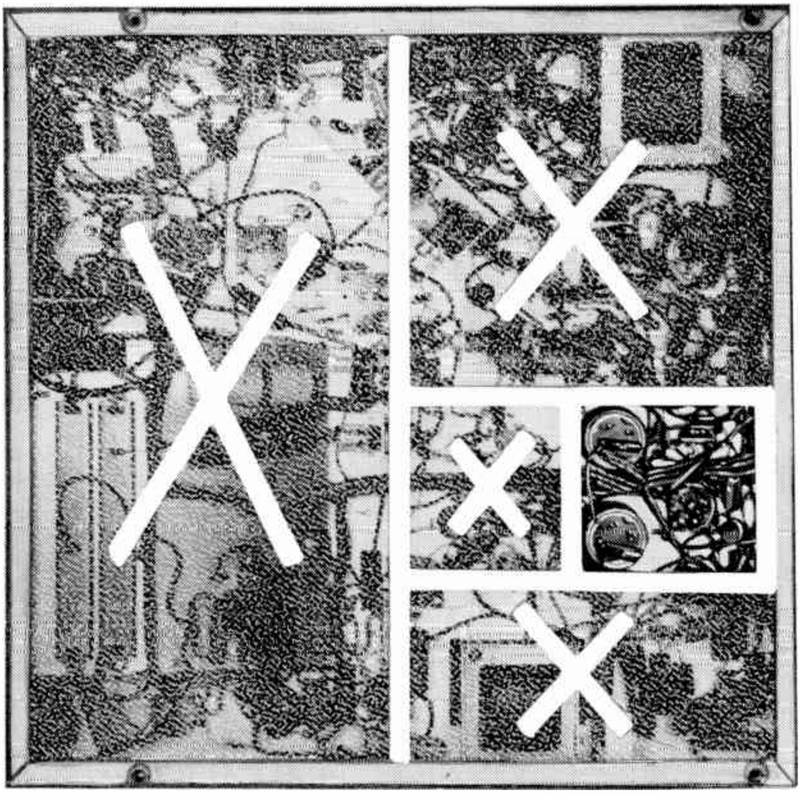


*Fig. 1. For fast trouble location we eliminate from suspicion one section after another until only a small group of parts remains for final checking.*

We cannot make such mathematical divisions as halves, quarters and eighths of all the parts and circuits in which trouble might exist, but we can do what amounts to the same thing. The basis of such systematic trouble location is in thinking of every receiver as consisting of the sections shown by blocks in Fig. 2, and thinking of signals and other voltages as following the lines.

Video signals follow the heavy solid lines. Sound signals follow the long dashes. Sync, sweep, and deflection voltages follow the light lines. Voltages and currents from the low-voltage power supply go directly or indirectly along dotted lines.

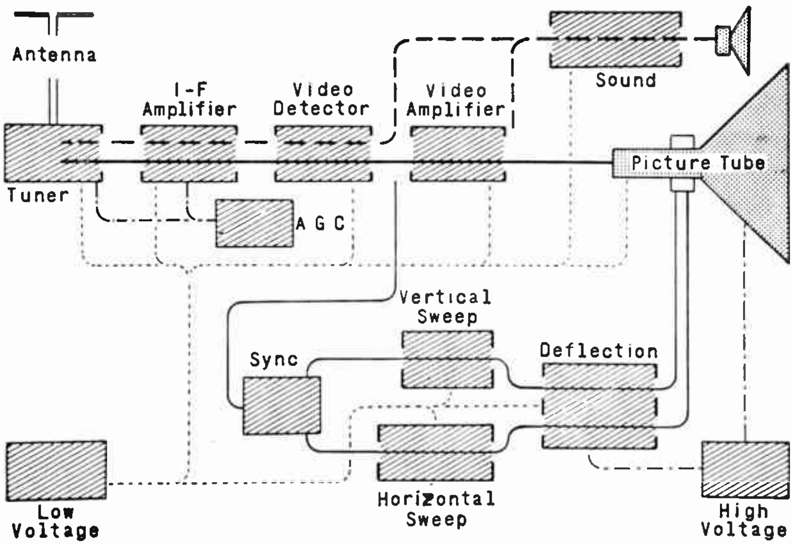



*Fig. 2. The technician thinks of every receiver as consisting of these sections.*

Merely by observing whether pictures, a raster, and sound are present or absent we may go a long ways toward determining which sections cannot contain the existing trouble, which sections most probably are in difficulty and which ones may only possibly be at fault. We eliminate anywhere from two-thirds to nine-tenths of the sections from further consideration.

**Note:** To observe a raster place the channel selector where there are no programs or transmissions in your locality. If necessary, advance the brightness control to cause illumination of the viewing screen of the picture tube. The raster consists of luminous horizontal trace lines which cover the screen as in Fig. 3. Each line is produced by action of the horizontal sweep and deflection sections. The lines are spread from top to bottom of the screen by the vertical sweep and deflection sections.

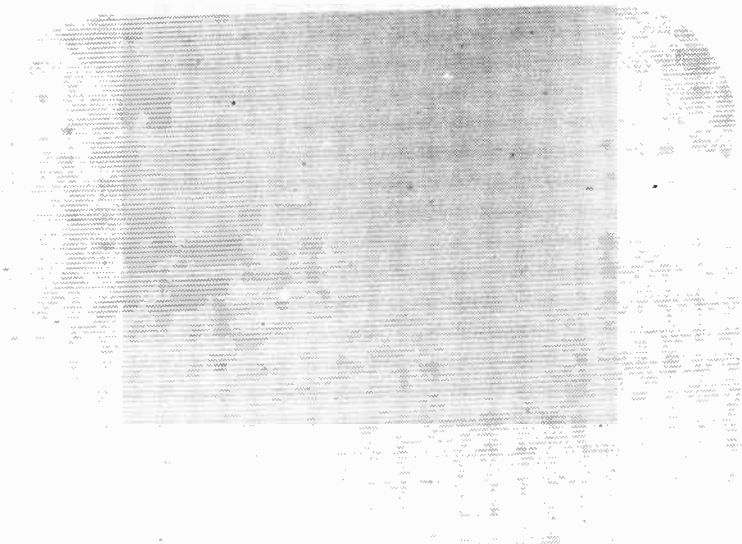


*Fig. 3. A raster is made up of horizontal luminous traces.*

The first steps in trouble location are outlined by the table *Preliminary Observations*. Supposing, as an example, there are no pictures and no raster, but sound is present. These are the conditions listed as case *B*. We look first for trouble in the high-voltage section. If high voltage is satisfactory at the picture tube anode we check the picture tube itself, then the horizontal sweep, and finally certain parts of the deflection section. Why the tests are made as outlined, and what they signify, are explained briefly for each of the cases in paragraphs which follow.

## PRELIMINARY OBSERVATIONS

### No Picture, Raster or Sound (A)

The set is dead. Looking at Fig. 2 we note that the low-voltage section furnishes power through dotted line paths to all other sections except the one for high voltage, and indirectly to the high-voltage section. Consequently, performance of all other sections is dependent on the low-voltage power supply, and there we commence looking for trouble.

## No Pictures or Raster—Sound Present (B)

The fact that sound is present eliminates from suspicion all the sections along the long-dash line of Fig. 2, also the low-voltage section which is supplying power for sound. No raster means that the electron beam is not being deflected across the picture tube face. Maybe there is no beam, so we begin by checking the high-voltage section.

| | PRELIMINARY OBSERVATIONS | | | | |
|---|---|---|---|---|---|
| | SYMPTOMS | | | SECTIONS IN TROUBLE | |
| | Picture | Raster | Sound | Most Probable | Possible |
| A | No | No | No | Low-voltage | |
| B | No | No | Yes | High-voltage | Picture tube<br>Horizontal sweep<br>Deflection |
| C | No | Yes | No | I-f amplifier | Video detector<br>Tuner<br>Agc<br>Antenna |
| D | No | Yes | Yes | Video amplifier<br>Picture tube | I-f amplifier<br>Tuner |
| E | Yes | Yes | No | Sound | Tuner<br>I-f amplifier |

If high voltage is satisfactory at the anode of the picture tube it is in order to measure voltages at the second grid, the control grid and the cathode. Having cleared the picture tube, thus determining that a beam may be formed, we proceed to check the horizontal sweep section wherein originate voltages which directly or indirectly affect both horizontal and vertical deflections of the electron beam. The final step would be a check of the deflection section.

## No Picture Or Sound — Raster Present (C)

Presence of a raster proves that vertical sweep, horizontal sweep, deflection, high-voltage and low-voltage sections are working. Picture signals and sound signals, which are lacking, would have to come through antenna, tuner, i-f amplifier, video dectector, and video amplifier sections. I-f amplifier trouble is most probable, but if this section is operative we check, in order, the video detector, tuner, automatic gain control (agc) and antenna.

## No Picture — Raster And Sound OK (D)

A raster always indicates that vertical and horizontal sweep, deflection, high-voltage and low-voltage sections are working. Sound signals, which here are present, must be coming through antenna, tuner, i-f amplifier, video detector, and often through at least part of the video amplifier section. Accordingly, there can be nothing radically wrong from antenna to the sound takeoff.

It remains to investigate, first, any portion of the video amplifier section that does not carry sound signals, also the control grid-cathode circuits for the picture tube. The i-f amplifier or tuner may pass sound signals even though so far out of adjustment as to prevent formation of pictures, so these latter two sections are possibilities for trouble.

## Picture And Raster OK — No Sound (E)

Sound signals should come through antenna, tuner, i-f amplifier, video detector, and part or all of the video amplifier section on their way to the sound section. All these sections that precede the sound takeoff carry picture signals, and pictures are present. Then, naturally, we look first to the sound section as containing the fault.

Incorrect adjustments in the tuner, and possibly in the i-f amplifier, might prevent picture formation while allowing sound to come through, so these two sections should be examined in case the sound section is cleared.

## Symptoms And Their Causes

Up to this point we have talked only about pictures, raster and sound which are good or else entirely absent. There will, however, be many cases with which pictures, raster and sound may be present, but poor. By considering poor performance, as distinct from no performance whatever, we may more quickly eliminate groups of parts with minimum effort and time.

As an example, we might have pictures with bad smears or trailers, as in Fig. 4. Such faults might result from any one or more of about twenty-five kinds of trouble. At least half of all these troubles may be in the video amplifier, but a considerable number of possible causes are in the tuner, and an equal number in the video detector. Less common are faults in automatic gain control, picture tube input, and sync sections. Smearing might even result from wrong dressing of conductors and circuit components. Due to all these possibilities we cannot say that smearing (or any other single defect) indicates trouble in only one certain section.

*Fig. 4. Smearing may result from trouble in any of several sections.*

Neither is it true that troubles in one certain section will cause only one kind of picture fault. For instance, although smearing may result from trouble in the video detector section, various faults in this section may also cause multiple images, lack of contrast, poor definition, snow, loss of synchronization, tear out, or absence of pictures and sound.

To allow more definite tieups between symptoms and causes we may divide most of the major sections into subdivisions. One of the biggest major sections, that for the picture tube, contains everything shown by Fig. 5. In addition to the tube itself we have control grid-cathode signal input circuits, the brightness control, sometimes a contrast control, and the retrace blanking system. We have also an ion trap magnet and focusing and centering controls which may be separate or combined. Other major sections may be similarly broken down.

## Getting Down To Business

Our plan of attack will be this: First we shall examine all the major sections and their subdivisions solely with reference to their probable and possible troubles, the resulting symptoms, various tests for quickly isolating the seat of trouble, and suitable remedies.

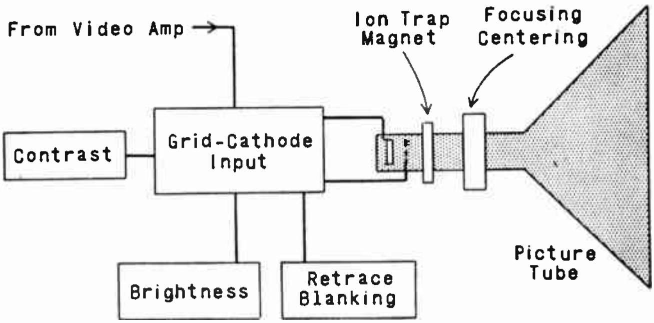



*Fig. 5. The picture tube section contains these subdivisions.*

Second, we shall apply the same procedure to circuit components such as capacitors, resistors, inductors, all the small tubes, and so on.

## How to Begin

No matter what details of tests and measurements we get into later on it is wise to commence every job of trouble shooting with these steps.

**1.** Tune in each locally active channel and observe performance. Trouble on only one channel may indicate temporary difficulty at the transmitter, or the fault may be in the receiver tuner.

**2.** Try to get best possible pictures and sound by careful adjustment of the operator's controls. If one control makes performance better or worse you have a clue to the section or circuit at fault — it might be the control itself.

**3.** Check the effect of any service adjustments which are definitely related to existing faults. As one example, horizontal sync difficulties point to adjustments for frequency and for hold in the horizontal oscillator circuits.

**4.** When symptoms or tests indicate one section as the probable or possible seat of trouble, try new tubes or tubes known to be good before checking other components in that section.

# SECTION 1

## ANTENNA

The antenna section or group includes the antenna itself and the transmission line connecting the antenna to the tuner of the receiver. The accompanying table lists common faults and picture symptoms most often resulting from each fault.

| **Table 1 ANTENNA** | Snow | Ghosts | Contrast lacking | Definition poor | Raster only, no pictures | Contrast excessive |
|---|---|---|---|---|---|---|
| ANTENNA FAULTS | | | | | | |
| 1 Wrong orientation, height or location | • | • | • | | | |
| 2 Built-in or indoor type | • | • | • | | | |
| 3 Non-directional | | • | | | | |
| 4 Excessive pickup | | | | | | • |
| LINE FAULTS | | | | | | |
| 5 Connections poor or open | • | | | | • | |
| 6 Mismatch | • | • | | • | | |
| 7 Routing wrong | • | | | | | |

### 1. Wrong Orientation, Height Or Location

As illustrated by Fig. 1-1, orienting an antenna means to rotate the dipole and parasitic elements around the mast to a position that allows most satisfactory pickup of desired signals, or least interference, or the most acceptable compromise of these factors. Orientation can be made only while receiving broadcast signals. Relative strengths of signals from different directions are compared by observing pictures, by measuring output from the video detector, or by using a field strength meter.

Although additional height of the antenna almost always improves reception, there may be unusual conditions with which better pickup is secured with less height. The best location among those which are accessible may be found only by moving the antenna from place to place before final erection. Movement of only a few feet to one side or the other may make great improvement, especially on high-band vhf channels and on uhf channels.

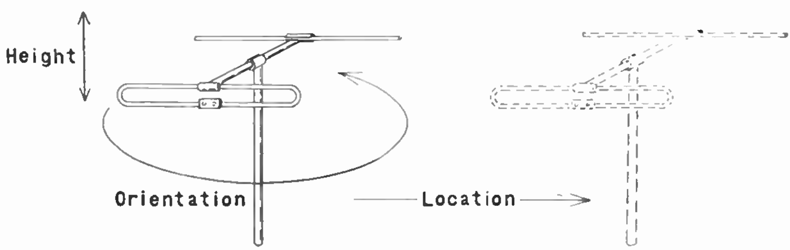



*Fig. 1-1. Factors which affect signal pickup by the antenna.*

## 2. Built-in Or Indoor Antenna

Such antennas can be oriented to only a limited extent, they cannot be raised or lowered, and choice of location is limited. These shortcomings account for the troubles which may be expected. The remedy is a good outdoor antenna.

## 3. Non-directional Antenna

Ghosts, which are due to signal reflections, often may be reduced or eliminated by an antenna of the Yagi type or some other which has marked directional properties. A reflector on any antenna provides a certain amount of directivity, but this property is greatly increased by the addition of one or more directors.

## 4. Excessive Pickup

An efficient antenna close to a transmitter may deliver to the receiver signals so strong as to overload tubes in the tuner or i-f amplifier. Signal strength may be reduced by changing the orientation or by use of an attenuation pad at the receiver end of the transmission line. A resistance pad reduces signals from all channels. A quarter-wave open resonant line, a tuned stub, sometimes is used to reduce signals from one channel.

## 5. Connections Poor Or Open

Loose or corroded terminal connections, shorted terminals, or broken transmission line conductors will reduce signal strength to the receiver and leave noise impulses so relatively strong as to cause snow in pictures. In extreme cases or in fringe areas there may be no pictures or sound.

## 6. Mismatch

A mismatch occurs when impedance of the transmission line differs from that of the antenna or the receiver input. Mismatch as great as two-to-one causes signal loss of 10 to 12 per cent, which should not be a serious loss except in extreme fringe areas. Loss increases rapidly with greater impedance differences.

Wave reflections due to bad mismatching may cause picture effects quite similar to wave reflection ghosts. Splicing the line anywhere between antenna and receiver may cause reflection. Close matching, when required, usually is obtained with any of various kinds of matching transformers or line sections designed for the purpose.

## 7. Transmission Line Routing

Rules for avoiding excessive signal loss when installing unshielded transmission line are as follows. Some are illustrated by Fig. 1-2.

Make the line as short as possible.

Use standoff insulators for all supports.

Make no sharp turns or twists, and don't squeeze the two conductors toward each other.

Clear all large bodies of exposed or concealed metal by at least 20 inches, when possible, and do not run the line parallel to such metal.

Stay as far as possible from power lines.

r he line through metal tubing.

Don't paint the line.

Avoid long horizontal runs if possible, keep such runs ove snow level and try to place them where protected from rain and sleet.

Make sure that tubular line is sealed at both ends or is drained at all low points.

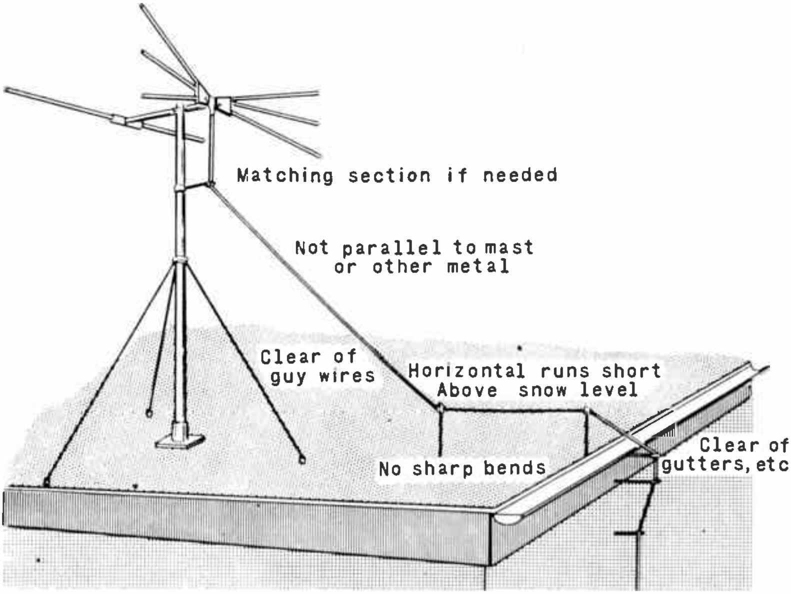



*Fig. 1-2. Much signal energy may be lost in the transmission line unless it is properly installed.*

# SECTION 2

## TUNER

The tuner group or section includes the subdivisions shown by Fig. 2-1. There are couplings for signal transfer between antenna and r-f amplifier, between r-f amplifier and mixer, and between oscillator and mixer. Coupling from oscillator to mixer often is referred to as oscillator injection; it may be a small capacitor, sometimes adjustable.

Tuning for channel selection varies the antenna to r-f coupling and the r-f to mixer coupling for resonance at carrier frequencies, and varies the oscillator frequency at the same time. There are service adjustments which allow correct alignment of tuned circuits for carrier and oscillator frequencies at one or more channels, commonly for channels 13 and 6. In addition there may be service adjustments for the degree or amount of coupling and for oscillator injection.

### Types Of Tuners

Tuners in present receivers are of two general types, turret and incremental. Principal circuit elements of a typical turret tuner are shown in Fig. 2-2. Tuning is by means of inductors for each channel, mounted on a tuner strip or strips. All the couplings are inductive, between coils on the strip.

The oscillator inductor for each strip or each channel has an adjustable core for alignment. R-f to mixer alignment is by means of adjustable capacitors *Cm* on the mixer grid and

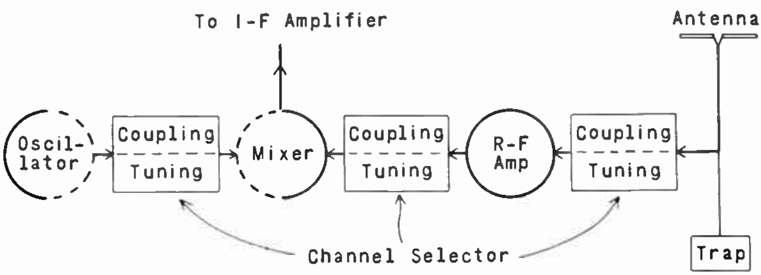



*Fig. 2-1. Every tuner section contains these subdivisions in one form or another.*

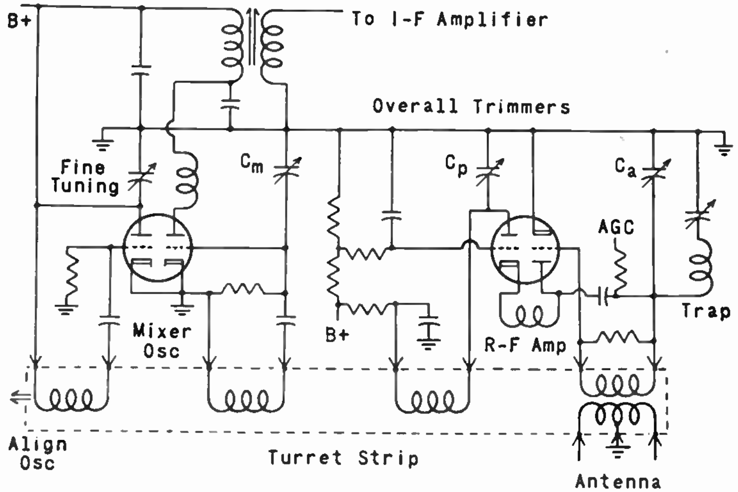



*Fig. 2-2. Principal circuit connections in a typical turret tuner.*

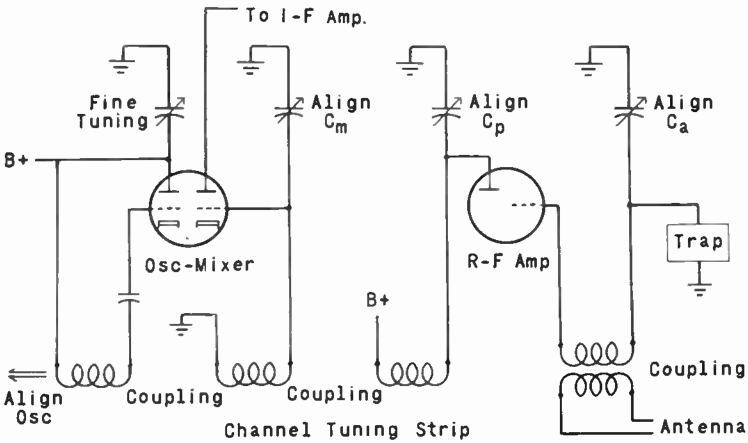



*Fig. 2-3. Elements for channel selection and for alignment in a turret tuner.*

*Cp* on the r-f amplifier plate. These two capacitors are the principal adjustments for bandwidth and for bringing video carrier and sound carrier frequencies to correct positions on the frequency response. Antenna to r-f alignment is by means of capacitor *Ca*, which has principal effect on tilt of the response.

The mixer-oscillator tube of Fig. 2-2 is shown as a twin triode. It might be a triode-pentode with the pentode section for mixer. The r-f amplifier is shown as a cascode type, but might be a pentode.

Couplings and service adjustments for the turret tuner are shown in Fig. 2-3 without connections from the low-voltage power supply to plates, grids and cathodes. This diagram includes components in which we are most interested during trouble shooting other than checks for voltages and resistances, and helps bring out the fact that any tuner consists essentially of the elements in Fig. 2-1.

Fig. 2-4 shows principal components and connections in a rather simple type of incremental or switch type tuner. Channel tuning is by means of switching more or less inductance into the antenna or r-f coupling by means of rotary switch *S1*, into the r-f to mixer coupling by switch *S2*, and for oscillator tuning by switch *S3*. The diagram shows front and back connections and inductors for each switch wafer.

Fig. 2-5 is a simplified diagram for parts of the incremental tuner with which we are most concerned during trouble location other than voltage and resistance checks.

Overall alignment for antenna to r-f coupling is by means of adjustable inductor *La*. High-band alignment for r-f to

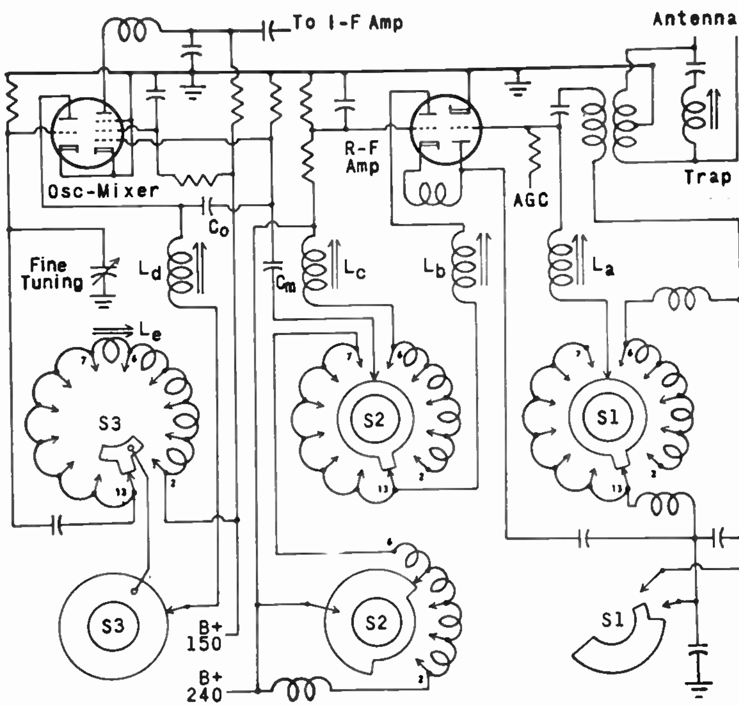



*Fig. 2-4. Circuit connections for a simple type of incremental or switch type tuner.*

| Table 2 TUNER | Brightness Lacking | Contrast Lacking | Definition Poor | Flashes | Jitter, Horizontal | Multiple Images | Noise in Pictures | Raster, No Pictures | Smearing | Snow in Pictures | Sound Bars | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TUBES FAULTY OR TUBE VOLTAGE WRONG** | | | | | | | | | | | | |
| 1 Any tube. R-f amp. mixer or oscillator | | • | | | | | • | • | | • | | |
| 2 R-f amplifier gassy | | | • | | | | | | • | | | |
| 3 No oscillation, or none on high band | | | | | | | | • | | | | |
| 4 Oscillator microphonic | | | | | | | | | | | • | |
| **WRONG ALIGNMENT** | | | | | | | | | | | | |
| 5 Bandwidth too narrow | | | • | | | | | | | | | |
| 6 Bandwidth too great, lack of gain | | • | | | | | | | | • | | • |
| 7 Excessive tilt | | • | | | | | | | | | | |
| 8 Excessive peaking | | | | | | • | | | | | | |
| 9 Video carrier too low | | • | | | | | | | | • | | • |
| 10 Video carrier too high | | | | | | | | | • | | | |
| 11 Sound carrier too high | | | | | | | | | | | • | |
| 12 High frequencies far down on response | | | • | | | | | | | | | |
| **MECHANICAL FAULTS** | | | | | | | | | | | | |
| Described in text | • | | | • | • | | • | • | | | | |

mixer coupling is by adjustable inductor *Ld*, and low-band alignment by means of inductor *Lc*. Hight-band alignment for the oscillator is cared for by adjustable inductor *Ld*, while low-band oscillator alignment is by means of inductor *Le* which is mounted on a switch wafer.

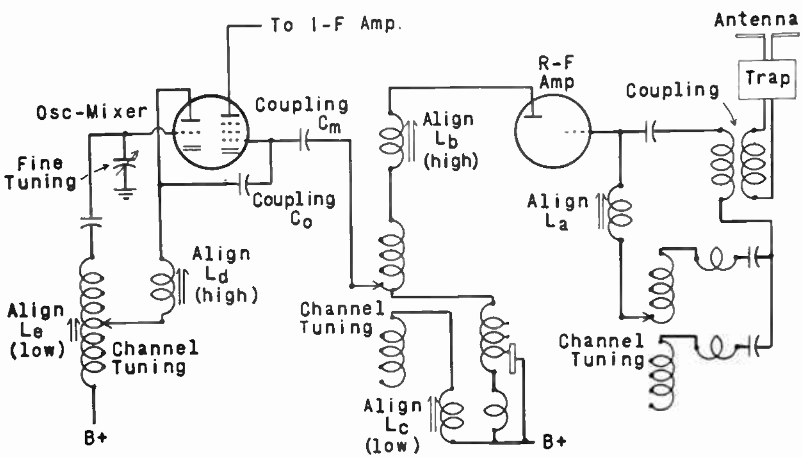
In this incremental tuner there is transformer coupling from antenna to the grid of the r-f amplifier. From r-f amplifier to mixer the coupling is by tuning inductor impedance, which is common to the plate circuit of the r-f amplifier and the grid circuit of the mixer, with blocking and coupling capacitor *Cm* keeping B-voltage from the mixer grid. Oscillator injection to the mixer is through capacitor *Co*.

If we omit from the fairly complete diagram of Fig. 2-4 all B-voltage and biasing connections to plates, screens, grids and cathodes we have the simplified diagram of Fig. 2:5. Considering only the functions of the elements in this latter diagram, and neglecting details of circuit connections, we have Fig. 2-1. Again we find that any tuner consists basically of the elements shown in Fig. 2-1 so far as principles of trouble location are concerned.

## Tuner Troubles And Their Symptoms

The accompanying table lists the more common tuner troubles and their probable symptoms as observed on the picture tube or on a tuner frequency response.

With reference to classification *3*, the r-f oscillator some-




*Fi.g 2-5. Elements for channel selection and for alignment in the incremental tuner.*

times will operate satisfactorily on the low band of the vhf range but not at frequencies required for high-band reception.

With reference to classification *4*, a microphonic oscillator tube will cause horizontal bars or "sound bars" corresponding to the rate of vibration of tube elements, which may be quite different from frequencies in an accompanying sound program.

Classifications *5* through *12* under *Wrong Alignment* in the table require observation of tuner frequency response with an oscilloscope, a sweep generator and a marker generator. Sweep voltage should be fed through a properly terminated cable to the antenna terminals of the receiver or tuner. Vertical input of the scope preferably should be connected, through a plain probe, to the grid return resistor of the mixer. If there is a test point on this resistor, part way from grid to ground, make the connection there. Otherwise use a 10K fixed composition resistor between scope lead and mixer grid.

Should the oscilloscope lack sensitivity to give a good response trace when connected to the mixer grid circuit the connection may be made through a detector probe to the mixer plate, thus obtaining additional gain due to conversion transconductance of the mixer tube.

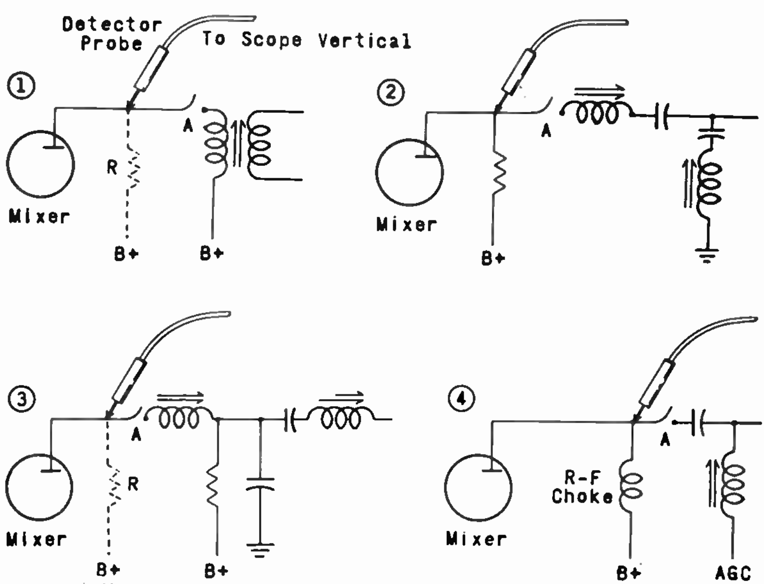



*Fig. 2-6. Taking a tuner response curve from the mixer plate.*

For scope connection to the mixer output the mixer plate must be disconnected from all following tuned circuits, as in Fig. 2-6, but B-voltage of normal or nearly normal strength must be applied from the regular mixer plate supply line to the plate.

In diagram *1* there is transformer coupling to the i-f amplifier, with mixer plate voltage applied through the transformer primary. The circuit is to be opened at *A* and a fixed

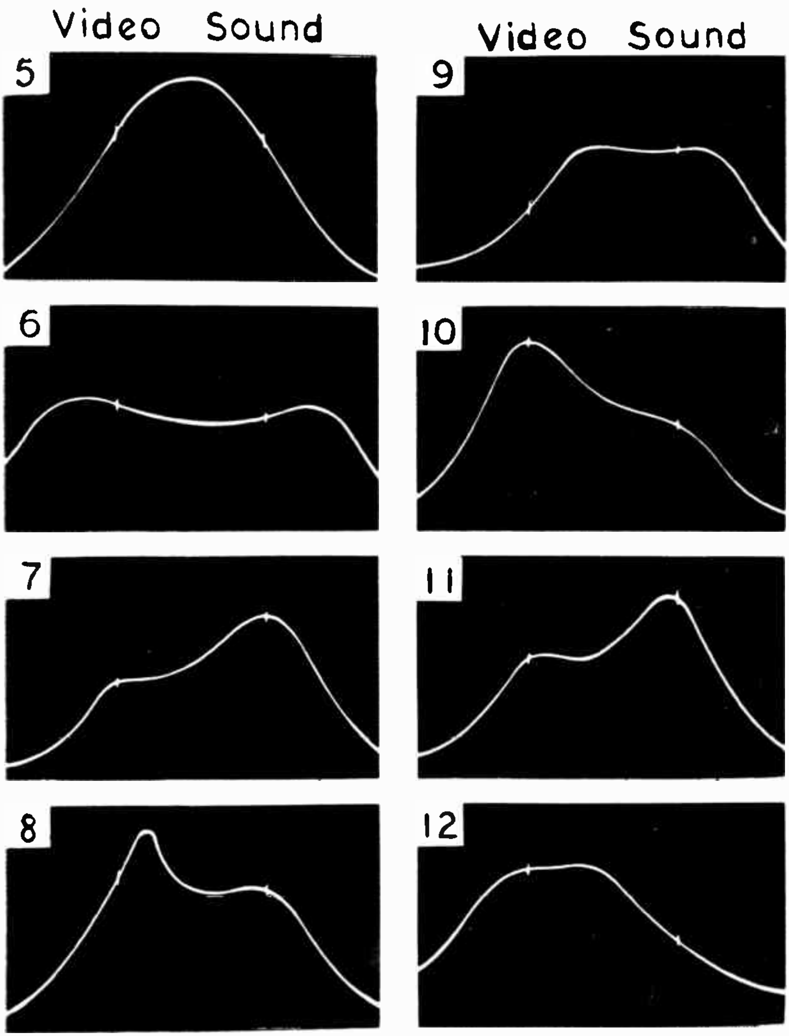



*Fig. 2-7. Here are incorrect tuner responses which are likely to cause symptoms listed in the table.*

resistor of abount 1,000 ohms or more connected temporarily from plate to B+.

Mixer plate voltage in diagram *2* is applied through a resistor ahead of the first tuned inductor, so it is necessary only to open the circuit at *A* and connnect the detector probe.

Diagram *3* shows a fairly common output coupling with which mixer plate voltage is applied through the first tuned inductor. This inductor is to be disconnected at *A* and a temporary resistor of 1,000 or more ohms connected at *R*, from mixer plate to B+.

In diagram *4* the r-f choke carrying mixer plate voltage remains connected while the circuit to following tuned elements is opened at *A*. Various other couplings may be handled in any way that leaves B-voltage on the mixer plate while cutting off all tuned elements which might upset the response.

Response traces taken from the mixer plate through a detector probe may not be so truly representative of actual performance as those from the mixer grid, but they serve the purposes of trouble location.

Fig. 2-7 illustrates typical response traces for conditions numbered *5* through *12* in the table of tuner troubles and symptoms. Marker pips on the traces indicate video carrier and sound carrier frequencies. All of the faults may be corrected by proper alignment of the various adjustments and couplings.

## Mechanical Faults

In case of symptoms listed for mechanical faults in the table look for loose cover plates and tube shields, and for shields not securely grounded to clean metal.

Remove the tuner tubes and examine their base pins. Removal and replacement may clean the socket contacts sufficiently to cure the trouble.

Examine all leads and terminal connections between tuner and other parts of the chassis for looseness or defective joints. Be sure to check all ground connections.

Switch contacts or turret strip contacts which are dirty may cause trouble. Use a liquid contact cleaner made for the purpose, brushing or spraying it onto the contacts and rotating the switch or turret through several turns. Dirty insulation may be cleaned with carbon tetrachloride on a lint free cloth.

Contact surfaces or detent mechanisms which feel rough in action may be lubricated with a little vaseline or with switch contact oil made for such uses. A missing detent ball may be replaced with a bicycle ball bearing obtainable from a bike repair shop. The long bolts or screws holding switch wafers and spacers sometimes need tightening.

Stationary contact members which have become bent or twisted, reducing their pressure on movable members, or such parts which have loose rivets usually cause trouble. Contact pressure sometimes may be improved by working carefully with a pointed tool. It is difficult or impossible to tighten loose rivets without disassembling the switch wafers or terminal strips from the tuner frame.

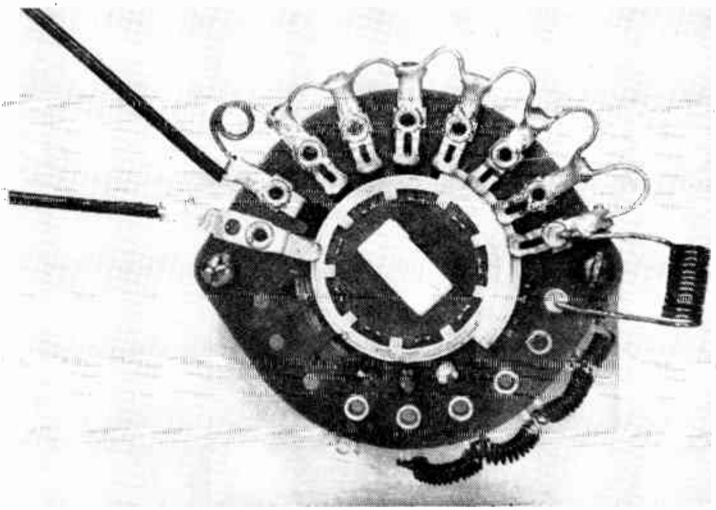


*Fig. 2-8. Inductors on a switch wafer for an incremental tuner.*

Many tuners have small inductors, as in Fig. 2-8, consisting of coiled enameled wire whose turns may be spread to raise the operating frequency or squeezed together to lower the frequency. When adjustment range is insufficient, a coil may be replaced with one wound from wire of the same or nearly the same gage size, using more turns to reach lower frequencies or fewer turns for higher frequencies. Use no more solder than on the original joints. Remove any remaining film of rosin flux with denatured alcohol on a cloth.

## Capacitors and Resistors

Fixed capacitors for coupling, blocking and bypassing in tuners usually are ceramic or mica types rated for working voltages well in excess of any normally applied, so there is little likelihood of puncture. These capacitors may become shorted or open, but it seldoms happens. The fixed resistors are called upon to dissipate much less than their wattage ratings, so run cool unless overloaded due to accidental shorts or grounds in connected circuits.

Most capacitors and resistors may be tested without disconnecting them provided you have a service diagram showing all connections in the tuner. Fig. 2-9 is such a diagram; it will be used for explaining the method. Resistors are marked *R* with subscript letters for identification. Capacitors are marked *C* with subscript identifications. Values of resistance and capacitance vary with the make and model of tuner.

The idea is to locate pairs of terminal points having between them only one capacitor or only one resistor, or not more than two such elements in series with each other. An ohmmeter or a capacitor tester may be connected to these terminal points for readings.

Easily accessible terminal points include the following: The terminals for wiring to chassis. Socket openings for base pins while the tubes are removed. Stationary contacts for a turret drum while the drum is held midway between channels or while the strip or strips for one channel are temporarily removed. A switch or incremental tuner will have selector positions at which certain circuit connections and terminals are opened. The tuner frame, acting as ground, serves for many test connections.

Remember that capacitors, if not shorted or leaky, act as open circuits for resistor checking. Inductors in good condition have negligible resistance and may be considered as a continuous circuit during tests. A capacitor may be checked for opens, shorts or leakage while connected in series with one or more resistors.

Here are a few examples of terminal points for capacitor tests on the tuner of Fig. 2-9.

*Ca:* Output i-f to mixer pin *2*.

*Cb:* Mixer pin *2* to oscillator pin *6*. *Rb* is in series.

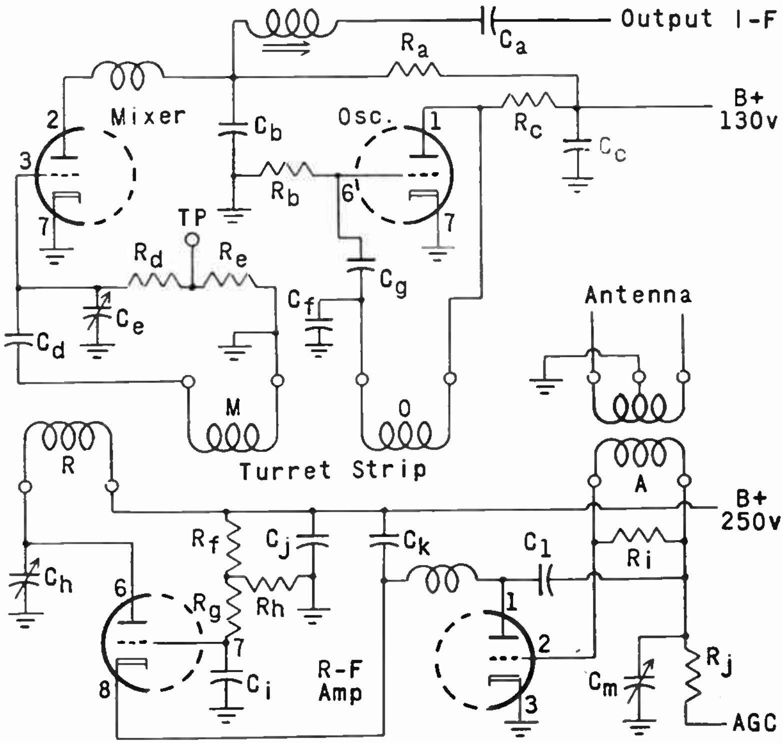



*Fig. 2-9. A complete service diagram for a tuner.*

*Cd:* Mixer pin *3* to turret inductor *M*, with strip opened.

*Ce:* Mixer pin *3* to ground will show up a dead short. However, leakage cannot be detected because *Rd* and *Re* are in parallel with *Ce* to ground, as are also *Cd* and turret inductor *M* unless the strip is opened.

*Cf:* Turret inductor *O* to ground, with the strip open. Note that *Cg* and *Rb,* in series with each other, are in parallel with *Cf* to ground, so *Cg* should be cleared before checking *Cf.*

*Cg:* Turret inductor *0* to oscillator pin *6.*

Examples of resistor terminal points on Fig. 2-9 are:

*Ra:* B+ 130v to mixer pin *2.*

*Rb:* Oscillator pin *6* to ground, assuming that *Cf* and *Cg* form d-c open circuits so far as resistance tests are concerned.

*Rd:* Test point *(TP)* to mixer pin *3.*

*Rf, Rg, Rh:* These three are tested as series pairs. *Rf* and *Rg* are in series from B+ 250v to r-f amplifier pin *7. Rf* and *Rh* are in series from B+ 250v to ground. *Rg* and *Rh* are in series from r-f amplifier pin *7* to ground.

*Ri:* Across turret inductor *A* terminals, with strip opened.

The chief precaution to be observed in all these tests is avoidance of unrecognized parallel paths which may cause erroneous conclusions.

## Frequency Drift

Frequency drift of the r-f oscillator in the tuner refers to a change, nearly always to lower frequency, which occurs while the receiver warms up to normal operating temperature or when there is variation of oscillator plate voltage. Drift may be corrected by readjustment of a fine tuning control during or after the warmup period.

Oscillator drift, or adjustment of a fine tuning control, in the tuner will vary the position of video and sound signals on the frequency response of the i-f amplifier, as observed at the video detector output. Fig. 2-10 is a normal i-f response. The sound marker, at the left, is in a dip caused by an accompanying sound trap. The video marker is about half way up the opposite slope.

If adjustment of a fine tuning control moves the video signal higher or to the left on the i-f response, as in Fig. 2-11, the sound signal also will move to the left. This happens when r f oscillator frequency is lowered because of drift, or by adjusting the fine tuning for more capacitance. Higher oscillator frequency, or fine tuning adjusted for less capacitance, would move both the video signal and the sound signal to the right on the i-f response.

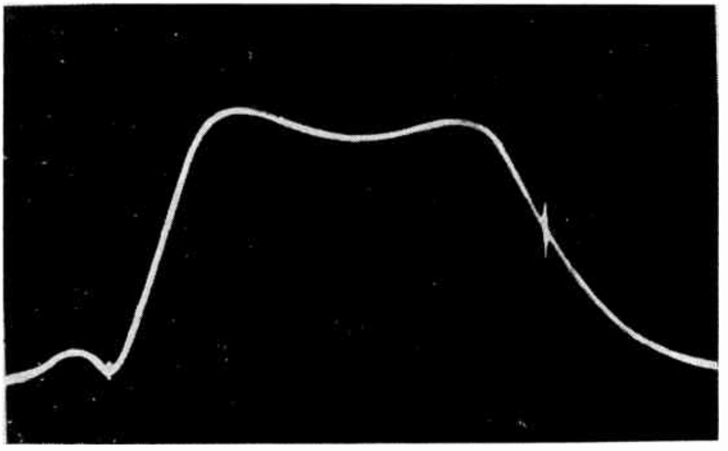


*Fig. 2-10. Normal i-f response with sound and video markers.*

Since video and sound carriers and the resulting video and sound intermediates always are 4.5 mc apart, oscillator drift or fine tuning adjustment affects both intermediates equally. On a set using intercarrier sound the sound intermediate may move away from a trap dip but it will remain within the pass band of the 4.5-mc sound amplifier.

With dual sound, used in many of the older standard receivers and in a few types at present, frequency drift so small as 0.2 mc throws the sound intermediate outside the pass band of the sound i-f amplifier, and there is little or no reproduction of sound until the fine tuning control is re-adjusted.

Drift to lower frequency is lessened in some tuners by one or more negative temperature coefficient (NTC) capacitors connected in the r-f oscillator circuit and mounted where affected by tuner temperature, usually on tube socket lugs. Capacitors *Cf*, *Cg* or both in Fig. 2-9 might be NTC types. An NTC capacitor may be in parallel with a zero temperature coefficient (NPO) type.

Excessive drift sometimes is corrected, as a service operation, by substituting for an original NTC capacitor another of the same capacitance but greater negative coefficient. That is, a coefficient of 330 might replace 150, or 750 might be substituted for 330. An NTC capacitor may be substituted for an NPO type, commencing with a small coefficient to observe the effect, then using a larger coefficient if needed.

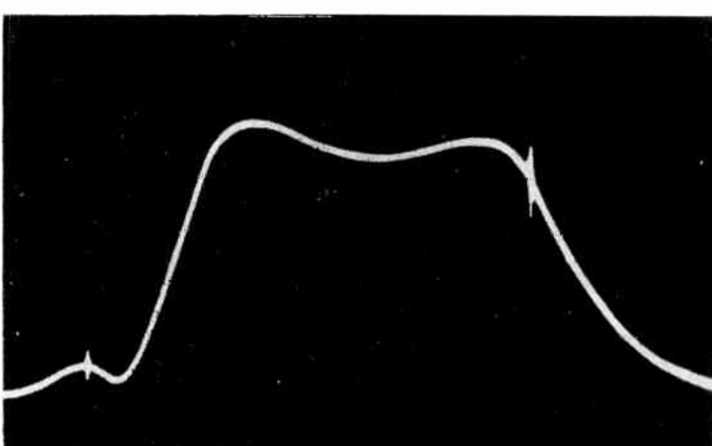


*Fig. 2-11. Video too high on the response and sound at frequency below the trap dip.*

## Increase Of Gain In Tuner

Fig. 2-12 shows a few of the methods for increase of gain in a tuner section. The following three methods are applicable to a tuner having a pentode r-f amplifier.

**1.** Remove automatic gain control voltage from the r-f amplifier grid return resistor by disconnecting the resistor from the agc line and reconnecting it to ground or B-. Be sure not to remove agc voltage from any i-f amplifier.

**2.** Substitute an r-f amplifier tube having greater transconductance than the original. This is easy when base pin connections are alike for both tubes, but otherwise requires difficult rewiring at the socket. B-voltages and bias may have to be changed to obtain the greater transconductance.

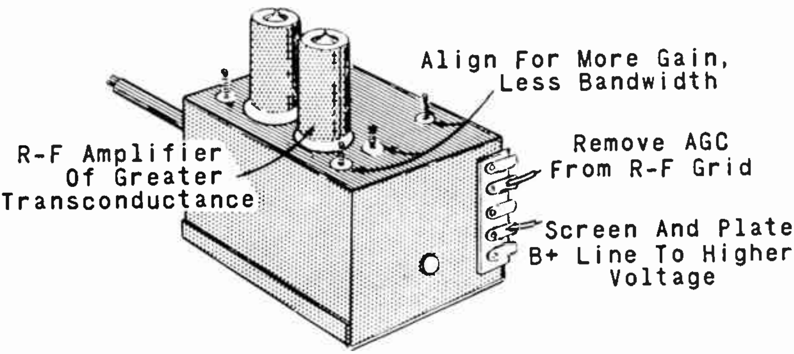



*Fig. 2-12. Methods for increasing gain in a tuner.*

**3.** Increase the screen voltage, also plate voltage if both elements are fed from the same line, by not more than 20 to 25 per cent — as from 120 to 150 volts or from 150 to 180 volts. Make the new connection to a higher B-voltage from the chassis rather than reducing internal dropping resistors, which usually are part of a decoupling system. Measure total screen and plate current before and after the change to make sure that tube ratings are not exceeded, especially when agc voltage is removed.

Two additional methods may be used with any type of r-f amplifier, either pentode or triode.

**4.** Realign for less bandwidth and greater gain. In Fig. 2-2 this would require adjustment of *Ca, Cp* and *Cm,* and in Fig. 2-4 of *La, Lb* and *Lc.* Bring the video carrier as high on the new response as still allows adequate sound. The sound carrier goes down on one side of an r-f response as the video carrier goes up on the opposite side.

**5.** If broadening resistors are across tuning inductors for r-f grid, r-f plate or mixer grid, substitute greater values of resistance. This will narrow the response, but increase the gain. Resulting peaking of the response may make it necessary to realign the tuner.

# SECTION 3

## INTERMEDIATE-FREQUENCY (I-F) AMPLIFIER

The i-f amplifier section consists of subdivisions in the block diagram of Fig. 3-1. Uuually there are three amplifier pentodes, although occasionally there are four and sometimes only two. Tuned couplings, adjustable for alignment, are between the tubes and ahead of the video detector.

The second, third and fourth couplings usually are of the same type, commonly two-winding transformers with a single adjustable slug for the two windings. The coupling from mixer to first i-f amplifier may be a series resonant type, a modified bandpass filter, a pair of link coupled inductors, or other type. One adjustable inductor for this coupling may be on the tuner and another on the chassis near the first i-f amplifer.

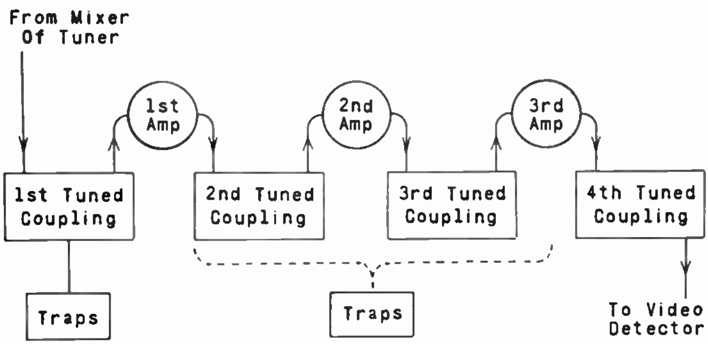



*Fig. 3-1. Subdivisions of an i-f amplifier section*

The mixer to i-f coupling is more critical in adjustment than others, and may be aligned last during service work. Most of these couplings have marked effect on bandwidth, tilt, and positions of video and sound i-f markers on the frequency response.

Most receivers have from one to three traps in the i-f section. Accompanying and adjacent sound traps are most

**Table 3**

**I-F AMPLIFIER**

| | Bending At Top | Brightness Excessive | Brightness Lacking | Contrast Excessive | Contrast Lacking | Definition Poor | Hum Bars | Interference Pattern | Multiple Images | Raster, No Picture | Smearing | Sound Bars | Speckling | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TUBES FAULTY | | | | | | | | | | | | | | |
| 1 Weak, low Gm | | | | | • | • | | | | | | | | |
| 2 Cathode-heater short | • | | | | | | • | | | • | | | | |
| 3 Microphonic | | | | | | | | | | | | • | | |
| 4 Gassy | | | | | | • | | | | | • | | | |
| TUBE VOLTAGES | | | | | | | | | | | | | | |
| 5 B-voltages low | | | • | | • | | | | | | | | | • |
| ALIGNMENT | | | | | | | | | | | | | | |
| 6 Bandwidth narrow | | | | | | • | | | | | | | | |
| 7 Bandwidth too great | | | | | • | | | | | | | | | |
| 8 Video I-F too low | • | | • | | • | | | | | | | | • | • |
| 9 Video I-F too high | | • | | • | | | | | • | | • | | | |
| 10 Sound I-F too high | | | | | | | | | | | | • | | |
| TRAP ADJUSTMENT WRONG | | | | | | | | | | | | | | |
| 11 Accompanying sound | | | | | | | | | | | | • | | |
| 12 Adjacent sound | | | | | | | | | | | | • | | |
| 13 Adjacent video | | | | | | | | • | | | | | | |
| MISCELLANEOUS | | | | | | | | | | | | | | |
| 14 Signal circuit open | | | | | | | | | | • | | | | |
| 15 Transformer shorted or leaky coupling capacitor | | | | | | • | | | • | | | | | |
| 16 Tube overloaded | | | | • | | • | | | • | | | | | • |
| 17 Regeneration | | • | | | | | | • | | • | | | | |

common, although there are quite a few for adjacent video. All traps may be on the coupling between mixer and first i-f amplifier, or some traps may be on other couplers or on amplifier grid, plate or cathode leads.

The accompanying table lists faults which are fairly common in the i-f amplifier section and shows the most probable picture symptoms for each kind of fault. Notes relating to some of the numbered troubles are in following paragraphs having corresponding numbers.

**1.** Snow in pictures may result from lack of gain in the first i-f amplifier, but is more likely to result from weak received signals or from tuner trouble. Snow indicates that noise impulses at the picture tube are strong in relation to desired signals. Unless noise enters at the antenna or in the early amplifying stages, desired signals acquire enough early amplification to overcome any noise added in following stages.

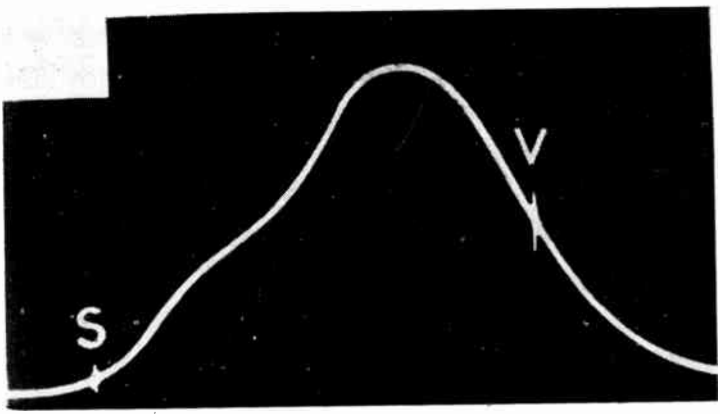



*Fig. 3-2 Bandwidth too narrow. The video marker is properly placed on the response.*

**2.** A cathode-heater leak must be of low resistance to cause serious trouble. This is because cathodes of most i-f amplifiers are connected to ground or B- through bias resistors of less than 200 ohms, or sometimes directly.

**Alignment** ( 6 to 10 in table)

A satisfactory frequency response is shown by Fig. 2-10. Faulty alignments are illustrated by frequency responses of Figs. 3-2 to 3-5.

The responses are taken with sweep and marker generators connected to the grid or to the grid return of the mixer tube in the tuner, or to an ungrounded metallic coupling sleeve slipped over the glass envelope of the mixer.

The oscilloscope is connected to the video detector load, assuming that the detector is operating properly. If there is any doubt, the video detector section should be checked before working on the i-f amplifier section. It is not practicable to take response traces through a detector probe applied to the output of the last i-f amplifier. Such traces would not show true responses unless all characteristics of the probe were precisely like those of the detector in the receiver.

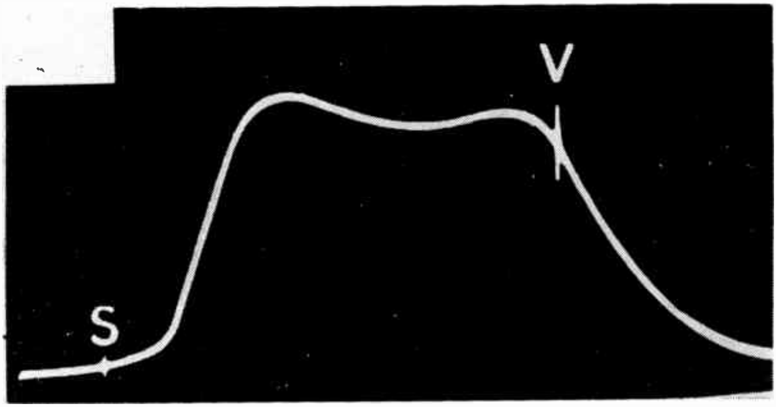



*Fig. 3-3. Excessive bandwidth and low gain.*

**6.** Narrow bandwidth (Fig. 3-2) causes poor reproduction of fine details because the higher video frequencies carrying such details are toward the sound side of the i-f response. This side will have little gain because a set operator naturally adjusts the fine tuning for a video intermediate high enough on the gain curve to produce satisfactory picture strength or contrast.

**7.** Excessive bandwidth (Fig. 3-3) will be accompanied by low gain, because any alignment adjustments which increase bandwidth will reduce overall gain, and vice versa.

**8.** Video i-f too low on the gain curve (Fig. 3-4) reduces strength of sync pulses, which are of low fundamental frequencies. It reduces picture strength or contrast, and when

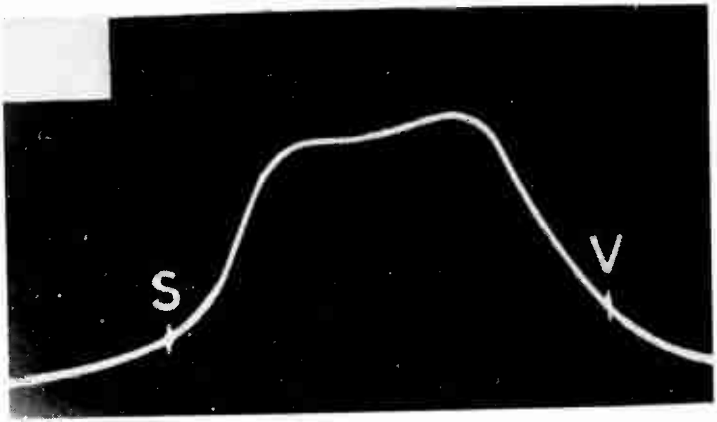



*Fig. 3-4. Video marker too low and sound too high.*

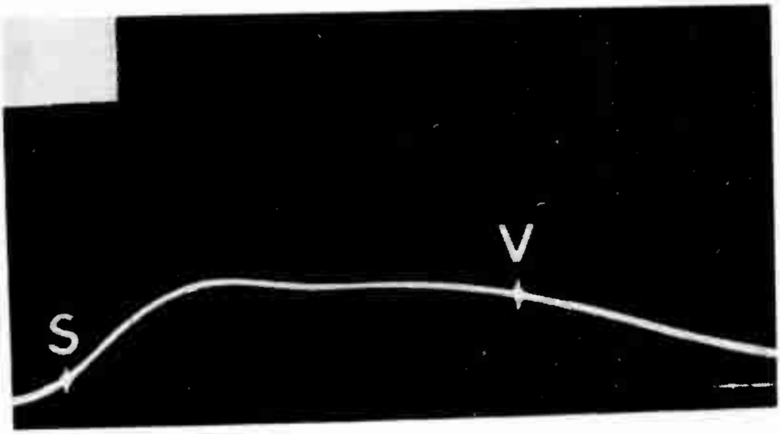



*Fig. 3-5. Video marker too high on the response, and sound possibly too low.*

bandwidth is normal the low video signal will be accompanied by a high sound signal which is likely to cause sound bars. This would be the condition numbered *10* in the table.

**9.** Video i-f too high on the gain curve (Fig. 3-5) causes excessive input to the video detector at the lower video frequencies. Then high video frequencies, which carry fine details for pictures, may be weaked unless bandwidth is unusually great. Sound may be weakened due to the sound intermediate going too low on the gain curve when the video intermediate is high.

If, at some certain position of the fine tuning control, adjustment one way causes pictures to have a grainy appearance, while opposite adjustment causes multiple images or slight smearing, it is probable that the video i-f is too high on the response.

## Frequency Response With Generator And VTVM

Frequency response or relative gains at various intermediate frequencies may be observed with an r-f signal generator and a vacuum tube voltmeter, using the setup of Fig. 3-6.

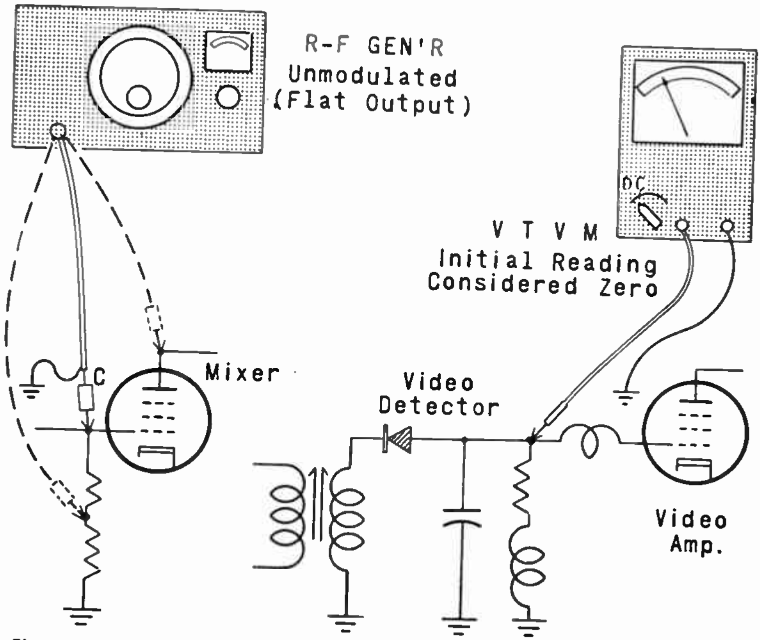



*Fig. 3-6. Test setup for observing frequency response of an i-f amplifier by means of a vacumm tube voltmeter.*

The generator should have calibrated output or should be flat throughout the i-f range, to allow application of constant signal voltage at all frequencies. Use the generator without modulation. Connect it through about 10 mmf (*C*) to the mixer grid or plate.

Set the VTVM function switch for d-c volts on a low range. Connect the meter through a plain probe to the video detector load. There will be either a positive or negative voltage reading with the receiver turned on and the generator at zero output. Consider this initial voltage as zero so far as response measurements are concerned.

Override the automatic gain control, disconnect the antenna from the receiver, and place the channel selector at any inactive channel.

With everything turned on and well warmed up, vary the generator frequency from well below the sound intermediate to well above the video intermediate frequency. Do this several times while adjusting generator output for maximum net reading of not more than two volts on the VTVM.

Note frequencies for zero net voltage, for video and sound intermediates, and for trap settings. Note relative voltages at any peaks. Readings may be plotted on graph paper.

## Trap Adjustments (*11* to *13* in table)

If the portion of the response at which there is high gain is narrow and does not extend close to the sound intermediate there is little likelihood of trouble when traps are slightly misadjusted. But if the response is good enough to cover nearly 4 mc there may be considerable gain at accompanying sound and even at adjacent video frequencies. Furthermore, if the response tapers far out on the video i-f side there may be much gain at adjacent sound frequencies. Then traps must be carefully adjusted.

## Signal Continuity (*14* in table)

To check for signal continuity through the i-f amplifier section proceed as follows, referring to Fig. 3-7.

The r-f signal generator should tune to frequencies in the i-f range of the receiver. Use the generator with audio modula-

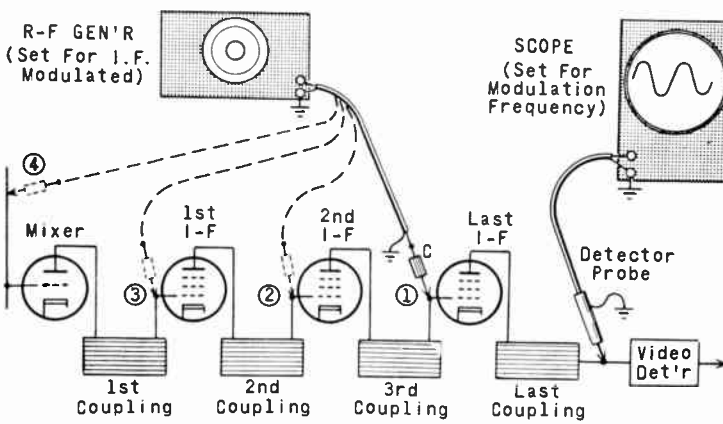



*Fig. 3-7. Testing continuity of signal circuits through an i-f amplifier with modulated r-f generator*

tion. Make connection through about 10 mmf, *C,* first to the grid of the last i-f amplifier, second to the grid of the preceding amplifier, and so on back to the mixer grid.

Connect the scope through a detector probe to the *input* of the video detector, or, if the detector is known to be operating properly, make connection through a plain probe to the top of the detector load. Adjust internal horizontal sweep of the scope to pick up the modulation frequency of the generator.

Disconnect the antenna line from the receiver and place the channel selector on an inactive channel.

With a connection at test point *1* of Fig. 3-7 the scope should be adjusted for high vertical gain and the generator for enough output to produce a clear modulation trace. Such a trace indicates that the last i-f amplifier and coupler are operative. If the trace is present, and higher, with the generator to point *2* the second i-f amplifier and third coupling are working. Point *3* checks the first amplifier and second coupling, while point *4* checks the mixer and first coupling.

The amount by which scope trace height increases from one test point to the next is a measure of additional gain in the stage last included. Should the trace flatten out or become very weak at any test point check, trouble is indicated between that point and the preceding one yielding a satisfactory trace.

**16.** Amplifier tube overload may result from low voltages on plate and screen, from bias or agc voltage insufficiently negative, from excessively strong signals from the tuner, or from any combination of these factors.

**17.** Regeneration usually results from in-phase feedback from the plate circuit of one amplifier to the grid circuit of the preceding amplifier. This may be due to defective shielding or omission of shields on tubes or couplings, or to improper dressing in plate and grid circuits. Regeneration may result also from aligning the couplings on grid and plate sides of the same amplifier to frequencies which are too near alike.

## Increase Of Gain In I-f Amplifier

Methods of increasing the gain in i-f amplifiers are quite like those used for tuners.

1. Substitute for one or more tubes others having greater transconductance. As a rule it is fairly easy to rewire i-f amplifier sockets if necessary because of different element connections. Amplifiers with higher gain usually take more plate and screen current, which may require different voltage dropping resistors or connection to leads supplying greater B-voltage. Original bias resistors often will maintain the grids too negative, and must be changed. Consult manufacturers' tube data books for suitable operating voltages and currents on any tubes used as replacements.

2. Increase screen or screen and plate voltages by shifting connections to a lead providing greater B+, rather than by lessening the values of voltage dropping and decoupling resistors. Measure total cathode current to make sure that tube ratings for combined plate and screen voltages are not exceeded. Cathode bias resistors may have to be changed to realize full possible improvement from higher plate and screen voltages. Consult tube manufacturers' data books.

3. Realign for greater gain and less bandwidth, even to the extent of a response with a rounded peak instead of a flat top. Position the video i-f at 60 to 80 per cent of maximum gain rather than at the usual 50 per cent. All this will make for stronger pictures on weak signals, but for poorer definition or detail. There should be no difficulty in obtaining sufficient sound, which ordinarily comes through well even when pictures are weak.

# SECTION 4

## VIDEO DETECTOR

Typical video detector sections employing crystal diodes are shown by Fig. 4-1. The arrowhead of a crystal diode symbol stands for the anode (equivalent to the plate of a tube)

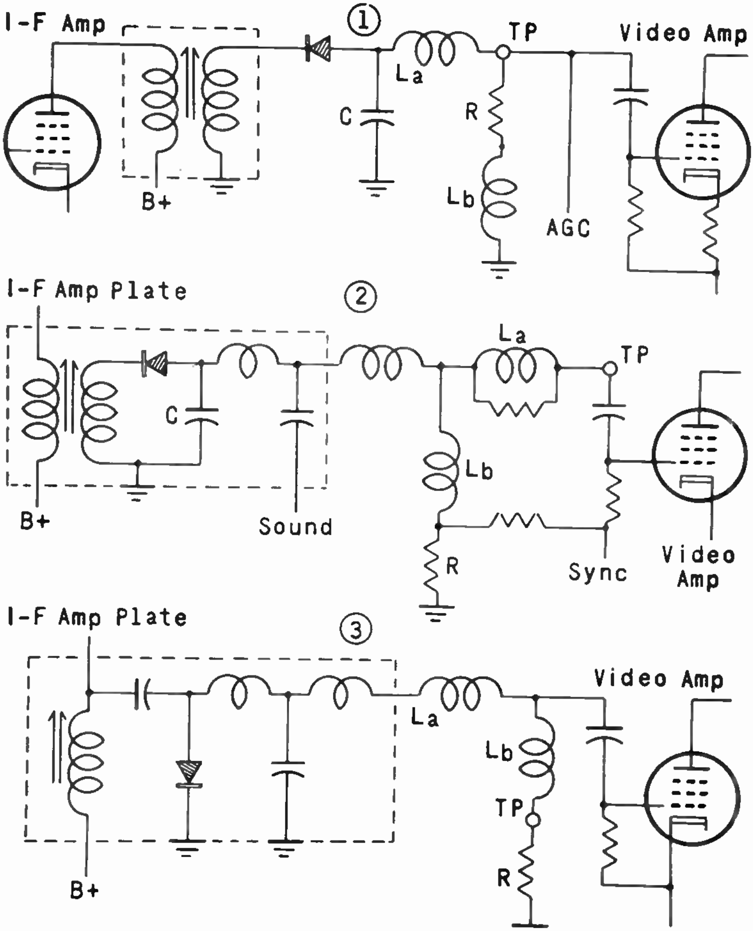



*Fig. 4-1. Crystal diode video detector circuits.*

and the straight bar stands for the cathode. Electron flow through the crystal is from cathode to anode, against the point of the arrowhead.

Shield enclosures are indicated by broken lines. In many cases the shield can for the transformer or coupler will contain also the crystal and one or more capacitors and inductors.

Fig. 4-2 shows half of a twin diode tube used as a video detector. The other half is an agc rectifier with positive delay bias on its cathode. In Fig. 4-3 the pentode of a pentode-diode tube is the last i-f amplifier and the diode is the video detector. A pentode-triode may have its triode plate and grid tied together to form a diode detector, or the triode grid and cathode may act as a diode detector while plate and cathode act as an agc rectifier.

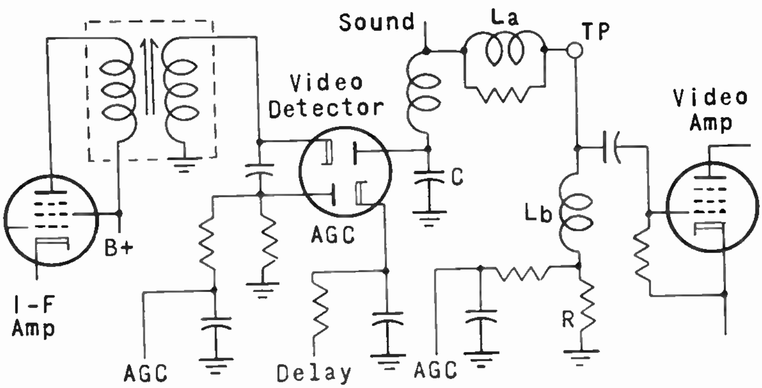


*Fig. 4-2. The video detector is half of a twin-diode tube.*

Symbols on all the circuit diagrams are marked as follows:

*C*. Bypass capacitor from detector output to ground or B-. For removing intermediate-frequency voltages which get through the detector and might load the video amplifier.

*La*. Peaker connected from detector output to grid of the video amplifier, for "splitting the shunting capacitances".

*Lb*. Peaker in series with the detector load resistor, to maintain satisfactory load impedance at high video frequences.

*R*. Detector load resistor.

*TP*. Test point for video dectector output, shown as positioned on various receivers. Output of any video detector may be measured or observed from the high side of the load resistor, whether or not any other test point is provided.

Video detector circuits or sections may be somewhat complicated by takeoffs for agc, sound and sync. A few of these connections are on the diagrams.

Faults in the video detector section and picture symptoms which usually accompany them are listed in the table. Numbered paragraphs which follow refer to faults as numbered in the table.

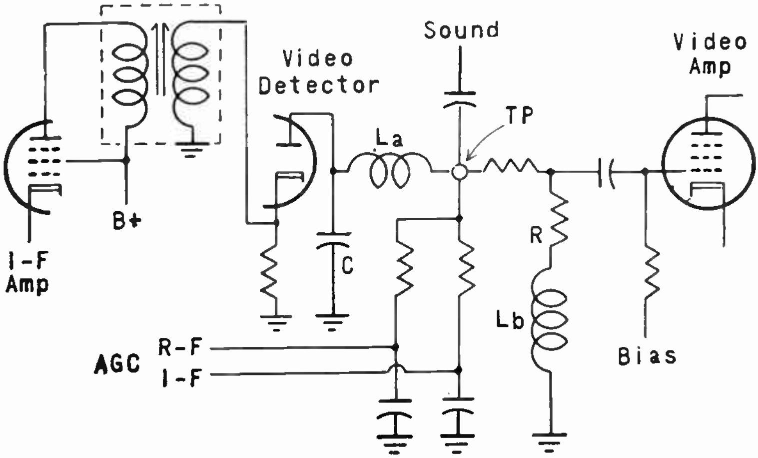



*Fig. 4-3. The video detector is one section of a pentode-diode tube.*

**1.** The remedy for a weak crystal is replacement with a type made especially for detector service, not with a general purpose type. Be sure to observe polarity of connections when making a replacement. If the crystal is not held by clips, leave its pigtails as long as will allow firm, vibration-free support. When soldering, hold the pigtails with pliers between the joint and the body of the crystal, to absorb heat. Do not mount an exposed crystal where it is close to hot resistors or tubes.

A crystal may be tested, but not very dependably, with the ohmmeter function of a VTVM or a VOM, measuring the back and forward resistance to determine their ratio. Readings are likely to vary on different ranges of the same meter. It is advisable to select a range having center-scale reading of about 100K ohms, and to stay with it for all measurements.

To measure back resistance, which is the higher resistance, connect the ohmmeter leads so positive potential from the meter goes to the crystal cathode. Reverse the leads to measure forward (lower) resistance. Satisfactory crystals usually

**Table 4**

**VIDEO DETECTOR**

| | Contrast Lacking | Definition Poor | Grainy Pictures | Hum Bars | Interference Pattern | Multiple Images | Raster, No Pictures | Smearing | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|
| CRYSTAL OR TUBE | | | | | | | | | |
| 1 Weak | • | | | | | | • | • | • |
| 2 Cathode-heater leak | | | | • | | | | | |
| OUTPUT BYPASS | | | | | | | | | |
| 3 Open. Too little C | • | | | | | | | | |
| 4 Too much C | | • | | | | | | | |
| LOAD RESISTOR | | | | | | | | | |
| 5 Open or disconnected | | | | | | | • | | |
| 6 Too little resistance | • | | | | | | | | • |
| 7 Too much resistance | | • | | | | | | • | |
| PEAKER, TO AMPLIFIER | | | | | | | | | |
| 8 Open or disconnected | | | | | | | • | | |
| 9 Too little inductance | | • | | | | | | | |
| 10 Too much inductance | | | | | | • | | | |
| 11 Short circuited | | • | | | | | | | |
| PEAKER, TO LOAD R | | | | | | | | | |
| 12 Open or disconnected | • | | • | | • | | | | |
| 13 Too little inductance | | • | | | | • | | | |
| 14 Too much inductance | | • | | | | | | | |
| 15 Short circuited | | • | | | | | | | |

measure more than 300K ohms back resistance, and should have forward resistance of no more than 1/500 the back value.

**2.** Cathode-heater leakage resistance as great as 100K ohms or more probably will cause serious trouble, because the video amplifier will amplify the hum frequency.

**3.** Check the bypass by paralleling it with a fixed capacitor or about 10 mmf. Improved picture strength or contrast indicates that the original capacitance is too small or is open.

**5.** If pictures appear when a fixed resistor of 5Kto 10K ohms is temporarily connected across the load resistor, the original resistor is open or disconnected.

**7.** Try paralleling the original resistor with another of about 10K ohms. Improved pictures indicate excessive resistance in the original unit.

**8.** Check for an open peaker by temporarily jumping it with a short wire fitted with alligator clips. If pictures then appear, or are improved, the peaker is open or disconnected.

**9.** In order to cause noticeably poor definition the peaker inductance would have to be very small, approaching zero.

**10.** Try jumping the peaker with a wire. If this prevents the multiple images, while possibly causing poor definition, the peaker probably has too much inductance.

**12.** Same as for number **8** above.

**14.** It is improbable that peaker inductance greater than required with cause trouble; it is more likely to add snap to pictures.

**Note:** If the receiver has operated satisfactorily until the present complaint it is unlikely that peakers, load resistors, or detector bypasses are causing the trouble. Check the detector crystal or tube, then investigate possibilities in other sections before coming back to further checks of the detector section.

# SECTION 5

## AUTOMATIC GAIN CONTROL (AGC)

Many basic principles employed in automatic gain controls are represented on the simplified diagram of Fig. 5-1. The source of negative voltage for grids of controlled tubes in receivers of recent design may be the video detector output or load circuit, a separate diode rectifier, or a keyed or gated agc system. The source may feed to a single agc bus, or, as shown, to one bus for the r-f amplifier in the tuner and to another bus for any i-f amplifiers which are automatically controlled.

During reception of weak signals it is desirable that the r-f amplifier in the tuner operate with small negative bias or agc voltage to allow maximum gain. On stronger signals the r-f bias should become more negative, to prevent overloading, but

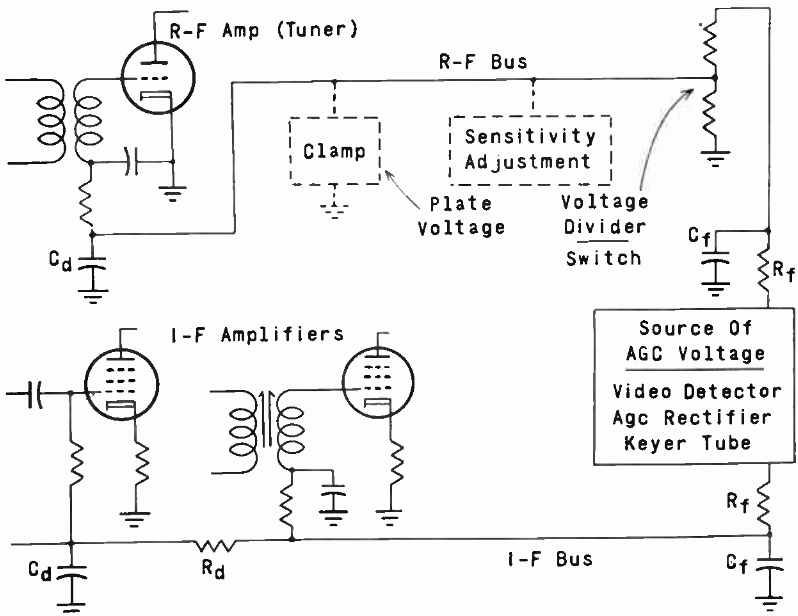



*Fig. 5-1. Principal subdivisions of an agc system furnishing two control voltages.*

always may be less negative than that applied to i-f amplifiers. Hence the separate buses for r-f and i-f amplifiers. R-f control voltage may be reduced below that for i-f amplifiers by divider resistors as on the diagram, or by opposing the source voltage with a small positive B-voltage, or in various other ways.

There may be a sensitivity adjustment for making r-f bias more negative when a receiver is used in a strong signal area and less negative for fringe localities. Sensitivity may be varied by an adjustable voltage divider, or a switch may alter connections to the r-f bus. Another method applies adjustable positive voltage to the plate of a clamp diode. Sensitivity adjustments may be called by such names as normal, local, fringe, distant or delay.

Filters for smoothing the control voltage from any agc source consist of series resistors marked *Rf* in Fig. 5-1 and of capacitors, *Cf*, to ground or B-minus. Series decoupling resistors, as at *Rd*, are in the agc bus between amplifier stages. Decoupling is completed by capacitors *Cd* to ground or B-minus.

Before taking up faults in the agc section and symptoms which may result it will be well to briefly review operating principles of clamp tubes and of the more generally used sources of agc voltage. Diagrams which follow will help identify various circuits and components referred to in the trouble tables.

## Clamp Action

A clamping diode tube usually is connected to the r-f agc bus essentially as in Fig. 5-2. Most often the diode is one of those in a first audio amplifier, but may be part of any other tube.

To the diode plate are connected: *1.* Negative control voltage of the agc source through resistor *Ra*, of about one or two megohms. *2.* Through 5 to 15 megohms at *Rb* to a B+ line carrying something like 125 to 275 volts. *3.* The r-f bus leading to the grid return of the r-f amplifier.

A small positive voltage gets through *Rb* and opposes negative voltage from the agc sources, thus making voltage at the diode plate and r-f bus less negative than control voltage going from the same source to the i-f bus.

On weak signals the entire control voltage from the agc source becomes less negative, and on very weak signals might become so little negative that opposing B+ voltage would tend to make the diode plate, the r-f bus and the r-f grid go positive. The r-f grid is prevented from actually going positive as follows:

Even a slight positive voltage on the diode plate makes the diode conduct. Conduction current must flow in resistance of many megohms at *Rb*. Even though current is only 10 to 20 microamperes, voltage drop in *Rb* becomes practically equal to voltage from the B+ line, and very little positive voltage remains at the diode plate.

Internal resistance of the diode is only 200 to 300 ohms, in which the few microamperes of conduction current cause only negligible voltage drop. Consequently, in spite of positive B-voltage, the diode plate would remain at very nearly the same potential as its cathode and ground. The diode plate and r-f bus could go positive by only a tiny fraction of a volt. Now we shall get rid of this fraction.

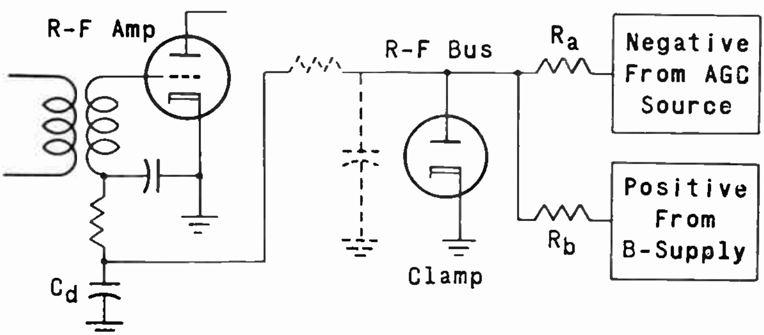



*Fig. 5-2. Voltage sources and connections for an agc clamp.*

In the diode, as in all tubes, the space charge causes any element near the cathode to acquire a contact potential which is negative with reference to the cathode. Effective negative contact potential at the clamp diode plate is on the order of 0.5 volt. This more than overcomes the slight positive voltage remaining from the B+ connection.

Accordingly, no matter how weakly negative may become control voltage from the agc source, voltage on the r-f bus never can go positive. Always it will remain at least a small fraction of a volt negative, due to contact potential.

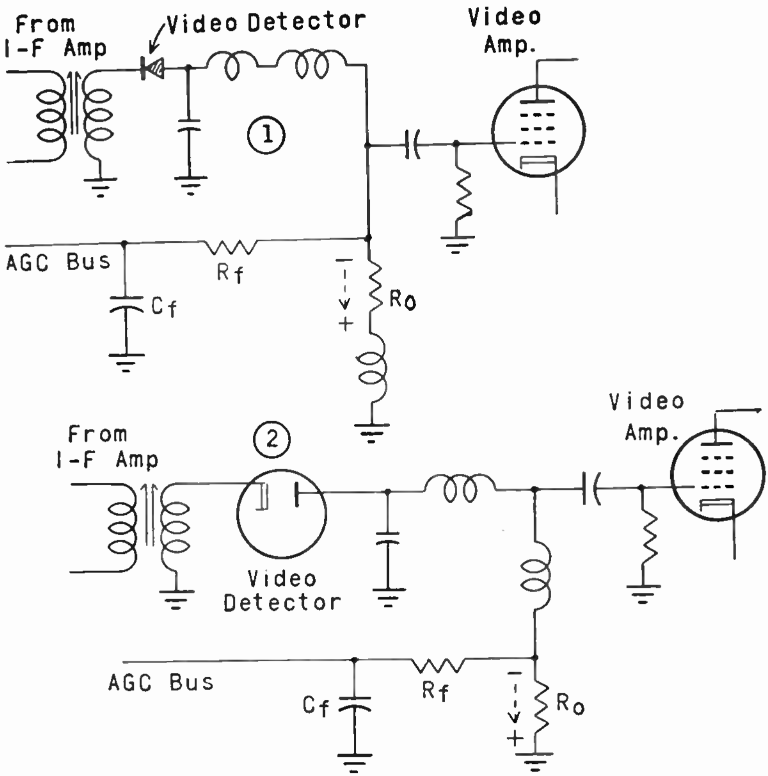



*Fig. 5-3. Agc. voltage from video detector load resistors*

## Agc From Video Detector

Fig. 5-3 illustrates the principle of obtaining negative voltage for automatic gain control from the output of a video detector, always on the high side of the detector load resistor. In diagram *1* the detector is a crystal diode and in diagram *2* it is a diode tube. The type of detector and the exact point in its output circuit from which agc voltage is taken make no difference in operating principles.

D-c electron flow always is away from the anode or plate of the detector. This flow goes through detector load resistor *Ro* in the direction of arrows. Accordingly there is negative potential to ground at the high side of the load resistor, to which is connected the agc bus.

If the video detector section is operating well enough to furnish video or picture signals to the video amplifier, any trouble with agc action will be in the parts shown by Fig. 5-1, not in the detector section.

## Agc Rectifiers

Fig. 5-4 shows separate rectifiers for furnishing negative agc voltage. In diagram *1* the rectifier is half of a twin diode tube whose other half is the video detector. The rectifier plate is connected through small capacitance at *Cc* to the output of the last video amplifier. The rectifier conducts positive alternations of i-f signal current to ground, but negative alternations cause d-c electron flow in the direction of the arrow through large resistance of load resistor *Ro*, making the high side of this resistor negative to ground. The negative potential charges capacitor *Cf* through resistor *Rf*.

The rectifier cathode may be connected directly to ground, as shown. Otherwise the cathode may be connected to a small positive B-voltage for delayed agc action. In some cases the rectifier cathode is biased slightly negative.

In diagram *2* of Fig. 5-4 the agc rectifier is a crystal diode so connected that it conducts on negative alternations of i-f signals. Conduction electron flow is through the resistors in the direction of arrows. This makes the top of *Ra*, the high sides of capacitors *Co* and *Cf*, and the agc bus negative to ground.

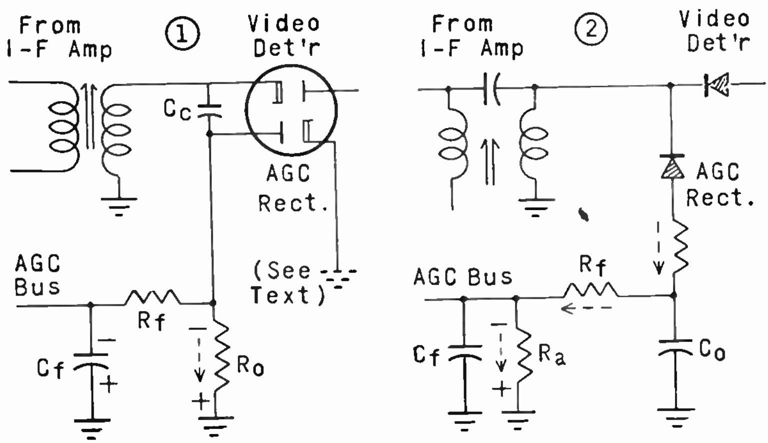



*Fig. 5-4. Circuit connections for agc rectifiers.*

## Keyed Agc

Principles of keyed or gated automatic control are illustrated by Fig. 5-5. The keyer tube usually is a pentode, but in some designs is a triode. The keyer cathode is maintained positive, commonly between 100 and 300 volts. The grid is

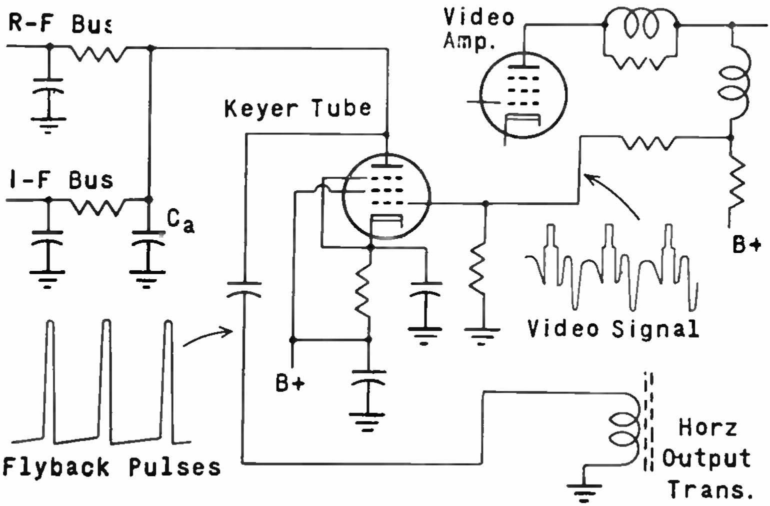



*Fig. 5-5. A typical circuit with voltage feeds for a keyed agc system.*

connected to a lower positive voltage so that the grid effectively is negative to the cathode by something between 5 and 70 volts. This negative bias holds the keyer tube at cutoff except while positive horizontal sync pulses from a video signal act on the grid to overcome most or all of the bias.

Sync pulses most often are taken to the keyer grid, as a composite video signal, from some point in the output or load circuit of a video amplifier. Sync pulses may be obtained from other sources, such as from a sync amplifier-clipper in which picture portions of the video signal have been reduced.

The keyer plate is connected to no B-voltage. This, considered alone, would leave the plate so negative with reference to the cathode as to prevent conduction even with strong positive sync pulses on the grid. However, the plate is supplied with strong positive pulses at the horizontal line frequency, pulses having peak value of 200 to 900 volts in various receivers.

In the digram of Fig. 5-5 the plate pulses are obtained from a separate insulated winding on the horizontal output transformer. In other designs these pulses may come from a width control inductor, or from a tap on the output transformer winding, and sometimes from the damper circuit.

When positive flyback pulses on the keyer plate coincide in time with positive sync pulses of the video signal on the grid, as they always should, the keyer tube conducts proportionately to strength of horizontal sync pulses. These pulses are proportional to strength of received signals.

Pulses of keyer conduction current, flowing away from its plate, impart a negative charge to the side of capacitor *Ca* that is toward the keyer plate and the agc buses. This negative potential on capacitor *Ca* is the reservoir agc voltage. Capacitor charge and negative voltage increase with stronger received signals, decrease with weaker signals.

In Fig. 5-5 the agc buses are connected to the keyer plate. In many receivers the keyer plate is connected directly, not through a capacitor, to one end of an insulated winding on the horizontal output transformer. Then the agc buses are connected to the other end of that winding, shown grounded in the diagram.

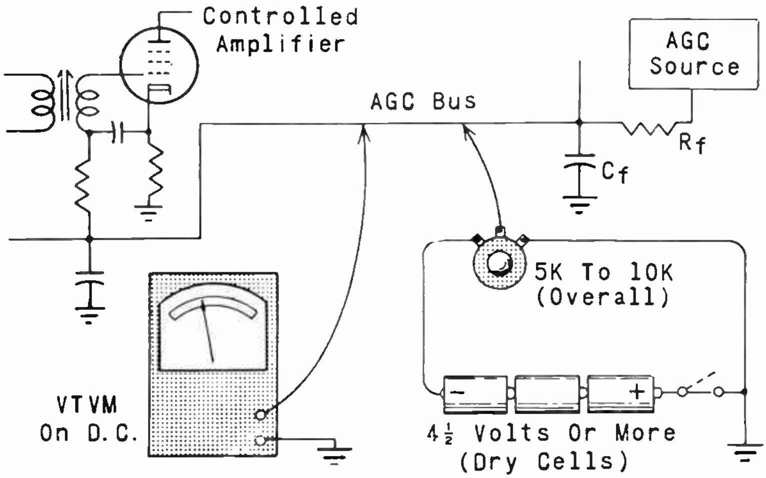



*Fig. 5-6. Measuring agc voltage and determining whether voltage is too high or too low.*

## Agc Voltage Tests

When any trouble symptoms listed at the top of Table 5-A indicate the possibility of wrong agc voltage, shown as faults *1* to *4*, this voltage should be measured as follows:

Connect the negative lead of a vacuum tube voltmeter, set for a low d-c range, to the agc bus anywhere on the side of the filter capacitor away from the agc source. Connect the common or low side of the meter to chassis ground or B-minus. Use only a VTVM. Even though an ordinary voltmeter has sensitivity of 20,000 ohms per volt or better, on a low range it places too much drain on the agc bus to allow correct indications.

Agc voltage should become more negative while pictures are from active channels than on channels not used locally, and should be more negative on strong received signals than on weaker ones. Make note of approximate or average agc voltage on each active channel.

Leaving the VTVM on the agc bus, connect an adjustable battery bias to the bus as in Fig. 5-6. Use dry cells in series, or a single battery, to provide a total of 4½ to 9 volts. Across the battery connect a potentiometer having total resistance of 5K to 10K ohms. Connect the positive side of the battery to chassis ground or B-minus. Use a switch at one end of the battery to prevent discharge while the apparatus is not in use. Connect the potentiometer slider to the agc bus on the side of the filter resistor away from the agc source.

Tune to channels for which agc voltages previously were noted. Vary the battery potentiometer for best picture reproduction on each channel, and note these negative voltages. Unless original agc voltages are fairly close to battery biases for good reproduction the agc voltages may be too great or too little, as will be apparent upon comparison.

If agc voltages are decidedly wrong refer to Table 5-B for probable causes. If agc voltages are close to satisfactory battery biases, but agc trouble still is indicated by Table 5-A, refer to faults number *5* to *14* in this latter table.

## Agc Faults

Following numbered paragraphs refer to similiarly numbered faults as listed in Tables 5-A and 5-B.

**3.** I-f amplifiers usually have cathode bias resistors which furnish some negative bias from grid to cathode even though agc bus voltage is very low or zero. If a cathode is connected to ground or B-minus, as with many r-f amplifiers, grid bias will follow agc voltage and may become so small as to allow severe overloading with normal and weak signals.

**6.** Where agc voltage is taken from a video detector a shorted filter resistor shorts the detector output and video amplifier input to ground or B-minus through the filter capacitor.

**7-8.** Excessive filter capacitance lengthens the agc time constant. This may prevent agc voltage from following rapid changes of signal strength or may allow strong noise pulses

| Table 5-A AUTOMATIC GAIN CONTROL | Contrast Excessive | Contrast Lacking | Contrast Varies | Dark, Momentarily | Definition Poor | Flicker Or Flutter | Hum Bars | Raster, No Picture | Smearing | Snow In Pictures | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **AGC VOLTAGE ON BUS** | | | | | | | | | | | |
| 1 Too negative | | ● | | | | | | ● | | ● | ● |
| 2 Not negative enough | | ● | | | ● | | | | ● | | ● |
| 3 Zero, to ground | | | ● | | | | | | | | ● |
| 4 Positive | ● | | | | ● | | | | | | ● |
| **FILTER RESISTOR** | | | | | | | | | | | |
| 5 Too great, open | | | | ● | | ● | | | | | |
| 6 Too small, shorted | | ● | ● | | | | | ● | | | |
| **FILTER CAPACITOR** | | | | | | | | | | | |
| 7 Too small, open | | | ● | | | | | ● | | | |
| 8 Too great | | | | ● | | ● | | | | | |
| 9 Shorted | ● | | ● | | | | | | | | ● |
| **DECOUPLING SYSTEM** | | | | | | | | | | | |
| 10 Resistor shorted | | | | | ● | | | | ● | | |
| 11 Capacitor too small, open | | | | | ● | | | | ● | | |
| 12 Capacitor leaky | | | | | ● | | | | ● | | |
| **CLAMP TUBE CIRCUIT** | | | | | | | | | | | |
| 13 Resistor to B+ too small | | | ● | | | | | | | | |
| **AGC RECTIFIER TUBE** | | | | | | | | | | | |
| 14 Cathode-heater leak | | | | | | | ● | | | | |

| Table 5-B<br>AUTOMATIC GAIN CONTROL | Too Negative | Not Negative Enough | Zero, To Ground | Positive |
|---|---|---|---|---|
| FILTER SYSTEM | | | | |
| 15 Resistor too great, open | | • | | |
| 16 Capacitor leaky | | • | | |
| 17 Capacitor shorted | | • | • | |
| DECOUPLING SYSTEM | | | | |
| 18 Resistor open | | • | | |
| 19 Capacitor leaky | | • | | |
| 20 Capacitor shorted | | | • | |
| SENSITIVITY CONTROL | | | | |
| 21 Misadjusted, defective | • | • | | |
| CLAMP TUBE AND CIRCUITS | | | | |
| 22 Weak, low emission | | • | | • |
| 23 Plate too positive | | • | | |
| 24 Plate not positive enough | • | | | |
| 25 Cathode open | | | | • |
| 26 Resistor to B+ open, too great | • | | | |
| 27 Resistor to B+ too small | | • | | |
| 28 Resistor to source open, too great | | • | | |
| 29 Resistor to source too small | • | | | |
| AGC RECTIFIER AND CIRCUITS | | | | |
| 30 Weak, low emission | | • | | |
| 31 Cathode-heater leak | • | | | |
| 32 I-F signal weak or zero | | • | | |

(Continued on next page)

(Continued from preceeding page)

| Table 5-B AUTOMATIC GAIN CONTROL (Cont) | Too Negative | Not Negative Enough | Zero, To Ground | Positive |
|---|---|---|---|---|
| 33 Cathode open | | • | | |
| 34 Cathode too positive | | • | | |
| 35 Cathode not positive enough | • | | | |
| 36 Load resistor open, too great | • | | | |
| 37 Load resistor too small | | • | | |
| KEYER TUBE AND CIRCUITS | | | | |
| 38 Tube weak | | • | | |
| 39 Cathode-heater leak | • | | | |
| 40 Plate pulses weak or zero | | • | • | |
| 41 Capacitor to Pulse source leaky, shorted | | | | • |
| 42 Video signal to grid weak, zero | | • | • | |
| 43 Cathode too positive | | • | • | |
| 44 Cathode not positive enough | • | | | |
| 45 Screen voltage too low | | • | • | |
| 46 Screen voltage too high | • | | | |

to momentarily cut off the amplifiers. Too little capacitance shortens the time constant and may allow agc voltage and amplification to follow airplane reflections and similar effects.

**10-11.** A shorted decoupling resistor or open decoupling capacitor may allow spurious interstage coupling to effect picture quality.

**13.** Too little resistance from a clamper to B+ may lessen changes of agc voltage when there are decided changes of received signal strength. Agc does not follow signals very well.

**15.** To check condition of a filter resistor use the VTVM to measure negative voltages on opposite sides of the resistor.

The two voltages should be practically equal, although the d-c meter may read slightly lower on the source side because of pulsating rather than smooth d-c voltage on that side.

**18.** An open decoupling resistor will effect agc voltage only on the portion of the bus which is beyond the open, away from the source.

**19-20.** If decoupling resistances are on the order of 50K ohms or more a defective decoupling capacitor will chiefly affect that part of the bus connected to the capacitor. With test connections as in Fig. 5-6, temporary disconnection of one end of a faulty capacitor will allow voltage to become more negative. Disconnecting a good capacitor will not affect test voltage.

**21.** A sensitivity control should be set for best picture reproduction on relatively strong received signals with the contrast fairly well advanced. With correct setting, pictures should appear quickly when switching from one active channel to another. Otherwise the sensitivity may need adjustment.

**34-35.** The cathode of the agc rectifier tube in some receivers is connected to the contrast control. Then cathode voltage should become more positive when contrast is advanced, less positive when retarded.

**40.** Observe pulses at the plate of a keyer tube with an oscilloscope set for horizontal line frequency or a submultiple. Unless it is certain that the scope input will not be damaged by high voltage make connection to the keyer plate through a fixed capacitor of no more than 10 mmf, rated for 1,000 volts or more.

**41.** Capacitors in the lead to the plate pulse source may be of high voltage rating. Check this when making a replacement.

**42.** Observe the signal at the keyer grid with an oscilloscope. Weak horizontal sync pulses may be due to defects in the keyer circuit, or possibly to an overloaded video amplifier which is limiting the pulses.

# SECTION 6

## VIDEO AMPLIFIER

The video amplifier receives the composite television signal as demodulated in the video detector and passes the amplified signal to the grid-cathode circuits of the picture tube.

Principal components of a single stage video amplifier section are represented in Fig. 6-1. Fig. 6-2 shows a two-stage video amplifier section. The tube for a single stage nearly always is a pentode or a beam power tube. Tubes in two stages may be two triodes, two pentodes, or other combinations of triode, pentode, and beam power amplifiers.

The video amplifier handles frequencies as low as 60 cycles per second for vertical sync pulses and as high as 4 megacycles for fine details of pictures. Proper amplification of lowest frequencies depends chiefly on (1) large capacitance for coupling or blocking at *Cc,* (2) suitable plate decoupling capacitance at *Cd,* also (3) on grid return resistance *Rg* and (4) plate decoupling resistance *Rd* of correct values in relation to each other and to the capacitances.

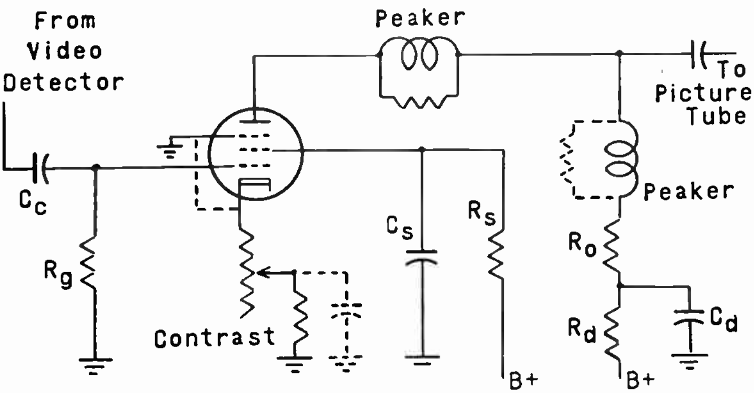



*Fig. 6-1. A single stage video amplifier.*

### Peakers

Amplification is extended to high video frequencies by peaker inductors. The peaker which is in series between the

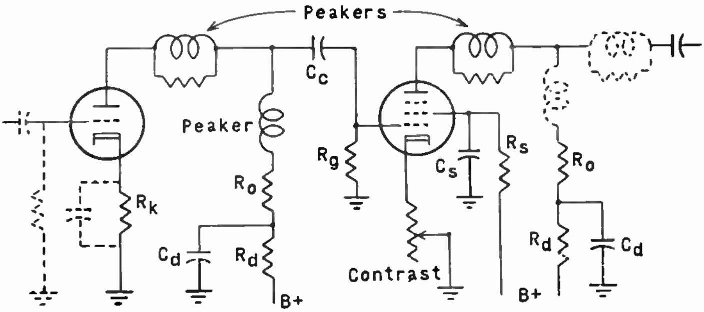



*Fig. 6-2. A two-stage video amplifier section.*

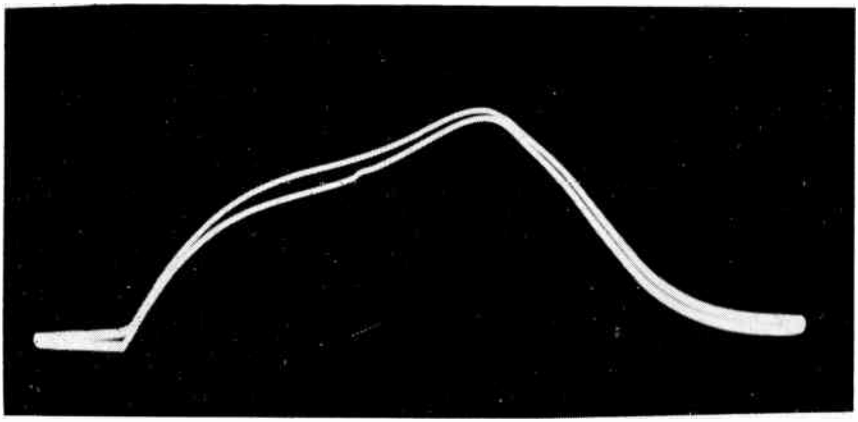


*Fig. 6-3. Video amplifier frequency response with gain control at normal setting.*

amplifier plate and the output connection to the picture tube or a second stage reduces the effect of stray capacitances and tube capacitances. These capacitances are effectively in parallel with the plate load. They "shunt" the load and tend to reduce load impedance as their reactances drop at high frequencies. We shall call these inductors "plate peakers".

The peaker which is in series with plate load resistor *Ro,* in the lead going to B+, increases its inductive reactance as frequency rises. This maintains or increases plate load impedance at the higher video frequencies. We shall call these units "load peakers".

A plate peaker ordinarily is paralleled with a resistor of a few thousand ohms to broaden the response and prevent excessively sharp peaking. The load peaker to B+ may or may not have a broadening resistor, as in Fig. 6-1, or the peaker may be omitted entirely as indicated by the broken-line symbol in Fig. 6-2.

Fig. 6-3 is a video amplifier frequency response showing the effect of peaker inductors on increasing the gain toward the right, which is the high-frequency side of the curve. This trace was taken with a cathode bias contrast control advanced about half way. Reducing the contrast, and thereby the gain, drops the entire response curve as in Fig. 6-4.

Peakers affect the shape of a video amplifier frequency response much as interstage couplers affect the shape of an i-f amplifier frequency response. Peakers in the detector output and in outputs of first and second video amplifiers may be of such values as to separately peak these outputs at different frequencies. This will make overall gain fairly uniform over a wide range of video frequencies.

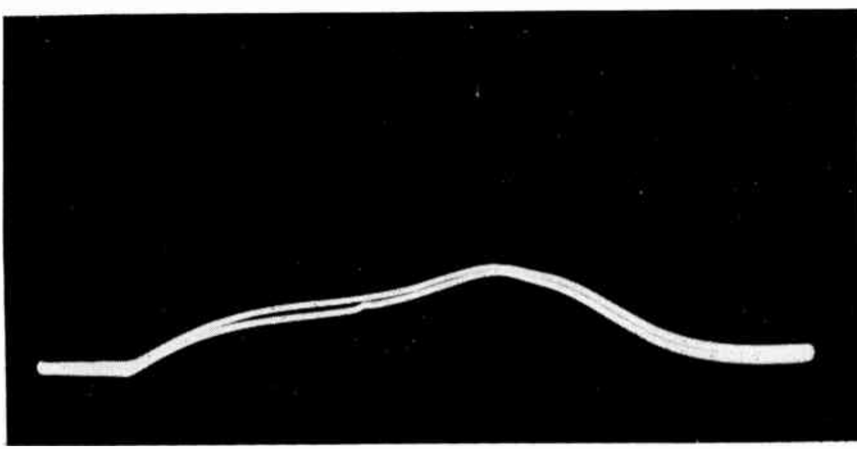


*Fig. 6-4. Frequency response with gain control or contrast control retarded.*

What we have called the plate peaker has principal effect on shifting the peak of the response to higher or lower frequency. Less inductance shifts the peak to higher frequency, while more inductance shifts the peak downward in frequency.

The load peaker has principal effect in raising or lowering the peak, or in increasing or decreasing the gain at higher video frequencies. Less inductance drops the gain, more inductance increases the gain. Of course, both kinds of peakers affect both the frequency of peaking and the gain, but their principal effects are as stated.

## Contrast Controls

It is common practice to provide contrast control or video amplifier gain control by means of an adjustable cathode bias resistor. There are, however, many receivers in which the contrast control is in the picture tube grid-cathode circuit rather than on the video amplifier.

To provide a minimum bias there may be a fixed resistor in series with an adjustable cathode resistor, as in Fig. 6-1. The fixed resistor sometimes is bypassed. With no fixed cathode resistor, and while a contrast control is set for zero resistance, there is grid-leak biasing action in capacitor *Cc* and resistor *Rg* of the diagrams.

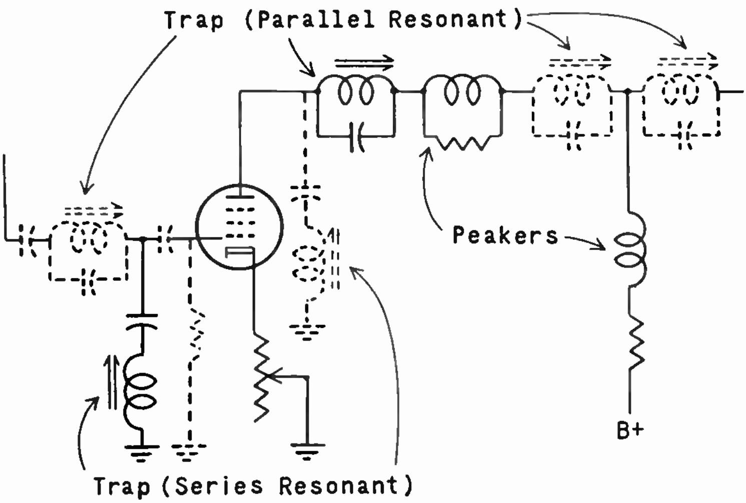



*Fig. 6-5. Various positions for 4½-mc traps of parallel resonant and series resonant types*

## 4½ Mc Traps

The video and sound intermediate frequencies, always separated by 4½ mc, combine in the video detector to produce a 4½-mc beat frequency in the detector output. If this beat frequency reaches the picture tube it modulates every horizontal line trace to cause a grainy effect in all pictures.

The 4½-mc beat may be kept from the picture tube by using one trap in any of the positions shown in Fig. 6-5. A parallel resonant trap most often is at the plate of a video amplifier, as shown in full lines, but may be in any of the other positions indicated by broken-line symbols. A series resonant

| Table 6-A<br>**VIDEO AMPLIFIER**<br>**Tube, Peakers and Contrast Control** | Bending | Contrast Excessive | Contrast Lacking | Definition Poor | Grainy Pictures | Hum Bars | Jitter | Multiple Images | Negative Pictures | Raster, No Picture | Smearing | Sound Bars | Sync Critical | Tear Out |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMPLIFIER TUBE | | | | | | | | | | | | | | |
| 1 Weak | | | • | | | | | | | • | | | • | |
| 2 Heater-cath leak | | | | | | • | | | | | | | | |
| 3 Microphonic | | | | | | | • | | | | | • | | • |
| 4 Gassy | | | | | | | | | | • | • | | | |
| TUBE VOLTAGES | | | | | | | | | | | | | | |
| 5 Plate too low | | | • | • | | | | | | | • | | • | |
| 6 Screen too low | | | • | | | | | | | | • | | • | |
| 7 Ripple | | | | | | | | | | | | • | • | |
| 8 Bias too Negative | | | • | | | | | | | | | | • | |
| 9 Bias not negative enough | | • | | | | | | | • | | | | | |
| PEAKERS | | | | | | | | | | | | | | |
| *To 2nd amp. or to picture tube* | | | | | | | | | | | | | | |
| 10 Open, disconnected | | | • | • | | | | | | • | | | | |
| 11 Shorted | | | | • | | | | | | | | | | |
| 12 Too much inductance | | | | • | | | | • | | | • | | | |
| 13 Shunt R too great | | | | | | | | • | | | | | | |
| 14 Shunt R too small | | | | • | | | | | | | | | | |
| *To load resistor and B+ line* | | | | | | | | | | | | | | |
| 15 Open, disconnected | | | • | | | | | | | • | | | | |
| 16 Shorted or too little inductance | | | | • | | | | | | | | | | |
| 17 Too much inductance | • | | | • | | | | • | | | | | | |

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| Table 6-A VIDEO AMPLIFIER Tube, Peakers and Contrast Control | Bending | Contrast Excessive | Contrast Lacking | Definition Poor | Grainy Pictures | Hum Bars | Jitter | Multiple Images | Negative Pictures | Raster, No Picture | Smearing | Sound Bars | Sync Critical | Tear Out |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTRAST CONTROL | | | | | | | | | | | | | | |
| 18 Open | | | | | | | | | | • | | | | |
| 19 Shorted | | • | | | | | | | | | | | | |
| 4½ Mc TRAP | | | | | | | | | | | | | | |
| 20 Misadjusted | | | | • | • | | | | | | | | | |
| 21 Parallel type open | | | | | | | | | | • | | | | |
| 22 Parallel type shorted | | | | | • | | | | | | | | | |
| 23 Series type open | | | | | • | | | | | | | | | |
| 24 Series type shorted | | | | | | | | | | • | | | | |

trap most often connects from the amplifier grid to ground, but may be on the plate side. Most beat frequency traps are adjustable by a movable core in the inductor, although a few have adjustable capacitors.

## Troubles And Symptoms

Two tables list video amplifier faults and their symptoms as evident in pictures. Table 6-A covers the video amplifier tube and its voltages, also the peakers, the contrast control, and the 4½-mc trap. Table 6-B deals with capacitors and resistors in the video amplifier section.

Numbered paragraphs which follow refer to faults of similar numbers in the two tables.

**1.** A weak amplifier tube may cause critical sync where the sync takeoff is from beyond the tube output, but not where the takeoff precedes the faulty tube.

**2.** Heater-cathode leakage must be of low resistance to cause serious trouble. Leakage resistance must be comparable to resistance of a cathode bias resistor or to maximum resistance of a contrast control on the amplifier cathode.

| Table 6-B<br>VIDEO AMPLIFIER<br>Capacitors and resistors | Bending | Contrast Excessive | Contrast Lacking | Definition Poor | Multiple Images | Negative Pictures | Raster, No Picture | Smearing | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|
| CAPACITORS | | | | | | | | | |
| *Coupling or blocking* | | | | | | | | | |
| 25 Too small | ● | | | | | | | | ● |
| 26 Open | | | | | | | ● | | |
| 27 Shorted, leaky | ● | ● | ● | ● | | | | | |
| 28 Capacitance to ground | | | | ● | | | | ● | |
| *Plate decoupling* | | | | | | | | | |
| 29 Too small | ● | ● | | | ● | | | | |
| 30 Open | ● | ● | | ● | ● | | | | |
| 31 Shorted, leaky | | | ● | | | | ● | | |
| *Screen decoupling, bypass* | | | | | | | | | |
| 32 Too small | | | ● | | | | | ● | |
| 33 Open | | | ● | | | | | | |
| 34 Shorted, leaky | | | ● | | | | ● | | |
| *Cathode bypass* | | | | | | | | | |
| 35 Too small or open | | | ● | ● | | | | ● | |
| 36 Shorted | | ● | | | | | | | |
| RESISTORS | | | | | | | | | |
| *Plate load* | | | | | | | | | |
| 37 Too small, shorted | | | ● | | ● | ● | ● | | |
| 38 Open | | | | | | | | ● | ● |
| 39 Too large | | ● | | ● | | | | | |
| *Decoupling, plate* | | | | | | | | | |
| 40 Too large | | | | ● | | | | ● | |
| 41 Open | | | | | | | ● | | |
| 42 Too small, shorted | | | | | | | | | |

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**Table 6-B**

**VIDEO AMPLIFIER Capacitors and resistors**

| | Bending | Contrast Excessive | Contrast Lacking | Definition Poor | Multiple Images | Negative Pictures | Raster, No Picture | Smearing | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|
| *Decoupling, screen* | | | | | | | | | |
| 43 Too large | | | • | | | | | • | |
| 44 Open | | | | | | | • | | |
| 45 Too small, shorted | | | • | | | | • | | |
| *Grid return* | | | | | | | | | |
| 46 Too small | | | • | • | | | | | • |
| 47 Shorted | | | | | | | • | | |
| 48 Open | | | • | | | | | | |

**5-6.** Abnormally low voltage to the plate, the screen, or both may allow amplifier tube overloading on strong signals, also on any signals for pictures of very light tone or containing a great deal of white. These latter kinds of pictures increase the peak-to-peak signal voltage. Overloading cuts off the sync pulses, and where sync takeoff follows the overloaded tube there may be critical sync.

Plate voltage may be considerably lower than the proper value provided screen voltage is no more than about 20 per cent lower than normal.

**7.** If plate decoupling and screen decoupling capacitors are in good conditon there is little likelihood of picture trouble due to ripple in the main B-voltage lines to the video amplifier section.

**8-9.** Incorrect bias refers to fixed bias or bias resistors, not to adjustable bias used for contrast control. Where there is a conductive connection, not a capacitor, from detector output to amplifier input or grid the d-c grid voltage will be the same as at the high side of the detector load resistor.

The amplifier grid sometimes is biased by a negative voltage obtained from somewhere in the B-supply system, or both the amplifier grid and video detector output may be so biased. Watch for such additional fixed biasing voltages when making measurements at the amplifier grid.

**10.** A peaker winding may be open or disconnected while leaving a paralleled broadening resistor in the circuit. The resistor alone will pass a greatly weakened video signal.

**11.** A shorted peaker is not likely to cause complaint unless the viewer is critical of picture quality.

**12.** Slightly too much inductance in the plate peaker lowers the frequency of maximum or peak gain and may impair definition. A great excess of inductance causes multiple images or smearing.

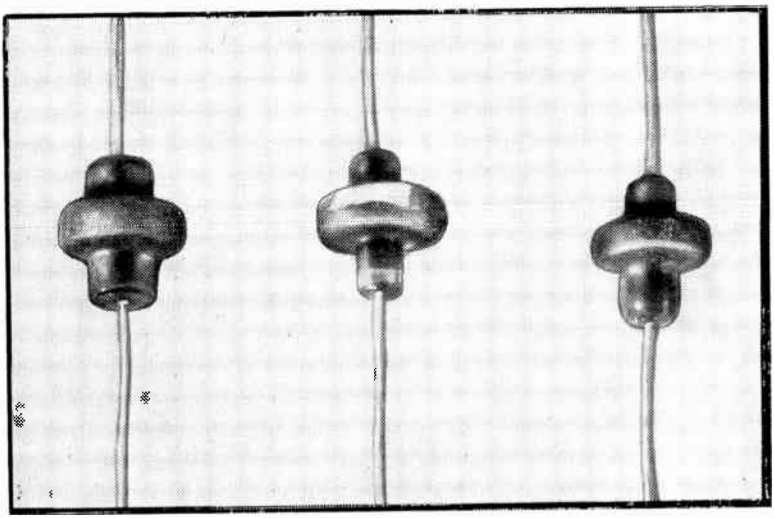

*Fig. 6-6. Peaker inductors supported on shunting resistors.*

**13-14.** Non-adjustable peaker inductors as pictured in Fig. 6-6 have the ends of their fine-wire winding soldered to pigtails of the supporting and broadening resistors. Low resistance of the paralleled winding makes it impossible to measure broadening resistance without unsoldering the inductor wire, with great danger of breakage. The best procedure is to try substituting a new peaker-resistor unit.

**15.** An open or disconnected load peaker winding may leave a broadening resistor in circuit, but plate voltage will be so low as to impair contrast and definition.

**18-19.** These contrast control troubles exist only when the contrast control is on a video amplifier cathode.

**21-24.** Keep in mind that a parallel resonant trap is in series with the signal path and, in case of trouble, may act similarly to an open signal circuit. A series resonant trap is between the signal path and ground or B-, and in case of trouble may become a short circuit for signals.

**25.** A coupling capacitor from detector to first video amplifier, may be of less capacitance than one in the output to the picture tube without causing picture defects.

**27.** A shorted or very leaky capacitor from video detector to amplifier grid may place an excessively negative biasing voltage on the amplifier, from a negative voltage on the high side of the detector load resistor.

A leaky capacitor from an amplifier plate to a following stage or to a picture tube grid makes the following grid less negative or possibly positive to cause overloading of the following amplifier or picture tube. A leaky capacitor to a picture tube cathode makes the cathode too positive, and the picture tube grid relatively too negative.

**28.** Coupling or blocking capacitors should be separated from all chassis metal by a quarter-inch or more. Capacitance of less than 100 mmf to ground greatly impairs definition. Capacitors of large physical size are likely to get close to chassis metal. A paper capacitor having considerable internal inductance, due to the foil being in the form of a winding, may cause slight smearing.

**29-33.** A test for decoupling capacitors too small or open is made by temporarily paralleling them with an electrolytic capacitor of about 10 mf and 450-volt rating. Be sure to make connection on the low side of a plate load resistor, as shown for capacitor *Cd* in Fig. 6-1, and directly to the screen, as for capacitor *Cs* in that diagram.

**35-36.** A cathode resistor bypass capacitor, when used, increases the gain by lessening degeneration, but makes for narrower frequency response (poor definition) and may allow excessive peaking (slight smearing).

## Square Wave Tests

Performance of a video amplifier section at low frequencies is best tested with a square wave generator and an oscilloscope. The scope must have frequency compensating vertical input, and must be used with a frequency compensating probe. The test setup is illustrated by Fig. 6-7.

Before attempting to test the amplifier connect the output of the generator directly to the input probe of the scope and observe waveform traces at fundamental square wave frequencies between 100 and 600 cycles per second, also at generator outputs up to 5 or 6 volts peak-to peak. If traces are other than true square waves it will be necessary to make allowances when checking the amplifier. Then proceed as follows:

**1.** Disconnect the antenna and place the channel selector on an inactive channel.

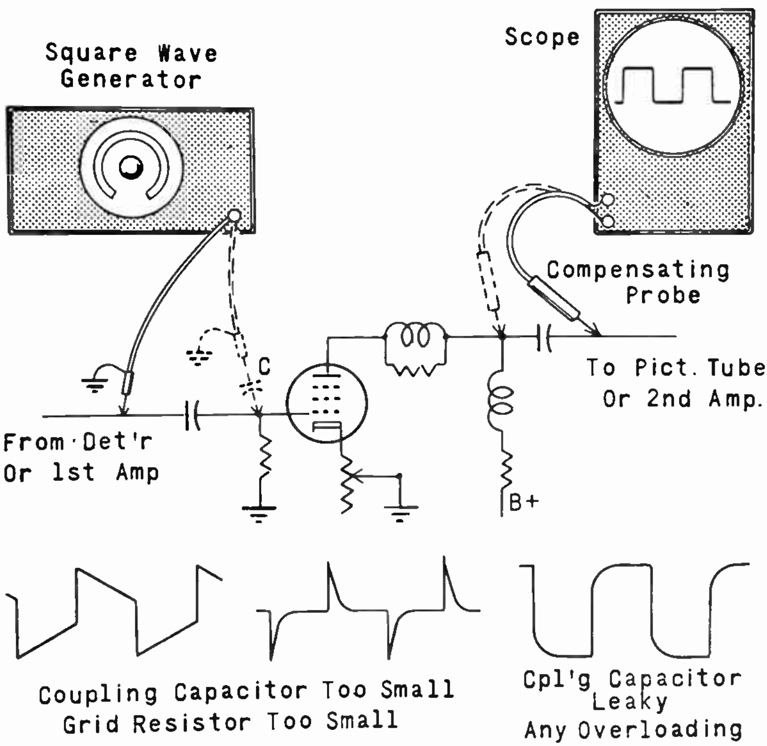


*Fig. 6-7. Square wave test setup for a video amplifier and some traces which indicate particular faults.*

**2.** It is best to temporarily disconnect the grid of the amplifier being tested, without disconnecting its d-c grid return.

If the grid is not opened, remove the video detector if it is a tube. Should part of the detector tube be an agc clamper, remove the r-f amplifier tube to prevent its operating with positive bias. If a second video amplifier is being tested, temporarily remove the first video amplifier if it is a separate tube.

**3.** Connect the output of the square wave generator ahead of any coupling capacitor leading to the amplifier grid, as shown by full lines. If there is no coupling capacitor make the generator connection through a fixed capacitor *(C)* of about 0.1 mf.

**4.** Connect the scope through a compensating probe to the amplifier output beyond a coupling capacitor, as in full lines, or, as in broken lines, to point following the plate peaker and on the high side of a load peaker.

**5.** If the contrast control is on the video amplifier cathode advance this control enough to obtain a trace of sufficient height for observation with the vertical gain of the scope at or near maximum.

The form of the trace should be very close to a square wave, or like that observed with generator and scope directly connected, for all fundamental square wave frequencies down to at least 400 cycles per second. This would indicate satisfactory amplification from frequencies of 40 to 4,000 cycles per second. An additional check may be made with the generator set approximately for the horizontal line frequency of 15,750 cycles per second.

As illustrated at the bottom of Fig. 6-7, a traced waveform with decided slope at top, bottom, or both probably indicates a coupling capacitor or a grid resistor which is too small. Sharp peaks indicate very severe faults of this nature. Rounded corners may mean a leaky coupling capacitor or overloading of the amplifier tube due to any cause. Overload may be caused by too strong output from the generator.

## Frequency Response Observations

High-frequency performance of a video amplifier section is best observed with a sweep generator, a marker generator and an oscilloscope used as in Fig. 6-8.

The sweep generator must be capable of furnishing a center frequency of about 3 mc with sweep width of 5 to 6 mc. Use a detector probe on the scope vertical input.

Proceed as follows:

**1.** Disconnect the antenna and place the channel selector on an inactive channel.

**2.** To prevent small peaks or pips from moving back and forth across the response trace remove the vertical sweep oscillator. General fuzziness all over the trace is caused by horizontal sync pulses. This may be prevented by removing the damper tube or the horizontal output amplifier. Removing either of these latter tubes will raise B-voltages throughout the receiver, but the rise should not be enough to cause trouble.

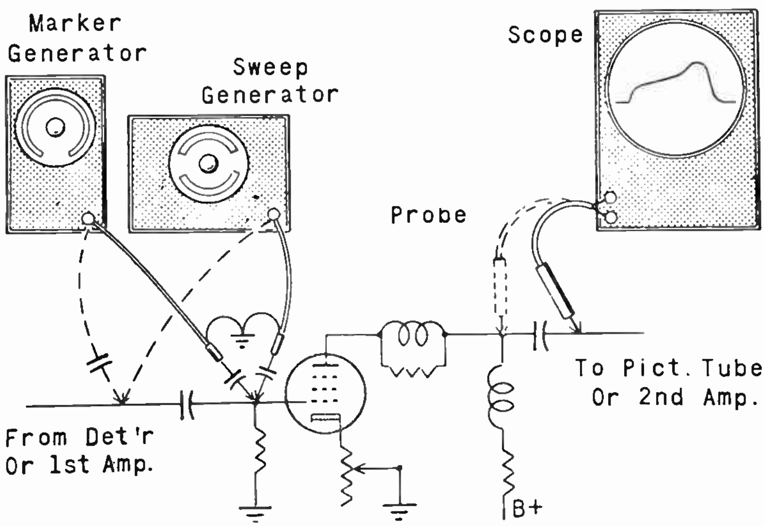


*Fig. 6-8. Test setup for measuring frequency response of a video amplifier and noting peaker effectiveness.*

**3.** Temporarily disconnect the grid input of the amplifier being tested, without disconnecting its grid return.

**4.** Connect the sweep generator through about 1,000 mmf fixed capacitance to the amplifier grid, as in full lines, or directly to a point ahead of a coupling capacitor, as in broken lines.

**5.** Connect the marker generator through fixed capacitance of 10 or more mmf to the same point as the sweep generator.

**6.** Connect the scope on the output side of a coupling capacitor, as in full lines, or, as in broken lines, to a point following the plate peaker and on the high side of a load peaker.

**7.** Adjust the contrast control, when it is on the amplifier cathode, to a position giving the highest trace. This may not be at maximum contrast.

To test a single stage make connections as in Fig. 6-8. For two stages connect the generators to the grid input of the first amplifier and the scope to the output of the second amplifier.

Use the marker generator to measure the frequency at the peak of response. Preferably it should be between 3 and 3½ mc, but not lower than 2½ mc. The response should drop well toward zero at 4½ mc or only slightly higher, and may show a dip due to a 4½ mc trap. These observations will check effectiveness of the peakers in maintaining and peaking the gain at high video frequencies.

# SECTION 7

## PICTURE TUBE INPUT

When locating trouble in the picture tube input or grid-cathode circuits we are concerned chiefly with (1) the brightness control, (2) the retrace blanking system, (3) voltage at the second grid and (4) whether signals from the video amplifier are applied to the cathode or to the control grid of the picture tube.

Whether signal input, brightness and retrace blanking are on the picture tube cathode or the control grid has much to do with the kinds of symptoms which result from various faults. Following diagrams illustrate circuit combinations most commonly used in present receivers. It is, however,

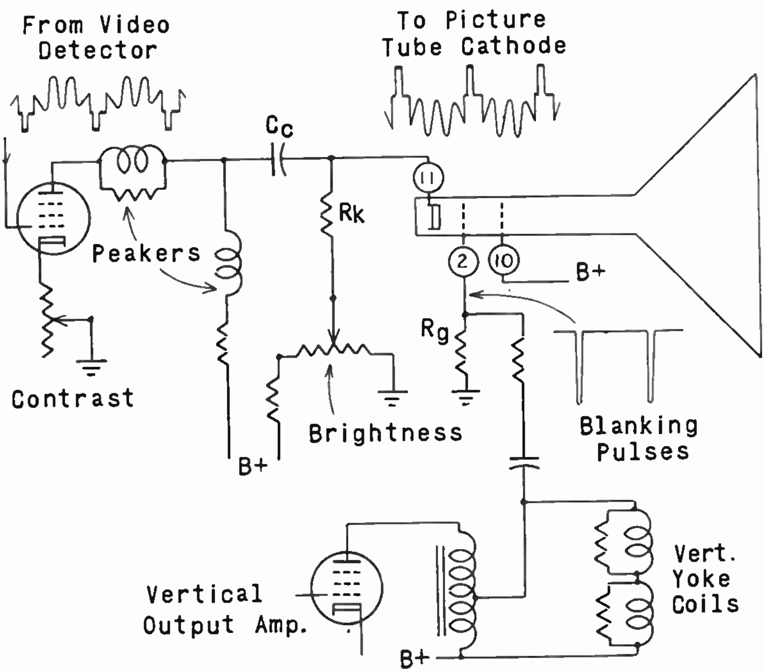


*Fig 7-1 These connections are widely used for picture tube input circuits.*

possible to combine brightness controls and retrace blanking systems in other ways. Also, almost any of the various sources of blanking pulses may feed to picture tube elements in combinations other than shown without affecting the general procedure of trouble shooting.

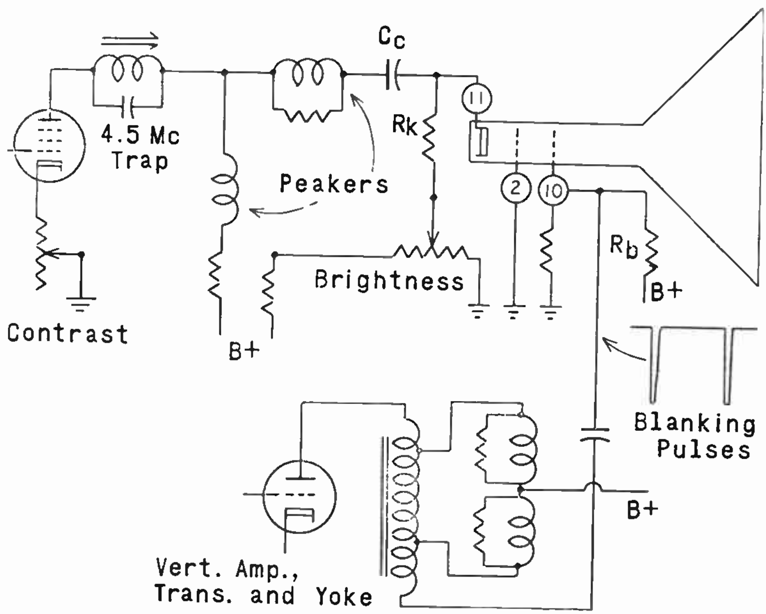


*Fig. 7-2. Retrace blanking pulses from an extension on the vertical output transformer are applied to the second grid.*

**Fig. 7-1**

Video signals pass through capacitor *Cc* to the picture tube cathode (pin 11). Picture signals must be negative and sync pulses positive at the cathode. Because there is polarity inversion in the video amplifier, signals from the video detector to this amplifier must have picture signals positive and sync pulses negative.

The brightness control is connected to the picture tube cathode.

Pulses for blanking of vertical retrace lines are taken from the high side of the vertical deflection coils or from the vertical output transformer and carried through a capacitor and resistor to the picture tube control grid (pin 2). Pulses applied to the grid must be negative in order to blank the beam.

The control grid is conductively connected to ground through resistor *Rg*, thence through the brightness control to the cathode. Resistor *Rg* is necessary in order that blanking pulses may not be grounded.

**Fig. 7-2**

Retrace blanking pulses taken from the vertical output transformer are applied to the second grid (pin 10) of the picture tube. To this grid is applied also a B+ voltage, without which the viewing screen would remain dark. Resistor *Rb* prevents blanking pulses from dissipating themselves in the lines from this resistor to the source of B-voltage.

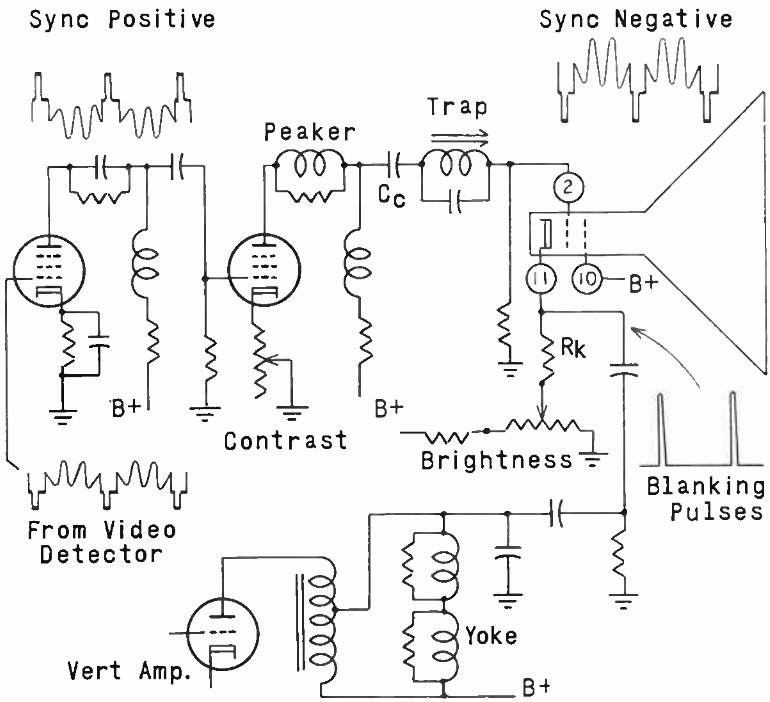


*Fig. 7-3. Signal polarities are different when video input is to the picture tube control grid.*

**Fig. 7-3**

A two-stage video amplifier feeds signals to the picture tube control grid (pin 2) at which sync pulses must be negative and picture signals positive. Then, because of polarity inversion in the amplifiers, sync must be positive and pictures negative between the two amplifiers, and sync negative with pictures positive at the output of the video detector.

Retrace blanking pulses are applied to the cathode, and must be of positive polarity because the cathode must be made more positive with reference to the control grid for extinguishing or reducing the electron beam.

A 4½-mc trap is on the side of coupling capacitor *Cc* toward the picture tube. Positions of this trap and of the preceding peaker might be interchanged without affecting trouble shooting.

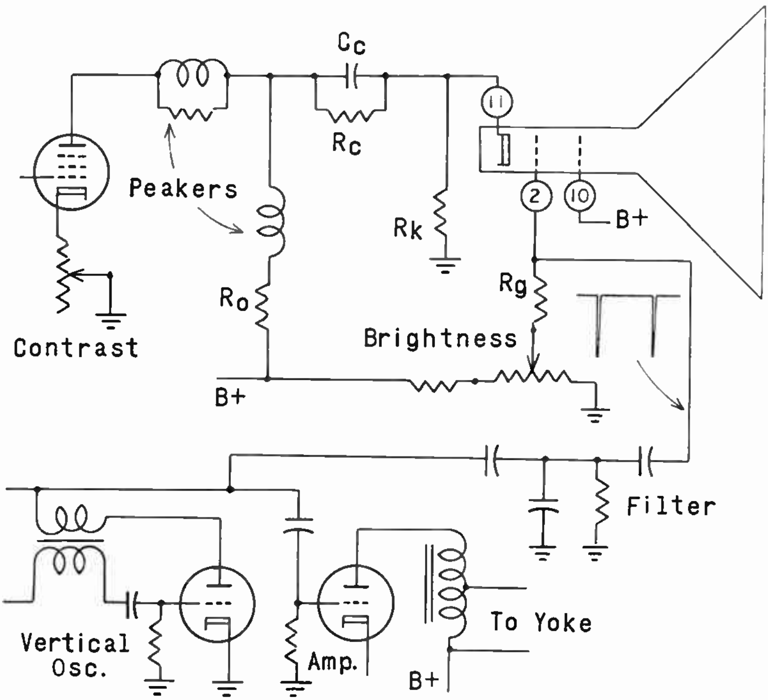


*Fig. 7-4. The coupling capacitor from video amplifier to picture tube is paralleled with a resistor.*

## Fig. 7-4

The brightness control is on the control grid of the picture tube. In parallel with coupling capacitor *Cc* is a resistor *Rc* B+ voltage goes through resistors *Ro, Rc* and *Rk* to ground. Resistors *Rc* and *Rk* act as a voltage divider. The portion of positive B-voltage at the junction of *Rc* and *Rk* is applied to the picture tube cathode.

B-voltage is applied also through the brightness control to the picture tube control grid. Thus both the control grid and the cathode are positive to ground, but their circuit resistances are so proportioned that the grid remains less positive than the cathode, or effectively negative with respect to the cathode. Cathode and grid may be fed from the same B+ voltage, as shown, or from different B-voltages so long as circuit resistances are such as to keep the grid less positive than the cathode.

Retrace blanking pulses are taken from the plate of the vertical oscillator. Pulses may be taken from anywhere in the vertical sweep or deflection sections where there is required pulse polarity and strength. Pulses may be taken from the vertical deflection yoke coil circuit or from the vertical output transformer, from the vertical amplifier plate, the amplifier grid, or the vertical oscillator plate. All these pulse sources are illustrated in our diagrams.

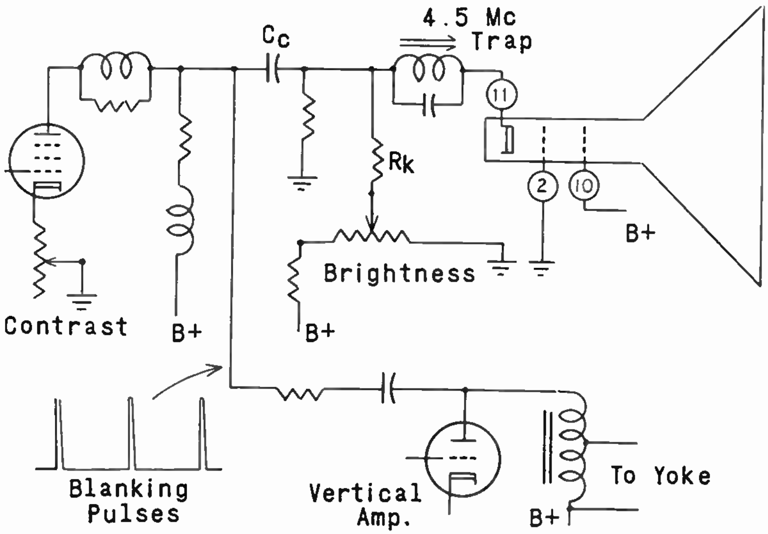


*Fig. 7-5. Retrace blanking pulses to the plate circuit of the video amplifier act through the coupling capacitor on the picture tube cathode.*

## Fig. 7-5

Positive blanking pulses from the vertical amplifier plate are applied to the plate circuit of the video amplifier, and act on the picture tube cathode through capacitor *Cc.* Otherwise this diagram shows no features not illustrated on those preceding.

## Fig. 7-6

Negative retrace blanking pulses are taken from the plate of the vertical output amplifier and applied to the picture tube control grid.

The contrast control potentiometer is across the load in the plate circuit of the video amplifier, with the slider of the pot feeding to the picture tube cathode. This allows running the video amplifier at constant gain. Any one or more of the bypass capacitors *Ca* may be used. A peaker may be in either of the positions indicated. Coupling capacitor *Cc* may be in either of the positions shown. The brightness control might be on the picture tube control grid rather than on its cathode.

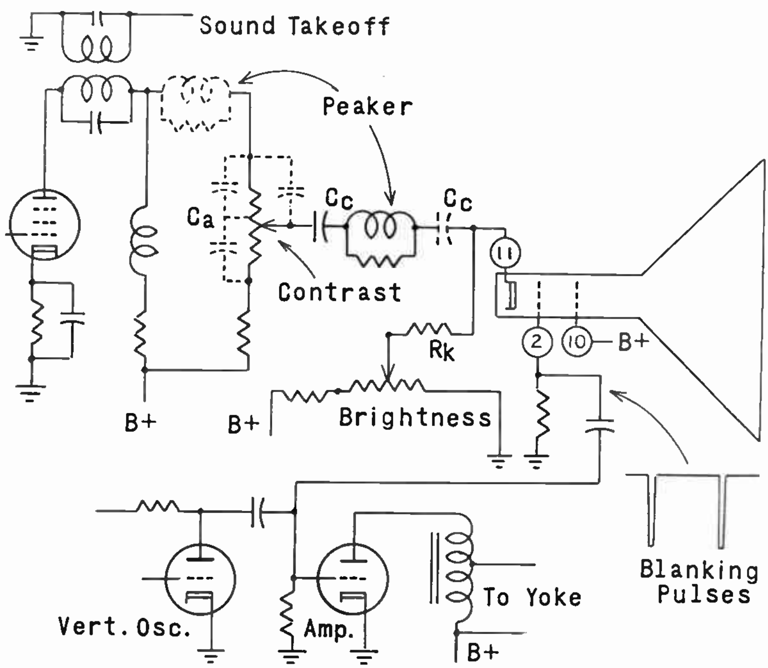


*Fig. 7-6. The contrast control is between video amplifier plate and picture tube cathode.*

## D-c Restoration

D-c restoration by means of a diode is shown at *1* of Fig. 7-7 and by means of a triode at *2*. The cathode and grounded grid of the triode are employed for restoration exactly as are the cathode and grounded plate of the diode. The triode plate is used to obtain sync pulses for use in the sync section. D-c restoration seldom is used in receivers of recent design.

The purpose of restoration is automatic variation of picture tube control grid bias to maintain the black level of video signals close to the voltage of beam cutoff both for pictures of light tone and of dark tone.

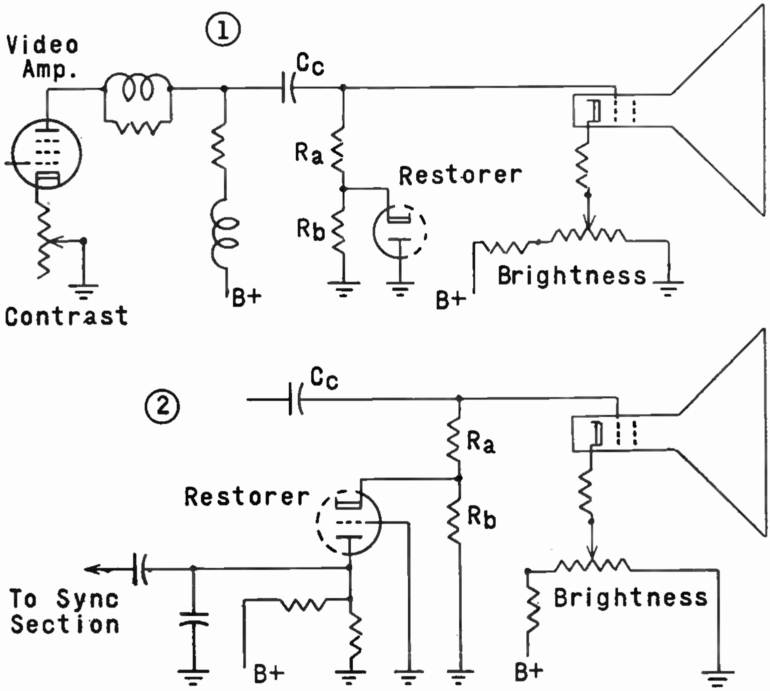


*Fig. 7-7. D-c restoration systems which have been commonly used.*

Video signals for light-toned pictures have greater peak-to-peak amplitude than those for darker tones. For light-toned pictures the restorer system makes the picture tube control grid slightly less negative to the cathode. This you may observe by connecting a d-c VTVM from control grid to cathode of an operating picture tube and watching the small voltage variations as pictures change between light and dark.

There is little noticeable effect on picture quality with a restorer circuit disconnected provided the conductive grid return through resistors *Ra* and *Rb* of Fig. 7-7 remains complete. Of course, removing or disconnecting a triode restorer tube would cut off pulses from the sync section and there

## Retrace Blanking Filters

Both the duration and amplitude or strength of retrace blanking pulses are determined by resistors and capacitors which form a filter of one type or another between the source of pulses and the picture tube element to which the pulses are applied. Fig. 8 shows separately the filters for preceding Figs. 7-1 to 7-6, similarly numbered.

Duration of each pulse is lengthened by either more resistance or more capacitance in the filter, and is shortened by less resistance or capacitance. A pulse which lasts too long blanks the top of pictures as well as the vertical retrace, and tops are darkened. A pulse too short leaves retrace lines at the top of pictures.

Duration of blanking pulses is determined chiefly by these resistors and capacitors:

Diagram 1. *Rp* and *Cp*

Diagrams 2 and 6. *Cp*

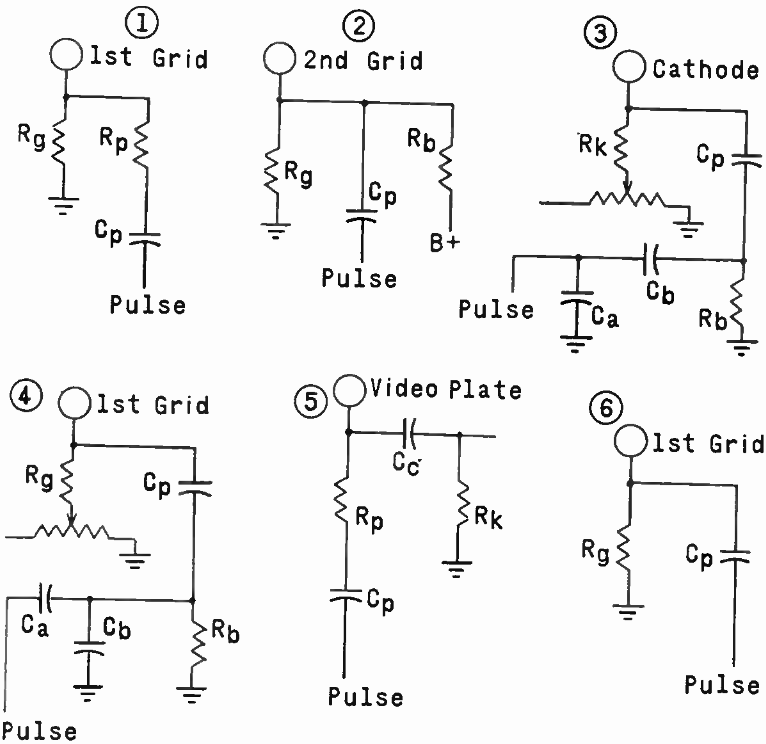


*Fig. 7-8. Various forms of retrace blanking pulse filters as used in preceding figures 7-1 to 7-6.*

Diagram 3. *Rb, Ca* and *Cb*
Diagram 4. *Rb, Ca* and *Cb*
Diagram 5. *Rp* and *Cp*

Other resistors and capacitors in the blanking circuits affect chiefly the amplitude or strength of pulses, although every resistor and every capacitor affects pulse duration to some extent.

## Brightness Control Troubles

There must be a complete conductive path through wiring, resistors or chassis metal from the control grid to the cathode of the picture tube in order that grid biasing potential and control of brightness may be maintained. D-c biasing voltage and brightness control voltage cannot act through a capacitor.

If the picture tube control grid is not conductively connected to chassis ground or B-minus and thence to the cathode, pictures will be excessively bright, there may be blooming, definition will be very bad, and with some circuits the action of the brightness control may be reversed.

With the picture tube cathode not conductively connected to chassis ground or B-minus and thence to the control grid, the viewing screen may remain dark, without even a raster, or pictures will be of very low brightness and the brightness control will have no effect.

With the brightness control on the picture tube cathode (Figs. 7-1, 2, 3, 5 and 6) a resistor *Rk* is in series between the cathode and the brightness control pot. The value of *Rk* usually is 100K to 200K ohms, but may be smaller or larger. Except in the case of Fig. 7-5 all d-c electron flow to the cathode is through resistor *Rk* in a direction such that voltage drop biases the cathode positively. This is equivalent to negative bias on the control grid.

Brighter pictures or stronger signals increase cathode current in resistor *Rk,* increase voltage drop in this resistor, and make the control grid more effectively negative to the cathode. This action tends to limit cathode current and maximum brightness.

In Fig. 7-4 the brightness control is on the control grid of the picture tube. Resistor *Rg* in series between control grid and the brightness control pot prevents grounding of retrace blanking pulses, as would occur were the control grid connected directly to ground. The value of *Rg* usually is about 100K ohms. Since the control grid normally remains negative with respect to the cathode there is no d-c current in *Rg* and no degenerative effect.

## Brightness Control Test

Connect the positive of a high-resistance d-c voltmeter or a VTVM to the picture tube socket lug for pin 11, the cathode. Connect the negative side of the meter to the lug for pin 2, the control grid. The socket may remain on the tube or be removed. With the socket removed it is easy to make meter connections to pieces of wire put into the pin openings.

Use a meter range of 100 volts or more, turn on the receiver, and operate the brightness control. Readings should vary from something like 10 volts with the control advanced to 60 volts or more with the control retarded.

## Troubles And Symptoms

Three accompanying tables list possible faults in the picture tube input circuits and elements, and show probable symptoms as observed in picture reproduction. Main headings in the left-hand columns of the tables list types of circuits, with subheadings for circuit components. Following paragraphs, number to correspond with numbered faults in the tables, contain information useful in trouble location.

**1-3 and 7-9.** Zero voltage would indicate an open connection to the brightness control pot. Too little voltage might result from a series resistor which has been overheated. Too great voltage would indicate a shorted resistor in series with the brightness control pot. The control pot itself may be defective, having poor contact from slider to resistance element, a rough element or an open element. Connections in the brightness control circuits may be loose, open or shorted.

**12.** Even with an open capacitor some signal will go through the paralleled resistor.

**13.** A leaky or shorted capacitor allows positive voltage from the plate circuit of the video amplifier to reach the picture tube cathode. This make the cathode too positive and the control grid relatively too negative, thus diminishing the electron beam.

| Table 7-A<br>**PICTURE TUBE INPUT**<br>**Grid-Cathode Circuits and Brightness** | Brightness Excessive | Brightness Lacking | Brightness No Control | Dark, No Raster | Definition Poor | Pictures Weak | Raster, No Pictures | Retrace Lines Appear |
|---|---|---|---|---|---|---|---|---|
| BRIGHTNESS CONTROL ON CATHODE | | | | | | | | |
| B-voltage To Control Pot. | | | | | | | | |
| 1 Zero | | ● | ● | | | | | |
| 2 Too little, poor connections | | ● | | | | | | |
| 3 Too great | ● | | | | | | | |
| Resistor, Cathode To Pot. | | | | | | | | |
| 4 Open | | | | ● | | | | |
| 5 Too small | | | | | | ● | | |
| 6 Shorted | | | | | | | ● | |
| BRIGHTNESS CONTROL ON GRID | | | | | | | | |
| B-Voltage To Control Pot. | | | | | | | | |
| 7 Zero | | | | ● | | | | |
| 8 Too little | | ● | | | | | | |
| 9 Too great | ● | | | | | | | |
| Resistor, Grid To Pot. | | | | | | | | |
| 10 Open | ● | | | | | | | |
| 11 Shorted | | | | | | | | ● |
| SIGNAL TO PICTURE TUBE CATHODE | | | | | | | | |
| Resistor Paralleling Capacitor | | | | | | | | |
| 12 Capacitor open | | | | | | ● | | |
| 13 Capacitor leaky, shorted | | ● | | ● | | | | |
| 14 Parallel R open, too great | ● | | | | | | | |
| 15 Parallel R too small | | | | | | ● | | |
| 16 Parallel R shorted | | | | ● | | | | |

(Continued on next page)

(Continued from preceeding page)

**Table 7-A**
**PICTURE TUBE INPUT**
**Grid-Cathode Circuits and Brightness**

| | Brightness Excessive | Brightness Lacking | Brightness No Control | Dark, No Raster | Definition Poor | Pictures Weak | Raster, No Pictures | Retrace Lines Appear |
|---|---|---|---|---|---|---|---|---|
| 17 Resistor to ground open | | • | | | | | | |
| 18 Resistor to ground shorted | | | | • | | | | |
| No Parallel Resistor | | | | | | | | |
| 19 Capacitor open | | | | | | | • | |
| 20 Capacitor leaky, shorted | | • | | • | | | | |
| 21 Resistor to ground open | | • | | | | | | |
| 22 Resistor to ground shorted | | | | • | | | | |
| SIGNAL TO PICTURE TUBE GRID | | | | | | | | |
| 23 Cplg capacitor open | | | | | | | • | |
| 24 Cplg capacitor leaky, shorted | • | | | | | | | |
| 25 Resistor to ground open | • | | | | | | | |
| 26 Resistor to ground shorted | | | | | | | • | |
| GRID-CATHODE RETURNS | | | | | | | | |
| 27 Cathode return open or poor connections | | • | • | • | | • | | |
| 28 Control grid return open or poor connections | • | | • | | • | | | |

**24.** A leaky or shorted capacitor allows positive voltage from the video amplifier plate circuit to make the picture tube grid positive with respect to the cathode.

**27-28.** See the earlier heading, *Brightness Control Troubles.*

**29-30** and **44-45.** Blanking pulses may be observed by connecting the vertical input of an oscilloscope to the picture tube cathode or control grid through a frequency compensating probe. Pulses to a cathode or control grid usually have normal amplitudes of less than 100 volts peak-to-peak, but pulses applied to a second grid usually are of greater amplitude.

| **Table 7-B**<br>**PICTURE TUBE INPUT**<br>**Retrace Blanking.** | Brightness Excessive | Bright Band At Top | Dark Area At Top | Retrace Lines Appear |
|---|---|---|---|---|
| RETRACE BLANKING TO CONTROL GRID (C and R references to Fig. 8) | | | | |
| 29 Pulses absent | | | | • |
| 30 Pulses too strong | | | • | |
| Series Capacitor, Cp | | | | |
| 31 Open, too small | | | | • |
| 32 Too great | | | • | |
| 33 Leaky, shorted | • | | | |
| Series Resistor, Rp | | | | |
| 34 Open, too great | | | | • |
| 35 Shorted | | | | • |
| Capacitor To Ground, Cb | | | | |
| 36 Open | | | | • |
| 37 Too small | | | • | |
| 38 Too great | | | | • |
| 39 Leaky, shorted | | | | • |
| Resistor To Ground, Rb | | | | |
| 40 Open | | | | • |
| 41 Shorted | | | | • |
| Resistor, Grid-ground, Rg | | | | |
| 42 Open | • | | | |
| 43 Shorted | | | | • |



(Continued on next page)

| **Table 7-B (Con't)** **PICTURE TUBE INPUT** **Retrace Blanking.** | Brightness Excessive | Bright Band At Top | Dark Area At Top | Retrace Lines Appear |
|---|---|---|---|---|
| RETRACE BLANKING TO CATHODE (C and R references to Fig. 8) | | | | |
| 44 Pulses absent | | | | • |
| 45 Pulses too strong | | • | | |
| Series Capacitor, <u>Cp</u> | | | | |
| 46 Open, too small | | | | • |
| 47 Too great | | | • | |
| 48 Leaky, shorted | • | | | |
| Series Resistor, <u>Rp</u> | | | | |
| 49 Open, too great | | | | • |
| 50 Shorted | | | | • |
| Capacitor To Ground, <u>Cb</u> | | | | |
| 51 Open | | | | • |
| 52 Too small | | | • | |
| 53 Too great | | | | • |
| 54 Leaky, shorted | • | | | |
| Resistor To Ground, <u>Rb</u> | | | | |
| 55 Open | | | • | |
| 56 Shorted | • | | | |

**31-41** and **46-56.** Refer to the earlier heading, *Retrace Blanking Filters.* As observed on a frequency compensated oscilloscope a satisfactory retrace blanking pulse may be only about one-fifth as wide as a vertical blanking interval. This is illustrated by Fig. 7-9.

Peak or peak-to-peak pulse amplitude, when applied to the picture tube cathode or control grid, need be only about half the peak or peak-to-peak amplitude of the composite video signal from sync pulse tips to maximum white for pictures.

| **Table 7-C** **PICTURE TUBE INPUT** **Retrace Blanking. D-C Restoration** | Brightness Excessive | Brightness Lacking | Contrast Excessive | Dark, No Raster | Definition Poor | Pictures Weak | Raster, No Pictures | Retrace Lines Appear | Sync Critical |
|---|---|---|---|---|---|---|---|---|---|
| RETRACE BLANKING TO 2nd GRID (C and R references to Fig. 8) | | | | | | | | | |
| Series Capacitor, Cp | | | | | | | | | |
| 57 Open, too small | | | | | | | | • | |
| 58 Leaky, shorted | • | | | | | | | • | |
| Resistor To B+, Rv | | | | | | | | | |
| 59 Open | | | | • | | | | | |
| 60 Too small, shorted | | | | | | | | • | |
| Resistor To Ground, Rg | | | | | | | | | |
| 61 Open | • | | | | | | | • | |
| 62 Too Small, shorted | | • | • | | | | | | |
| D-C RESTORATION (See Fig. 7) | | | | | | | | | |
| 63 Tube weak | | | | | | | | | • |
| 64 Tube cathode-heater leak | | | | | | • | | | • |
| 65 Resistor Ra open | • | | | | | | | | |
| 66 Resistor Ra shorted | • | | | | | | | | |
| 67 Resistor Rb open | • | | | | | | | | • |
| 68 Resistor Rb shorted | | | | | • | | • | | |

Blanking pulses applied to the second grid of the picture tube must have peak amplitudes several times that of the composite signal peak-to-peak voltage.

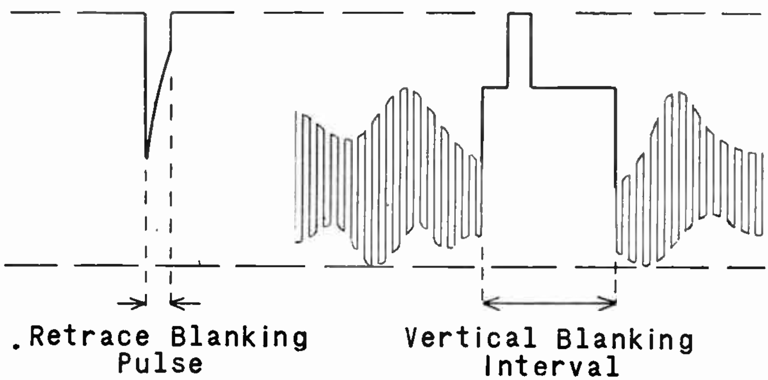


*Fig. 7-9. Relations between retrace blanking pulses and vertical blanking intervals.*

# SECTION 8

## THE PICTURE TUBE

Picture tube elements and accessories with which we now are concerned are shown by Fig. 8-1. The cathode (pin 11), the control grid (pin 2) and the second grid, first anode or accelerating grid (pin 10) are found in all tubes.

The widely used method of applying video signals to the picture tube cathode is referred to as cathode drive. The less used method of applying video signals to the control grid is called grid drive.

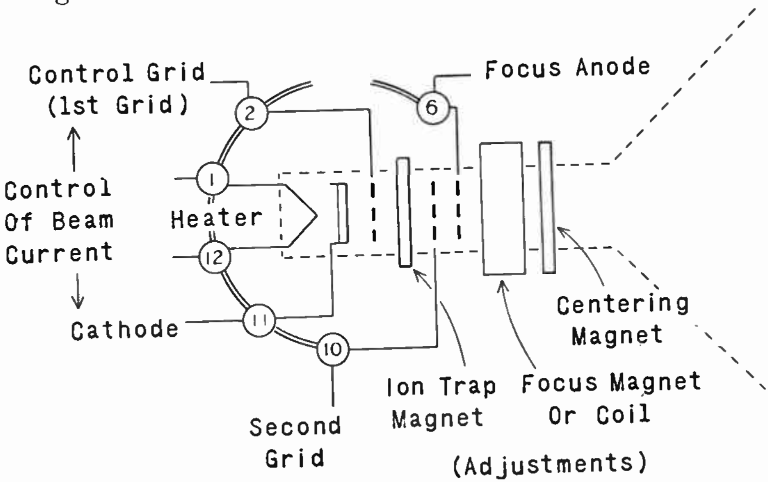


*Fig. 8-1. Picture tube elements and accessories considered in this group.*

Focusing may be electrostatic or magnetic. For electrostatic focusing there is an additional focusing anode connected to base pin 6. This element is not present in tubes designed for magnetic focusing. With electrostatically focused tubes the centering of pictures is by an adjustable external permanent magnet or magnets.

Magnetic focusing most often is by means of an external device containing permanent magnets with means for adjusting the focusing field. Most permanent magnet focusing devices include the necessary parts and a separate adjustment for centering of pictures. With the few PM focusing devices which do not provide centering there is used a separate adjustable permanent magnet centering unit.

Magnetic focusing sometimes is provided by a wound focusing coil which carries direct current. Focus is adjusted by varying the coil current. The focusing coil may be supported in a mount which allows the coil to be tilted one way or another for centering of pictures. Otherwise there may be a separate adjustable permanent magnet centering device.

The yoke is not considered as part of this group or section because the deflecting coils are in the sweep and deflection system. The second anode or ultor is not included here because it is part of the high-voltage section.

Accompanying tables list faults which may occur with elements and parts of Fig. 8-1. Following the tables are instructions for tests and repairs, also notes helpful during trouble location in this section of the receiver. Instruction paragraphs are numbered to correspond with numbered faults in the tables.

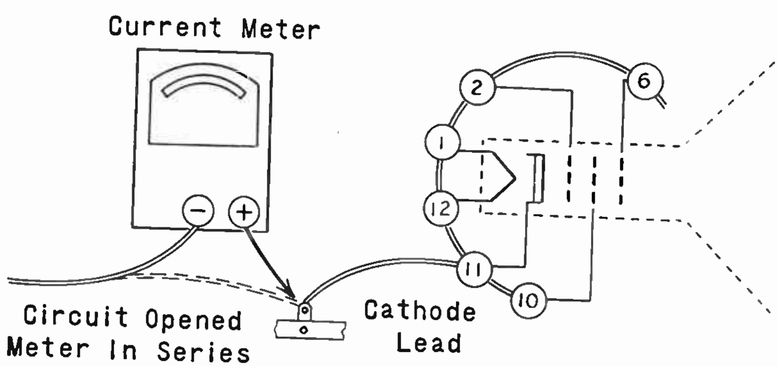


*Fig. 8-2. Measuring cathode emission current of a picture tube.*

## 1. Emission Measurements

While a picture tube is in normal operation the cathode current is practically the same as beam current or current for the high-voltage anode. The first grid or control grid is negative to the cathode and carries no current. Current either to or from the second grid and to or from a focusing anode will be negligible or zero in spite of the fact that these elements may be highly positive to the cathode.

**Table 8-A**
**PICTURE TUBE**

| PICTURE TUBE | Blooming | Brightness Excessive | Brightness Lacking | Brightness Control Poor | Dark, No Raster | Definition Poor | Focus Poor | Linearity Poor | Pictures Weak | Raster, No Pictures | Size Too Small |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Emission low | | | • | | | • | | | • | | |
| 2 Heater voltage low | | | • | | • | | | | | | |
| **Second Grid Voltage** | | | | | | | | | | | |
| 3 Zero, or grid grounded | | | | | • | | | | | | |
| 4 Too low | | • | | | | | • | | | | |
| **Electrostatic Focus Voltage** | | | | | | | | | | | |
| 5 Too high, too low | | | | | | | • | | | | |
| **Socket Contacts** | | | | | | | | | | | |
| 6 Dirty, loose | | | • | | • | | | | | • | |
| **Leakage** | | | | | | | | | | | |
| 7 Cathode-heater | | • | | • | • | • | | | | | |
| **Internal Opens** | | | | | | | | | | | |
| 8 Cathode | | | | | • | | | | | | |
| 9 Control grid | | | | • | | | | | | • | |
| 10 Second grid | | | | | • | | | | | | |
| **Internal Shorts** | | | | | | | | | | | |
| 11 Control grid-cathode | | • | | • | | | | | | • | |
| 12 Other elements | | • | | | • | | | | | | |
| **Vacuum** | | | | | | | | | | | |
| 13 Tube gassy | • | | | | | | • | | | | • |
| **Magnetized Parts** | | | | | | | | | | | |
| 14 Cone of metal tube | | | | | | | • | • | | | |
| 15 Brackets for any tube | | | | | | | • | • | | | |

Cathode current may be measured with a microammeter or with a volt-ohm-milliammeter having a d-c current range of 500 microamperes or 0.5 milliampere, connected as in Fig. 8-2.

Cathode current is increased by any of the following:

**A.** Received pictures of lighter tone. Tests should be made with the receiver tuned to an inactive channel, so only a raster will show.
**B.** Advancing the contrast control while receiving pictures. On an inactive channel the contrast control will have little effect or none at all. This control should be set at minimum.
**C.** Advancing the brightness control, for a brighter raster.
**D.** Greater heater voltage.
**E.** Greater voltage on the second grid.
**F.** Greater voltage on the second anode or ultor.
**G.** Some types of picture tubes.

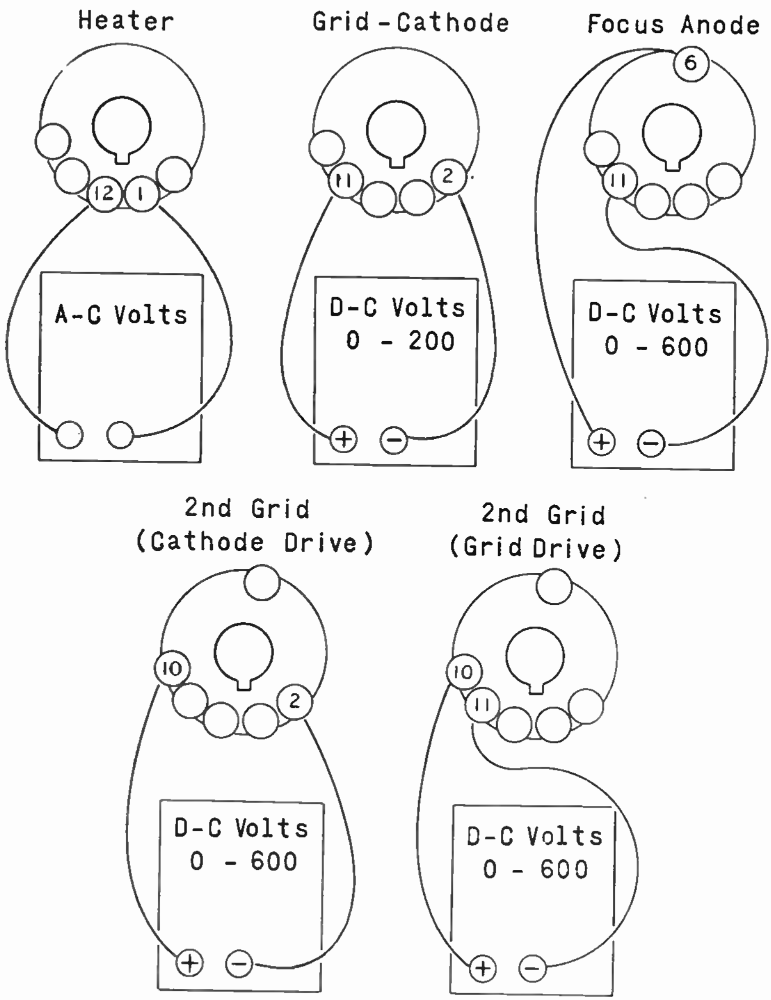


*Fig. 8-3. Connections for checking voltages at the various elements of a picture tube.*

When emission is low the viewer is likely to advance the contrast control too far, giving the appearance of excessive contrast although the primary trouble is low emission.

## 2 to 5. Element Voltages

Check element voltages at the picture tube socket as in Fig. 8-3. Use only a VTVM. Even a high-resistance moving coil meter will show incorrect control grid-cathode voltages and second grid voltages with many kinds of receiver circuits. Remove the socket from the tube. Connect the VTVM leads to short pieces of wire inserted in the socket openings.

A-c heater voltage between socket openings for pins 1 and 12 should read no less than 6.0 volts.

## 3 and 4. Second Grid Tests

Measure second grid voltage with a d-c range of 500 volts or more. Connect positive of the meter to the socket opening for pin 10 and the negative to the opening for pin 2 for a set with cathode drive, or the negative to the opening for pin 11 for a set with grid drive.

Nearly all recent picture tubes are designed for 500 volts maximum positive on the second grid with reference to the cathode with grid drive, and for 625 volts with reference to the control grid with cathode drive. A few older 17-inch tubes are designed for maximum of 410 volts to the cathode. Anything much less than 250 to 350 positive volts on any second grid is likely to mean unsatisfactory performance.

Increasing the voltage on a second grid allows handling stronger video signals or signals with greater peak-to-peak amplitude while preserving a full range of shadings from darkest to lightest. There is increased brightness on the viewing screen, and more cathode current, for any given setting of the brightness control.

The increase of brightness with more voltage on the second grid requires that the control grid be made more negative to the cathode, or the cathode more positive to the grid, in order to have beam cutoff. This is merely another way of saying that more voltage on the second grid allows handling stronger signals or greater signal drive voltage.

Any change of second grid voltage may affect electrostatic focusing. It may be necessary to change the focusing voltage on pin 6 when there is any decided change of second grid voltage.

## 5. Electrostatic Focus

Measure electrostatic focus voltage with the positive of a d-c meter to the socket opening for pin 6 and negative to the cathode (pin 11) for sets with grid drive, or negative to the control grid (pin 2) for cathode drive.

Focusing voltage may measure almost anything — from negative with respect to the cathode (for grid drive) up to 400 volts or more positive with respect to either the cathode or the control grid. In some sets the focusing anode (pin 6) is connected to chassis ground, usually with a connection at the socket from pin 6 to the grounded pin for the heater. Pin 6 sometimes is connected at the socket to pin 10, thus applying the same voltage to the focusing anode as to the second grid.

During service work it is permissible to connect the focusing anode to some voltage either higher or lower than originally used, provided this improves the focus. The source for focus voltage quite often is a line carrying boosted B-voltage, with a resistor in series to pin 6.

Some receivers have a potentiometer for adjusting the focus voltage. With a pot of 2 megohms resistance connected to a source of 500 volts the pot has to dissipate less than 1/6 watt and should give no trouble.

## 7. Cathode-heater Leakage

In addition to symptoms listed in the table, cathode-heater leakage of low resistance may cause hum bars, making the upper or lower part of pictures much darker than the remainder.

When video signal input is to the control grid of the picture tube, not to the cathode, ill effects of cathode-heater leakage may be overcome by using a separate heater transformer as in Fig. 8-4. The transformer must have an insulated secondary.

If a separate transformer is used where signal input is to the picture tube cathode, pictures may be of poor quality. Quality will be definitely bad if leakage resistance is less than about 10,000 ohms.

Disconnect the leads for socket openings 1 and 12 from the receiver heater circuit and connect these leads to the transformer secondary. Do not connect either side of the secondary to ground. However, try connecting one side and

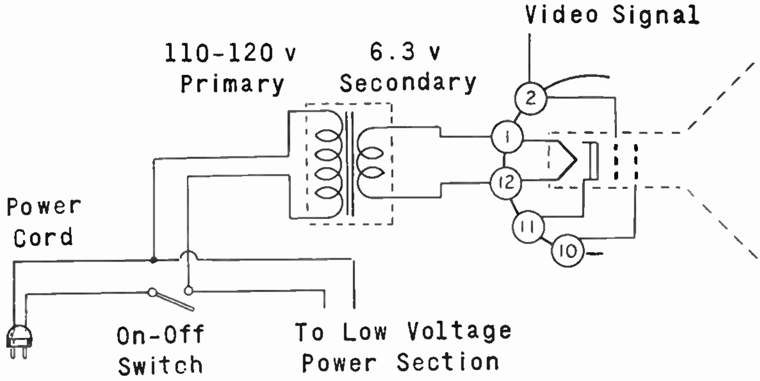


*Fig. 8-4. Using a transformer to prevent ill effects of cathode-heater leakage.*

then the other of the secondary to the cathode (pin 11) and leave it so connected if picture quality is improved.

When using a transformer designed to reduce a-c power line voltage to 6.3 volts connect the transformer primary to the same receiver leads that go to the power transformer, as illustrated, or to the leads on the receiver side of the off-on switch where there are series heaters.

When using a one-to-one heater transformer connect one side of its primary to the high side of a 6.3 volt parallel heater circuit and the other side of the primary to the other side of the heater circuit, usually ground.

If the receiver has series heaters, disconnecting the picture tube heater as in Fig. 8-4 would leave the receiver heater line open. Continuity must be restored with a resistor connected between points from which leads to heater socket terminals have been disconnected. Resistance should be 10 to 11 ohms. Actual dissipation will be about 3.8 watts, so the resistor should be rated for at least 5 watts and preferably for 10 watts.

Some tube brighteners contain a transformer with insulated secondary and have provisions for a one-to-one voltage ratio. Such a brightener may be installed much more easily than a separate transformer.

## 8 to 10. Internal Opens

Open circuits at base pins or within the tube envelope to the cathode, control grid and second grid may be checked with the setup of Fig. 8-5. Heater voltage is applied during the tests.

A control grid test is shown at *A*. In series between cathode and control grid connect a single dry cell, a d-c current meter reading to 0.5 ma or more, and a resistor of about 22K ohms.

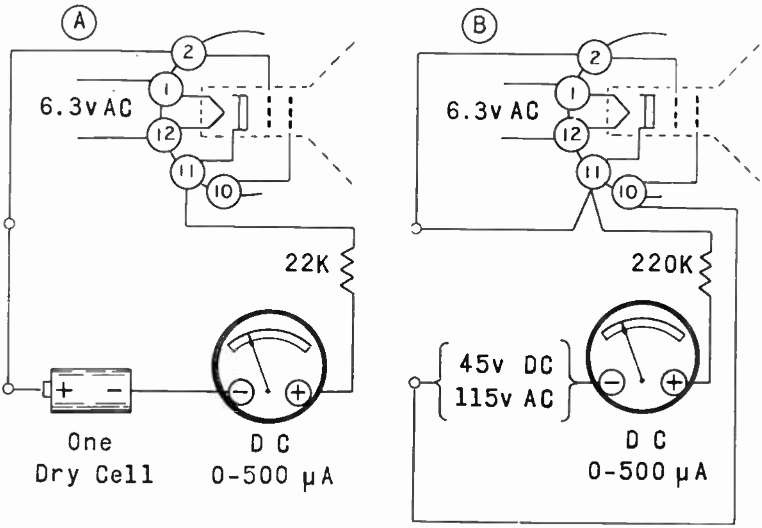


*Fig. 8-5. Tests for elements internally open in the picture tube.*

Check the second grid as in diagram *B*. Change the resistor to about 220K ohms. Connect the control grid to the cathode. Connect the second grid to the meter through a battery of about 45 volts or else to an a-c power line (110-120 voltage.

Zero reading on *both* tests indicates that the cathode is open.

Zero on test *A*. but not on *B*. shows that the control grid is open.

Zero on test *B* but not on *A* shows that the second grid is open.

An open circuit may be due to poor connection of an internal lead wire into a base pin. Resoldering may cure the fault, and can do not harm since the tube is useless with an open element.

Clean the tip of the pin with a fine sandpaper. Hold a hot soldering iron against the side of the pin near the tip while applying rosin core wire solder to the tip until some solder flows into the tip. An iron not hot enough or continued heating with any iron may loosen the pin in the base.

Some workers slip a piece of number 20 bare tinned hook-up wire into the pin while it is heated, then apply solder. Excess wire is cut off after cooling. If solder gets on the outside of the pin shave it off with a penknife blade.

## 11 and 12. Internal Shorts

Internal shorts sometimes may be discovered and located by using the highest resistance range of an ohmmeter as in Fig. 8-6. Remove the second anode (high-voltage) connector from the picture tube, cover the connector and place it where there is no chance of shorting to metal or giving you a shock.

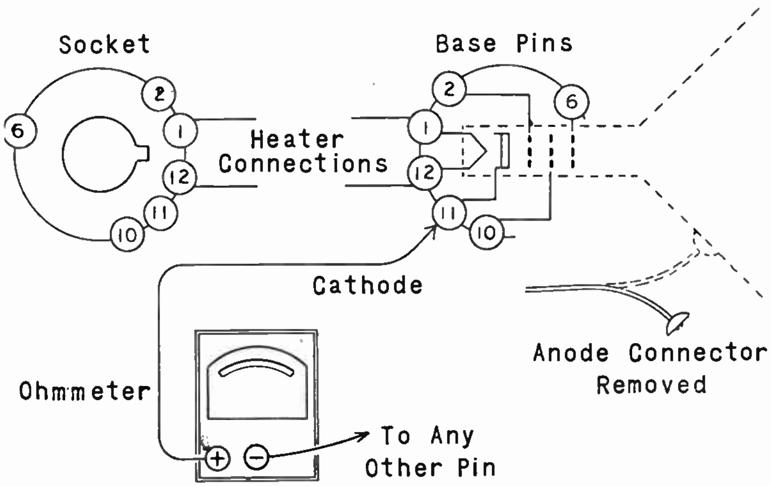


*Fig. 8-6. Testing for elements shorted within the picture tube.*

Remove the socket from the picture tube and make temporary connections from the heater line, or the line and ground, to pins 1 and 12 in order to light the heater.

Either lead of any ohmmeter may be positive with respect to the other lead. Determine which lead is positive. While checking for shorts to the cathode always connect the positive lead of the ohmmeter to the cathode. Otherwise the ohmmeter will show a low resistance reading which is due to emission current in the tube.

All internal elements may be checked by making the following connections in the order listed.

*A*. From cathode (pin 11) to control grid, second grid, focusing anode, second anode cap.

*B*. From control grid (pin 2) to second grid, focusing anode, second anode cap.

*C*. From second grid (pin 10) to focusing anode, second anode cap.

*D*. From focusing anode (pin 6) to second anode cap.

Internal shorts sometimes are burned out with high voltage from the high-voltage power supply of the receiver, using the cable that normally goes to the second anode cap on the picture tube. This method is likely to damage the high-voltage section.

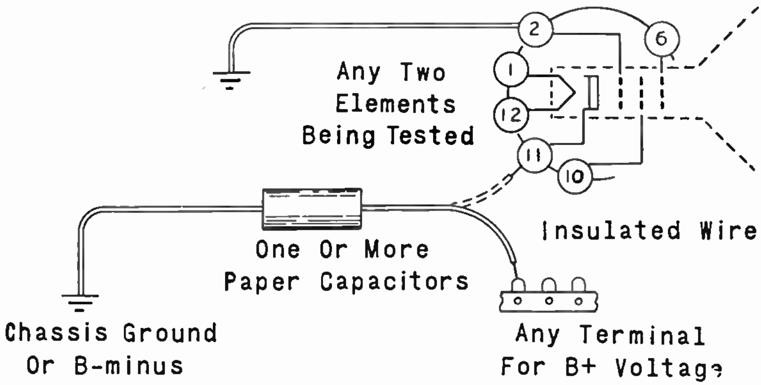

*Fig. 8-7. Burning out internal shorts with the charge from a capacitor.*

With another method of burning out shorts, illustrated by Fig. 8-7, a capacitor is charged from a d-c source and then discharged through the short. The discharge provides large current but discharge time is too brief to overheat the tube elements. The capacitor should be of at least one microfarad, or several units of less capacitance may be connected in parallel to make up the total. Capacitor voltage rating should at least equal the charging voltage, which may be taken from a B+ line or from a boosted B-voltage line of the receiver.

Remove the socket from the picture tube, also the high-voltage second anode connector. Connect the bared end of an insulated wire to one side of the capacitor. Connect the other side of the capacitor to chassis ground or B-minus. Connect either of the two shorted elements to chassis ground or B-minus.

Touch the other bared end of the insulated wire to the source of B-voltage for a moment, then touch this end of the wire to the pin for the shorted element that has not been grounded. The process may be repeated or a higher charging voltage may be used should the ohmmeter show that the short persists.

## Picture Tube Brighteners

When cathode emission has become low due to aging of a picture tube the emission usually may be increased to obtain some further useful life by applying greater than normal voltage to the heater. This is done most conveniently with a tube brightener or booster consisting of a small transformer in a housing on which is a picture tube base with pins. There is a picture tube socket on leads connected into the brightener housing. The regular socket is removed from the picture tube and placed on the brightener while the socket on the brightener leads is put onto the base of the picture tube.

Some brighteners are designed to operate only where heaters are wired in parallel. Others will operate where heaters are wired either in series or in parallel.

A brightener will improve the performance of most old picture tubes. The improvement may last for only a week or so, or for many months.

## Reactivation Or Rejuvenation

Picture tubes often are reactivated or rejuvenated by applying greater than normal voltage to the heater for a limited time while no voltages are applied to the second anode, the second grid, a focusing anode or the control grid. To the heater may be applied 9 to 10 a-c volts for about one minute, then about 7 volts for an hour or more. This may be done with a brightener which provides a choice of heater voltages.

Fig. 8-8 shows all connections for rejuvenation employing a step-down transformer which will supply secondary voltage adjustable from 6 to 10 volts. A small toy transformer with a 5-ohm 2-watt resistor in series is satisfactory. A non-adjustable 6.3-volt heater transformer may be tried instead of the adjustable type. The picture tube rectifies the a-c voltage. D-c

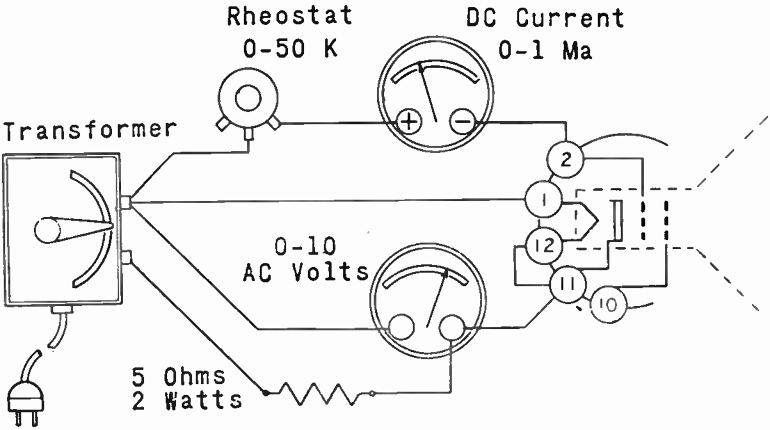


*Fig. 8-8. Connections for picture tube rejuvenation from a stepdown transformer.*

emission current flows from the control grid through a d-c milliammeter and adjustable rheostat.

With 7 to 8 volts on the heater the rheostat is set to limit emission current to no more than 0.1 to 0.2 ma in the beginning. The process is allowed to continue while emission current increases with the original setting of the rheostat. This current should not be allowed to exceed 0.5 ma.

Rejuvenation may allow improved performance for short or long periods, as is also true when a brightener remains on the picture tube. Often a brightener may be used for a few hours or days, after which the picture tube will continue to perform well for a considerable period without the brightener.

### PICTURE TUBE ACCESSORIES

The second table relating to this group lists faults and symptoms for ion trap magnets, focusing magnets or coils, and centering magnets. Following explanatory paragraphs are numbered to correspond with numbers of faults in the table.

## Ion Trap Magnets

**16.** Extreme misadjustment of an ion magnet may allow the viewing screen to show only a faint glow, visible only in a darkened room. Such misadjustment, if continued for more than a few minutes, will permanently damage the picture tube.

Adjust the magnet while tuned to an inactive channel with brightness advanced only enough to allow a dim raster. Rotate the magnet around the tube neck and slide the magnet forward or back to attain the maximum brightness. Retard the brightness control as adjustment proceeds.

Do not attempt shadow elimination by adjustment of the trap magnet if this causes any reduction of brightness. Eliminate shadows by the centering adjustment.

Focus sometimes is improved by slight readjustment of the trap magnet within the range of positions where brightness is not reduced. Check this on a raster of low brightness. Good focus may be impossible if the ion trap magnet has long remained misadjusted.

Any change of adjustment of a focusing magnet or coil, or of a centering device, should be followed by readjustment of the ion trap magnet for maximum brightness.

**17.** Strength of ion trap magnets is measured in gausses. The gauss is a unit related to concentration or density of magnetic field strength in a given cross sectional area of the field. Strengths of commonly used magnets range from 30 to 50 gausses.

For tubes of recent design the strength of the ion trap magnet is increased by about one gauss for every 1,000-volt increase at the second anode or ultor. There is no direct relation between magnet strength and size of the viewing screen.

A magnet which has to be moved well toward the yoke for maximum brightness probably is too weak. One that has to be moved close to the tube base for maximum brightness probably is too strong. Good brightness may be unobtainable with a weak magnet in any position.

**18.** As a general rule a single-field ion trap magnet won't work on a picture tube designed for a double-field magnet, nor the other way around. There are a few tubes which operate satisfactorily with either kind of magnet.

**19.** A double-field magnet turned front for back will cause severe shadowing when moved to the position for maximum brightness. A single-field magnet may be rotated to the position for maximum brightness and good picture reproduction regardless of front and back relations.

## Focus Magnet Or Coil

**20.** If a focusing magnet or coil is moved lengthwise of the picture tube neck to improve focus or prevent shadowing it is necessary to readjust the ion trap magnet.

**21.** It is important that a focusing magnet or coil be centered around the tube neck, with practically uniform spacing between the outside of the neck and the inside of the magnet or coil at all points. A unit off center may cause generally poor pictures.

**22.** A focusing coil rotated to the wrong position around the tube neck may make good focusing difficult or impossible. The effects usually are worse with a coil than with a PM focuser.

**23.** A focusing magnet of wrong strength for the picture tube may allow good focus only at the sides of pictures or only at the center.

**26.** Reversed leads to a focusing coil may have little effect on focus, but one connection will require more or less coil current than the other connection. If the focus current adjustment cannot provide enough variation of current there will be poor focus.

**27.** Turning a focusing coil front for back does not have just the same effects as reversing the coil leads, because a magnetic gap on the inside of the coil housing should be toward the yoke, not away from the yoke.

**28.** Changes anywhere in the B-supply circuits of some receivers, or deterioration of resistors in such circuits may either limit or increase focusing coil current to such an extent that the adjusting pot cannot make compensation. Then good focus can be had only at the center or only at the sides of the viewing screen.

## Centering

**30-31.** In cases where shadowing persists when there is correct centering the trouble sometimes may be overcome by rotating the picture tube on its neck axis to a new position.

| Table 8-B<br>PICTURE TUBE ACCESSORIES | Brightness Lacking | Centering Difficult | Dark, No Raster | Definition Poor | Focus Poor | Ion Burn | Shadowing | Skew Or Tilt |
|---|---|---|---|---|---|---|---|---|
| ION TRAP MAGNET | | | | | | | | |
| 16 Misadjusted | • | • | • | • | | • | • | |
| 17 Too weak or too strong | • | | | • | | | | |
| 18 Wrong style for tube | • | | | | • | | | |
| 19 Turned front for back | | • | | | | | • | |
| FOCUS MAGNET OR COIL | | | | | | | | |
| 20 Too far forward or back | | | | | • | | • | |
| 21 Not centered on tube neck | | • | | | • | | • | |
| 22 Rotated to wrong position | | • | | | • | | | |
| FOCUS MAGNET | | | | | | | | |
| 23 Too weak or too strong | | | | | • | | | |
| 24 Wrong type for tube | | | | | • | | | |
| FOCUS COIL | | | | | | | | |
| 25 Control pot defective | | | | | • | | | |
| 26 Leads reversed | • | • | | | • | | | • |
| 27 Turned front for back | | • | | | • | | | • |
| 28 Current too great or small | | | | | • | | | |
| 29 Internal open or short | | | | | • | | | |
| CENTERING MAGNET | | | | | | | | |
| 30 Wrong position | | • | | | | | • | |
| 31 Weak | | • | | | | | | |

# SECTION 9

## THE SYNC SECTION

As shown by Fig. 9-1, signal input to the sync section is from the video amplifier or detector. Sync output is to vertical and horizontal sweep oscillators. The input to all sync sections is a composite television signal consisting of horizontal sync pulses, vertical sync pulses, equalizing pulses, blanking intervals, and picture signals.

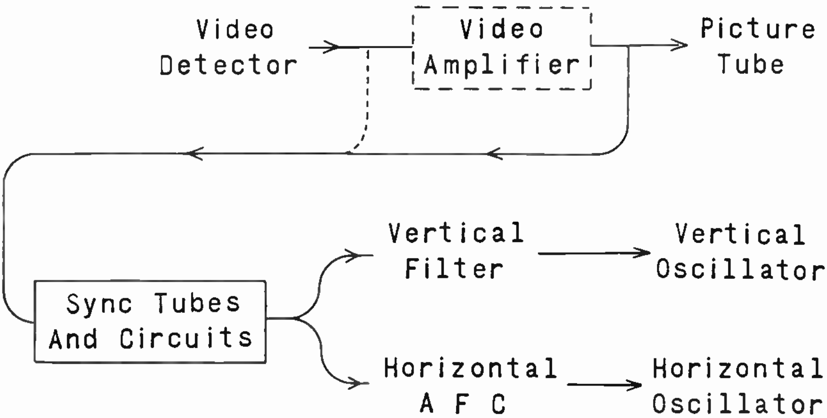


*Fig. 9-1. Signal paths through the sync section.*

From the composite signal the sync section must form vertical synchronizing pulses which go through a vertical (integrating) filter and trigger the vertical sweep oscillator, also horizontal synchronizing pulses which go to the horizontal afc system for control of the horizontal sweep oscillator.

### Oscilloscope For Testing

The function of the sync section is to receive waveforms of a complete video signal and deliver waveforms suitable for synchronizing the sweep oscillators. Since necessary changes of waveform may be observed only with an oscilloscope, the scope is a great time saver when locating faults in any sync section.

The oscilloscope need have only moderate vertical gain, something like 0.05 rms volt per inch or even less being sufficient. The vertical attenuator should be frequency compensated and a compensating probe with shielded cable should be used. This is especially necessary for observing horizontal pulse traces.

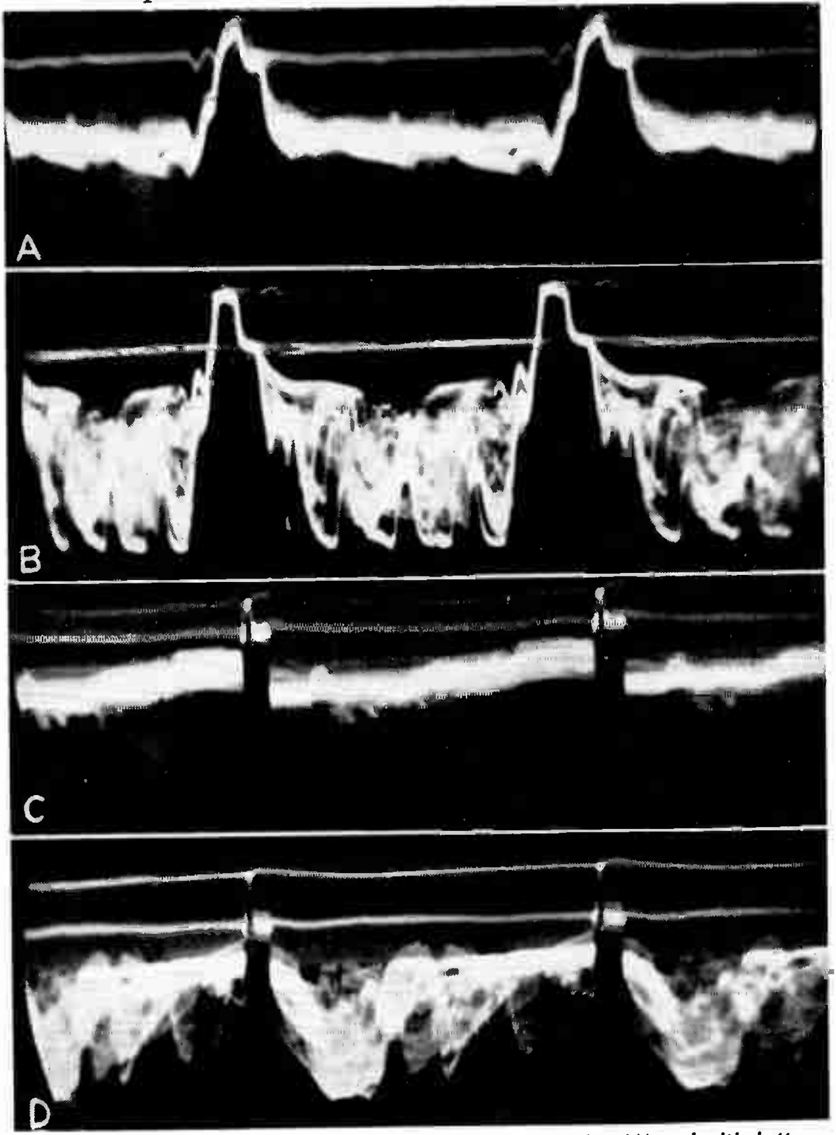


*Fig. 9-2. Horizontal trace with poor frequency compensation (A) and with better compensation (B). Vertical trace with poor compensation (C) and with better compensation (D)*

At *A* of Fig. 9-2 is a horizontal trace seen with poor compensation, and at *B* is a similar signal with satisfactory compensation. At *C* is a vertical trace with poor compensation, and at *D* with good compensation for similar signals.

## Sync Sections With Triodes

In Fig. 9-3 are circuit connections for a widely used sync section employing two triodes which may be in the same envelope or else portions of two separate tubes used also for other purposes.

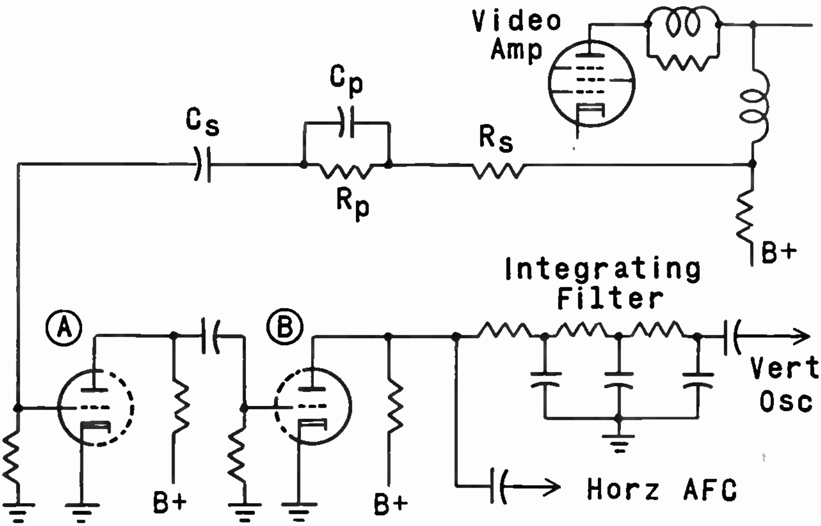


*Fig. 9-3. Two triodes in a sync section.*

Input for this sync section is taken through resistors and capacitors from the plate load of the video amplifier to the grid of tube *A*. Tube *A* often acts chiefly as a sync amplifier, but is operated with plate voltage low enough to limit or clip the positive peaks of sync pulses that come from the video amplifier.

There is polarity inversion in tube *A* and again in tube *B*, making pulse polarity at the plate of *B* the same as at the plate of the video amplifier. Output from tube *B* goes through an integrating filter to the vertical oscillator and through a capacitor to the horizontal afc system.

At the sync takeoff from the video amplifier the horizontal and vertical waveforms should have, as in Fig. 9-4, reasonably

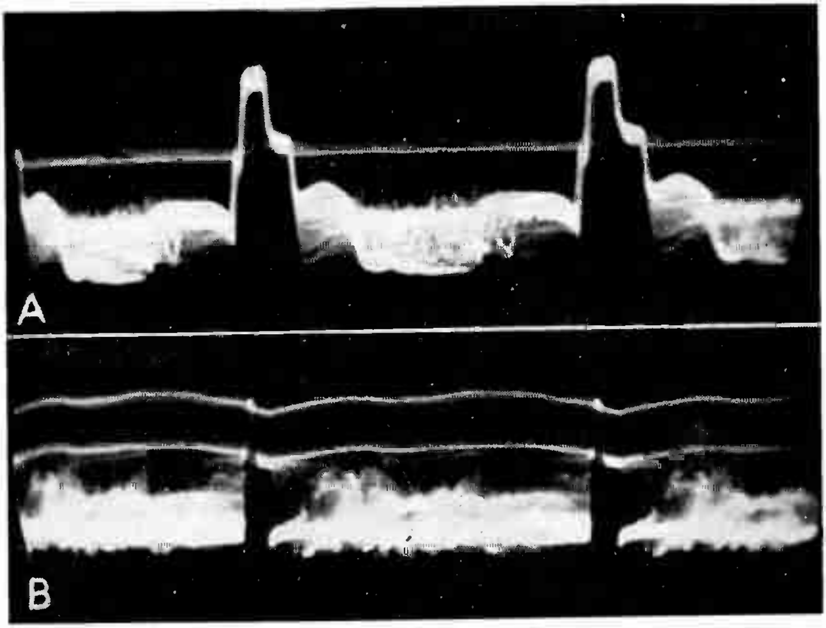


*Fig. 9-4. Satisfactory video signals are the first requisite for good synchronization. Horizontal (A) and vertical (B).*

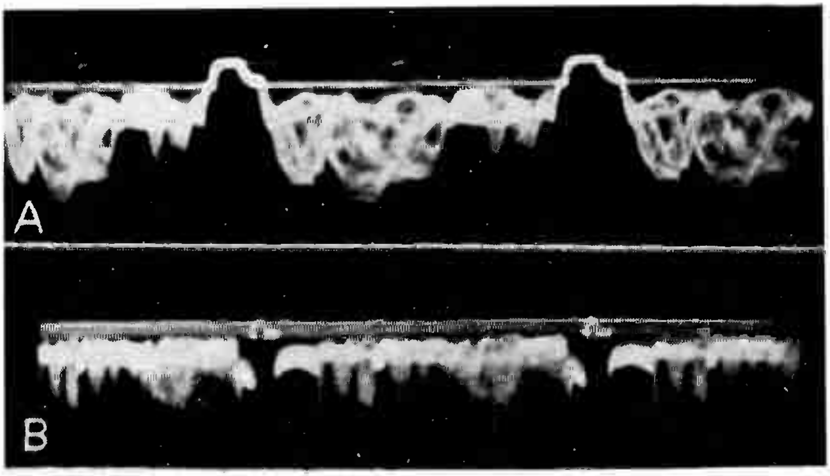


*Fig. 9-5. Sync pulses of limited amplitude make synchronization difficult or impossible. Horizontal (A) and vertical (B).*

flat topped sync pulses without excessive slope or fuzziness. Height of the pulses alone should be at least one-fourth or total peak-to-peak height of video signals for light-toned pictures.

If sync pulses are low in proportion to the total video signal, as illustrated by Fig. 9-5, it will be nearly impossible to have good synchronization of pictures. Such limiting of sync pulses nearly always is due to overloading in the video amplifier. Overloading may result from insufficient plate or screen voltage, from grid bias not sufficiently negative, or from excessively strong signals from the video detector.

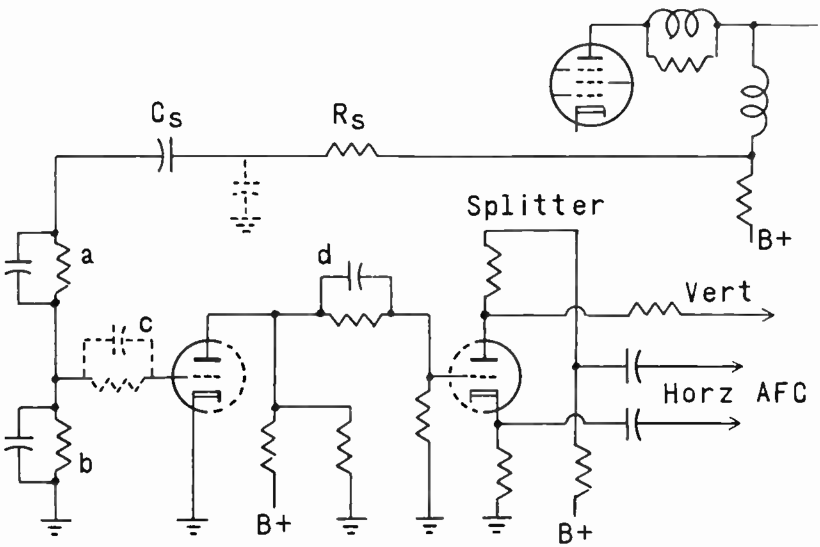


*Fig. 9-6. Resistors and capacitors in series or in parallel may be at various points in the sync circuits.*

## Video Signal Filtering

In Fig. 9-3 video signals on their way to the first sync tube pass through a series resistor *Rs* and series capacitor *Cs*, also through resistor *Rp* and capacitor *Cp* in parallel. A resistor and capacitor paralleled might be at any one or more of the positions marked *a*, *b*, *c* and *d* in Fig. 9-6.

A series resistor, *Rs*, prevents the first sync tube from taking too much signal strength away from the video amplifier output, it isolates the sync section from the video amplifier.

Resistance value usually is from 10K to 33K ohms, which reduces strength of signals reaching the sync section. Resistance sometimes is changed to smaller value if more effective sync action is needed, and if the change does not adversely affect signals from video amplifier to picture tube.

A series capacitor, *Cs*, blocks high B+ voltage in the video amplifier plate circuit from the grid of the first sync tube, and thus allows suitable grid biasing for the sync tube. Series capacitors most often range from 0.002 mf to 0.02 mf.

A resistor and capacitor in parallel have the apparent effect, as observed with the scope, of "cleaning up" the pulses

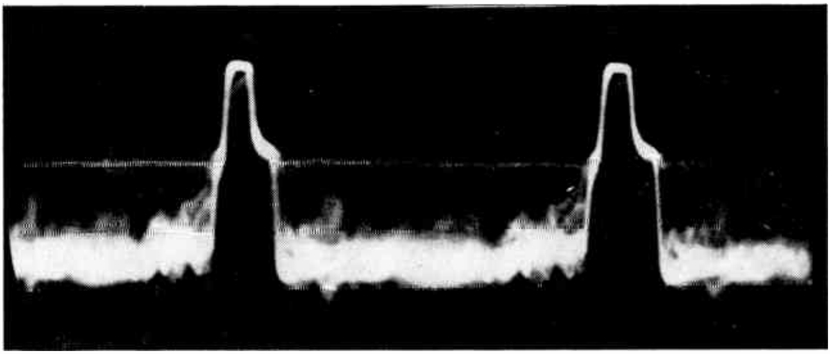

*Fig. 9-7. Filter capacitors help improve the waveform of sync pulses. Compare Fig. 9-4-A.*

when it is needed. Horizontal pulses of Fig. 9-4 appear as in Fig. 9-7 upon reaching the grid of the first sync tube. Fuzziness is removed and steepness of leading edges is maintained or improved.

Effects of a parallel resistor-capacitor filter are not so apparent in vertical pulse traces, but the effects are there just the same. Paralleled resistors range from 100K to 470K in most sets while paralleled capacitors range from 220 to 470 mmf. Values are chosen for best results in each receiver circuit.

All or most of the series and parallel resistors and capacitors may be in a single printed circuit unit, such as a couplate, enclosed in molded plastic with pigtail leads.

## Sync Amplifier

One of the triodes in Fig. 9-3 is an amplifier and the other is a separator or clipper. The first tube might serve either function while the second tube serves the other function. How a tube performs depends on plate and grid voltages.

For example, about 50 volts on a triode plate and 5 or 6 volts negative bias on its grid allows considerable amplifica-

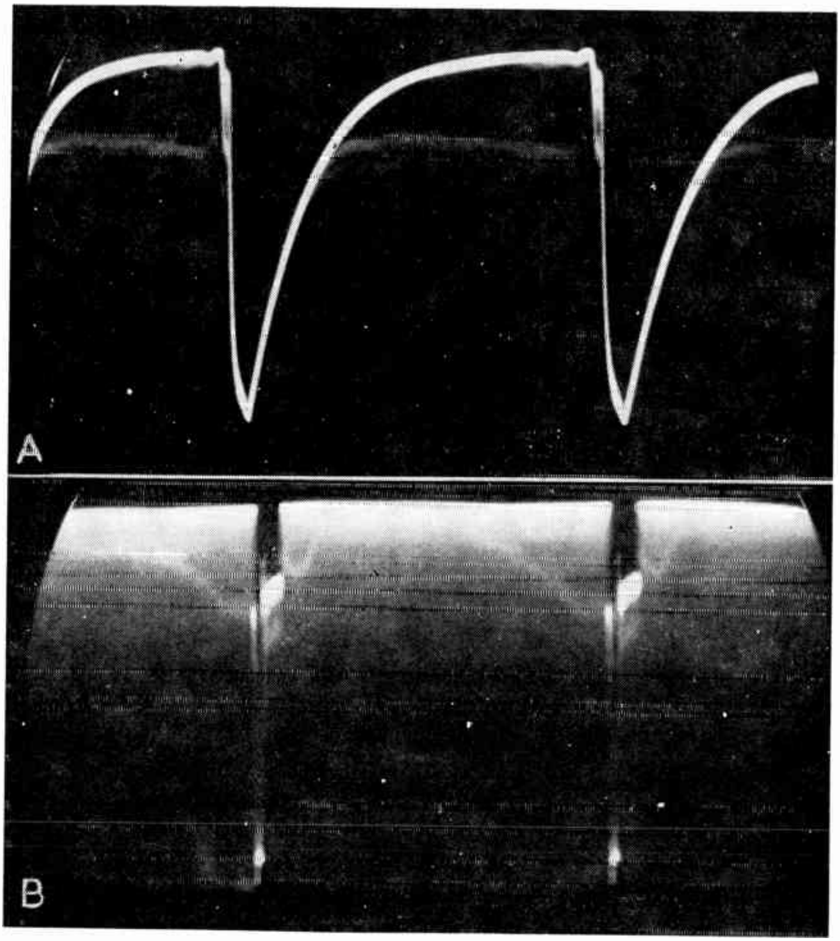


*Fig. 9-8. Horizontal waveforms (A) and vertical (B) of these general types should appear after a sync separator triode.*

tion. But strongly positive peaks of sync pulses, also noise pulses, exceed the bias and there is plate current limiting of pulse peaks on the plate output.

## Sync Separator Or Clipper

With voltage so low as 15 to 30 on a triode plate, and with grid-leak biasing, negative picture signals and often the lower portions of sync pulses drive the grid to plate current cutoff. The result is removal of picture signals and maybe part of the sync pulses. The tube is called a separator or clipper, two names used to describe the same function.

At the separator plate appear horizontal pulses of the general form in Fig. 9-8 at *A* and vertical pulses such as at *B*. Whether polarity of these pulses is negative, as shown, or is positive depends on whether the separator immediately follows a video amplifier whose output has sync pulses positive or negative. Any sync tube between video amplifier and separator will invert the pulses.

These horizontal and vertical pulses accompanied by little or no picture signal are highly important. Something of this kind will appear somewhere in every sync section that is working properly.

The separator or clipper is the essential tube of the sync section. Other tubes may amplify, limit or invert the pulses, but the separator forms the pulses for application to following sweep oscillator circuits.

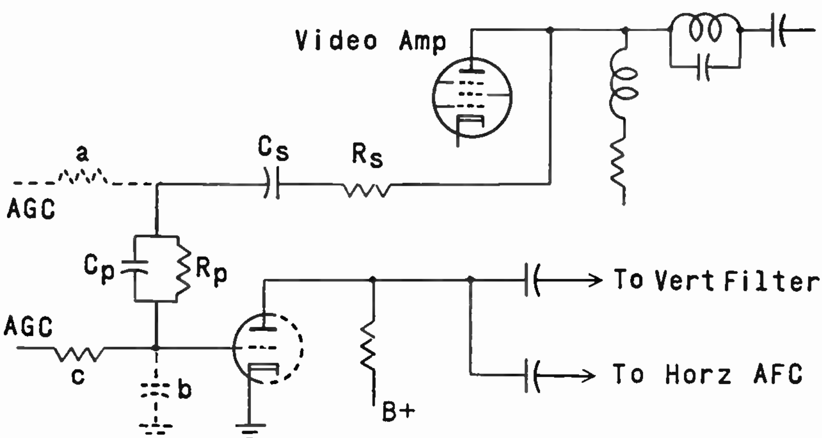


*Fig. 9-9. A sync section consisting of one triode acting as a separator or clipper.*

In Fig. 9-9 the only sync tube is a separator or clipper with the usual series and paralleled resistors and capacitors in the line from the video amplifier. The separator grid return might be through a high resistance to ground, as in other diagrams, or, as here, to a line carrying agc voltage. The agc connection may be through a resistor at *a,* with a capacitor used at *b,* or the agc connection may be through a resistor at *c.*

A separator grid always is negatively biased to a degree which, acting with low voltage on the plate, causes plate current cutoff of all negative portions of video signals. These are

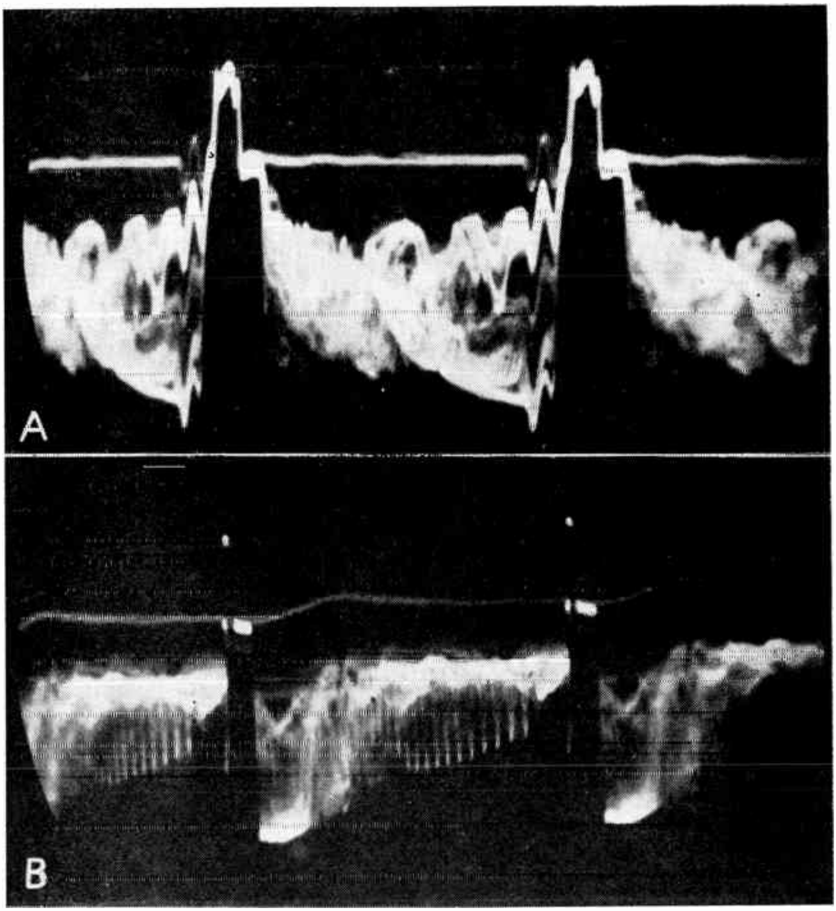


*Fig. 9-10. Horizontal signals (A) and vertical (B) at sync takeoff from video amplifier plate circuit.*

the portions containing picture signals. The required negative bias may be from the agc system, as in Fig. 9-9 but more often is secured from grid-leak biasing.

The separator amplifies the sync pulses to some extent while cutting off the picture signals. In addition, because of low plate voltage, the separator limits the positive peaks of sync pulses. This limiting occurs at the point where grid current commences to flow for maintaining a charge in the capacitor used for grid-leak biasing.

In a receiver using the sync system of Fig. 9-9 the horizontal and vertical signals from the video amplifier plate appeared as in Fig. 9-10. After passing through the resistors and capacitors the signals at the separator grid were as in Fig. 9-11. At the separator plate the signals to vertical integrating filter and to horizontal afc appeared as in Fig. 9-12.

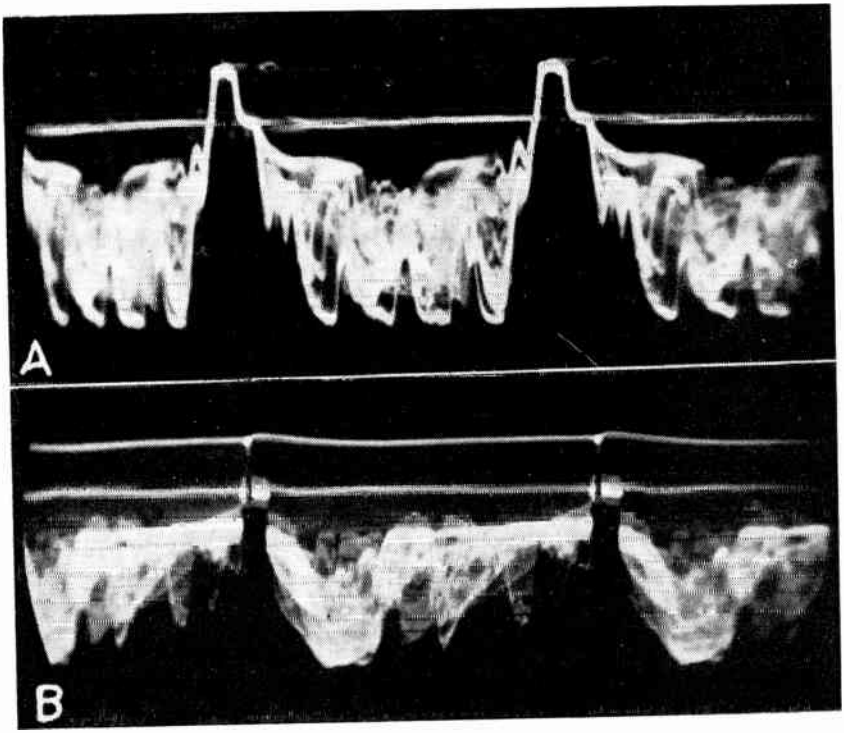


*Fig. 9-11. Signal waveforms are improved as they pass through the sync input filter system. Horizontal (A) and vertical (B).*

Note that separator output waveforms of Fig. 9-12 are essentially equivalent to those of Fig. 9-8. These are the typical separator outputs which always should appear.

Traces of Figs. 9-10, 11 and 12 were taken without altering vertical gain of the oscilloscope. It is apparent that sync pulses at the separator plate (Fig. 9-12) have been amplified in comparison with pulses at the grid (Fig. 9-11).

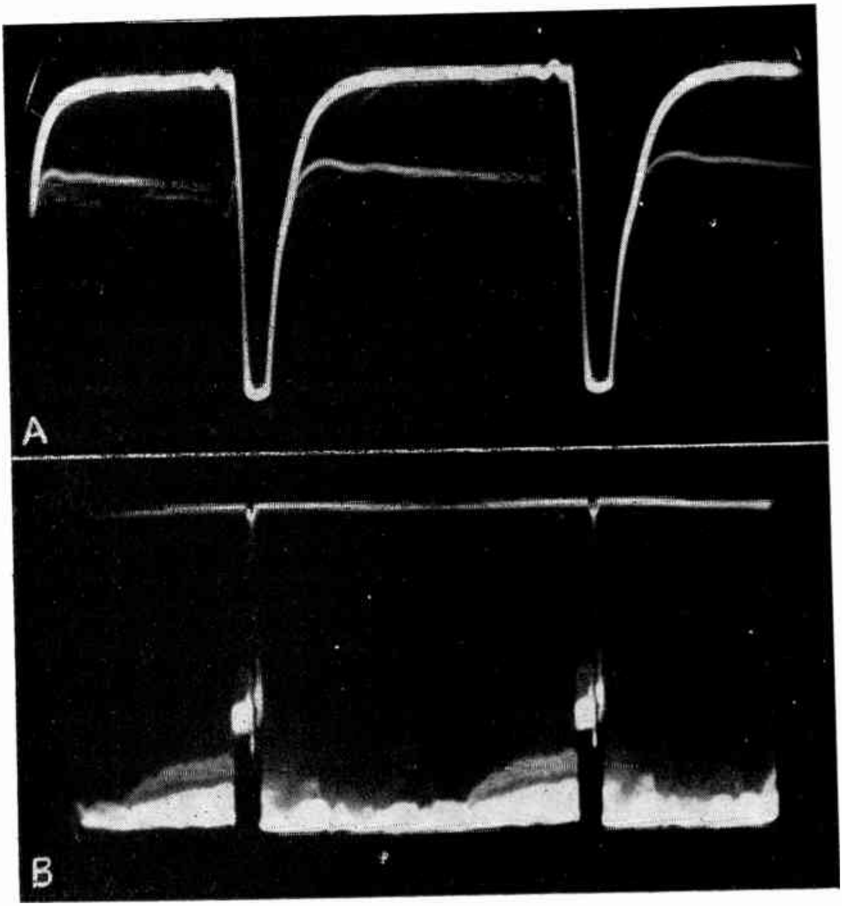


*Fig. 9-12. These signals are delivered from the separator plate to horizontal and vertical sweep sections. Both the horizontal (A) and vertical (B) signals go to both sweep sections.*

Fig. 9-13 shows another sync section using only a separator. The separator feeds to a phase splitter which is considered part of a following afc system employing a phase detector. Note the direct conductive coupling from separator plate to splitter grid. The separator plate and splitter grid may operate at something like 10 to 15 volts positive. Cathode

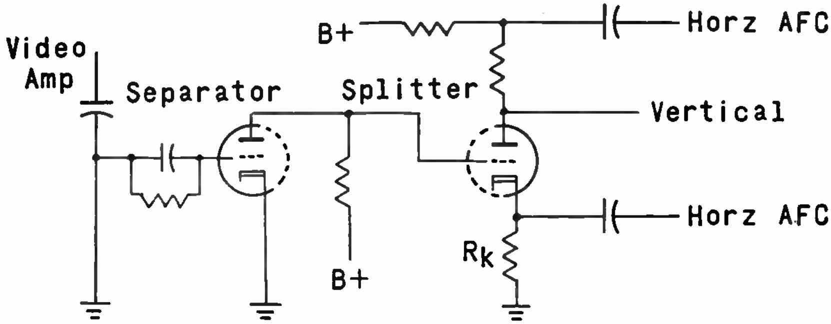


*Fig. 9-13. The single sync tube, a triode separator, feeds to a splitter or inverter used with a phase detector for horizontal automatic frequency control.*

bias from resistor *Rk* on the splitter is slightly greater than positive voltage on the grid, thus providing a small effective negative bias for this tube.

## Two-stage Separator-clipper

In Fig. 9-14 one tube is called a separator, another is called a clipper, and a third is a sync amplifier. The clipper is operated with a grid grounded for signal voltages, input being a direct connection from separator plate to clipper cathode. In a typical case the element voltages are as follows:

| | Plate | Grid | Cathode |
|---|---|---|---|
| Separator | + 80 | — 20 | 0 |
| Clipper | + 130 | + 50 | + 80 |
| Amplifier | + 80 | — 3 | 0 |

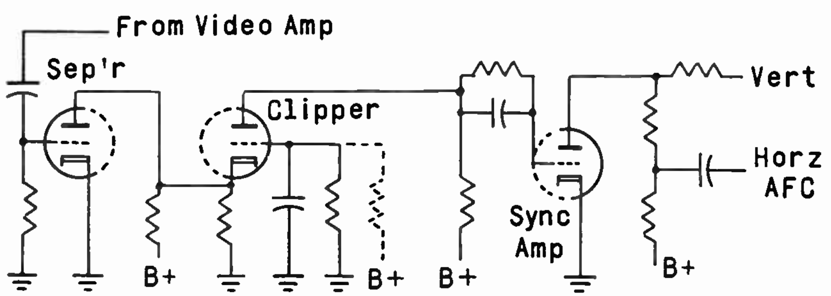


*Fig. 9-14. Separate separator and clipper triodes are used for removing picture signals and for clipping or leveling the sync pulses.*

Sync pulses are positive and picture signals negative from video amplifier to separator grid. The highly negative grid of the separator causes cutoff of negative picture signals in spite of the rather high plate voltage.

Due to polarity inversion in the separator, sync pulses at its plate and at the clipper cathode are negative. The clipper grid is 30 volts less positive than its cathode, giving an effective 30-volt negative grid bias. Negative pulse peaks are cut off by the clipper to uniform height or amplitude.

## Horizontal And Vertical Separators

In Fig. 9-15 there is a horizontal separator, a vertical separator, and a sync output tube. We shall follow signals through

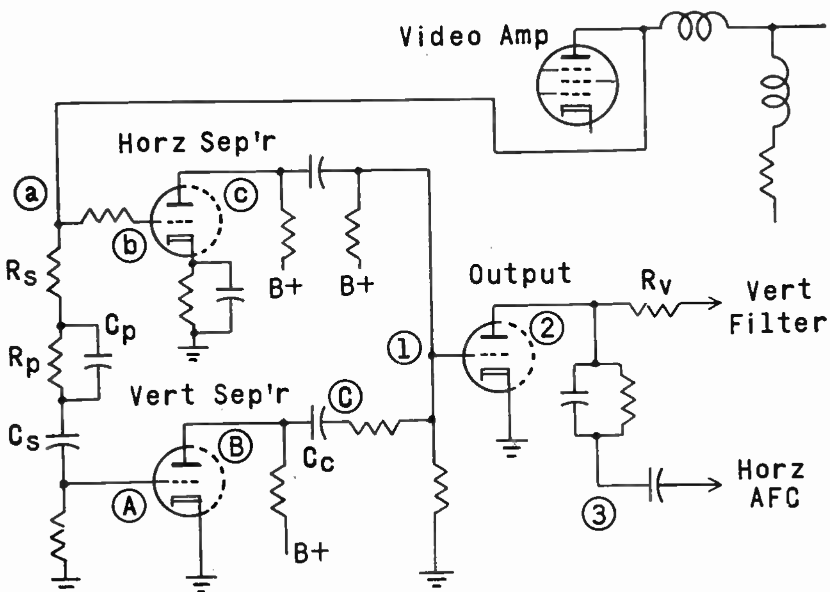


*Fig. 9-15. A sync section having individual separators for horizontal and vertical sync pulses, with combined pulses fed to a sync output tube.*

this rather elaborate sync section to learn that certain changes of waveform should occur in any sync section, no matter how the tubes are arranged. All traces were made without altering vertical gain of the oscilloscope.

Fig. 9-16-a shows video amplifier output signals observed at *a* of Fig. 9-15. At *b*, the horizontal separator grid, signals are weaker and slightly rounded due to 10K ohms in series with the grid. At *c*, the horizontal separator plate, signals have the familiar forms observed earlier in Figs. 9-8 and 9-12.

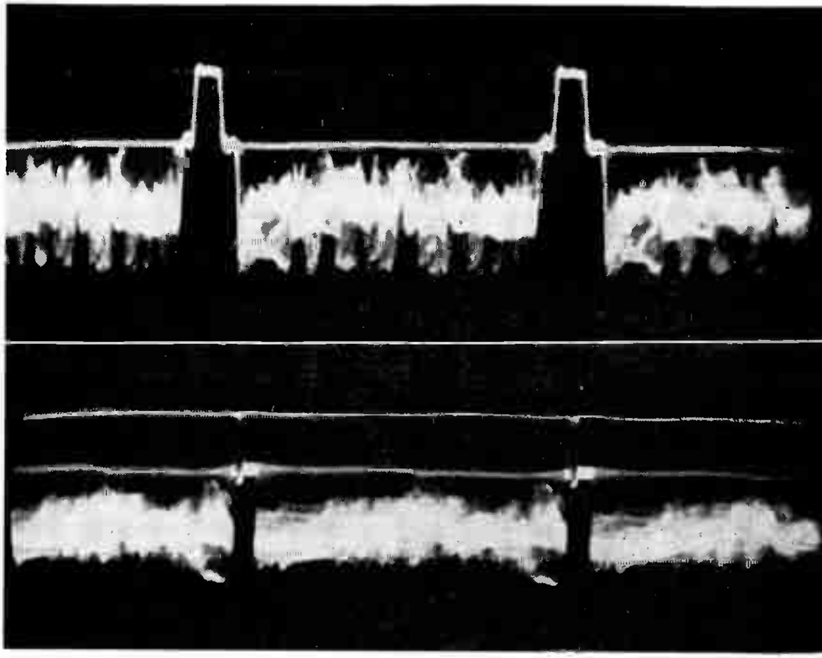

*Fig. 9-16-a. Horizontal and vertical signals from the video amplifier as observed at a of Fig. 9-15.*

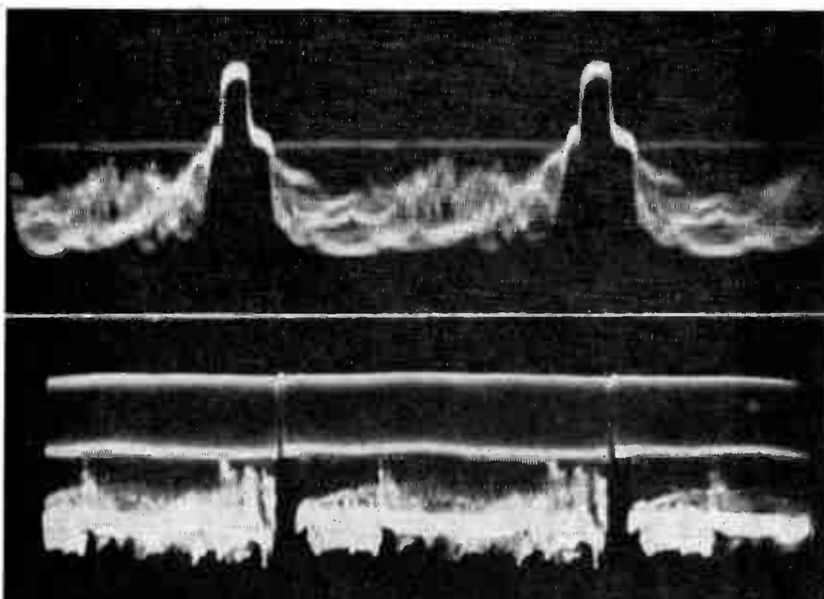

*Fig. 9-16-b. Signals at horizontal separator grid, observed at b of Fig. 9-15.*

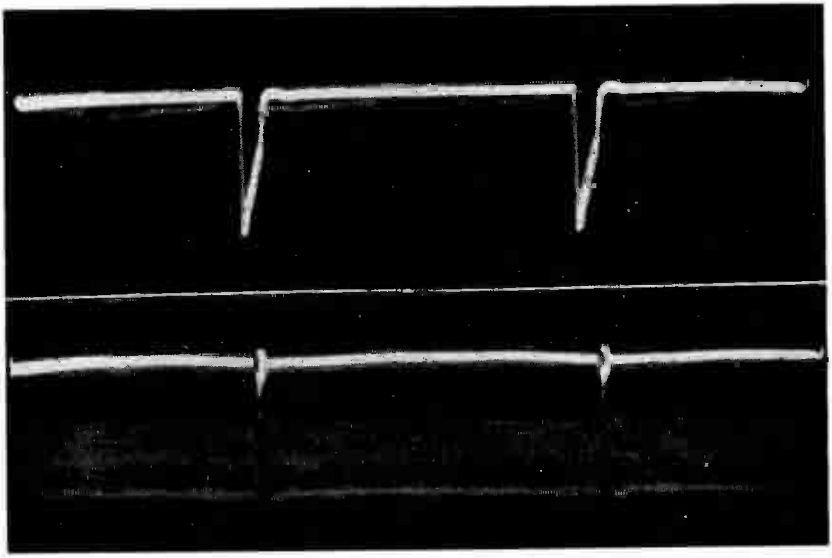

*Fig. 9-16-c. Signals at horizontal separator plate, observed at c of Fig. 9-15. Either a horizontal or a vertical waveform may be seen, depending only on the sweep frequency of the oscilloscope.*

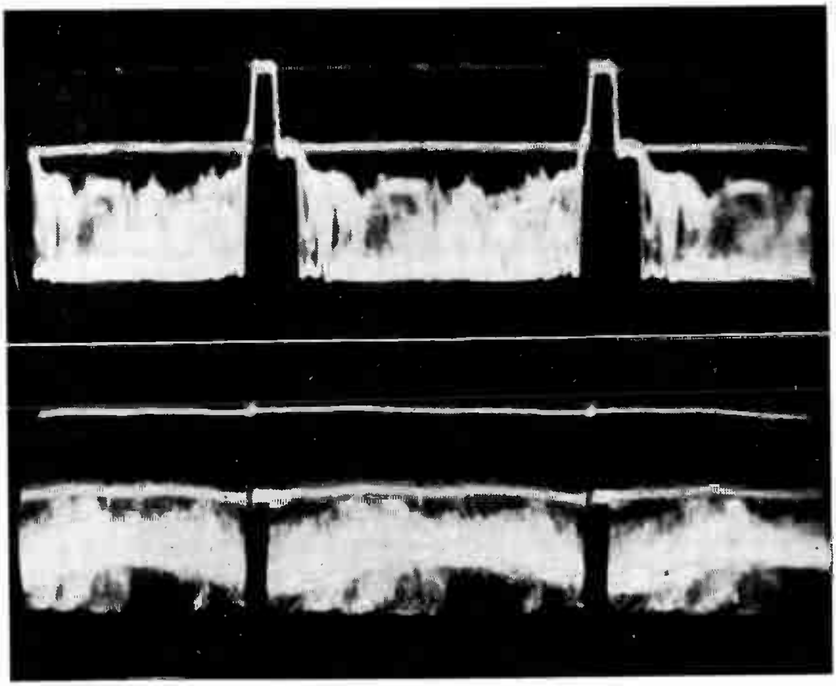

*Fig. 9-17-A. Waveforms at the vertical separator grid, A of Fig. 9-15, after passing through sync filter elements.*

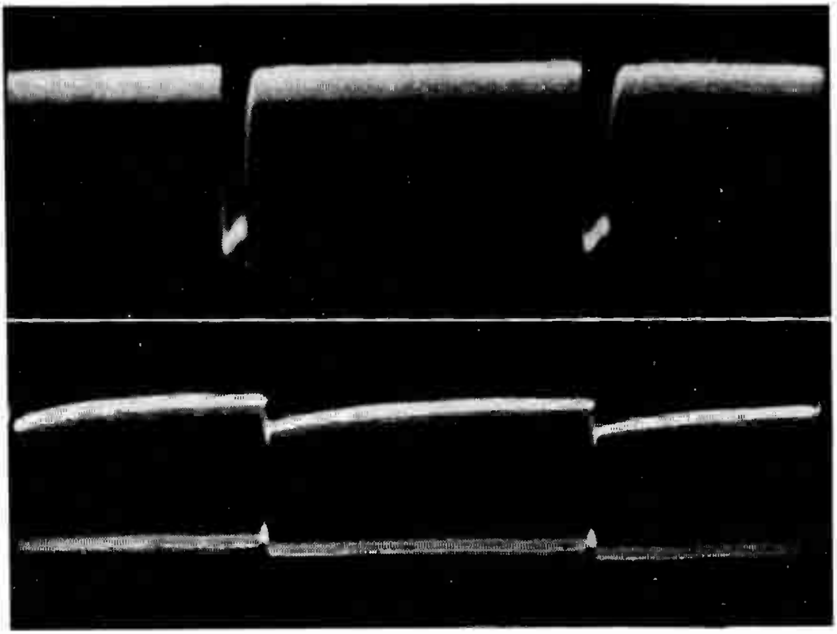

*Fig. 9-17-B. At the plate of the vertical separator, B in Fig. 9-15, these pulses appear with the scope internal sweep timed for horizontal and vertical intervals.*

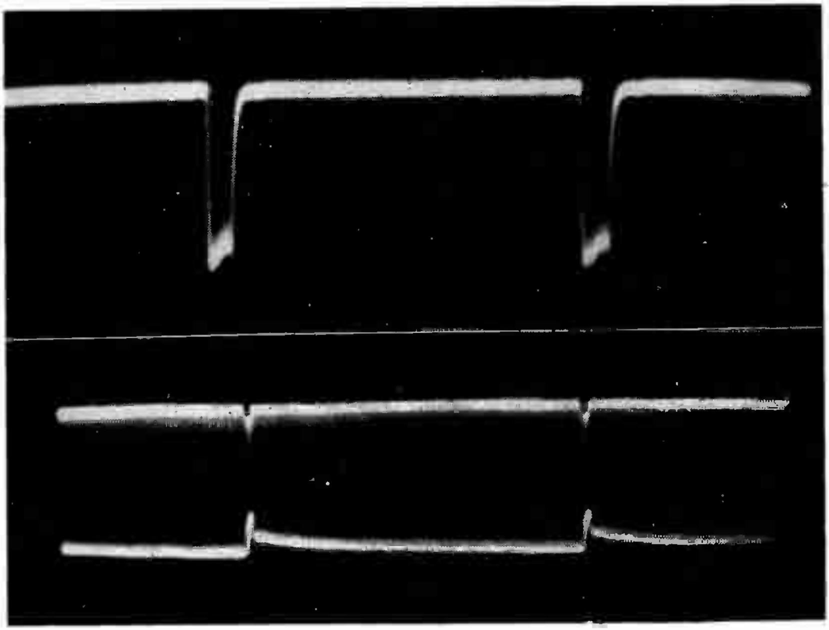

*Fig. 9-17-C. At C of Fig. 15 the pulse waveforms are nearly the same as at B.*

Video amplifier output signals go from *a* of the circuit diagram through series and paralleled resistors and capacitors to *A*, the vertical separator grid, and there are seen to be well formed and sharp as in Fig. 9-17-A. At the vertical separator plate, *B*, we find waveforms of Fig. 9-17-B. These are generally similar to waveforms in Figs. 9-8, 9-12 and 9-16-c. Beyond capacitor *Cc*, at point *C* on the circuit diagram, the pulses appear as in Fig. 9-17-C.

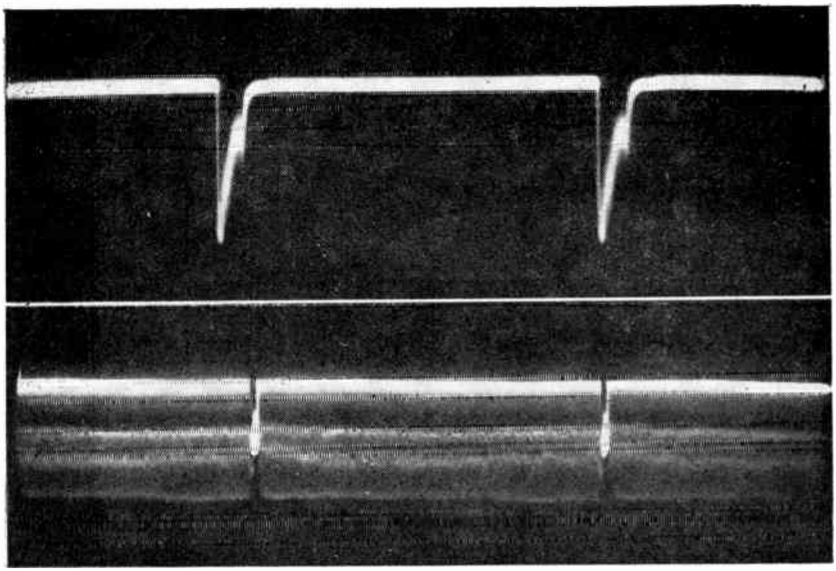

*Fig. 9-18-1. Pulses from horizontal and vertical separators combine at the grid of the sync output triode, 1 of Fig. 9-15.*

Signals from the horizontal and vertical separators combine at the sync output grid, *1* on the circuit diagram, and appear as in Fig. 9-18-1. Combined signals at the output plate, *2* on the diagram, are as in Fig. 9-18-2. These signals go to the vertical integrating filter through resistor *Rv*, also to the horizontal afc system through a paralleled resistor and capacitor. From this paralleled combination we have, at *3* on the diagram and in Fig. 9-18-3, sharp and well-defined horizontal pulses.

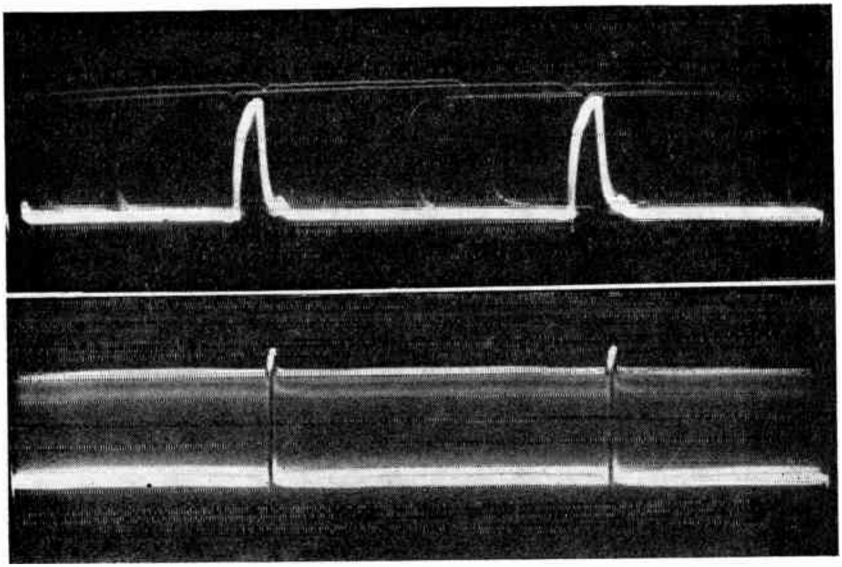

*Fig. 9-18-2. These horizontal and vertical waveforms appear at the sync output plate, 2 of Fig. 9-15.*

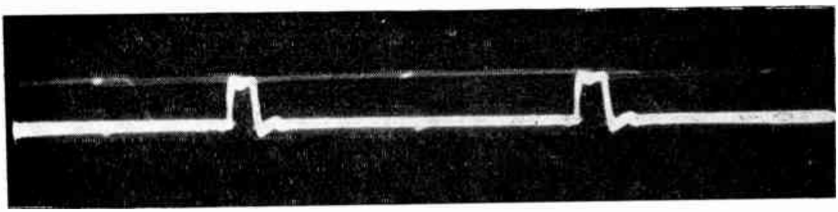

*Fig. 9-18-3. These horizontal pulses go to the horizontal afc system, from 3 of Fig. 9-15.*

Element voltages for the sync section of Fig. 9-15 were approximately as follows while traces were photographed.

| | Voltages Measured To Chassis Ground | | | Effective Voltages, Measured To Cathode | |
|---|---|---|---|---|---|
| | Plate | Grid | Cathode | Plate | Grid |
| Horz Sep'r | + 240 | + 80 | + 120 | + 120 | — 40 |
| Vert Sep'r | + 80 | — 35 | 0 | + 80 | — 35 |
| Output | + 50 | — 2 | 0 | + 50 | — 2 |

Note that the separators have rather high effective plate voltages, but also highly negative grid biases. It is relative values of plate voltage and grid bias that determine whether a tube acts as a separator or an amplifier.

In other sync sections employing individual horizontal and vertical separators the plates are tied directly together. Combined plate signals go to the grid of a splitter or else to a vertical integrating filter and a horizontal afc system.

## Sync Gating Or Keying

Fig. 9-19 shows one method of gating or keying a sync separator to lessen the effects of noise pulses which may accompany video signals.

From the cathode of the video amplifier rather weak signals with sync pulses negative go to the separator cathode.

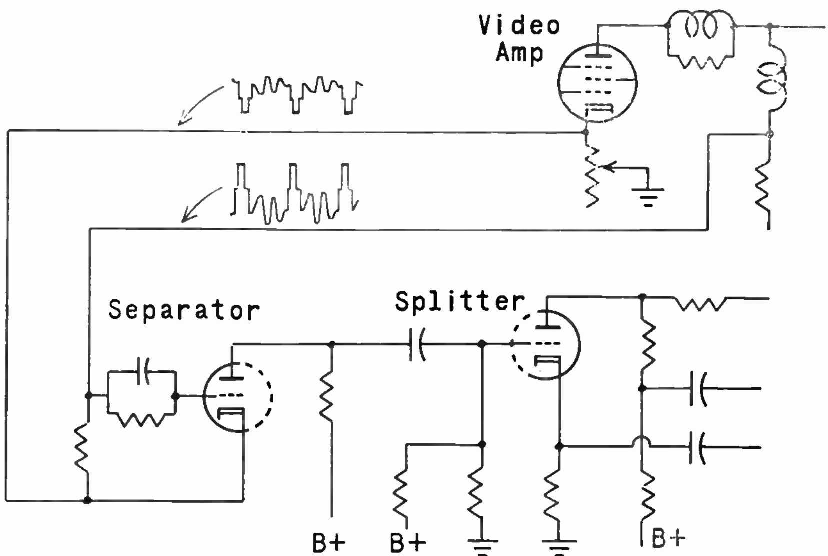


*Fig. 9-19. One method of gating a sync separator triode.*

These negative pulses at the cathode tend to make the separator conduct. From the video amplifier plate a stronger signal with sync pulses positive goes to the separator grid, where these pulses tend to make the separator conduct.

The separator operates with grid bias so negative as to maintain plate current cutoff except when separator cathode and grid are simultaneously acted upon by sync pulses from the video amplifier.

## Pentagrid Or Heptode Sync Tube

Fig. 9-20 shows circuit connections for a widely used sync section employing a single pentagrid or heptode tube as combined sync separator, sync amplifier and noise suppressor. Base pin numbers on the diagram are for tube types 6CS6, 6BY6 and 6BE6, all of which are 7-pin miniatures.

To grid 1 (pin 1) is applied a composite signal from the video amplifier grid or video detector output, with sync pulses negative. Amplitude of this signal at the separator usually is 0.1 to 0.2 volt peak-to-peak.

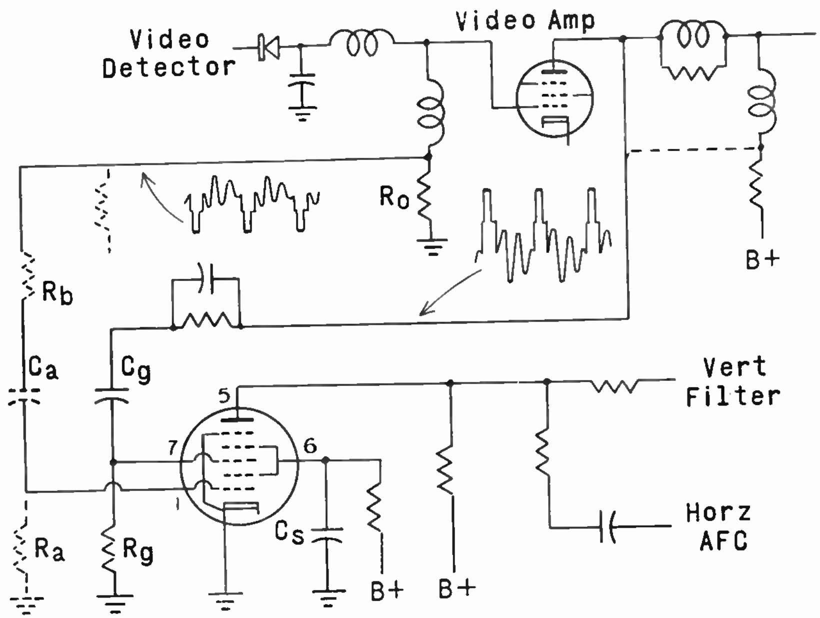


*Fig. 9-20. A pentagrid or heptode tube acting as sync separator, amplifier and noise suppressor.*

To grid 3 (pin 7) is applied a strong composite signal from the video amplifier plate, with sync pulses positive. The screen (pin 6) is grounded for pulse voltages through capacitor *Cs*. Pulse output is from the plate (pin 5) to a vertical integrating filter and a horizontal afc system as shown, or to a splitter grid where the horizontal afc tube is a phase detector.

The return for grid 1 may be through the broken-line resistor *Ra* to ground, in which case the grid line will contain capacitor *Ca*. This resistor and capacitor provide grid-leak biasing. Otherwise the return from grid 1 may be direct or through resistor *Rb* to the video detector load *Ro* where there is negative d-c voltage for biasing grid 1 of the separator.

Grid 1 is used only for gating the tube to exclude strong noise pulses which may accompany video signals. So far as separator action is concerned the tube would work as well with no signal to grid 1, or even with that grid grounded.

The separator function is carried out by grid 3 acting like the control grid in a triode separator, with the pentagrid plate acting like the triode plate, but with the suppressor of the pentagrid allowing greater amplification, as in a pentode.

Grid 3 is held highly negative by grid-leak biasing of capacitor *Cg* and resistor *Rg*. This grid bias, in connection with low plate voltage, removes negative picture signals as in other separators. Because of low plate voltage there is limiting or clipping for peaks of sync pulses.

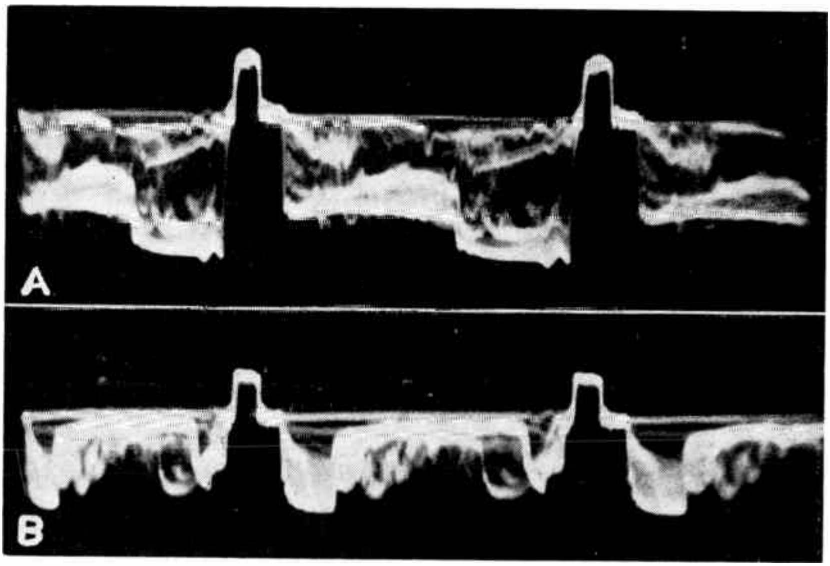


*Fig. 9-21 A, video signal from amplifier plate. B, video signal at grid 3 of the pentagrid or heptode sync tube.*

Bias voltage on grid 1 determines average plate current. This bias is only enough negative for operation at or close to plate current cutoff except when sync pulses reach grid 3. Any noise pulse stronger than a regular sync pulse causes cutoff in spite of the fact that the same noise pulse comes from video amplifier plate to grid 3.

Waveforms shown by following figures were observed in a receiver having a pentagrid or heptode sync tube. Traces are shown only for horizontal pulses at most points. D-c voltages on pentagrid elements were as follows, all measured to chassis ground.

| | | | |
|---|---|---|---|
| Grid 1 (pin 1) | — 0.1 | Plate (pin 5) | + 35 |
| Cathode (Pin 2) | 0 | Screen (pin 6) | + 16 |
| Grid 3 (pin 7) | — 13 | | |

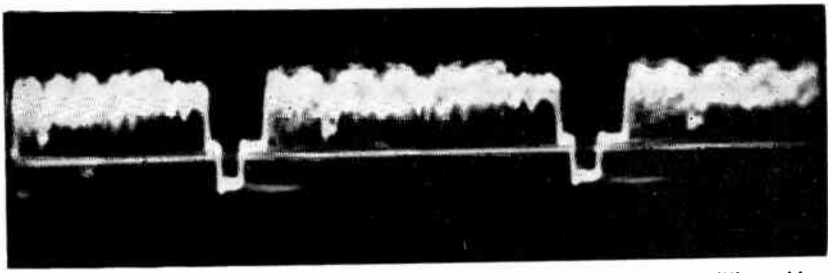

*Fig. 9-22. A signal such as this goes from video detector or video amplifier grid to grid 1 of the pentagrid or heptode sync tube.*

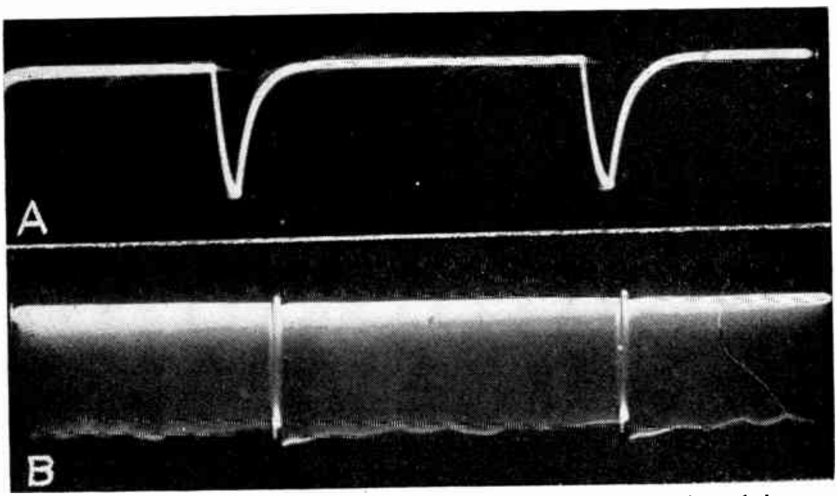


*Fig. 9-23. Horizontal pulses (A) and vertical pulses (B) from the plate of the pentagrid or heptode sync tube.*

Fig. 9-21 shows at *A* the signal from the video amplifier plate or plate load and at *B* the signal at grid 3 of the sync tube, after passing through a paralleled resistor and capacitor.

The video signal at grid 1 of the sync tube normally is too weak for easy observation, but should be of the same form and polarity as at the video detector load or video amplifier grid, Fig. 22.

Fig. 9-23 at *A* shows normal horizontal pulses from the plate of the pentagrid sync tube, and at *B* normal vertical pulses from the plate. Note the similarity to separator output pulses in Figs. 9-8, 9-12, 9-16-c and 9-17-B.

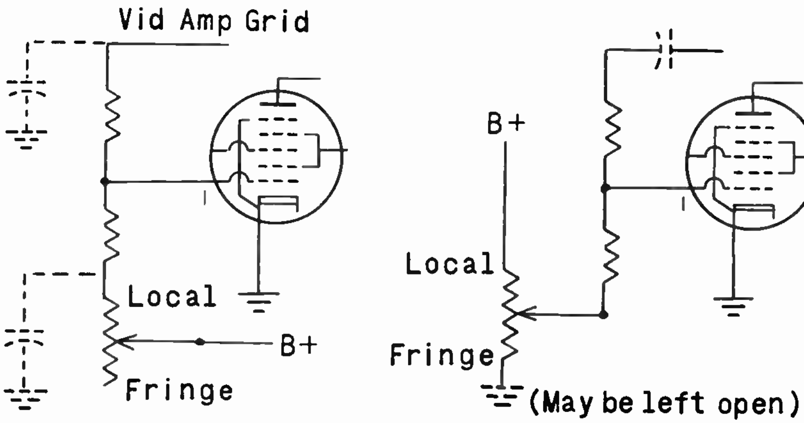


*Fig. 9-24. Potentiometers for adjustment of bias on grid 1 of a pentagrid sync tube.*

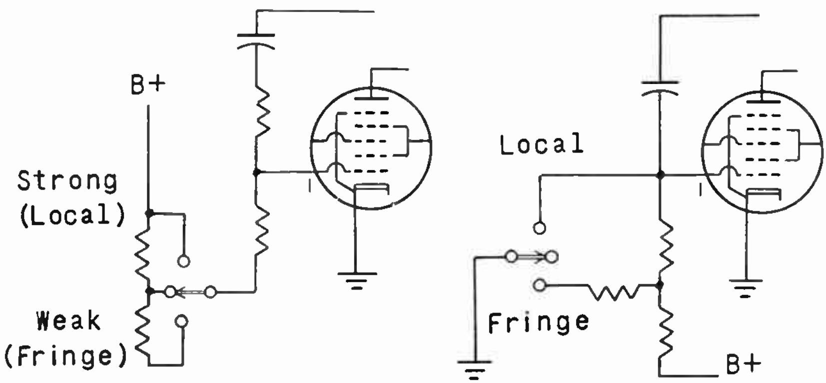


*Fig. 9-25 Switches for adjustment of bias on grid 1 of a pentagrid sync tube.*

Grid 1 often is provided with adjustable bias by means of circuits such as those in Figs. 9-24 and 9-25. These adjustments may be given names such as: Fringe lock. Noise canceller, noise control, or noise gate. Pix lock. Sync control, sync lock, or sync stability. Positions of the adjuster may be marked Local-Normal-Fringe, or Strong-Normal-Weak, or anything equivalent.

Bias voltage usually is variable between something like 0.5 volt negative and 0.3 volt positive. Bias is made less negative or slightly positive for localities where noise is weak in relation to received signals. Bias is made more negative where noise is strong in comparison with desired signals. The adjustment is set to prevent loss of sync due to noise but not so negative as to cause pulling or bending of pictures.

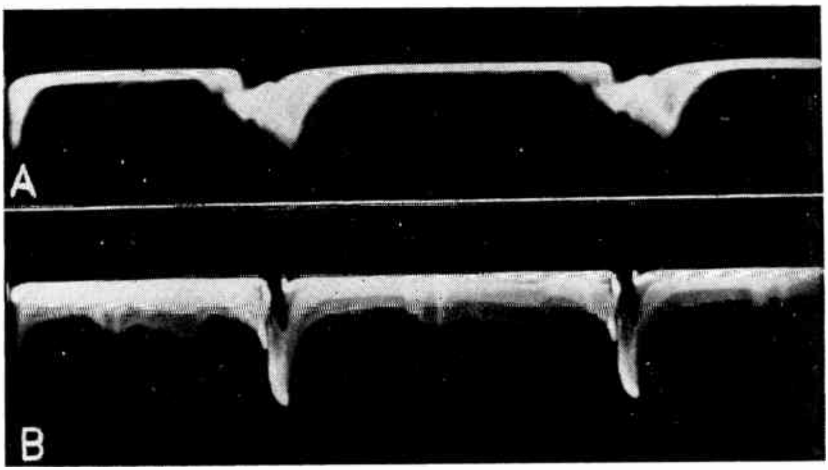


*Fig. 9-26. When bias on grid 1 of the pentagrid sync tube is too negative, horizontal pulses from the plate appear as at A, and vertical pulses as at B.*

Excessive negative bias increases amplitude of video signals observed at grid 1. Then, as in Fig. 9-26, horizontal and vertical traces from the separator plate appear ragged and unsteady.

## Oscillator Feedback

In many receivers the vertical sweep oscillator is a blocking type with a feedback transformer between oscillator plate and grid. At the grid of such an oscillator there are strong negative pulses, as shown by Fig. 9-27. These pulses feed back through the vertical integrating filter to the output of the last tube in the sync section.

If the last sync tube is a separator its sync output will be affected by the oscillator feedback. Separator output (for vertical periods) will show the negative spikes of Fig. 9-27. To observe true sync pulses it is necessary to remove or disable the vertical sweep oscillator. If this oscillator is part of a twin tube that cannot be removed without disturbing the sync section, oscillation may be stopped temporarily by connecting the oscillator grid to ground through fixed resistance of 300 to 500 ohms.

If the sync separator or clipper is followed by any other sync tube such as a phase splitter or an amplifier, vertical oscillator pulses will not reach the separator output.

Troublesome feedback does not occur with multivibrator vertical oscillators.

There is some feedback from horizontal afc systems to the output tube of the sync section, but it is not troublesome. The effect is small irregularities at the tips of horizontal sync pulses from a sync tube preceding an afc control.

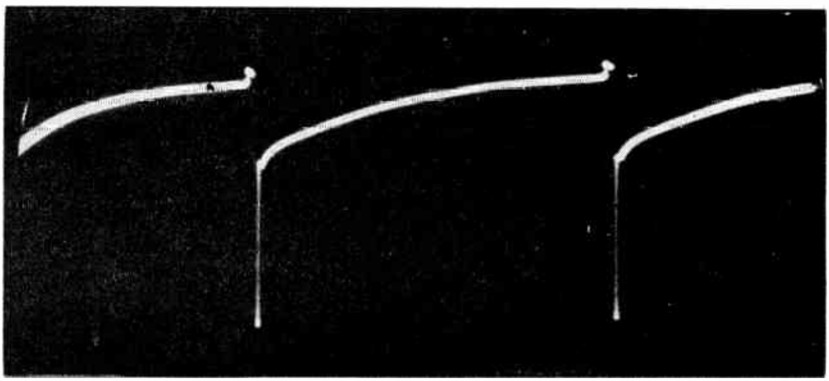

*Fig. 9-27. This waveform at a blocking oscillator grid may feed back to the output of the sync separator.*

## Oscilloscope Signal Tracing

To determine whether trouble is in a sync section or elsewhere make the following observations:

Temporarily remove or disable the vertical sweep oscillator and horizontal afc tube to prevent troubles in these following sections from affecting sync performance. If sync output then is the general form in Figs. 9-8, 9-12, 9-16-c, 9-17-B, and 9-23, and is of satisfactory peak-to-peak voltage, the sync section is operating normally.

If sync output waveform is faulty, observe next the composite signal at the takeoff from video amplifier to sync section. It is advisable to temporarily remove the first tube of the sync section so that trouble in the section will not react on the video signals. If the video signal is satisfactory, as shown by many preceding scope traces, but sync section output is faulty there is trouble in the sync section.

It is necessary to have a good video signal before checking for incorrect waveforms in the sync section. An unsatisfactory video signal usually means trouble in the video amplifier or ahead of it, but trouble could be in connections from sync takeoff to first sync tube. To check this latter possibility and observe a video signal free from all sync section influences the sync takeoff from video amplifier plate or grid circuit may be temporarily disconnected.

## Peak-to-peak Voltages

When measuring peak-to-peak voltages of a video signal the total height of an oscilloscope trace depends on whether received pictures are of light or dark tone. Picture portions of traces for bright pictures are high, and for dark pictures are low. But sync pulse height is independent of picture tone and remains constant until there is change of actual strength in received signals.

Published peak-to-peak voltages for video signals usually are based on pictures containing areas of maximum white. Unless measurements can be made while receiving such pictures it is better to measure voltage of sync pulses, then multiply by 3.4 or 3.5 to determine equivalent peak-to-peak voltages for bright pictures.

When both vertical and horizontal traces may be observed it is easier and more accurate to measure either pulse heights or peak-to-peak values on vertical traces. Some of the voltages measured on scope traces of preceding figures are as follows:

| | | | | | |
|---|---|---|---|---|---|
| Fig. 9-10 | Pulse | 4.8 | Fig. 9-18-1 | Peak-p | 60 |
| 9-11 | Pulse | 2.5 | 9-18-2 | Peak-p | 48 |
| 9-12 | Peak-p | 16 | 9-18-3 | Peak-p | 22 |
| Fig. 9-16-a | Pulse | 32 | Fig. 9-21-A | Pulse | 8.0 |
| 9-16-b | Pulse | 28 | 9-21-B | Pulse | 7.5 |
| 9-16-c | Peak-p | 56 | | | |
| | | | Fig. 9-22 | Pulse | 0.72 |
| Fig. 9-17-A | Pulse | 28 | Fig. 9-23-A | Peak-p | 36 |
| 9-17-B | Peak-p | 60 | 9-23-B | Peak-p | 36 |
| 9-17-C | Peak-p | 54 | | | |

| Table 9 SYNC SECTION | Bending At Top | Fold, Horizontal | Pulling | Smearing | Split, Left-right | Sync Absent | Sync Critical | Tear Out | Wavy All Over |
|---|---|---|---|---|---|---|---|---|---|
| VIDEO SIGNAL | | | | | | | | | |
| 1 Too weak | | | • | | • | | • | | • |
| 2 Too strong | | | | | | | | | • |
| 3 Pulses limited | • | | • | | • | | | • | • |
| SERIES RESISTOR | | | | | | | | | |
| 4 Too small, shorted | | | | • | | | | | • |
| 5 Open | | | | | | • | | | |
| SERIES CAPACITOR | | | | | | | | | |
| 6 Leaky, shorted | | • | | | • | | • | | • |
| 7 Open | | | | | | • | | | |
| 8 Wrong type | | | | | | | • | | |
| PARALLELED R-C | | | | | | | | | |
| 9 Shorted, leaky | • | | • | | | | | | |
| SEPARATOR TUBE | | | | | | | | | |
| 10 Weak | | | | | | | • | | |
| 11 Cathode-heater leak | | | | | | | • | | |
| Plate Or Screen Voltage | | | | | | | | | |
| 12 Low or zero | | | • | | | • | • | | |
| 13 Too high | | | | | | | | | • |
| Pentagrid Grid 3 Or Triode Grid 1 | | | | | | | | | |
| 14 Not negative enough | | | • | | | | • | | • |
| Pentagrid Grid 1 | | | | | | | | | |
| 15 Too negative | • | | • | | | | • | | |
| 16 Not negative enough | | | | | | | | • | |

## Troubles And Symptoms

The accompanying table lists faults which are fairly common in sync sections and gives the usual picture symptoms. Following paragraphs, numbered to correspond with faults in the table, give additional information.

**1.** A weak video signal at grid 1 of a triode or grid 3 of a pentagrid separator prevents complete removal of picture components, which appear in the plate output to cause trouble. The signal from video amplifier to sync separator grid should be examined with the oscilloscope to determine where there is undue loss of strength.

**2.** An excessively strong video signal at the sync separator may be caused by a leaky or shorted capacitor in the line to the separator, or by a series resistor which is too small.

**3.** Sync pulses which are limited or compressed (Fig. 9-5) most often indicate trouble in the video amplifier, usually plate or screen voltage too low, grid bias not enough negative, or excessively strong signals into or out of the video detector. Check agc voltage and action.

**4.** If there is too little series resistance to properly isolate the sync section from the video amplifier the added load may so affect video amplifier output as to cause poor definition or interference patterns as well as smearing or waviness.

**6.** A leaky or shorted series capacitor makes separator grid bias insufficiently negative. This allows parts of picture signals to go through into the separator output.

**8.** When following sync signals with an oscilloscope from video amplifier through the sync section the traces may be sharp at one point and ragged or fuzzy at the following point. This may be due to a faulty paper capacitor between the two points. Make replacement with a good quality 600-volt paper capacitor or else with a ceramic or mica type.

**11.** The cathode of most separators and other sync tubes is grounded. Then cathode-heater leakage causes no visible trouble. If there is a cathode resistor there may be critical sync in case of a low-resistance cathode-heater leak.

**12-13.** Plate or screen voltages on sync tubes usually may vary as much as 50 per cent up or down from normal values without seriously affecting sync action.

**14.** Grid 3 of a pentagrid or heptode sync separator is equivalent in action to grid 1 or the control grid of a triode separator. Picture components will not be removed from applied video signals unless this grid 3 is sufficiently negative. Negative bias usually is secured from a capacitor and resistor in a grid-leak system. These units should be checked.

**15-16.** Grid 1 of a pentagrid or heptode sync separator is used for noise suppression, not for separator action. Where noise is strong or received signals weak, voltage on grid 1 should be only negative enough to prevent noise from upsetting sync or hold action. In localities of strong signals or low noise level, grid 1 may be made the least negative or most positive allowed by its adjustment.

# SECTION 10

## VERTICAL SWEEP

The vertical sweep section extends from the output of the sync section to the vertical deflecting coils in the yoke, being comprised of elements whose electrical relations are shown by Fig. 10-1.

The integrating filter changes each long serrated vertical sync pulse to a form capable of triggering the vertical sweep

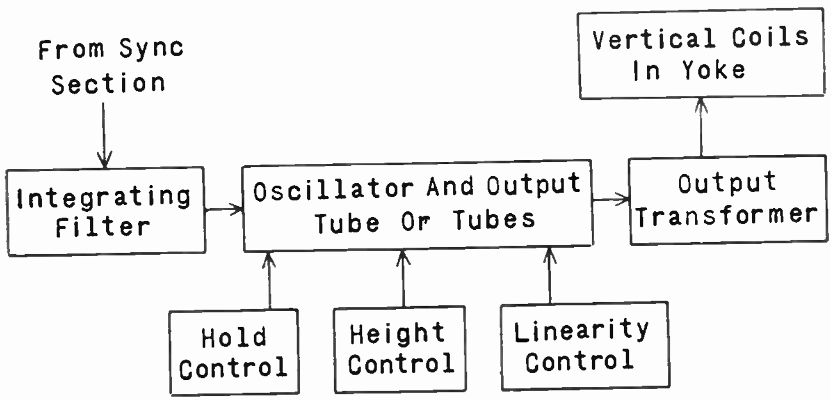


*Fig. 10-1. Principal parts of the vertical sweep section.*

oscillator. At the same time this filter gets rid of horizontal sync pulses which come to it from the sync section.

There are two principal types of vertical sweep oscillators, blocking and multivibrator. With one variety of blocking oscillator the transformer coupled feedback is from plate to grid, as shown by the simplified diagram at *A* of Fig. 10-2. With another variety of blocking oscillator, diagram *B*, the transformer feedback is from cathode to grid. With any blocking oscillator the oscillatory current and voltage are generated in a single tube or tube section. The blocking oscillator is followed by an output amplifier tube or tube section.

A multivibrator oscillator requires two tubes or tube sections for generation of oscillatory current and voltage. The output voltage from each section is fed to the input of the other section to maintain oscillation. With a cathode coupled multivibrator, shown in elementary form at *A* of Fig. 10-3, feedback is by means of voltage pulses developed across a cathode resistor common to both sections. The oscillator is followed by an output amplifier.

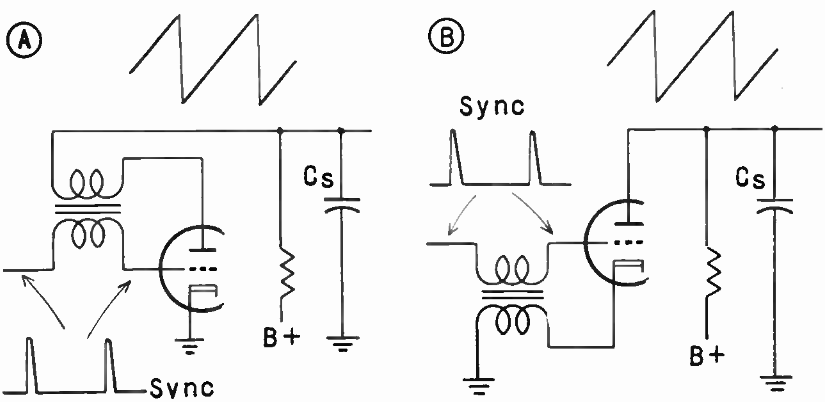


*Fig. 10-2. Blocking oscillators in simplified form.*

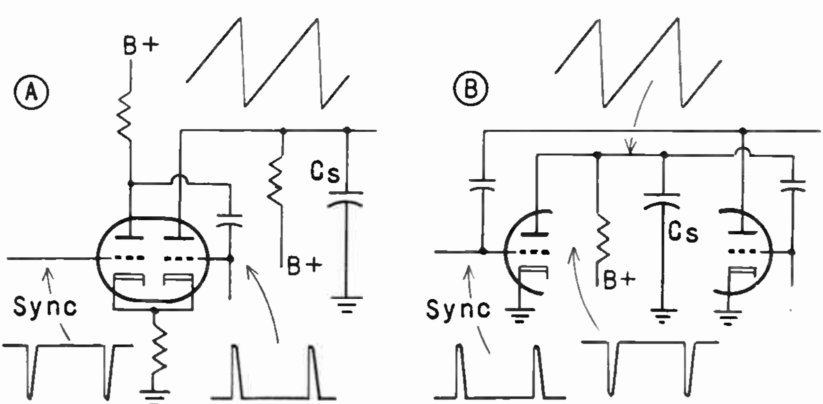


*Fig. 10-3. Cathode coupled and plate coupled multivibrators.*

With a more commonly used vertical multivibrator the feedback is through capacitors from each plate to the other grid. A simplified circuit is illustrated by diagram *B* of Fig. 10-3. This is called a plate coupled, grid coupled or capacitor coupled multivibrator. In nearly all receivers using this type the second section acts also as an output tube which feeds to the vertical output transformer.

It is important to remember, while locating trouble, that any vertical sweep section will operate to deflect the beam in the picture tube whether or not the oscillator is supplied with sync pulses. The only function or sync pulses is to time the oscillator with received pictures.

## Integrating Filter

A few of the many variations of integrating filter circuits are shown by Fig. 10-4. Inputs from the sync section are assumed to be at the left of each filter, and outputs to the vertical oscillator are at the right.

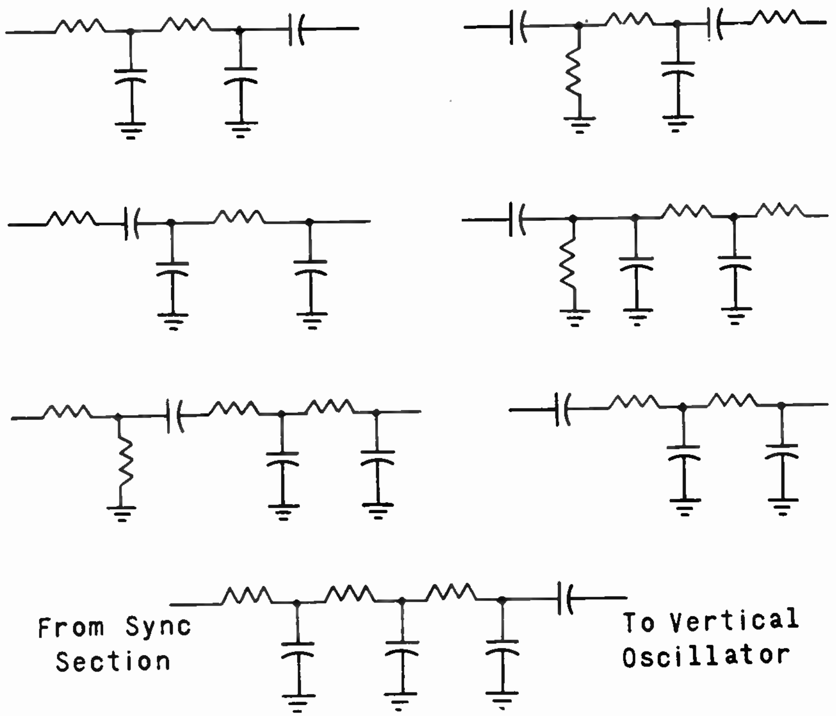


*Fig. 10-4. Combinations of capacitors and resistors found in vertical integrating filters.*

All these are essentially low pass filters in which 60-cycle vertical pulses pass through series resistors while the higher frequency horizontal pulses are bypassed to ground through shunt capacitors. In addition there may be resistors to ground which act as voltage dividers, also series capacitors which block d-c voltage on the last sync tube from the grid or input of the vertical oscillator.

All or part of the filter and associated resistors and capacitors may be in a printed circuit unit molded in plastic with pigtail leads.

## Triggering Polarities

Sync pulses for triggering any blocking oscillator must be positive at the oscillator grid, as indicated in Fig. 10-2. Positive pulses make the tube conductive and allow discharge of capacitor *Cs*, whose charges and discharges form a sawtooth voltage.

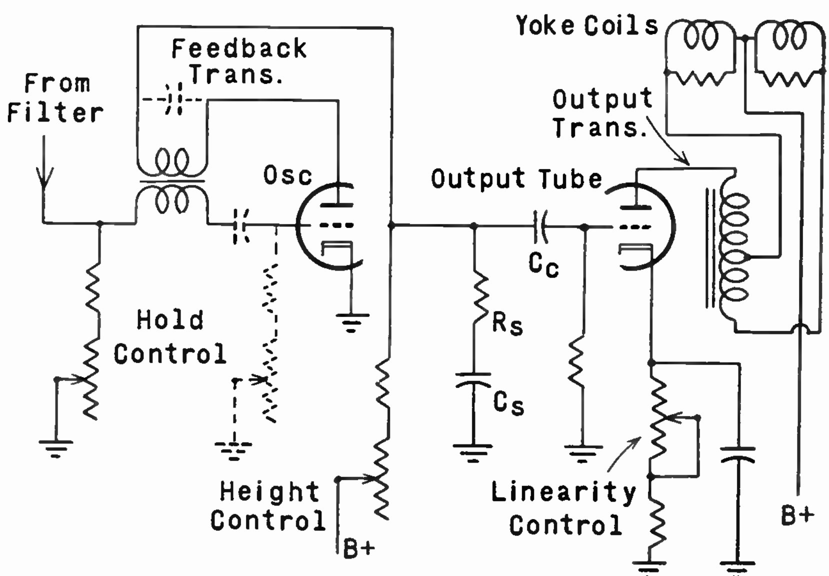


*Fig. 10-5. Connections for a blocking oscillator with plate feedback, furnishing sawtooth voltage to an output section or tube.*

With a cathode coupled multivibrator, Fig. 10-3-A, the sawtooth forming capacitor *Cs* is in the plate circuit of the second section. Sync pulses applied to the grid of the first section are negative. Due to polarity inversion in the first section the pulses become positive at its plate and at the grid of the second section, thus allowing discharge of the sawtooth capacitor. Were pulses applied directly to the grid of the second section they would be positive.

With plate coupled multivibrators whose second section acts as the output tube, Fig. 10-3-B, the sawtooth forming capacitor *Cs* is in the plate circuit of the first section. Sync pulses applied to the grid of this first section are positive to cause conduction and allow discharge of the capacitor. When sync pulses are applied to the plate circuit of the first section and thereby to the grid of the second section the pulses are negative.

## Blocking Oscillator With Plate Feedback

Fig. 10-5 shows typical circuit connections for a blocking oscillator with feedback from plate to grid. Sync input from the integrating filter is to the oscillator grid through the feedback transformer. The hold control varies discharge time for the sawtooth capacitor and determines free running frequency of the oscillator. The hold control resistors may be on either side of the transformer secondary.

The sawtooth capacitor is charged by electron flow through the height control resistance during periods when the oscillator is blocking or is at plate current cutoff. More resistance in the height control decreases the charge put into the capacitor during time in which the tube is blocked, thus decreasing amplitude of sawtooth voltage and lessening vertical sweep distance of the beam in the picture tube. Less resistance in the height control has, of course, the opposite effects.

In Fig. 10-5 a resistor *Rs* is in series with sawtooth capacitor *Cs*. This series resistance slows capacitor discharge so that some charge remains at the beginning of each recharge. Recharge then commences at a voltage higher than maximum negative and there is negative peaking on the retrace for each cycle. There are many other sawtooth forming circuits, with or without negative peaking resistors.

Sawtooth voltage is applied through capacitor *Cc* to the grid of the output tube. Often there is a direct conductive connection instead of a coupling capacitor, making the output grid 75 to 150 volts positive to ground. Cathode bias on the output tube then must be sufficiently positive to make the grid relatively negative.

Vertical linearity control is by means of an adjustable cathode resistor. An autotransformer couples the output plate circuit to the vertical coils in the yoke. Some receivers have a transformer with insulated secondary.

To observe pulses applied to the oscillator grid without these pulses being obscured by voltage generated in the oscillator it is necessary to remove or disable the oscillator tube. Typical sync pulses observed in this manner are shown by Fig. 10-6-A. Peak-to-peak amplitude measured 3 volts in this example.

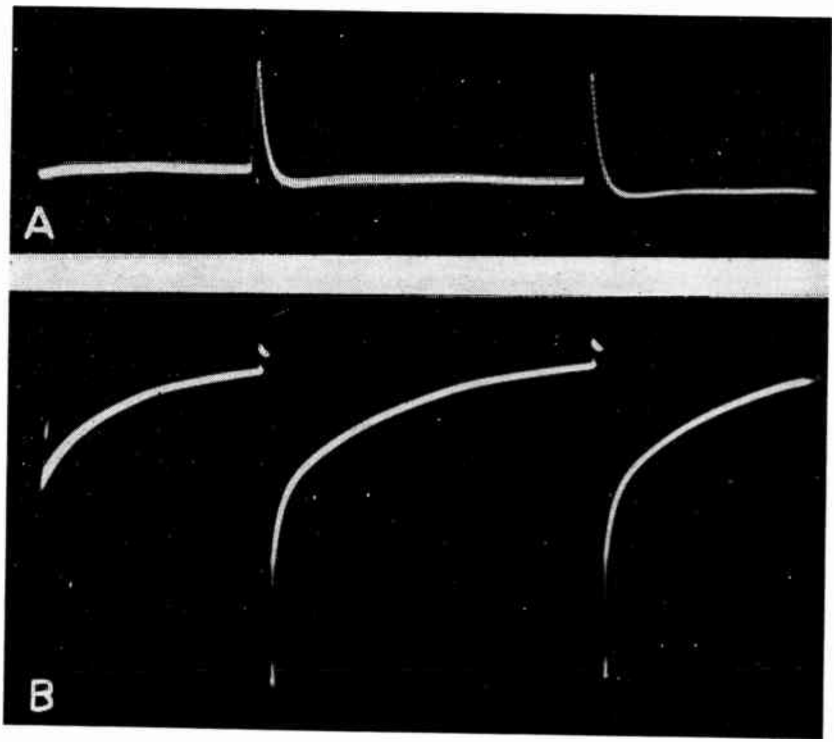


*Fig. 10-6. A, sync pulses applied to the blocking oscillator grid. B, pulses at the grid while the oscillator is operating.*

With the oscillator operating, pulses at its grid appeared as at *B* and measured 250 peak-to-peak volts. Peak-to-peak voltage range at this point is from 50 to 300 volts in various receivers. Note the small positive peaks, due to sync pulses, which are followed instantly by a negative swing and plate current cutoff. Then, as the grid capacitor discharges through the hold control resistance, grid voltage returns slowly to a value allowing conduction in the tube.

Voltage at the oscillator plate appears as in Fig. 10-7-A (130 peak-to-peak volts) and at the grid of the output tube as at *B* (95 peak-to-peak volts). Plate voltages commonly range from 50 to 200 and output grid voltages from 30 to 150. Due to the feedback transformer the waveform at the output grid has lost the small positive peaks seen at the oscillator plate.

At the plate of the output tube the voltage waveform is as shown by Fig. 10-8-A, here with 1000 volts peak-to-peak. This is quite typical of voltage waveforms at plates of all vertical output tubes regardless of the type of oscillator.

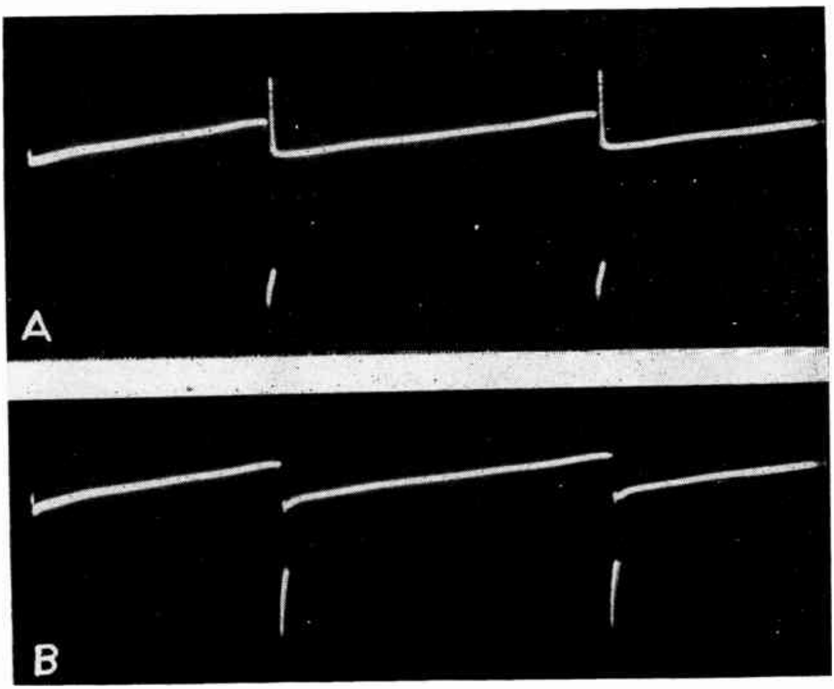


*Fig. 10-7. Voltage at the blocking oscillator plate (A) and at the grid of the output tube (B).*

Peak-to-peak voltage commonly is between 800 and 1200 but may be as high as 2000 in some sets.

At the high side of the vertical coils of the yoke, or at the output transformer secondary, the voltage waveform is as at Fig. 10-8-B, with 100 volts peak-to-peak in this example. It is evident that the output transformer has a step down voltage ratio of 10-to-1 in this particular receiver.

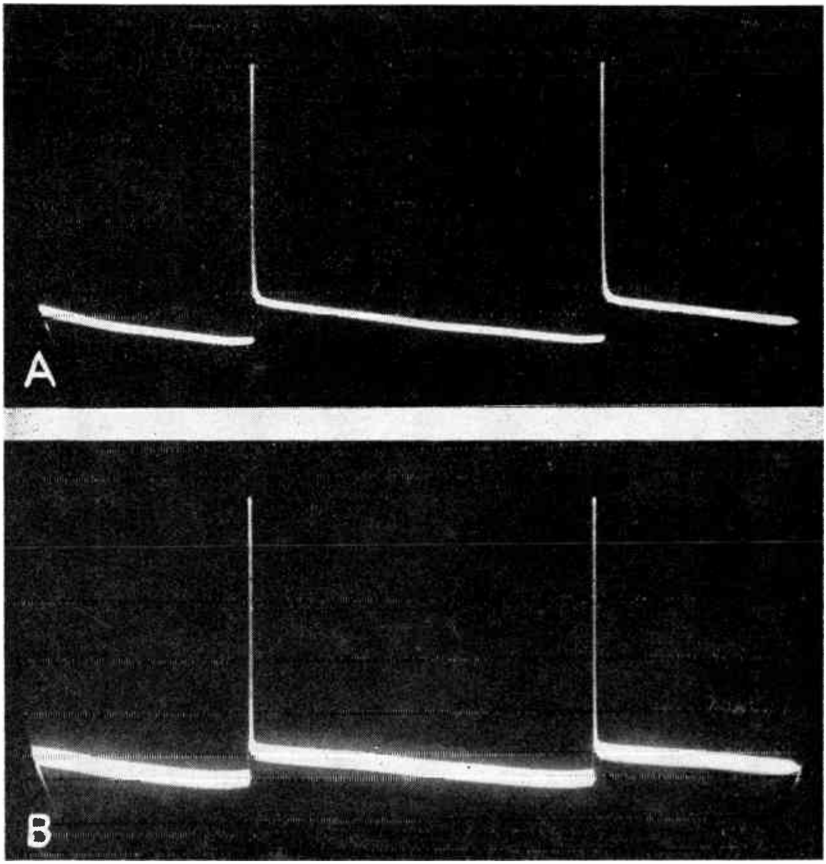


*Fig. 10-8. Voltage at the plate of the output tube (A) and at the vertical yoke coils (B).*

Slight fuzziness along the nearly horizontal portions of this trace from the yoke circuit is due to horizontal pulses from the horizontal coils coupling into the vertical coils of the yoke. This effect is found is most traces taken from a vertical yoke connection or an output transformer secondary.

## Blocking Oscillator With Cathode Feedback

Fig. 10-9 shows typical connections for a vertical blocking oscillator with feedback through a transformer from cathode to grid. Cathode feedback acts similarly to plate feedback because cathode current is the same as triode plate current except for very small pulses of grid current while the grid is made positive by sync pulses.

The hold control may be on either side of the grid winding in the feedback transformer. As usual, the height control varies the rate of charge for the sawtooth capacitor and thus varies the amplitude attained by sawtooth voltage between discharges.

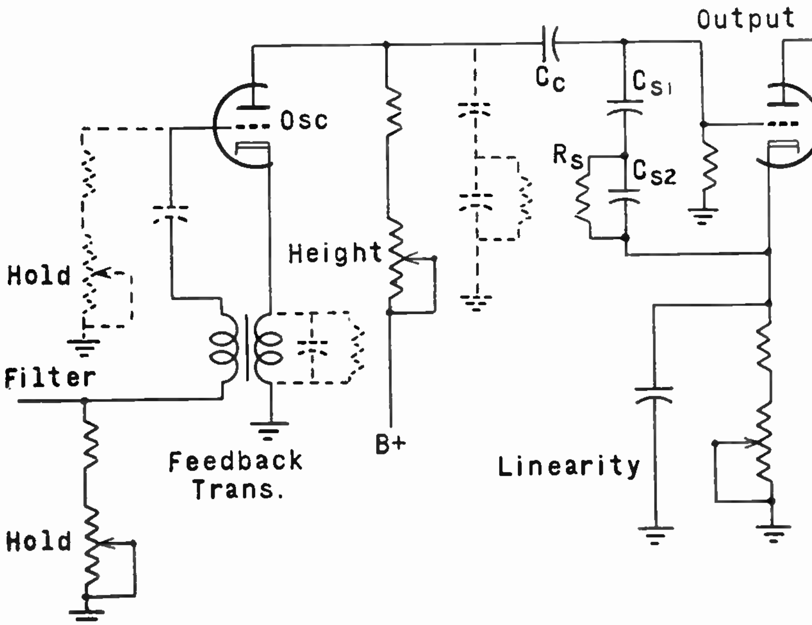


*Fig. 10-9. Blocking oscillator with feedback from cathode to grid.*

The sawtooth capacitor-resistor network is shown with broken lines on the oscillator side of coupling capacitor *Cc*, and with full lines as *Cs1*, *Cs2* and *Rs* on the grid of the output tube. This or any other combination of sawtooth-forming capacitors and resistors may be found on either side of a coupling capacitor in any oscillator system.

With one exception the waveforms for a cathode feedback blocking oscillator system are similar to those for such an oscillator with plate feedback. The exception is that waveforms and peak-to-peak voltages with cathode feedback are practically alike at the plate of the oscillator and grid of the output tube. This is because only a capacitor separates the plate and grid, instead of one winding of a feedback transformer.

## Multivibrator With Cathode Coupling

Typical circuits for a cathode coupled vertical multivibrator system are illustrated by Fig. 10-10. The multivibrator consists of two triodes, usually in a single tube, which form the oscillator. The oscillator is followed by an output tube or amplifier which may be a triode, pentode or beam tube.

Height controls in Fig. 10-10 are on the grid inputs of the output tubes rather than in the oscillator plate circuits. The

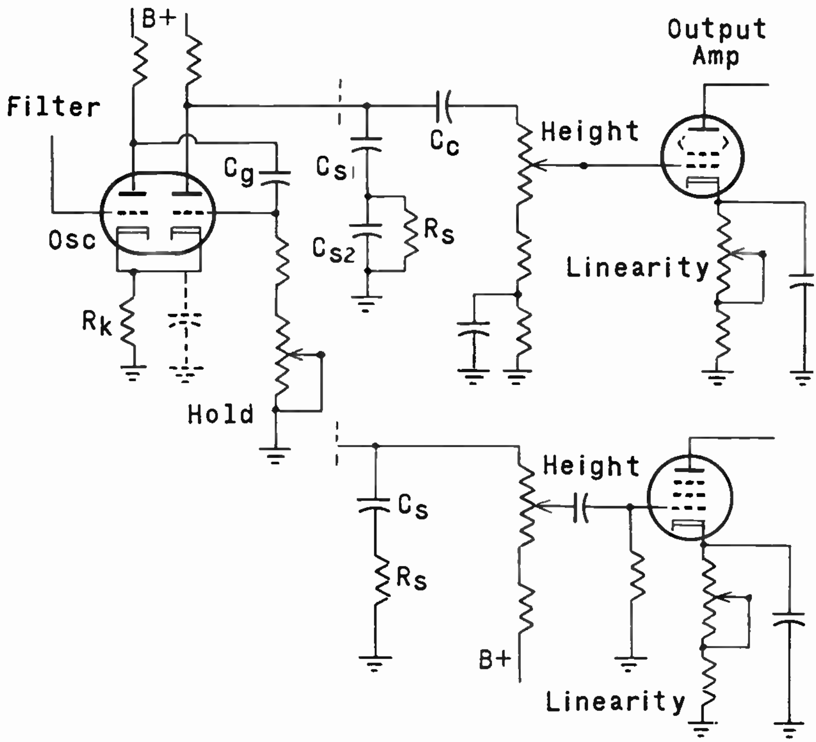


*Fig. 10-10. A cathode coupled vertical multivibrator feeding to beam or pentode output amplifiers.*

control potentiometers allow applying various fractions of oscillator sawtooth voltage to the output tube. The height control may be on the amplifier or output tube side of coupling capacitor *Cc,* as in the upper diagram, or on the oscillator side as shown below.

Height controls on an amplifier grid are shown here with a cathode coupled multivibrator merely to illustrate circuit connections. Such height controls may be found with other oscillators, and cathode coupled multivibrators may have other kinds of height controls.

At the plate of the input section of the cathode coupled multivibrator, the left-hand section in the diagram, are pulses

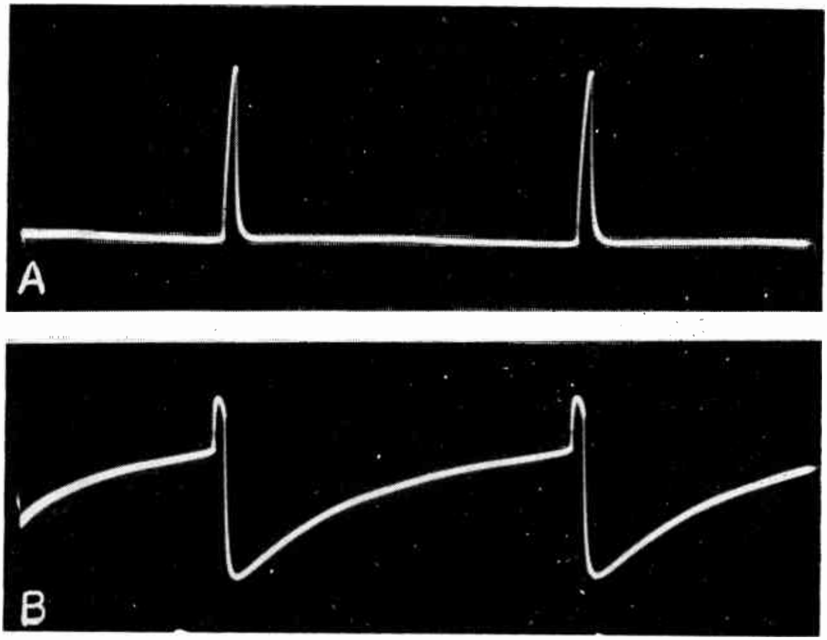


*Fig. 10-11. Pulses at the first plate of a cathode coupled multivibrator (A) and at the grid of the second section (B).*

shown at *A* of Fig. 10-11. These positive pulses are applied through capacitor *Cg* to the grid of the second section, where appears the waveform at *B*. This latter waveform shows the positive pulses as sharp peaks followed by a quick negative swing as capacitor *Cg* discharges through the tube. Then there is slow recovery of capacitor charge and grid voltage as *Cg* again charges from a B+ connection on the first plate.

Discharge current from *Cg* passes through cathode resistor *Rk* to form voltage pulses which are positive at the cathodes, as in Fig. 10-12. These pulses have the same effect as negative pulses at the grid, and help the first section to reach plate current cutoff.

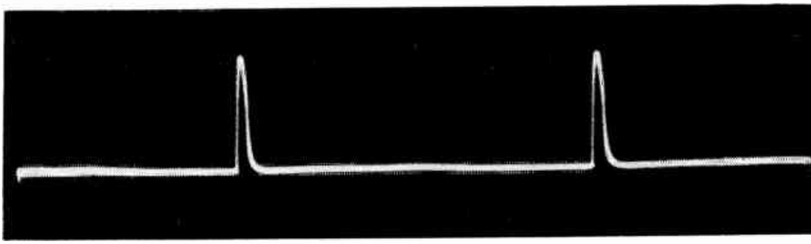

*Fig. 10-12. Voltage pulses at the two cathodes of a cathode coupled multivibrator.*

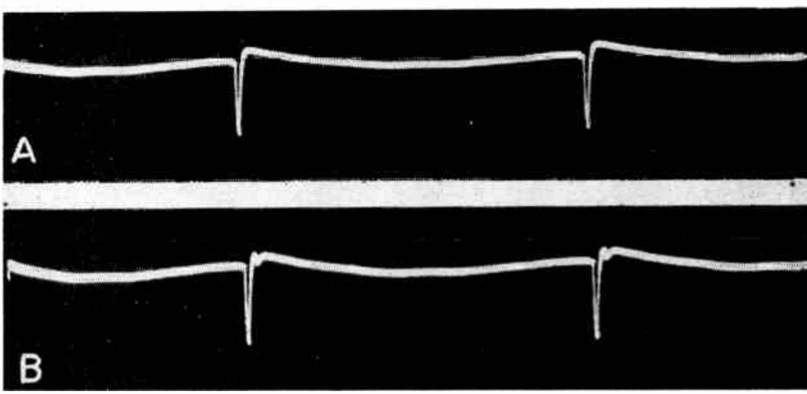


*Fig. 10-13. Sync pulses at the first grid of the cathode coupled multivibrator. A, with oscillator removed. B, with oscillator operating.*

At *A* of Fig. 10-13 are negative pulses which come from the sync section to the grid of the first section of the multivibrator. These pulses were photographed with the oscillator tube removed. With the oscillator operating, pulses at the first grid appear as at *B*.

At the plate of the second section of the multivibrator and at the grid of the following amplifier is the sawtooth waveform of Fig. 10-14. The sharp negative drops result from discharge of sawtooth capacitors through the second section of the multivibrator. The relatively slow rises represent recharging of the sawtooth capacitors through a B+ connection in the upper diagram of Fig. 10-10 or through the height control of the lower diagram.

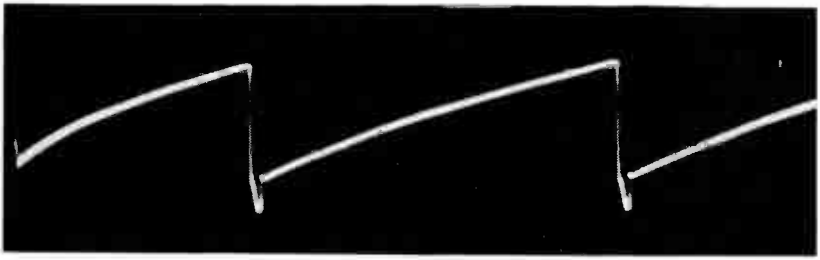

*Fig. 10-14. Sawtooth developed at the second plate of the cathode coupled multivibrator.*

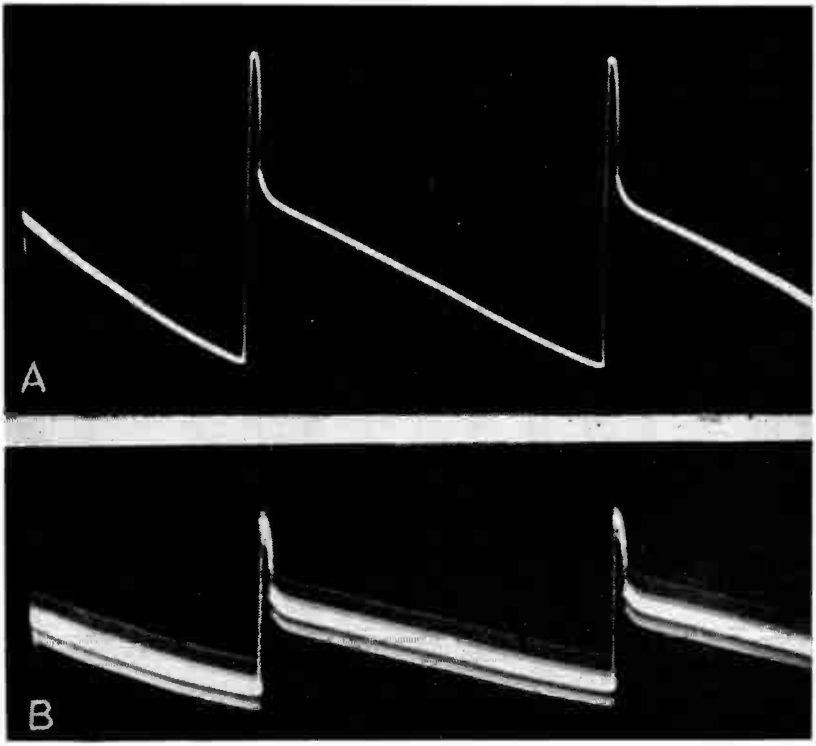


*Fig. 10-15. Voltage waveforms at the plate of the output amplifier (A) and at the high side of the vertical yoke coils (B) following a cathode coupled multivibrator.*

At the plate of the output amplifier there is a waveform shown at *A* of Fig. 10-15. This is essentially like the output waveform of Fig. 10-8-A. At the vertical output transformer and high side of vertical coils in the yoke is the voltage waveform at *B* of Fig. 10-15. Note the effect of coupling from horizontal to vertical yoke coils. If the internal sweep of the scope is changed to a horizontal rate this fuzziness resolves into separated pulses of rather irregular form.

Peak-to-peak voltages measured on the cathode coupled multivibrator used for an example are as follows for the several waveforms. The very small sync voltage at the first grid is characteristic of this type of oscillator.

| | | |
|---|---|---|
| Multivibrator 1st plate | 55v | Fig. 10-11-A |
| Multivibrator 2nd grid | 58v | Fig. 10-11-B |
| Multivibrator cathodes | 7.5v | Fig. 10-12 |
| Multivibrator 1st grid | 0.6v | Fig. 10-13 |
| Multivibrator 2nd plate and amplifier grid. | 45v | Fig. 10-14 |
| Amplifier plate | 320v | Fig. 10-15-A |
| Yoke coils | 31v | Fig. 10-15-B |

## Multivibrator With Plate Coupling

The plate coupled multivibrator shown in an elementary way by Fig. 10-13-B is illustrated in practical form by Fig. 10-16. The feedback filter from output plate to oscillator or discharge grid, represented only by a broken-line block, consists actually of various combinations of resistors and capacitors.

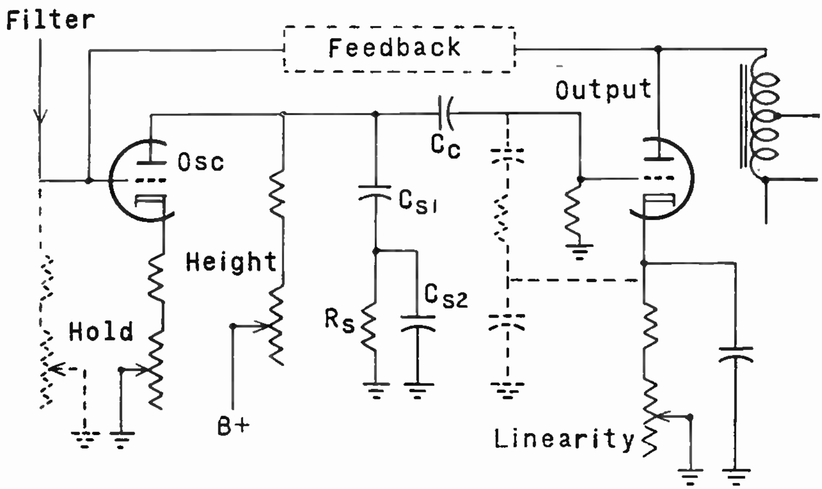


*Fig. 10-16. Typical connections for a plate coupled vertical multivibrator. One section serves as output tube.*

A few of the feedback networks which might be put in place of the block are shown by Fig. 10-17. In these feedback circuits the output sawtooth waveform with its strong spikes is changed to get rid of nearly all the sawtooth, and the spikes are weakened to provide a waveform suitable for application to the grid of the oscillator or discharge section.

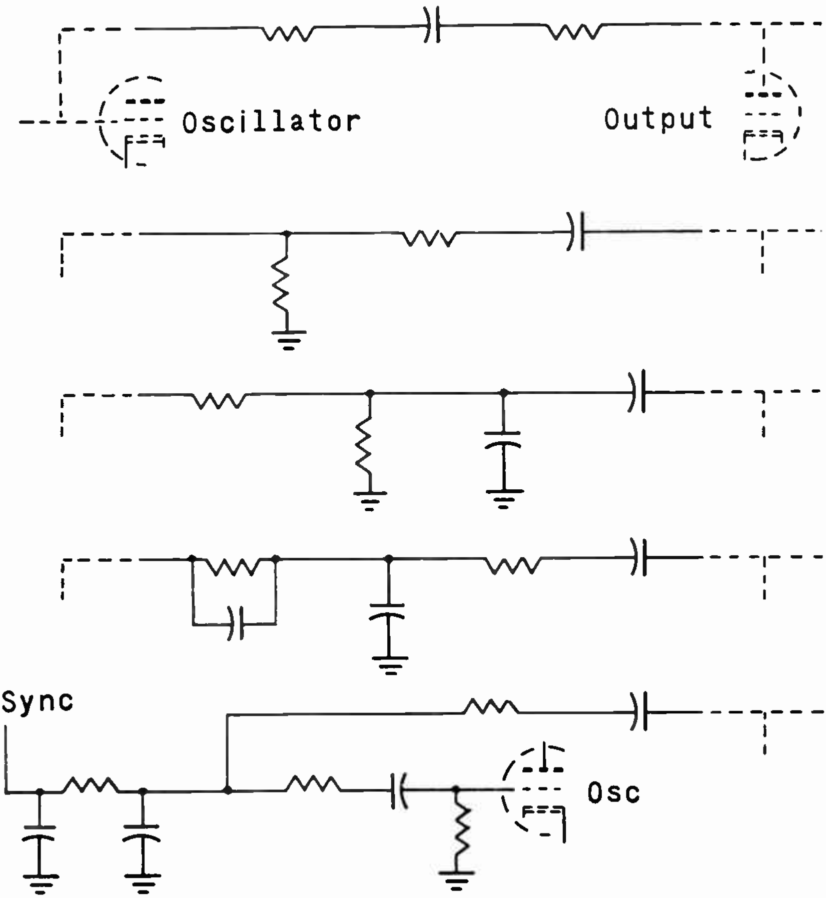


*Fig. 10-17. Some of the feedback filter combinations used between output plate and input grid of plate coupled multivibrators.*

The vertical hold control may be on the oscillator grid as shown with broken lines in Fig. 10-16, or on the oscillator cathode as in full lines.

The height control is in the oscillator plate circuit where it regulates the charging rate of the sawtooth capacitor or capacitors and thus determines peak-to-peak amplitude of the sawtooth voltage.

The sawtooth capacitor system (*Cs1*, *Cs2* and *Rs*) may be on the oscillator side of coupling capacitor *Cc*, or on the output side as in broken lines. The sawtooth capacitor system may consist of any of a wide variety of capacitor-resistor combinations other than the two shown by the diagram.

When sync pulses from the integrating filter are applied to the oscillator grid, as in Fig. 10-16, these pulses are positive in order to make the oscillator conductive for discharging the sawtooth capacitors.

To observe the sync pulses unaffected by oscillator action it is necessary to disconnect the oscillator grid from the integrating filter and connect the scope to the filter output. Then the sync pulses will appear as at *A* of Fig. 10-18 or as something equivalent like the waveform in Fig. 10-6-A.

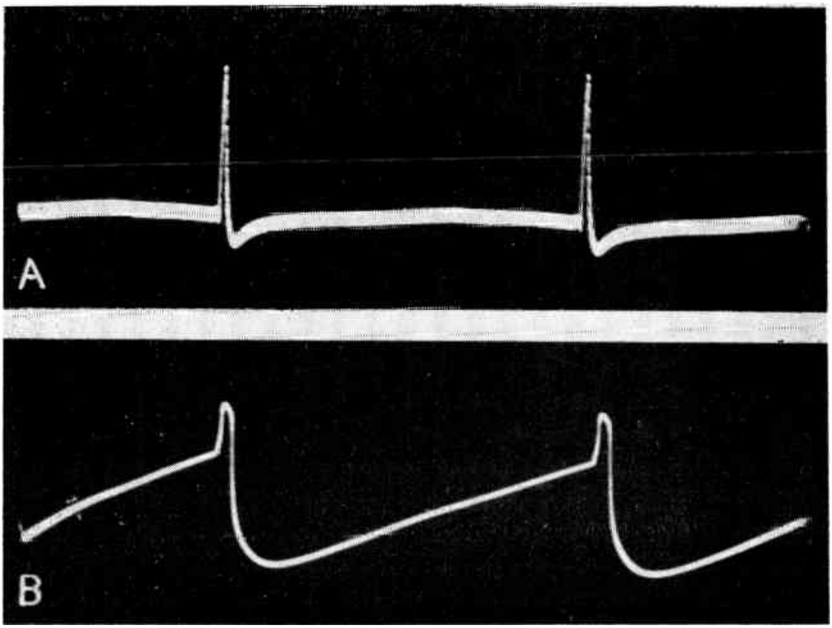


*Fig. 10-18. Waveforms at grid of input or discharge section of plate coupled multivibrator. A, with oscillator and integrating filter disconnected. B, with them connected.*

With the integrating filter still disconnected the waveform at the oscillator grid will be of the general form pictured in Fig.10-18-B. This waveform will remain the same with the filter reconnected, but oscillator frequency then will be synced instead of at the free running rate. Pictures should lock in vertically when the integrating filter is connected and should roll or float vertically with it disconnected.

At the oscillator plate the waveform would be a sawtooth such as at *A* of Fig. 10-19 or something very similar except that negative peaking pulses are not always present or evident. This same waveform should appear at the grid of the output tube or section.

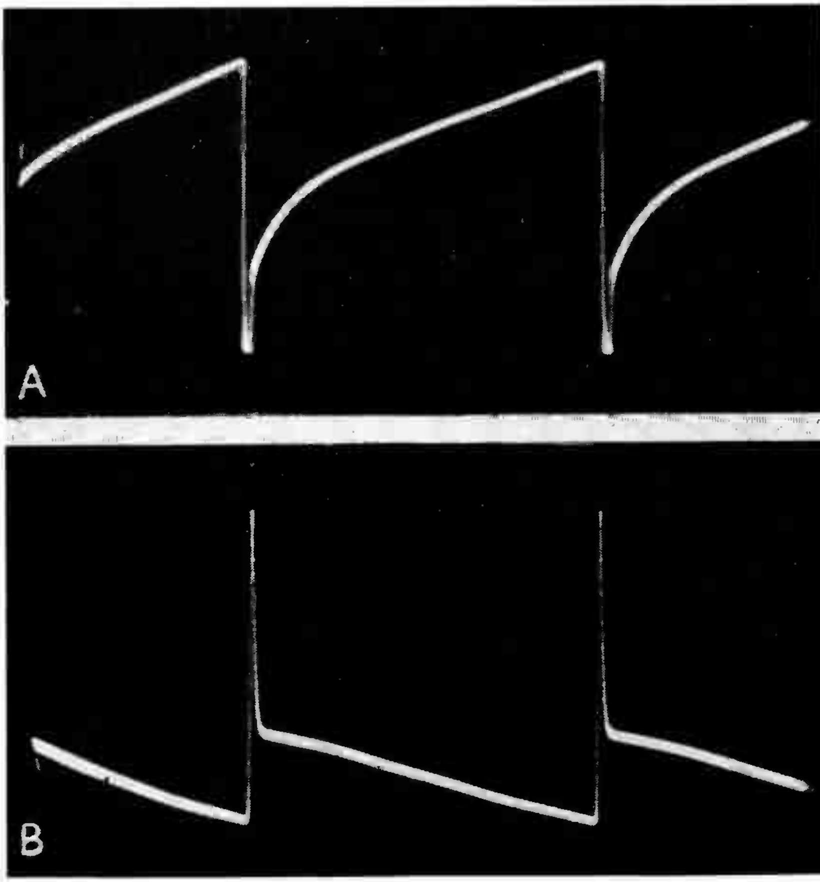


*Fig. 10-19. A, voltage at oscillator plate and output grid of a plate coupled multivibrator. B, at the plate of the output section.*

At the plate of the output section or tube is the waveform at *B* of Fig. 19. This is practically the same as output plate waveforms in Figs. 10-8-A and 10-15-A. At the high side of the vertical coils in the yoke or of the output transformer secondary appears the voltage waveform of Fig. 10-20. As usual, there is the fuzziness that indicates coupling from horizontal to vertical coils in the yoke.

Fig. 10-21 shows some of the modifications or variations in plate coupled vertical multivibrators. Sync input from the integrating filter here is to the oscillator plate and output

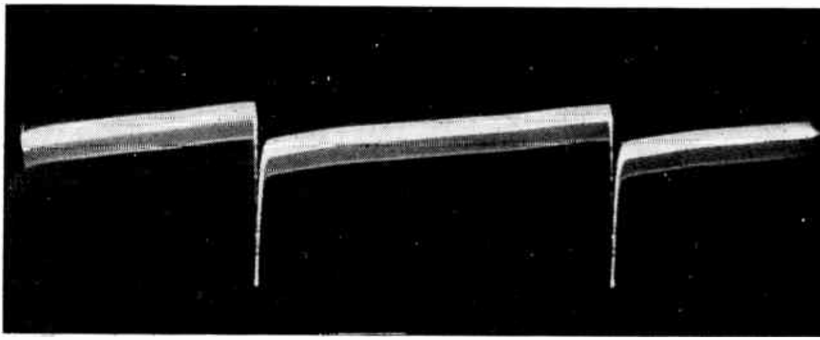

*Fig. 10-20. Voltage waveform at vertical yoke coils connected to a plate coupled multivibrator.*

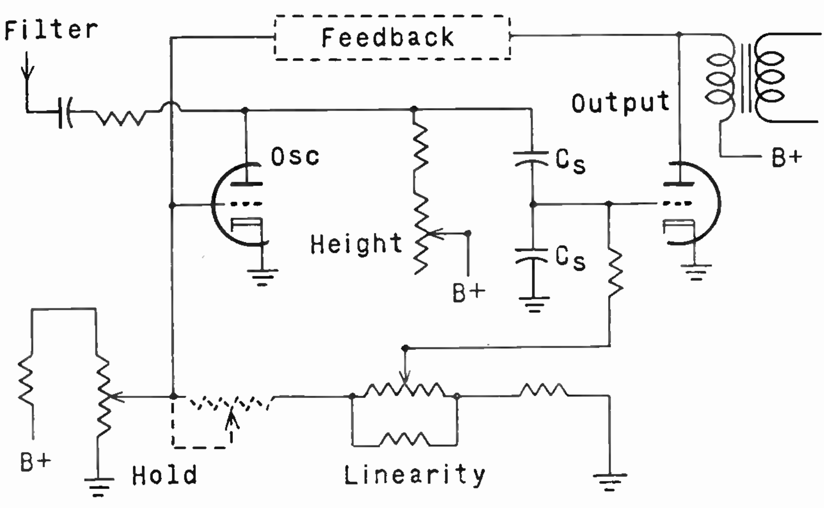


*Fig. 10-21. Some of the variations found in circuits for plate coupled multivibrators.*

grid. Sync pulses must be negative. The pulses are inverted in the output section, fed back in positive polarity to the oscillator grid, and there make the oscillator conductive for discharge of the sawtooth capacitors. Of course, the sync pulses become mixed with sawtooth waveforms but the pulse effects remain.

The vertical linearity control is on the grid of the output tube rather than on its cathode. The hold control, on the oscillator grid, may be in the same line as the linearity control or in a separate line.

With sync input to the first plate or second grid the sync pulses may be observed alone by temporarily short circuiting the primary of the vertical output transformer and connecting the scope to the oscillator plate. This should leave negative

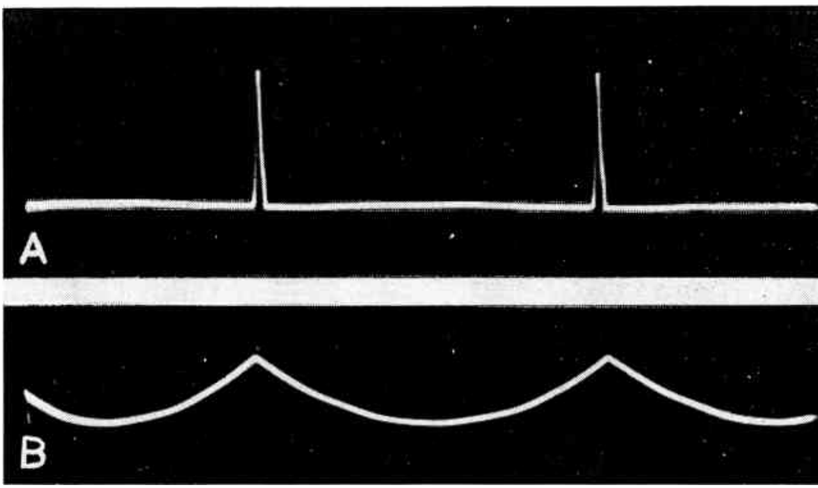


*Fig. 10-22. Voltage pulses at the cathode of the discharge section when there is resistance to ground (A) and at the cathode of the output section of a plate coupled multivibrator (B).*

sync pulses of small amplitude. With the short removed from the transformer there will be a sawtooth waveform with negative peaks.

## Multivibrator Discharge Sections

Regardless of the type of multivibrator, both sections must operate together to produce oscillating current and voltage. Neither section alone will oscillate. In spite of this it is rather common practice to call one section the oscillator and the other an output tube or amplifier.

One section of every multivibrator, usually a triode section, is made conductive by sync pulses in order that the sawtooth capacitor may discharge through this section, which properly may be called a discharge section or tube.

Discharge current from the sawtooth capacitor passes through the plate-cathode path of the discharge section. In a cathode coupled multivibrator the discharge current is utilized in a cathode resistor to produce voltage pulses for coupling.

In many plate coupled multivibrators the cathode of the discharge section connects directly to ground. If this ground connection is opened and a resistor of 5 to 10 ohms temporarily connected in series to ground, discharge current will cause pulses at the cathode such as in Fig. 10-22-A.

The cathode of the second section commonly has in series the linearity control, which is bypassed with large capacitance. The waveform at this cathode is typically of the form shown in Fig. 10-22-B. Here the peak-to-peak amplitude is only a fraction of a volt.

## High-voltage Observations

Pulse voltages at the plates of vertical output tubes may be strong enough to damage the vertical input and attenuator of an oscilloscope. Unless it is known that the scope will stand the highest voltage to be encountered, these output plate voltages should be observed with the help of a capacitance voltage divider for the probe. Such dividers usually provide step-down ratios of about 100 to 1.

One method of making a satisfactory capacitance divider is illustrated by Fig. 10-23. A schematic diagram is at the lower left. Capacitance for the probe is provided by a 9-pin 1X2-A or -B high-voltage rectifier tube whose internal plate to filament capacitance is approximately 1 mmf. The filament is not heated; it is used only as one plate of a capacitor.

The cord end of an alligator clip will spread to make a snug fit on the plate cap of the tube and provide convenient connection to tested circuits. On the tube base is placed a 9-pin socket from which the metal mounting flange has been removed. All lugs on the socket are connected together and to the central conductor of a shielded cable going to the scope vertical input.

The resistance element is made up of a number of half-watt units soldered together end to end. Instantaneous peak drop across one resistor should be no more than 500 volts. Therefore, the number of resistors in series with one another should be equal to maximum probable pulse voltage divided by 500. For example, 6000 pulse voltage would call for at least 12 resistors. One end of the resistor string is connected to the alligator clip and the other is soldered to the socket lugs. The whole assembly will fit inside a fibre or plastic tube for insulation.

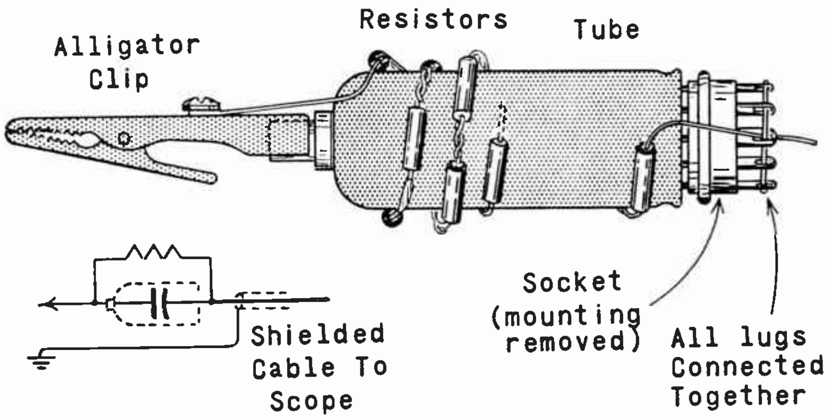


*Fig. 10-23. Construction of a probe for a capacitance voltage divider used for observing high-voltage waveforms.*

Total probe resistance depends on vertical input resistance and capacitance of the scope and on capacitance of the shielded cable. Scope input capacitance and resistance may be learned from the instrument specifications. Cable capacitance may be measured well enough on a capacitor tester.

Add together the scope and cable capacitances, in mmf, them multiply this sum by scope input resistance in megohms. In theory this product should be divided by probe tube internal capacitance to find required megohms of paralleled resistance. Because of stray capacitances it is better to commence with a divisor of 2 for the 1X2 tube construction.

For an example, assume scope vertical input resistance of 5 megohms and input capacitance of 28 mmf, used with cable capacitance of 48 mmf. The sum of capacitances is 76 mmf. Multiplying by 5 (input megohms) gives 380. Dividing by 2 indicates about 190 megohms of paralleled resistance in the probe. Using a string of 13 resistors, each of 15 megohms, would provide 195 megohms.

To check the probe observe any pulsed waveform of a few hundred peak-to-peak volts with an ordinary frequency compensated probe, then with the capacitance divider probe. If waveforms do not appear practically alike with both probes,

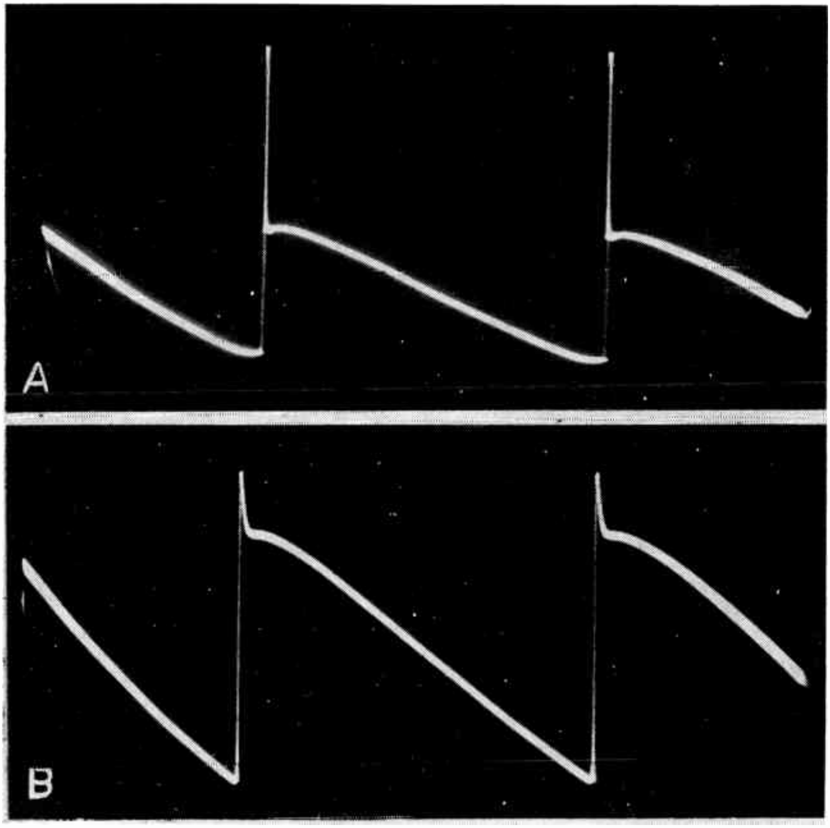


*Fig. 10-24. Distorted waveforms due to using capacitance voltage divider without frequency compensation.*

try a little more or less parallel resistance in the capacitance divider probe.

Using a poorly compensated capacitor probe for the waveform of Fig. 10-8-A makes it appear as in Fig. 10-24-A, and makes the waveform of Fig. 10-19-B appear as at 10-24-B.

## Current Waveforms

An oscilloscope is primarily designed to exhibit voltage waveforms, not current waveforms. To observe a current waveform open the low side of the circuit carrying the current, connect in series a carbon resistor of very few ohms, then connect the scope vertical input across the ends of this resistor. Variations of current in the resistor are accompanied by corresponding variations of voltage across the resistor.

By using a direct probe and maximum vertical sensitivity in the scope the small voltage across the resistor may be

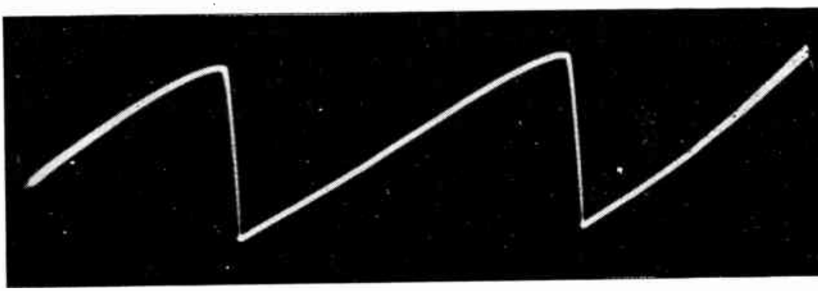

*Fig. 10-25. A trace showing sawtooth current in vertical deflecting coils.*

observed, and will represent circuit current. To avoid upsetting normal performance of the circuit the inserted resistor should be of fewest ohms which will allow readable traces. One to 10 ohms should be enough in any case.

Current observed in the low side of vertical deflecting coils should appear as in Fig 10-25, with sawtooth slopes straight or nearly so. Cutting a series resistor into the high side of a yoke circuit may allow seeing spurious voltage peaks.

## Linearity Control

The usual effect of adjusting a vertical linearity control is to either stretch or compress the upper portion of pictures. With some controls the bottom of pictures may be affected.

When pictures are vertically linear or uniformly distributed from top to bottom of the viewing screen the voltage waveform at the high side of the vertical coils or output transformer will appear as in Figs. 10-8-B, 10-15-B or 10-20, with the long sloping portion of the trace nearly straight.

If linearity is such that tops of pictures are compressed, the voltage waveform at the vertical deflecting coils will be as at *A* of Fig. 10-26 and the current waveform will be as at *B*.

The top of each vertical field is at the beginning or the left-hand side of the upward slope of the current waveform, while the bottom of the field in the picture tube is at the right-hand end of this slope, just before the sudden retrace.

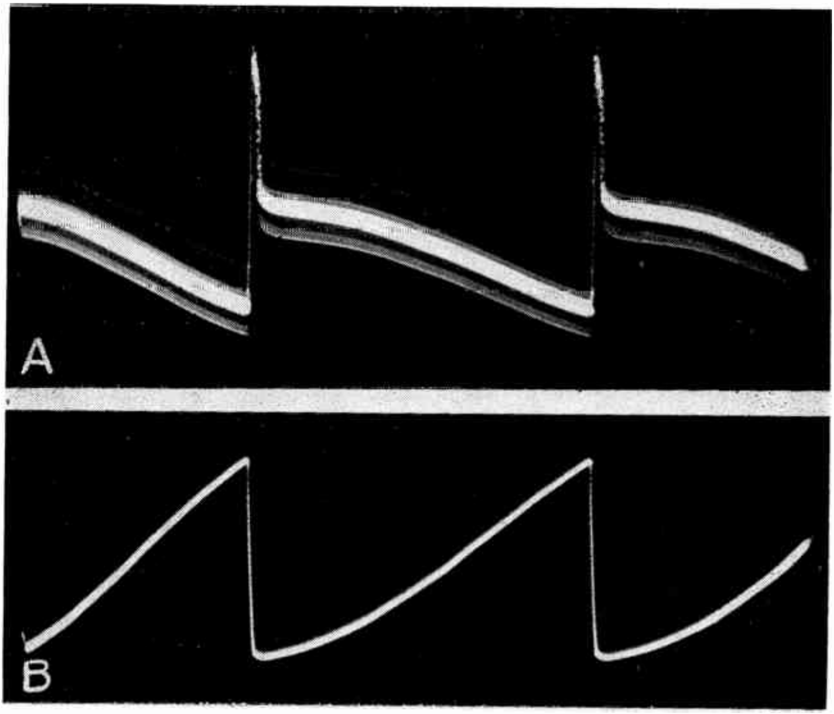


*Fig. 10-26. Waveforms showing non-linearity with tops of pictures compressed. A, voltage. B, current.*

Where the current slope is too nearly horizontal at the left the beam in the picture tube is traveling downward too slowly. Too much of the picture appears during this slow travel, hence the compression. This occurs when there is too much resistance in a linearity control on the cathode of a vertical output tube.

When linearity is such that tops of pictures are stretched, the voltage waveform at the vertical deflecting coils will be as at *A* of Fig. 10-27 and the current waveform will be as at

*B*. Here the electron beam in the picture tube will travel too fast at the beginning of each field or at the tops of pictures. Too little of the picture will be distributed over the upper portion of the viewing screen. This happens when a linearity control on an output tube cathode has too little resistance.

## Oscilloscope Checks Of Vertical Sweep Section

For a quick check of the vertical sweep section observe voltage waveforms at the following points.

**1.** (a) In the case of a plate coupled multivibrator or a blocking oscillator check at the first grid or the grid to which con-

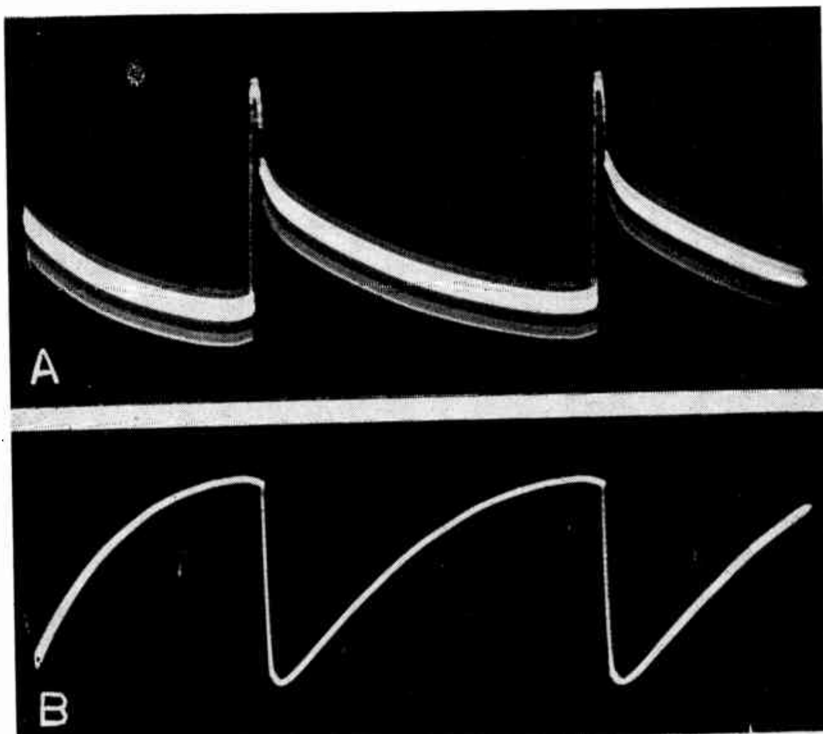


*Fig. 10-27. Non-linear waveforms which accompany pictures stretched at the top. A, voltage. B, current.*

nects the integrating filter. The waveform should show short positive (sync) pulses followed by negative swings and rather slow recovery. See Figs. 10-6-B and 10-18-B.

**1.** (b) With a cathode coupled multivibrator check at the grid of the second section, where the waveform should be as described in preceding paragraph 1 (a). See Fig. 10-11-B.

**2.** (a) With a plate coupled multivibrator or a blocking oscillator make a check at the oscillator plate. This would be the plate of the first or discharge section of the multivibrator. The waveform should be a sawtooth, nearly always with greater or less negative peaking. See Figs. 10-7-A and 10-19-A.

**2.** (b) With a cathode coupled multivibrator check at the plate of the second section or output section. There should be a sawtooth, usually with negative peaking. See Fig. 10-14.

**3.** Check at the grid of the tube or tube section which is fed from the plate mentioned in preceding paragraphs *2*. The waveform should be practically the same as at that preceding plate.

**4.** At the plate of the tube feeding into the vertical output transformer the waveform should be similar to those of Figs. 10-8-A, 10-15-A or 10-19-B.

**5.** At the high side of vertical deflecting coils or of the output transformer secondary the voltage trace should be

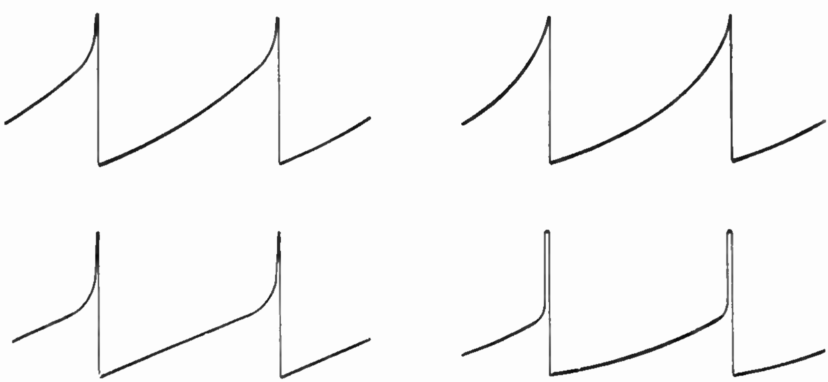

*Fig. 10-28. All these waveforms have the same general characteristics and would be considered equivalent to one another during a preliminary check for trouble location.*

similar to those of Fig. 10-8-B, 10-15-B or 10-20. Spikes may be positive or negative; this depending on design or connection of yoke and transformer.

When following through the vertical sweep section according to preceding numbered paragraphs, traces will be normal until a fault has been passed. Look for trouble between the point at which waveforms first become abnormal and the last point at which they are normal.

Waveforms need not be precisely like those shown by photographs of typical examples, but should be generally similar and free from noticeable peculiarities or unusual fuzziness other than at yoke coils. To illustrate, when checking various receivers having plate coupled multivibrators, waveforms at the plate of the first or discharge section were about as shown in Fig. 10-28. It is apparent that all are fairly equivalent to traces in Figs. 10-7-A and 10-19-A.

## Troubles And Picture Symptoms

Accompanying tables list picture symptoms which most often or most probably result from various faults in the vertical sweep section.

The same trouble often will cause different symptoms, depending on severity of the trouble. For instance, picture symptoms due to a leaky capacitor might merge into symptoms due to the same capacitor being internally short circuited. The short is a case of extreme leakage.

Some symptoms are closely related to others. A certain trouble might cause pictures to roll upward or downward, but should the pictures hold stationary the same trouble might cause splitting, top and bottom, along a horizontal line or bar.

Vertical hold controls in some receivers have greater range of resistance adjustment than in others, and may be set to prevent rolling even when some faults are present in moderate degree. With less range of adjustment the same faults would cause uncontrollable rolling.

In one of the tables is a top listing of *Lines (Horz), Many.* This refers to a viewing screen covered with thin, bright trace lines which shift irregularly. The condition results from extreme vertical stretching which separates horizontal trace lines by wide dark areas.

| **Table 10-A** **VERTICAL SWEEP** **Integrating Filter. Plate Coupled MV** | Compressed At Bottom | Compressed At Top | Fold, Vertical | Height Excessive | Height Lacking | Interlace Poor | Line (Horz), One | Rolling, Vertical | Stretched, Bottom | Sync Critical (Vert) |
|---|---|---|---|---|---|---|---|---|---|---|
| INTEGRATING FILTER | | | | | | | | | | |
| Capacitor In Series | | | | | | | | | | |
| 1 Open | | | | | | | | • | | |
| 2 Leaky | | | • | | | • | | • | | |
| 3 Shorted | | | | | | | • | | | |
| Capacitor To Ground | | | | | | | | | | |
| 4 Leaky, shorted | | | | | • | | | • | | |
| 5 Too great | | | | | | | | • | | • |
| Resistor In Series | | | | | | | | | | |
| 6 Open | | | • | | | | | • | | |
| Resistor To Ground | | | | | | | | | | |
| 7 Open | | | | | | • | | | | |
| 8 Shorted | | | | | | | | • | | |
| MULTIVIBRATOR, PLATE COUPLED | | | | | | | | | | |
| Discharge Section | | | | | | | | | | |
| 9 Plate voltage zero | | | | | | | • | | | |
| 10 Plate voltage low | | | | | • | | | | | |
| 11 Plate voltage high | | | | • | | | | | | |
| Output Section | | | | | | | | | | |
| 12 Plate voltage zero | | | | | | | • | | | |
| 13 Plate voltage low | | | | | • | | | | | |
| 14 Cathode-heater leak | | | | | • | | | | | |

(Continued on next page)

(Continued from preceeding page)

**Table 10-A**

**VERTICAL SWEEP**

**Plate Coupled MV**

| | Compressed At Bottom | Compressed At Top | Fold, Vertical | Height Excessive | Height Lacking | Interlace Poor | Line (Horz), One | Rolling, Vertical | Stretched, Bottom | Sync Critical (Vert) |
|---|---|---|---|---|---|---|---|---|---|---|
| 15 Grid resistor open | | | | | | | • | | | |
| 16 Grid resistor too small | | | | | | | | • | | |
| 17 Grid resistor too great | | | | | • | | | | | |
| Coupling Capacitor (Discharge to output) | | | | | | | | | | |
| 18 Open | | | | | | | • | | | |
| 19 Leaky | | | • | | | | | • | | • |
| 20 Shorted | | | • | | | | | | | |
| Feedback Capacitors | | | | | | | | | | |
| 21 Series. Open | | | • | | | | | | | |
| 22 Series. Leaky | | | • | • | | | | | | |
| 23 Series Shorted | | | • | | | | | | | |
| 24 To ground. Open | | • | | | | | | | • | |
| 25 To ground. Leaky, shorted | • | | • | | | | • | | | • |
| 26 To ground. Too small | | • | | • | | | | | | |
| Feedback Resistors | | | | | | | | | | |
| 27 Series. Open | | | • | | | | | | | |
| 28 Series. Shorted | | • | | | • | | | | | |

| **Table 10-B** **VERTICAL SWEEP** **Blocking Oscillator. Cathode Coupled MV.** | Bright Bar, Bottom | Compressed At Bottom | Compressed At Top | Fold, Vertical | Height Excessive | Height Fluctuates | Height Lacking | Line (Horz), One | Rolling, Vertical | Split, Top-Bottom | Stretched, Bottom | Stretched, Top | Sync Critical (Vert) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BLOCKING OSCILLATOR | | | | | | | | | | | | | |
| 29 Plate voltage zero | | | | | | | | • | | | | | |
| 30 Plate voltage low | | • | | | | | • | | | | | | |
| 31 Plate voltage high | | | • | | • | | | | | | • | | |
| 32 Cathode-heater leak | | | | • | | | | | • | | | | • |
| Grid Capacitor | | | | | | | | | | | | | |
| 33 Open | | | | | | | | | • | | | | |
| 34 Leaky, shorted | | | | | | | | • | | | | | |
| 35 Too great, too small | | | | | | | | | • | | | | |
| Feedback Transformer 36 Defective | | | | • | | | | • | • | | | | • |
| MULTIVIBRATOR, CATHODE CPLD | | | | | | | | | | | | | |
| 37 Plate voltage zero | | | | | | | | • | | | | | |
| 38 Plate voltage low | | | | | • | | | | | | | | |
| 39 Plate voltage high | | | | • | | | • | | | | | | |
| 40 Cathode-heater leak | | | | | | | | | • | • | | | |
| Cathode Resistor | | | | | | | | | | | | | |
| 41 Open | | | | | | | | • | | | | | |
| 42 Shorted | | | | • | | | | | | | | | |
| 43 Too small | | | | • | | | • | | | | | | |
| 44 Too great | | | | • | | | | | | | | | |

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| **Table 10-B** **VERTICAL SWEEP** **Cathode Coupled MV. Output Tube** | Bright Bar, Bottom | Compressed At Bottom | Compressed At Top | Fold, Vertical | Height Excessive | Height Fluctuates | Height Lacking | Line (Horz), One | Rolling, Vertical | Split, Top-Bottom | Stretched, Bottom | Stretched, Top | Sync Critical (Vert) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cathode Bypass Capacitor | | | | | | | | | | | | | |
| 45 Leaky | | | | • | | | • | | | | | | |
| 46 Shorted | | | | • | | | | | | | | | |
| Coupling Capacitor (1st plate — 2nd grid) | | | | | | | | | | | | | |
| 47 Open | | | | | | | | • | | | | | |
| 48 Leaky | | | | • | | | | • | | | | | |
| 49 Shorted | | | | | | | | • | | | | | |
| 50 Too small | | | | • | | | | | • | | | | |
| 51 Too great | | | | • | | | | | | • | | | |
| OUTPUT TUBE (Not Oscillator) | | | | | | | | | | | | | |
| 52 Plate voltage zero | | | | | | | | • | | | | | |
| 53 Plate voltage low | | | • | | | | • | | | | | | |
| 54 Plate voltage high | | | | | • | | | | | | | | |
| 55 Cathode-heater leak | • | | | • | • | | | | | • | | | |
| Coupling Capacitor | | | | | | | | | | | | | |
| 56 Open | | | | | | | | • | | | | | |
| 57 Leaky | | | | • | | | | | | | | • | |
| 58 Shorted | | | | • | | | | • | | | | • | |
| Grid Resistor | | | | | | | | | | | | | |
| 59 Open | | | | | • | • | | | | | | | |
| 60 Too great | | | | | • | | | | | | | | |
| 61 Too small | • | | | | | | | | | | | | |

| Table 10-C<br>VERTICAL SWEEP<br>Controls.<br>Sawtooth System | Bright Bar, Bottom | Bright Bar, Top | Compressed At Bottom | Compressed At Top | Fold, Vertical | Height Excessive | Height Lacking | Line (Horz), One | Lines (Horz), Many | Rolling, Vertical | Split, Top-Bottom | Stretched, Bottom | Stretched, Top |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HOLD CONTROL (Entire resistance) | | | | | | | | | | | | | |
| 62 Open | | | | | | | | ● | | | | | |
| 63 Too great | | | | | ● | | | | | ● | ● | | |
| 64 Too little | | | | | ● | | ● | | | ● | | | |
| 65 Shorted | | | | | | | | ● | | | | | |
| HEIGHT CONTROL (Entire resistance) | | | | | | | | | | | | | |
| 66 Open | | | | | | | | ● | | | | | |
| 67 Shorted | | | | ● | | ● | | | | | | | |
| 68 Too great | | | ● | | | | ● | | | | | | |
| 69 Too little | | | | ● | | ● | | | | | | ● | |
| SAWTOOTH SYSTEM | | | | | | | | | | | | | |
| Capacitor | | | | | | | | | | | | | |
| 70 Open | | ● | | | ● | | | | ● | | | | |
| 71 Leaky | | | ● | | ● | | ● | | | | | | |
| 72 Shorted | | | | | ● | | | ● | | | | | |
| 73 Too great | | | ● | | | | ● | | | | ● | | |
| 74 Too small | | | | ● | | ● | | | | | | ● | |
| Peaking Resistor | | | | | | | | | | | | | |
| 75 Open | | ● | | | ● | | | | ● | | | | |
| 76 Shorted | | ● | | ● | | | | | | | | ● | |
| 77 Too great | ● | | | | ● | | ● | | | | | | |
| 78 Too small | | ● | | ● | | | ● | | | ● | | ● | |

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(Continued from preceeding page)

| Table 10-C VERTICAL SWEEP | Bright Bar, Bottom | Bright Bar, Top | Compressed At Bottom | Compressed At Top | Fold, Vertical | Height Excessive | Height Lacking | Line (Horz), One | Lines (Horz), Many | Rolling, Vertical | Split, Top-Bottom | Stretched, Bottom | Stretched, Top |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LINEARITY CONTROL (Entire resistance) | | | | | | | | | | | | | |
| 79 Open | | | | | | | | ● | | | | | |
| 80 Too great | | | | ● | | | | | | | | | |
| 81 Too little | ● | | | | | ● | | | | | ● | | ● |
| Bypass Capacitor | | | | | | | | | | | | | |
| 82 Open | | | | | | | ● | | | | | | |
| 83 Leaky, shorted | | | | | | ● | | | | ● | | | |
| 84 Too small or open | | | | | | | ● | | | | | | |
| OUTPUT TRANSFORMER | | | | | | | | | | | | | |
| 85 Internal open | | | | | | | | ● | | | | | |
| 86 Internal short | | | | | | | ● | ● | | | | | |

# SECTION 11

## HORIZONTAL SWEEP

The horizontal sweep section is considered as consisting of circuits and components named within the blocks of Fig. 11-1.

Pulses at horizontal line frequency come from the sync section to the automatic frequency control (afc) circuits. To

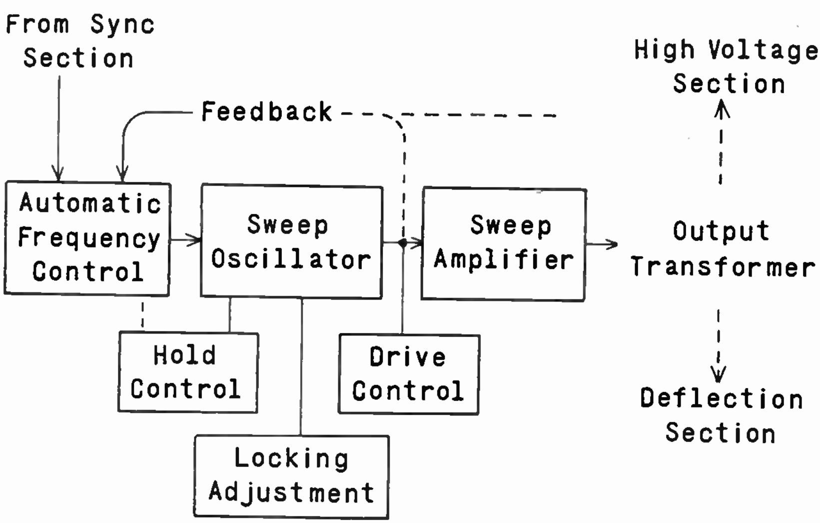


*Fig. 11-1. The horizontal sweep section extends from the sync output to the horizontal output transformer.*

the afc circuit comes also a waveform, usually a sawtooth, from some point in or beyond the output of the horizontal sweep oscillator. This waveform is at the actual operating frequency of the oscillator. The synchronizing pulses and the oscillator output waveform combine in the afc circuits to produce a d-c "correction" voltage that varies when the oscillator frequency tends to become higher or lower than sync pulse frequency.

This d-c correction voltage from the afc system is applied to the grid of the sweep oscillator or an associated tube. The resulting change of grid voltage causes oscillator frequency to become lower or higher, as may be required to bring this frequency into time with sync pulses.

Connected usually to the sweep oscillator but sometimes to the afc circuits is an adjustable horizontal hold control which varies the free running frequency of the oscillator to bring it within the range that may be synchronized by the afc system. There may be additional frequency adjustments for varying the resonant frequency of tuned circuits in the oscillator system.

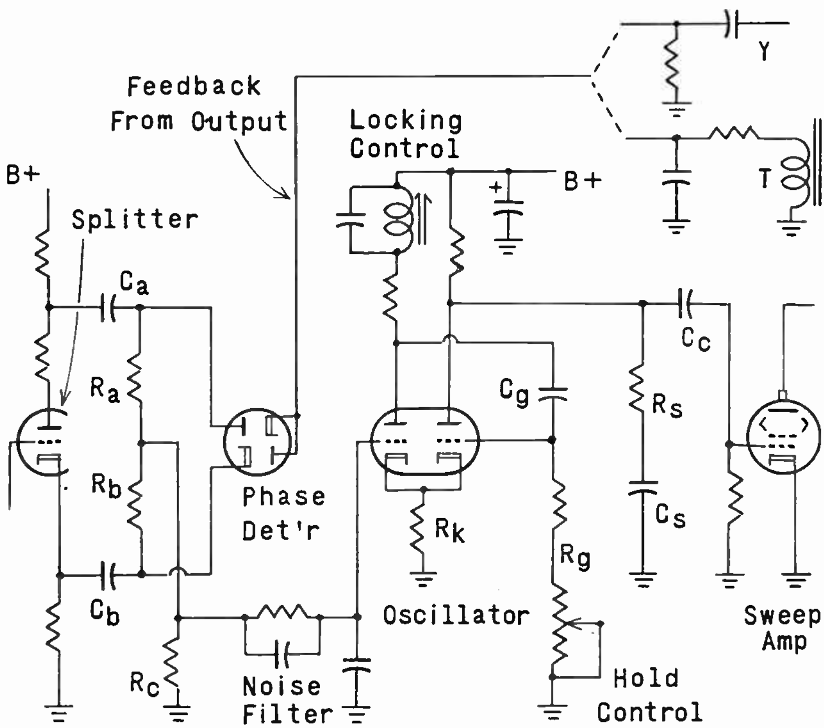


*Fig. 11-2. Horizontal sweep section including a twin diode phase detector, multivibrator oscillator, and sweep amplifier.*

The output waveform of the sweep oscillator, essentially a sawtooth, goes to the control grid of the horizontal sweep amplifier. There may or may not be a drive control for varying the amplitude of sawtooth voltage applied to the amplifier grid.

The plate of the horizontal sweep amplifier feeds to a horizontal output transformer. This transformer furnishes voltage for inducing sawtooth current in the deflection system which includes the yoke, also voltage to the high-voltage power section that handles second anode or ultor requirements of the picture tube.

## Circuit Classification

In receivers of recent design there are a number of widely used combinations of afc systems and sweep oscillators which are found between the output of the sync section and the input to the horizontal sweep amplifier. Following are the more common types.

| | AFC SYSTEM | SWEEP OSCILLATOR |
|---|---|---|
| 1. | Phase detector diodes with splitter tube. | Cathode coupled multivibrator |
| 2. | Phase detector triode with splitter tube. | Cathode coupled multivibrator |
| 3. | Phase detector diodes without splitter. | Cathode coupled multivibrator |
| 4. | Phase detector triode without splitter. | Cathode coupled multivibrator |
| 5. | Pulse width triode (Synchroguide) | Blocking type |
| 6. | Phase detector and reactance tube. | Hartley type with separate discharge tube. |

## Phase Detector Diodes With Splitter

Fig. 11-2 is a circuit diagram for a horizontal sweep system including a triode phase splitter, a twin diode phase detector and a cathode coupled multivibrator. Among variations or modifications which do not materially alter the processes of trouble location are the following.

1. The arrangement of resistors between splitter plate and B+, also of resistors between splitter cathode and ground may vary in their relation to takeoff points for the phase detector.

**2.** A phase detector commonly is a twin diode tube, but in some sets one or both sections of the phase detector are diode-connected triodes and in other cases the phase detector consists of two separate selenium rectifiers or else a dual selenium rectifier.

**3.** Resistors and capacitors in the noise filter between phase detector and multivibrator may be variously arranged.

**4.** The multivibrator cathode resistor may be partially by-passed with a capacitor to ground.

**5.** The horizontal hold control may be an adjustable resistor from second grid to ground on the multivibrator, as shown by the diagram, or this function may be served only by adjustment of the locking control in the plate circuit of the first section of the multivibrator.

**6.** The sawtooth system shown as resistor *Rs* and capacitor *Cs* may consist of other combinations, often with a capacitor and resistor or resistors in parallel.

**7.** An adjustable drive control may be between the multivibrator or sawtooth output and the grid of the sweep amplifier.

**8.** The feedback waveform applied to the joined plate and cathode of the phase detector may be taken from any of various points beyond the oscillator and output amplifier. The connection at *Y* on Fig. 11-2 would be to some point closely associated with the high side of horizontal coils in the yoke, possibly at a tap on the horizontal output transformer or at a damper circuit connection. At *T* is represented a small separately insulated winding on the output transformer.

**9.** Generally similar performance is had in some sets without a splitter tube. A pulse for one side of the phase detector is taken from the cathode or plate of the last sync tube. An inverted pulse for the other side of the phase detector is provided from the secondary of a small transformer connected to the same element of the last sync tube.

## Phase Detector Action

At the splitter grid of Fig. 11-2 are negative synchronizing pulses shown at *A* of Fig. 11-3. Inversion in the splitter causes positive pulses, as at *B*, to appear at its plate. Since there is no inversion between grid and cathode there are negative pulses, as at *C*, appearing at the splitter cathode.

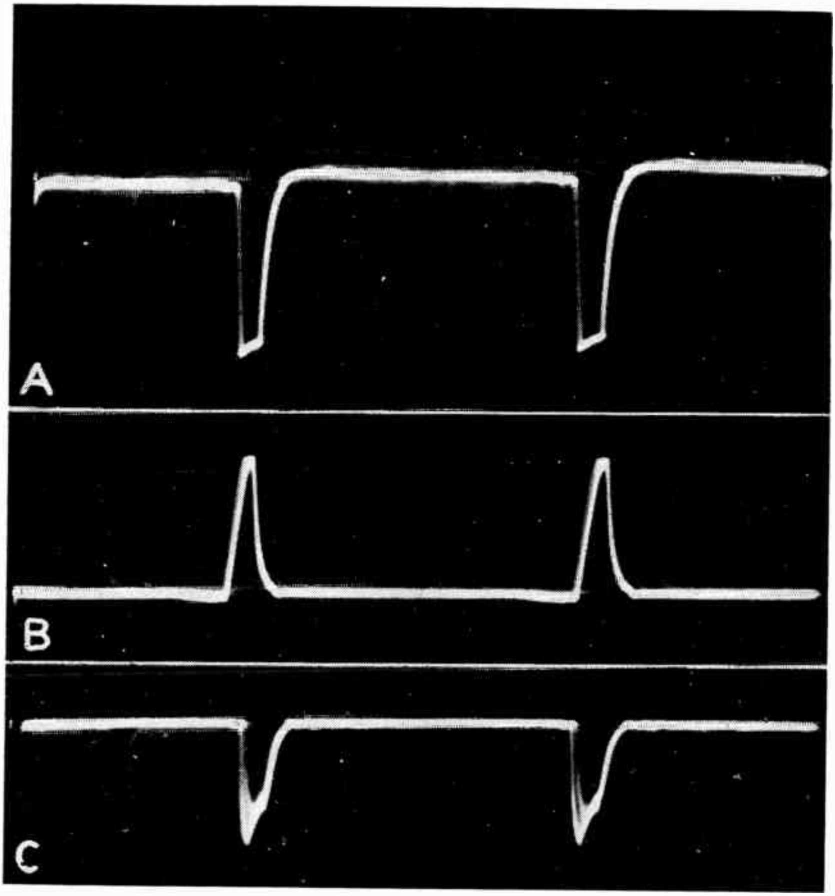


*Fig. 11-3. Synchronizing pulses at the elements of the splitter.*

There is no gain in a splitter, rather there is some loss. Grid pulses in Fig. 11-3 were almost 7 volts peak to peak, while pulses at both the plate and the cathode were about 5 volts peak-to-peak.

Positive pulses from the splitter plate go through capacitor *Ca* to a diode plate of the phase detector, where appears the waveform at *A* of Fig. 11-4. Negative pulses go through capacitor *Cb* to a diode cathode, where appears the waveform at *B*.

At the joined cathode and plate of the phase detector diodes appears the sawtooth waveform shown at *A* of Fig. 11-5. This sawtooth is derived from relatively sharp and brief positive pulses. Such pulses from a damper and horizontal yoke circuit, at about 1500 volts peak-to-peak, are shown at *B*. At *C* are pulses from a small insulated winding on a horizontal output transformer, at about 100 volts peak-to-peak.

These positive feedback pulses produce sawtooth waveforms by charging of capacitors which discharge rather slowly through resistors on the feedback line. Note that there must be a conductive or d-c connection from the joined cathode-plate of the phase detector to ground or B-minus in order that rectified direct current may flow in the diodes.

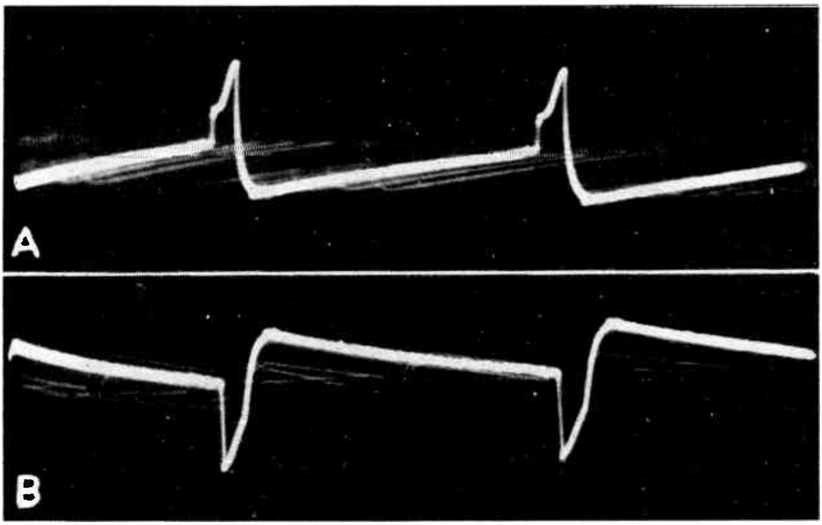


*Fig. 11-4. Pulses at the sync input elements of the twin diode phase detector. A, at the plate, B, at the cathode.*

The sawtooth feedback is at actual oscillator frequency, while pulses from the splitter are at sync frequency. Traces *A* and *B* of Fig. 11-4 show that sync pulses ride on the sawtooth. When oscillator frequency varies there is a time shift of the sawtooth with respect to sync pulses. Then sync pulse peaks at the separated plate and cathode of the phase detector rise or fall on the sawtooth, thus altering relative conductions in the two diodes.

The difference between d-c voltages caused by different conduction currents in resistors *Ra* and *Rb* of Fig. 11-2 appears across resistor *Rc*, and from the top of *Rc* the difference voltage is applied to the first grid of the multivibrator.

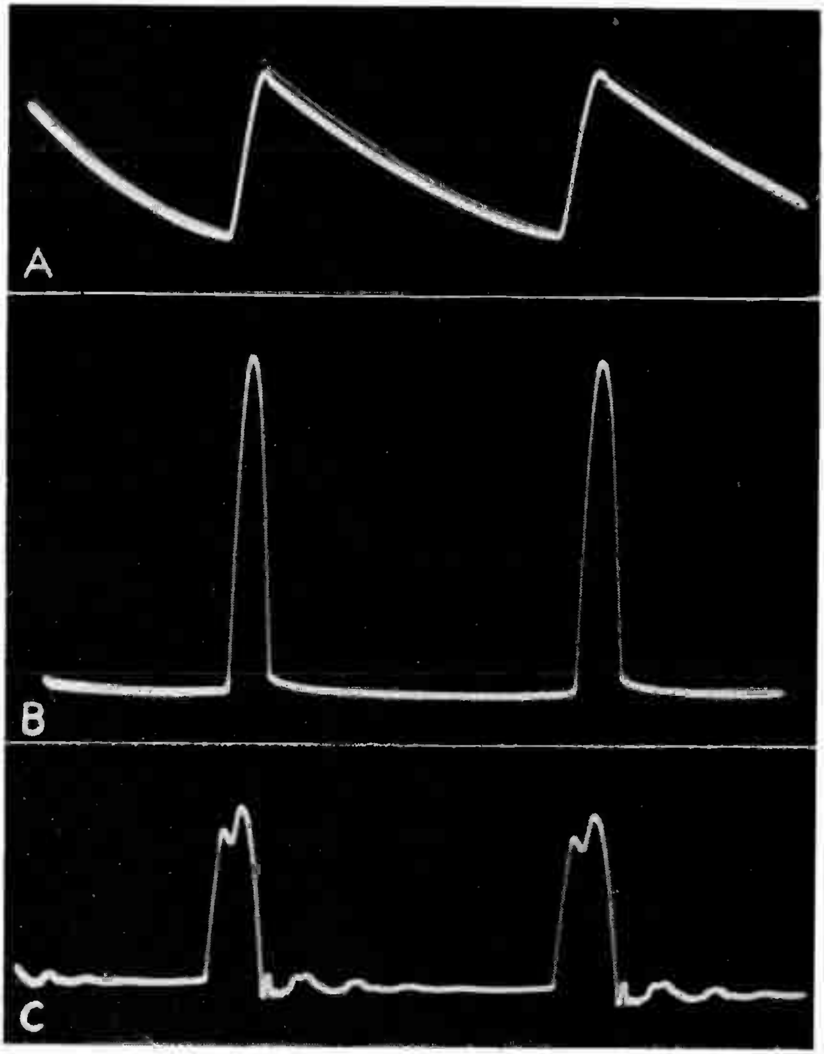


*Fig. 11-5. A, the sawtooth at joined plate and cathode of the phase detector. B and C, positive pulses from which the sawtooth is derived.*

## Multivibrator Action

When multivibrator frequency tends to increase, the feedback sawtooth shifts and causes the net or difference d-c voltage from the phase detector to change in value and to become either more positive or less negative. This change, at the multivibrator grid, lowers the oscillation frequency. Should oscillation frequency tend to decrease, the phase detector output becomes less positive or more negative, and raises the oscillation frequency.

D-c correction voltage at the multivibrator grid may be observed as it undergoes changes of strength by connecting

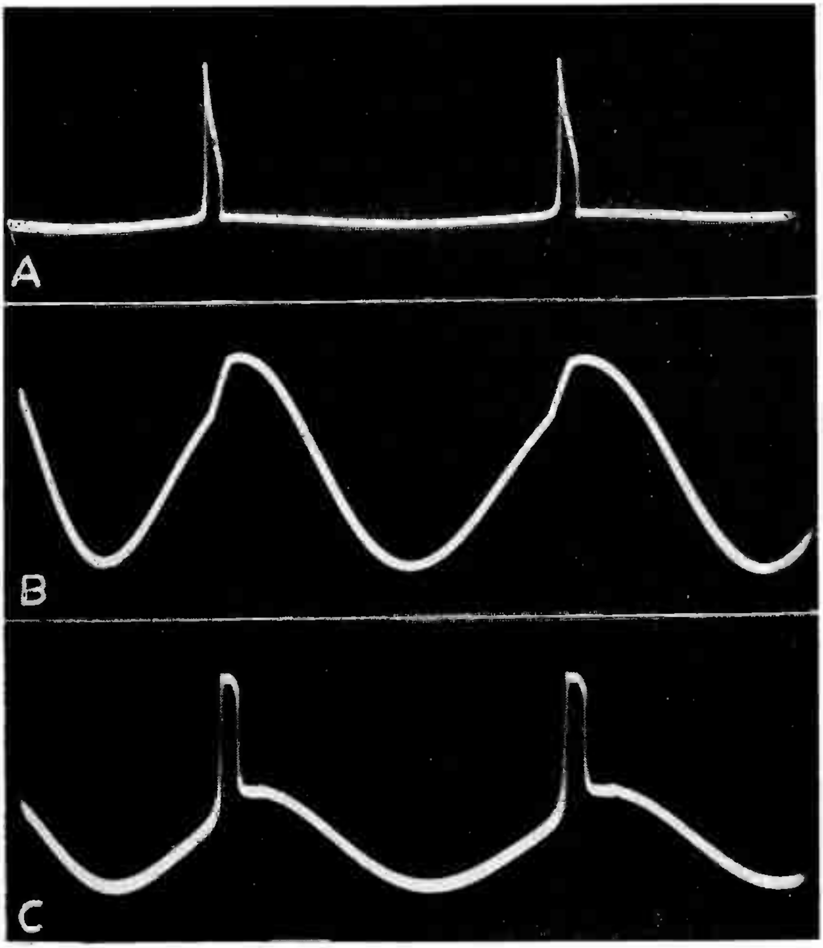


*Fig. 11-6. A, pulses at the multivibrator cathodes. B, approximate sine wave at the high side of the locking control. C, waveform at the first plate of the multivibrator.*

a VTVM, on a low d-c range, from grid to ground. The correction voltage may be made to vary by manipulating the horizontal hold control. This is a common means for determining whether the afc system is operative.

From multivibrator cathodes to ground, across resistor *Rk*, are voltage pulses such as in Fig. 11-6-A. These pulses are produced by discharge of sawtooth capacitor *Cs* through the second section of the multivibrator and the cathode resistor. Since the cathode resistor is part of the plate-cathode circuit of the first section of the multivibrator, corresponding pulses of plate current and voltage appear in this first section.

## Multivibrator Locking Control

Plate current and voltage in the first section of the multivibrator are forced to follow what is essentially a sine waveform by action of the tuned circuit marked *Locking Control* in Fig. 11-2. Other names for this adjustable resonant circuit are stabilizing control, horizontal frequency control, ringing coil, and others.

By means of an adjustable core the coil-capacitor combination is made resonant at or close to the horizontal line frequency, which is 15,750 cycles per second for black-and-white television and of practically this value for color. Voltage at the end of the coil-capacitor combination toward the multivibrator has the form shown at *B* of Fig. 11-6.

Pulses of plate voltage due to the cathode feedback of Fig. 11-6-A combine with the sine wave produced by the locking control to make the plate voltage waveform as at *C*. This waveform goes through capacitor *Cg* of Fig. 11-2 to the grid of the second section of the multivibrator.

## Multivibrator Output

The second grid of the multivibrator is negatively biased by grid-leak action of capacitor. *Gg* and resistor *Rg*. The strong positive pulses at *C* of Fig. 11-6 overcome this bias, make this section of the tube conductive, and allow discharge of sawtooth capacitor *Cs* through the second section and the cathode resistor.

Discharge and charge of the sawtooth capacitor produce at the plate of the second multivibrator section the waveform at *A* of Fig. 11-7. The negative peaking resistor *Rs* in series with capacitor *Cs* causes a negative peak on the discharge side of the sawtooth, as at *B*. This is the waveform at the second plate of the multivibrator. The waveform may have

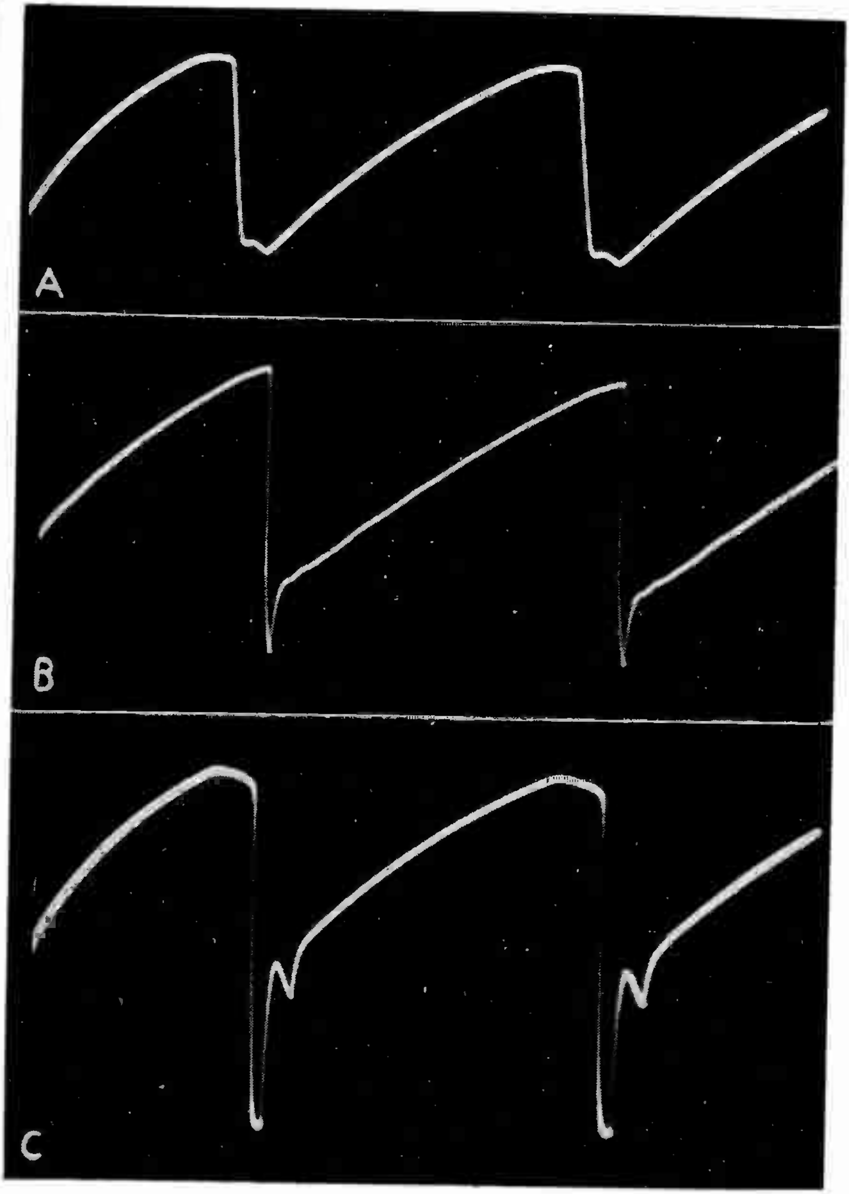


*Fig. 11-7 Sawtooth waves at the discharge or output plate of the multivibrator.*

other shapes, as at *C*, without altering the basic operation of the sweep section or the processes of trouble shooting.

The voltage waveform produced at the second plate of the multivibrator goes to the grid of the horizontal sweep amplifier or output amplifier. It provides the "drive" voltage for that grid.

## Phase Detector Triode With Splitter.

Fig. 11-8 shows typical connections for a triode phase detector used in a circuit which otherwise is similar to that of Fig. 11-2, where the phase detector is a twin diode.

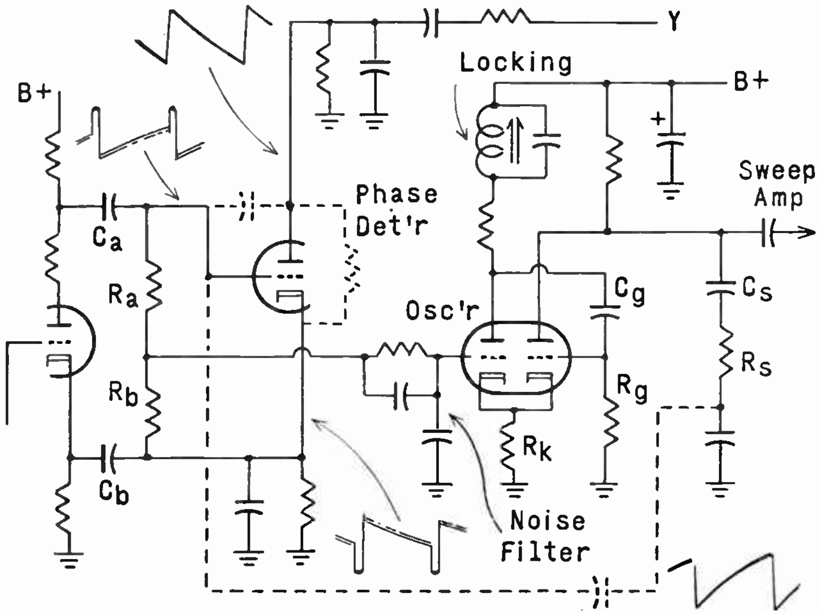


*Fig. 11-8. A triode phase detector fed from a splitter and controlling a multivibrator*

The plate of the triode phase detector acts similarly to the joined cathode-plate of the twin diode. To the triode plate is applied a sawtooth waveform derived from positive pulses beyond the output of the oscillator, usually from horizontal yoke coils or from a tap on the horizontal output transformer or from the damper circuit. This sawtooth is similar to that of Fig. 11-5-A.

The triode grid is connected through capacitor *Ca* to the splitter plate, and acts in much the same way as the twin-diode plate that is similarly connected. The waveform at the triode grid is much like that of Fig. 11-4-A for a diode plate.

The triode cathode is connected through capacitor *Cb* to the splitter cathode, and is comparable in action to the twin-diode cathode that is similarly connected. The waveform at the triode cathode is similar to that of Fig. 11-4-B for a diode cathode.

In addition to the sawtooth voltage applied to the plate of the triode phase detector, sawtooths may be applied to the triode grid and cathode by connections shown in broken lines. There may be a capacitor from triode plate to grid or a resistor from plate to cathode. In quite a few receivers there is applied to the triode grid a sawtooth taken from the low side of the sawtooth capacitor and resistor combination, *Cs* and *Rs*.

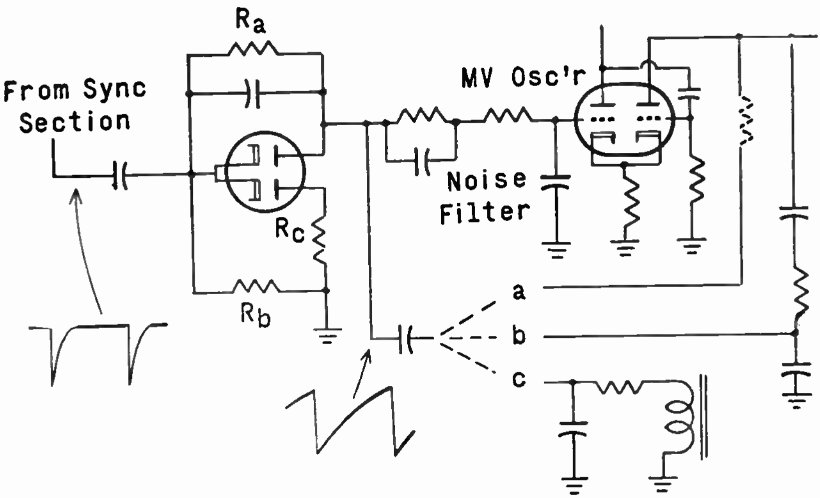


*Fig. 11-9. A twin diode or duo diode phase detector with cathodes tied together.*

A multivibrator circuit which follows the triode phase detector is no different from the multivibrator circuit previously described in connection with Fig. 11-2.

## Phase Detector Diodes Without Splitter

The phase detector of Fig. 11-9 consists of two diodes with their cathodes tied together or of a duo diode section formed by two plates and a cathode for only these plates. When using a duo diode triode tube the triode section often is employed as a sync separator or inverter. A dual selenium rectifier also is suitable and frequently used for this style of phase detector.

To the cathodes are applied negative pulses from a separator or inverter in the sync section. Note that synchronizing pulses are of only one polarity rather than of two opposite polarities as in systems employing a phase splitter. The voltage waveform at the cathodes should be of approximately the shape shown on the diagram.

The sawtooth feedback may be derived from various sources, three of which are shown in Fig. 11-9. At *a* the feedback is from the output plate of the multivibrator, at *b* it is from a point below the sawtooth capacitor and peaking resistor, and at *c* from a small insulated winding on the horizontal output transformer. The waveform should be of the general shape shown on the diagram.

The multivibrator oscillator is like cathode-coupled multivibrators employed with other kinds of phase detectors. Various arrangements of noise filter capacitors and resistors are used.

## Phase Detector Triode Without Splitter

In Fig. 11-10 are shown two methods of using a triode phase detector without a splitter and with only negative pulses from the sync section being applied to the phase detector input. These diagrams include only the phase detector triode at the left and the first or input section of a multivibrator sweep oscillator at the right. The remainder of the multivibrator circuits will be similar to those shown earlier.

D-c correction voltage for the multivibrator is taken from between resistors *Ra* and *Rb,* which may or may not be of equal values. Correction voltage goes through a noise filter to the multivibrator grid. Various styles of noise filters may be used.

In diagram *A* of Fig. 11-10 the sawtooth to the plate of the triode phase detector, which is the afc tube, is from a small auxiliary winding on the horizontal output transformer. In diagram B the sawtooth is derived from pulses at the high side of the horizontal yoke coils or from a tap on the horizontal output transformer or from the damper circuit.

In diagram *B* the phase detector plate is connected through a potentiometer to B+, for making the plate more or less positive within a range of about 5 to 6 volts measured to ground.

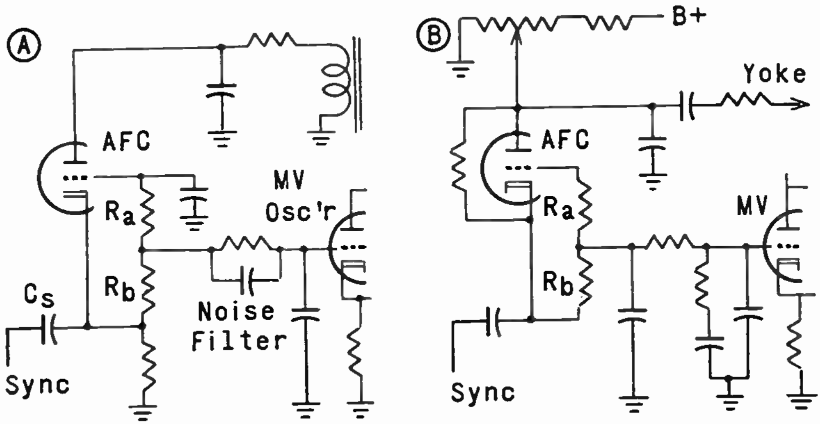


*Fig. 11-10. Triode phase detectors whose d-c correction voltage is taken from resistors between grid and cathode.*

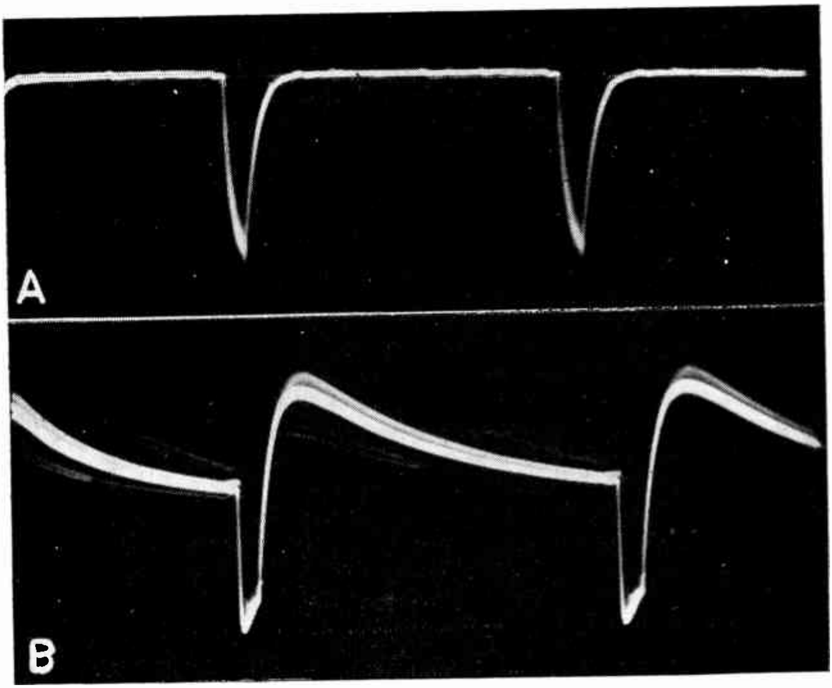


*Fig. 11-11. A, pulses from a sync separator feeding to a triode phase detector, and, B, pulses at the cathode of the phase detector.*

The adjustable potentiometer often is the horizontal hold control. In some sets this B+ connection is a fixed resistor of several megohms.

For a receiver having the connections of Fig. 11-10-A the waveform at the plate of a preceding sync separator connected to capacitor *Cs* appeared as at *A* of Fig. 11-11 (25 volts peak-to-peak) and at the cathode of the phase detector the waveform was as at *B* (17 volts peak-to-peak). This cathode waveform showing negative peaks on a sawtooth is characteristic of nearly all triode phase detectors used without a splitter, and will be present if the sync and afc systems are operating properly. Peak-to-peak voltages vary with the receiver.

At the plate of the triode phase detector the typical sawtooth feedback is as at *A* of Fig. 11-12 (10 volts peak-to-peak).

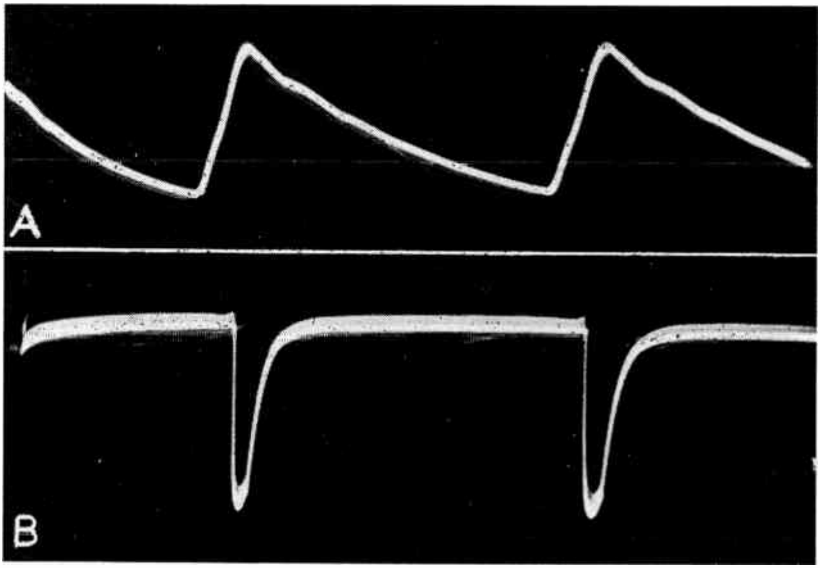


*Fig. 11-12. A, typical sawtooth at the plate of a triode phase detector. B, pulses at the grid of a phase detector in Fig. 11-10-A.*

This waveform is characteristic of all similar triode phase detectors and should be present. Voltage varies with the receiver. At *B* is the waveform observed at the phase detector grid (13 volts peak-to-peak).

For the phase detector connections of Fig. 11-10-B the waveforms are shown by Fig. 11-13. At *A* is the trace observed

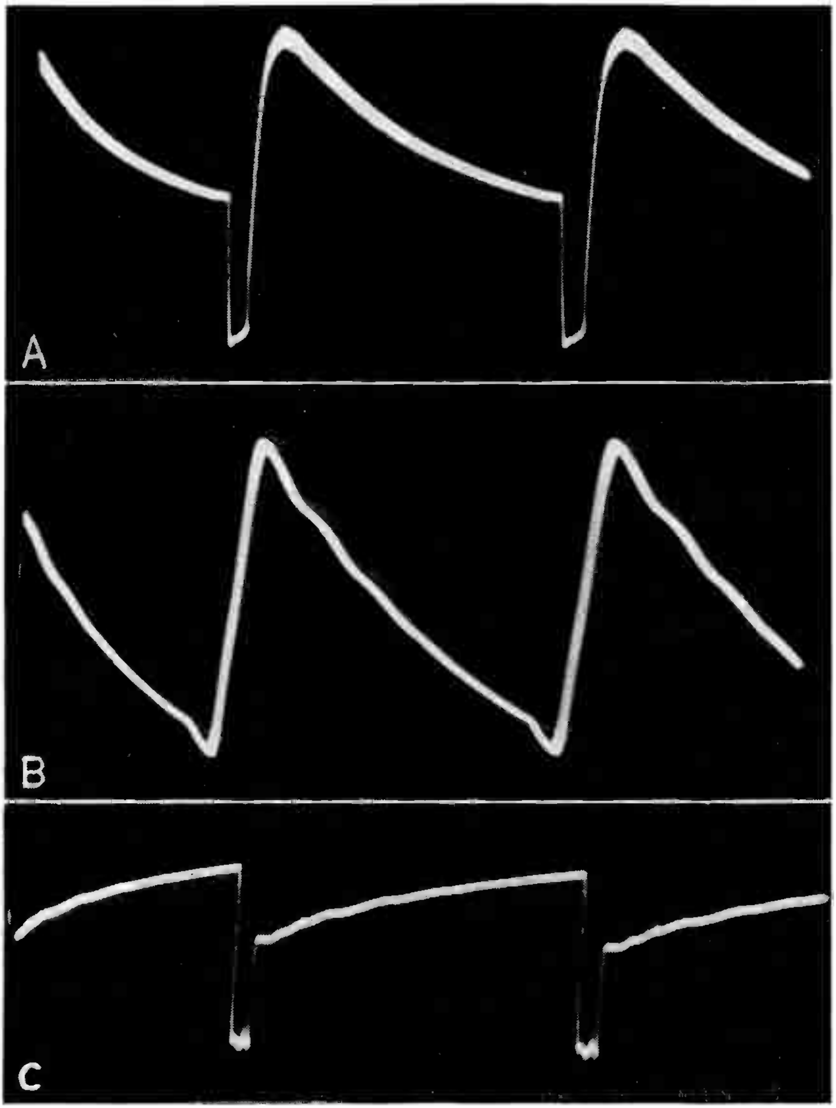


*Fig. 11-13. Waveforms at the elements of the phase detector in Fig. 11-10-B. A, cathode. B, plate. C, grid.*

at the cathode (14 volts peak-to-peak), at *B* is the trace at the plate (12 volts peak-to-peak), and at *C* is the trace from the phase detector grid (only 1.3 volts peak-to-peak). This low grid voltage is because, in the particular system of Fig. 11-10-B, resistor *Rb* is of several hundred times the value of the resistor at *Ra*.

Note the similarity of waveforms at the same triode elements for the two kinds of connections in Fig. 11-10. In all systems using a triode phase detector without a splitter there should be a sawtooth at the detector plate, and at both the cathode and the grid should be negative peaks with or without a sawtooth. In some modifications, to be shown, there will be no observable waveform at the phase detector grid because the d-c correction voltage is taken from this element.

A few modifications of the triode phase detector system of control are illustrated in Fig. 11-14. In diagram *A* the feedback sawtooth for the phase detector plate comes from a winding on the horizontal output transformer. In other cases this sawtooth may be derived from the horizontal yoke or the output transformer. There may or may not be a resistor between plate and cathode of the phase detector. D-c correction voltage for the multivibrator is taken from the phase detector grid. Resistor *Rb* sometimes is adjustable.

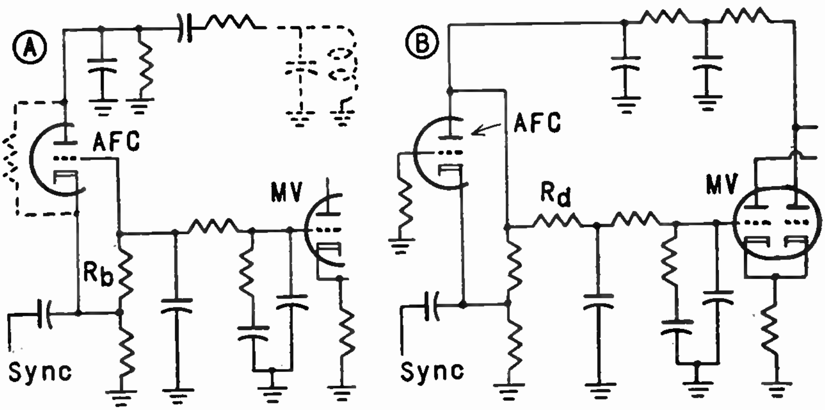


*Fig. 11-14. Triode phase detectors whose d-c correction voltages are taken from the grid (A) and from the plate (B).*

At the phase detector cathode of Fig. 11-14-A should be a sawtooth waveform with negative peaks similar to those of Figs. 11-11-B and 11-13-A. At the plate should be a sawtooth similar to those of Figs. 11-12-A and 11-13-B. No trace can be observed at the grid, which furnishes d-c correction voltage.

In diagram *B* of Fig. 11-14 the feedback sawtooth for the phase detector plate is derived from the second or output plate of the multivibrator oscillator. D-c correction voltage for the first grid of the multivibrator comes from the phase detector plate. The feedback sawtooth is kept from the noise filter and multivibrator input grid by an additional resistor *Rd* of about one megohm.

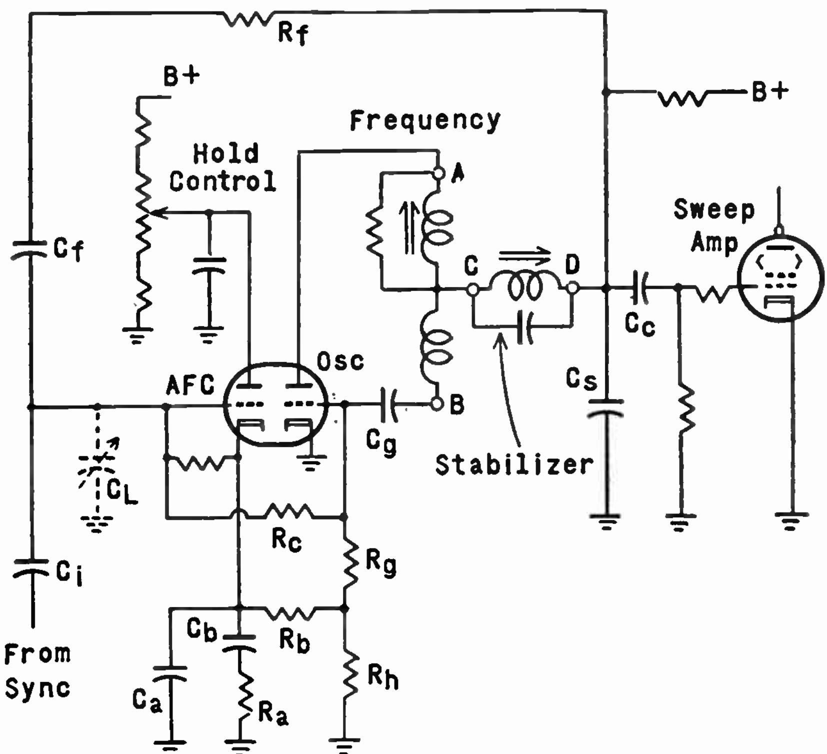


*Fig. 11-15. Typical circuit connections for a pulse width automatic frequency control.*

At the phase detector cathode of Fig. 11-14-B should be the usual sawtooth with negative peaks. At the plate should be a sawtooth without peaks. At the grid may be observed a relatively weak series of negative pulses somewhat like those of Fig. 11-12-B.

## Pulse Width Triode And Blocking Oscillator

Fig. 11-15 shows connections for a commonly used form of variable pulse width (Synchroguide) automatic frequency control with which is used a blocking oscillator with transformer feedback from plate to grid.

To the grid of the afc triode are applied positive pulses through capacitor *Ci* from the sync section. To this grid is applied also, through capacitor *Cf*, a sawtooth wave taken from the oscillator output at point *D*.

Typical synchronizing pulses are shown at *A* of Fig. 11-16 and a feedback sawtooth at *B*. The synchronizing pulses were photographed with the sawtooth disconnected. The sawtooth wave was photographed with the sync input disconnected.

Adjustable capacitor *CL*, when used, is called a locking control. Its chief purpose is compensation for slight differ-

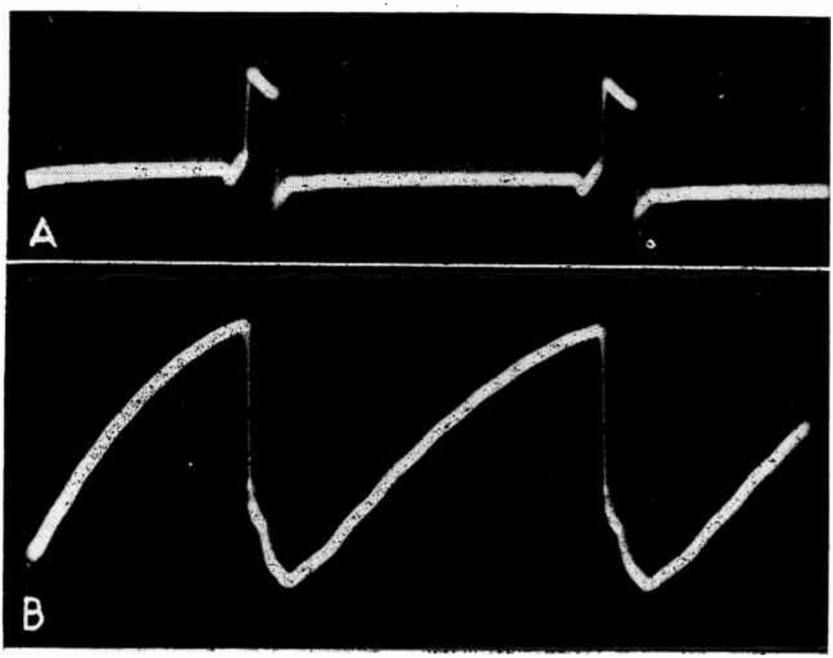


*Fig. 11-16. Input waveforms for the grid of a variable pulse width triode afc tube. A, from the sync section. B, from the oscillator output.*

ences between original and replacement tubes, without having to readjust other controls.

Combined input at the afc grid appears as at *A* of Fig. 11-17, with the sync pulses riding on the sawtooth peaks. This trace and the two of Fig. 11-16 were made without changing the vertical gain of the scope.

The afc grid is negatively biased through resistor *Rc*, from negative voltage at the oscillator grid, to a degree that prevents conduction in the afc triode except during the positive sync peaks that ride the sawtooth. Fig. 11-17-B shows the afc grid waveform from another receiver, illustrating that sync peaks on a sawtooth are characteristic of this type of frequency control.

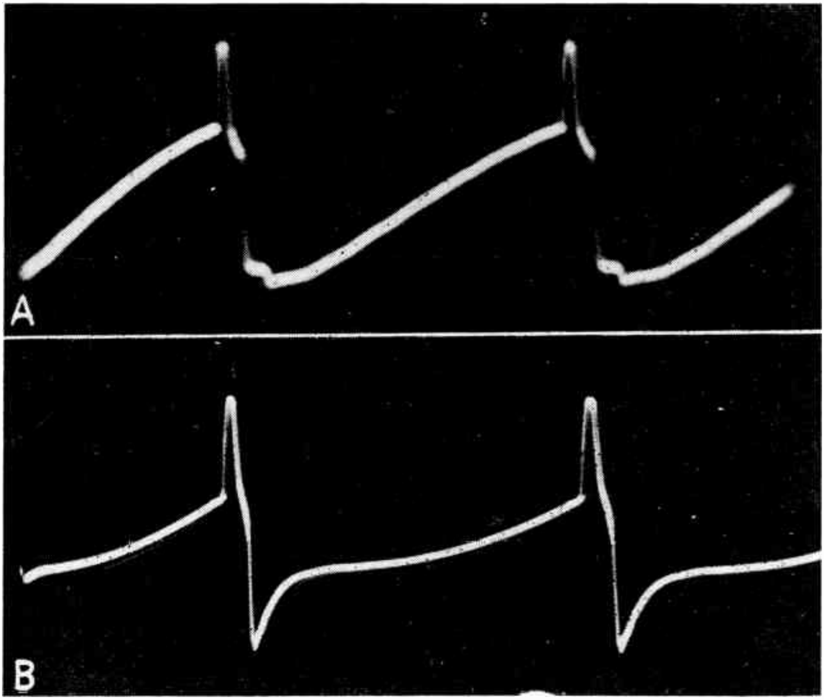


*Fig. 11-17. Waveforms at the grid of pulse width triode afc tubes in two receivers.*

When oscillator frequency tends to vary, the sawtooth peaks shift in their time relation to sync pulses. Then more of less of the wide sync pulses drop into the sawtooth valley with only the remainder staying on top of the sawtooth peak to cause conduction in the afc diode. There is conduction during smaller or greater portions of the sync pulse periods, depending the shift of oscillator frequency.

Conduction during sync pulses causes pulses of cathode *current* in the afc triode as shown at *A* of Fig. 18. These current pulses charge capacitors *Ca* and *Cb*, which discharge

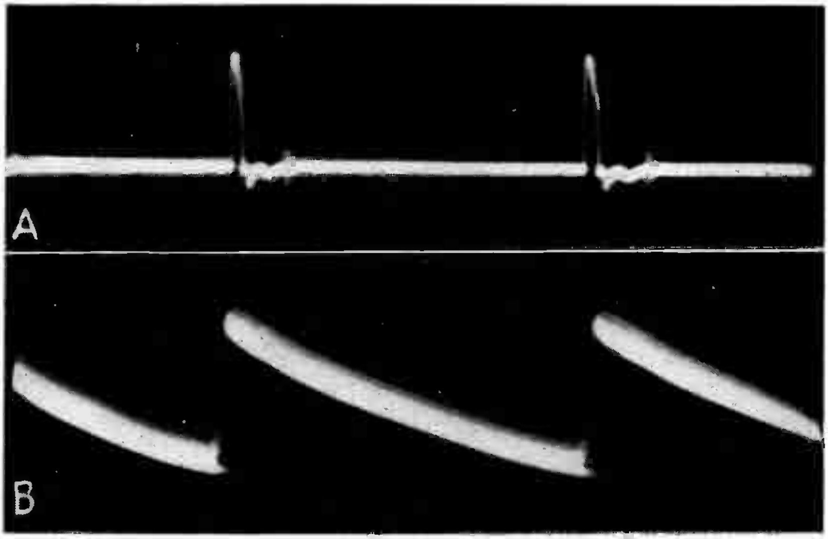


*Fig. 11-18. A, the current waveform at the cathode of the variable pulse width triode. B, voltage waveform at the cathode.*

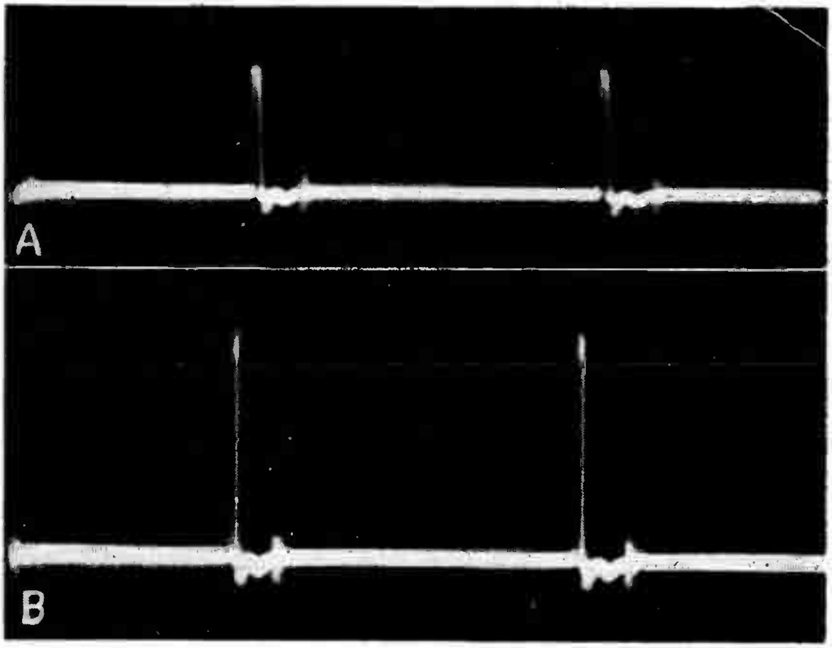


*Fig. 11-19. Increasing plate voltage on the pulse width triode increases the amplitude of cathode current pulses.*

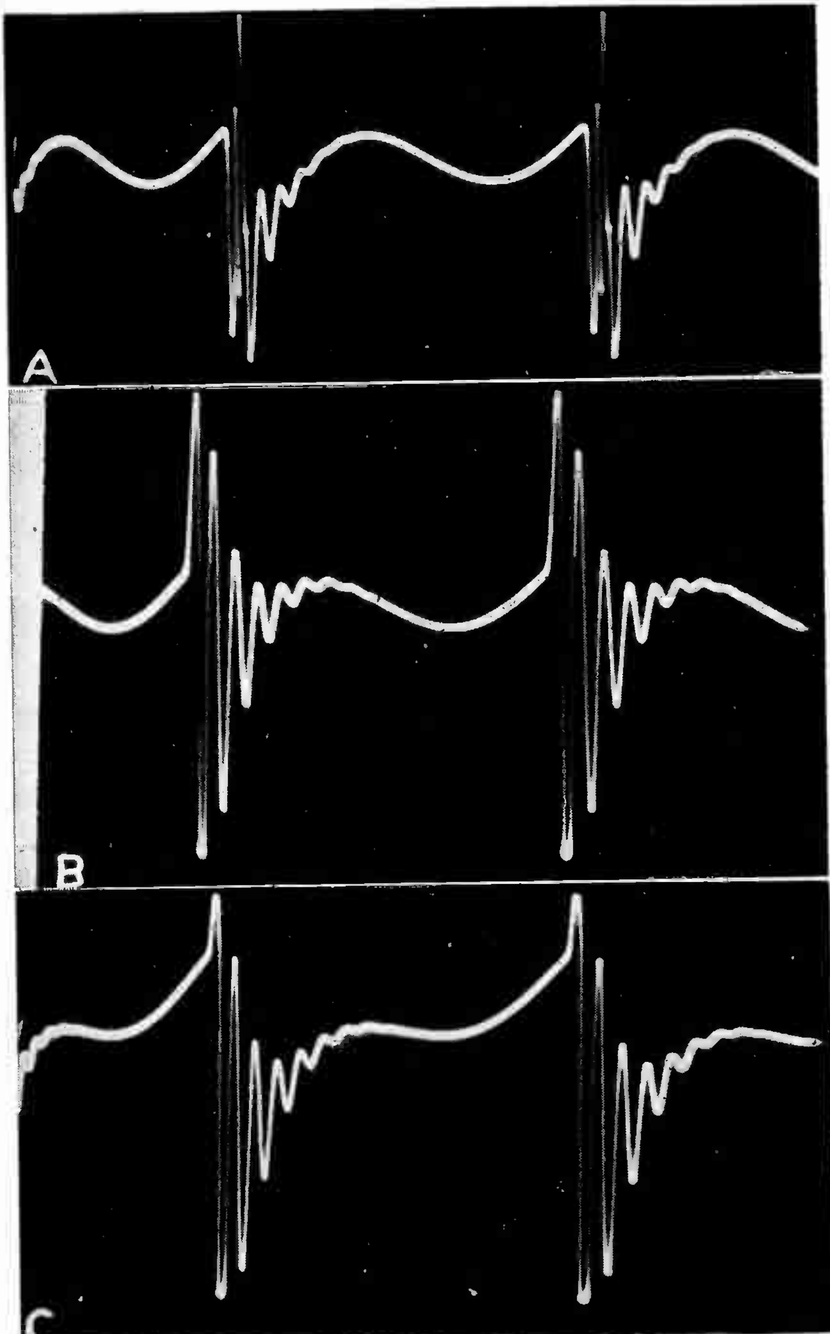


*Fig. 11-20. Waveforms in the blocking oscillator circuit. A, at the plate. B, transformer terminal B. C, the oscillator grid.*

through resistors *Ra, Rb* and *Rh*. The voltage waveform at the afc cathode, *B* of Fig. 11-18, represents charge and partial discharge of the capacitors.

Average voltage on capacitors *Ca* and *Cb* increases with greater conduction in the afc triode, decreases with less conduction. Capacitor voltage applied to the oscillator grid circuit through resistor *Rb* opposes negative grid voltage on the oscillator.

Making the oscillator grid less negative lowers the oscillation frequency. Allowing the oscillator grid to remain more negative raises the frequency. Thus the changes of conduction in the afc triode, due to shift of oscillator frequency and the feedback sawtooth, act on the oscillator grid to correct the frequency shift.

Plate voltage on the afc triode of Fig. 11-15 is adjustable by means of the hold control. Making the plate more positive increases the amplitude of conduction *current* pulses, as from *A* to *B* of Fig. 11-19. This increases the charge on capacitors *Ca* and *Cb* to more strongly oppose, and reduce, negative voltage at the oscillator grid.

At the oscillator plate and terminal *A* of the feedback transformer is the waveform at *A* of Fig. 11-20. The trace at *B* is taken from transformer terminal *B*, and the trace at *C* from the oscillator grid. These three traces are typical of blocking oscillators during normal operation.

Inductance of transformer windings connected between oscillator plate and grid is adjustable by a movable core. Usually this is called the horizontal frequency adjustment. Most often the adjuster is reached from the top of the transformer can or from the end opposite the one carrying terminal lugs.

In Fig. 11-15 is shown a stabilizer adjustment or control unit between tap *C* of the oscillator plate-grid transformer and the lead to the grid of the sweep amplifier. This unit may otherwise be called a waveform control, locking control, or phase adjustment.

The stabilizer coil and capacitor may or may not be in the same can with the feedback transformer. When mounted together the stabilizer adjuster usually is on the same end of the can as the terminal lugs.

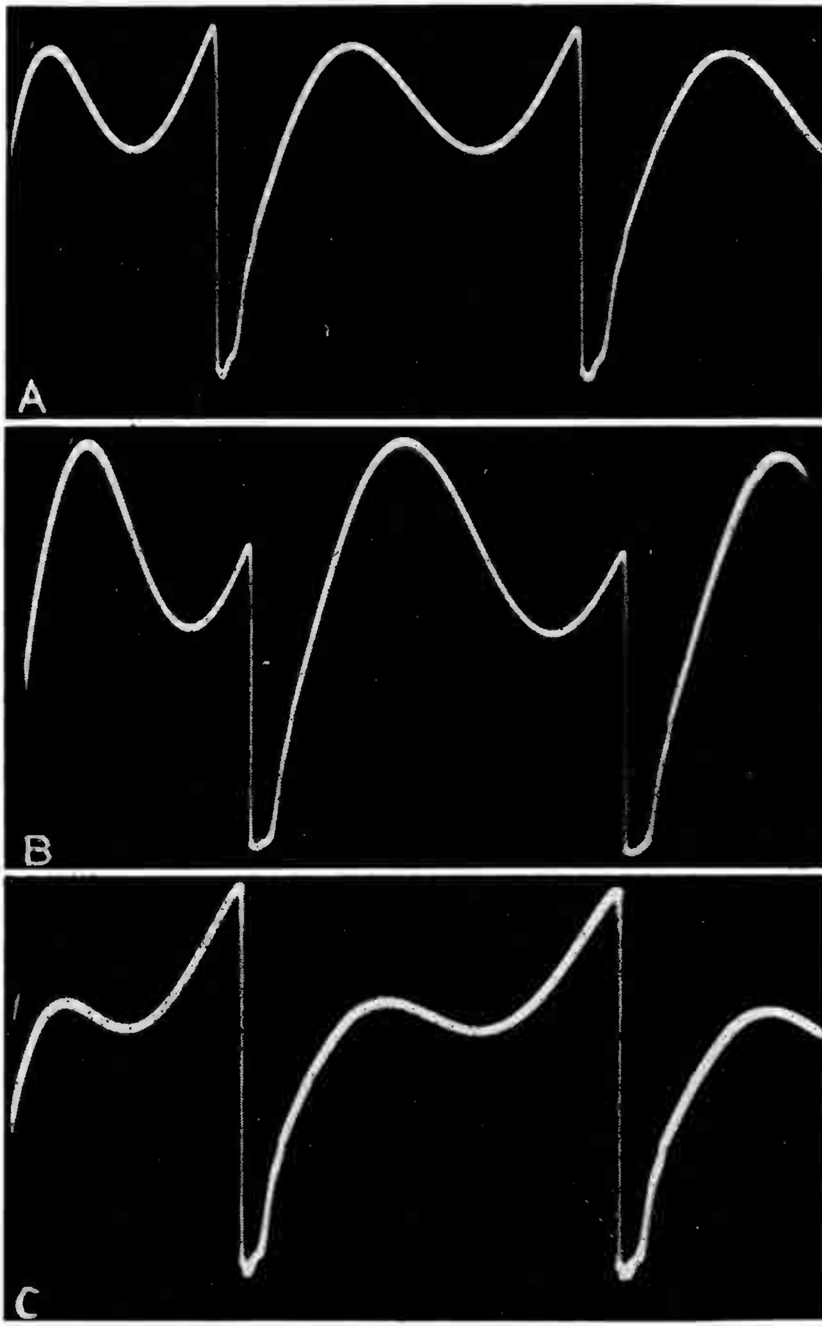


*Fig. 11-21. Effects of stabilizer adjustment on the waveform at terminal C of the blocking oscillator transformer. A, correct adjustment. B and C, incorrect.*

By adjustment of its movable core the stabilizer coil and paralleled capacitor are made resonant at or close to the horizontal line frequency. Then the stabilizer produces a sinewave voltage which adds itself to oscillator plate and grid voltages, as may be seen in Fig. 11-21.

The sinewave effect is seen most clearly with the scope connected to terminal *C* between the feedback transformer and stabilizer coil. When the stabilizer is properly adjusted the sharp peaks will be level with or only slightly higher than the rounded tops, as at *A* of Fig. 11-21. This is the adjustment giving best sync stability.

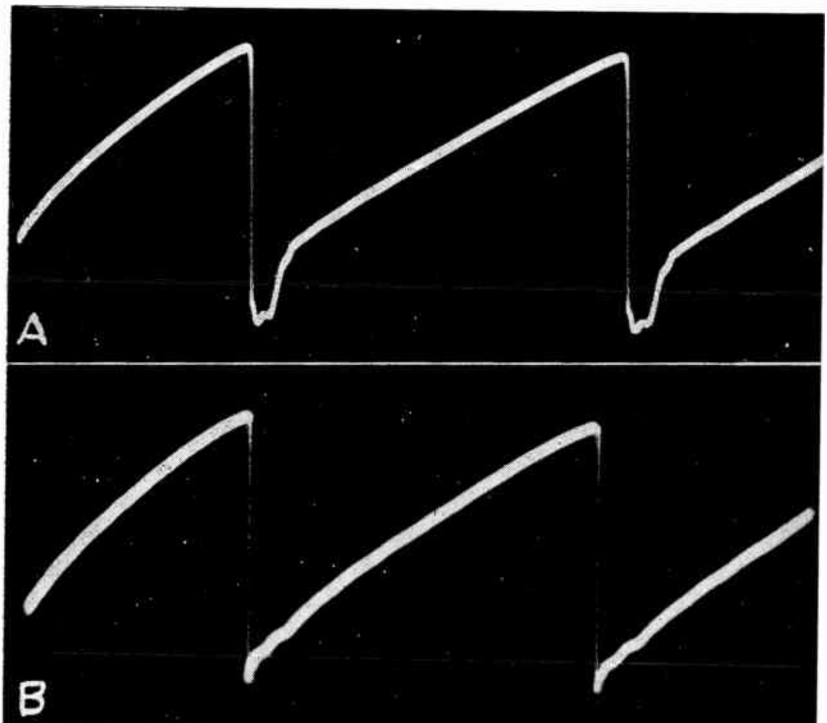


*Fig. 11-22. Sawtooth at the plate of the horizontal oscillator, as fed to the grid of the sweep amplifier.*

If the waveform at terminal *C* appears as at *B* of Fig. 11-21 the core of the stabilizer coil should be turned farther out of the winding, or counterclockwise, to make a correction. If the waveform appears as at *C* the core should be turned farther in or clockwise.

Waveforms observed at terminal *D* of the stabilizer unit or at the grid of the following sweep amplifier in two receivers are shown by Fig. 11-22. Always there must be a sawtooth at this point, and nearly always there will be more or less negative peaking. It is the sawtooth wave from terminal *D* that is sent back to the grid of the afc triode.

In Fig. 11-23 are illustrated some of the variations found in pulse width afc systems with blocking oscillators. These differences do not materially alter the characteristic waveforms

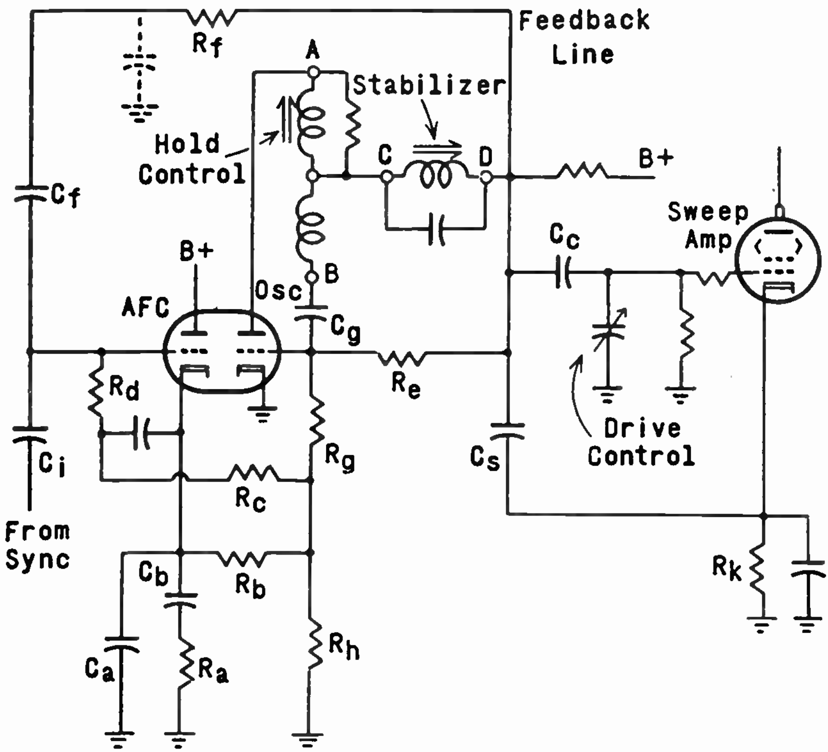


*Fig. 11-23. Modifications in variable pulse width frequency controls with blocking oscillators.*

which have been shown. Principal changes are that the plate of the afc triode here connects directly to a B+ line, with the frequency control or oscillator transformer core being used as the hold control. The stabilizer coil and capacitor may be a separate unit.

## Phase Detector, Reactance Tube, Hartley Oscillator

Fig. 11-24 shows one method of employing a reactance tube for automatic frequency control. Not shown by the diagram is a phase detector, either a triode or twin-diode type, which furnishes a d-c correction voltage to the grid of the reactance tube. This is exactly the same kind of correction voltage furnished to the first grid of a multivibrator oscillator.

The reactance tube, through its plate and cathode connections, is in parallel with or is connected across the tuned inductor $L$ for a Hartley type oscillator.

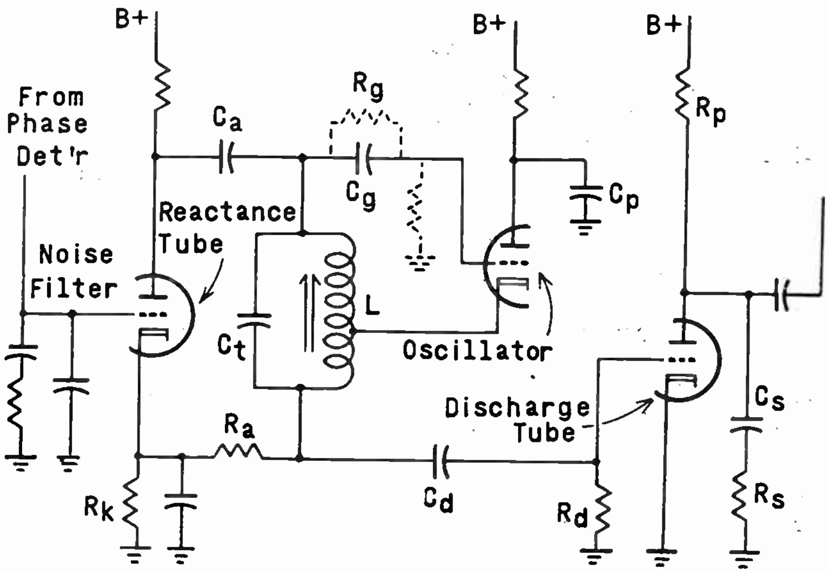


*Fig. 11-24. A reactance tube controls the frequency of a Hartley oscillator. The sawtooth is generated by a separate discharge triode.*

Positive voltage pulses obtained from the oscillator circuit are applied to the grid of a discharge tube. In the plate circuit of the discharge tube is a sawtooth capacitor and negative peaking resistor furnishing a sawtooth waveform to the grid circuit of the following sweep amplifier.

The reactance tube acts like a variable capacitor in parallel with the oscillator tuned circuit or "tank" circuit. The greater the amplitude of alternating voltage produced by the reactance tube the greater is its capacitive effect. Amplitude is increased when the grid of the reactance tube is made less negative, as would be the case were this tube acting as an ordinary amplifier. The reactance grid is negatively biased by resistor *Rk* in the cathode lead.

When oscillator frequency tends to increase, the phase detector puts out a positive correction voltage. This voltage makes the reactance grid less negative, increases the amplitude of alternating reactance voltage, increases effective capacitance across the oscillator tank, and thereby lowers the oscillation frequency.

When oscillator frequency tends to decrease there are opposite actions throughout the system, with lessening of reactive capacitance effect and resulting increase of oscillation frequency.

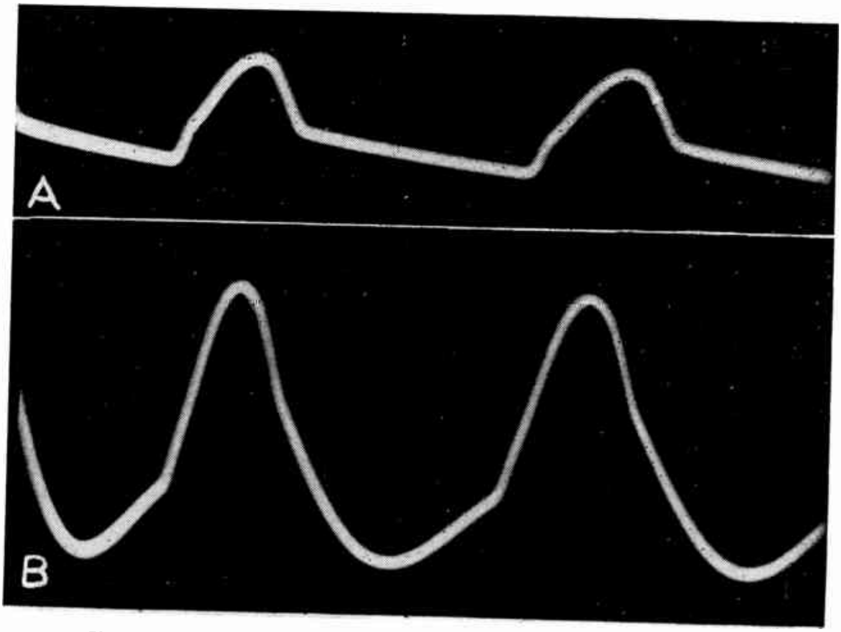


*Fig. 11-25. Waveforms at the reactance tube. A, cathode, B, plate.*

With the circuit of Fig. 11-24 the voltage waveform at the reactance tube cathode is as at *A* of Fig. 11-25 and at the reactance plate is as at *B*. Peak-to-peak voltage at the cathode usually is on the order of one volt, and at the plate may be 150 to 250 volts. This high peak voltage at the plate is due

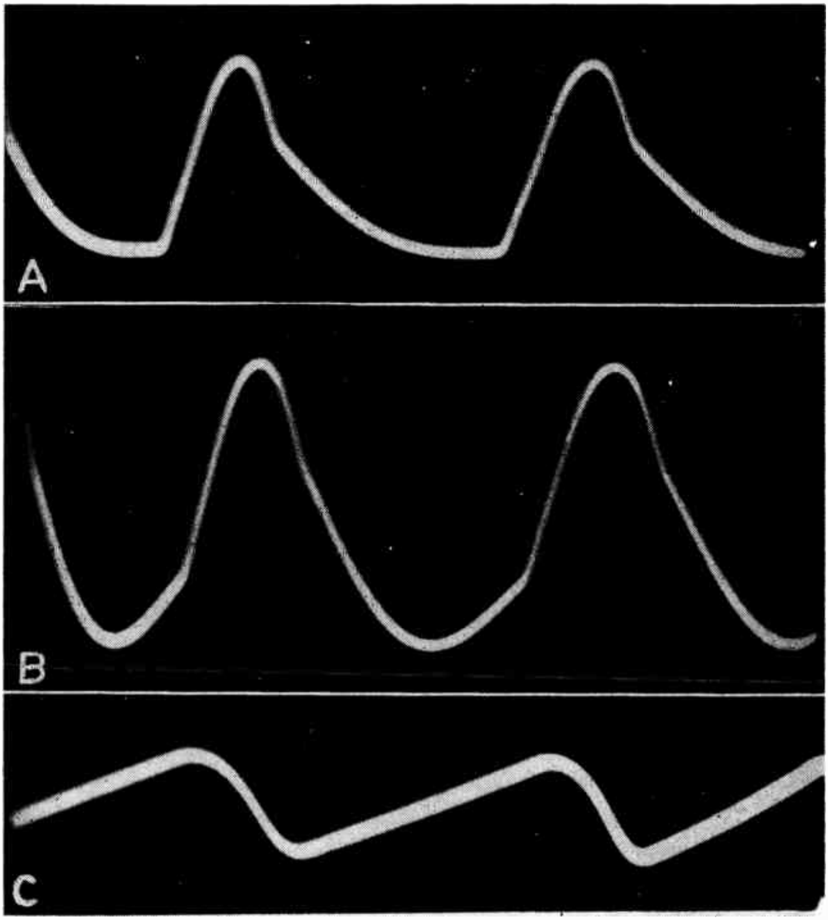


*Fig. 11-26. Waveforms at the Hartley oscillator. A, cathode. B, grid. C, plate.*

only partially to amplification in the reactance tube, part of it comes from the oscillator grid circuit to the reactance plate through capacitor *Ca*.

Fig. 11-26 shows voltage wavefoms at the Hartley oscillator. At *A* is the cathode waveform, 100 to 150 peak-to-peak volts. At *B* is the oscillator grid waveform, around 200 peak-to-peak volts. At *C* is the waveform at the oscillator plate where there are only about 10 peak-to-peak volts for this particular form of Hartley oscillator circuit.

Fig. 11-27-A shows the voltage waveform at the discharge tube grid, usually 80 to 100 peak-to-peak volts. At *B* is the waveform at the discharge tube plate and at the grid of the following sweep amplifier, close to 100 peak-to-peak volts at the plate.

A Hartley oscillator not influenced by voltages in associated circuits produces a sinewave output voltage. In the system illustrated by Fig. 11-24 the oscillator waveform is modified by the closely coupled discharge tube.

The positive pulses at the grid of the discharge tube (Fig. 11-27-A) make this tube conductive for discharging the sawtooth capacitor *Cs* in its plate circuit. The wide negative peaks on the discharge plate waveform (Fig. 11-27-B) are quite characteristic of these reactance tube systems of frequency control.

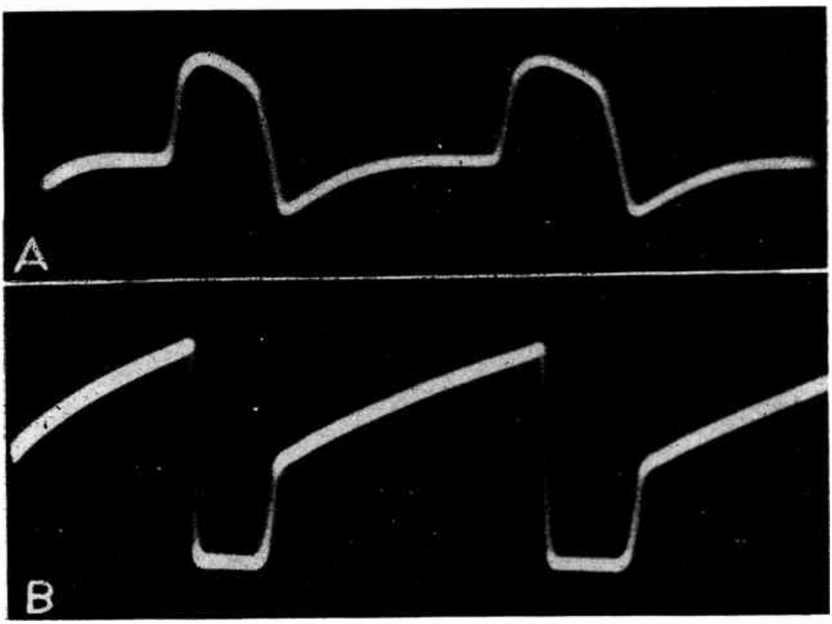


*Fig. 11-27. Waveforms at the discharge tube. A, grid, B, plate.*

The movable core in the oscillator inductor is the principal frequency adjustment, and is used as the horizontal hold control in some sets. In other cases the hold control may be an adjustable resistor from oscillator grid to ground. In still other sets the hold control is an adjustable resistor at *Rp* of Fig. 11-24, in the B+ lead to the discharge tube plate.

### TROUBLE LOCATION

When looking for causes of poor picture reproduction the horizontal sweep section should be thought of as consisting of the parts represented in Fig. 11-28. Accompanying tables listing circuit and component faults, and giving the probable picture symptoms, are based on this chart.

First, there may be faulty input to the afc tube, which may be any type shown in the chart. There are two inputs. One consists of negative pulses or of both positive and negative pulses from the sync section. If connections from sync to afc are good, fautly sync input indicates trouble in the sync section.

The other input to the afc system is a sawtooth derived from the output of the sweep oscillator, and taken from any point between the oscillator and horizontal coils in the yoke. Lack of this sawtooth indicates trouble in the oscillator or units beyond the oscillator.

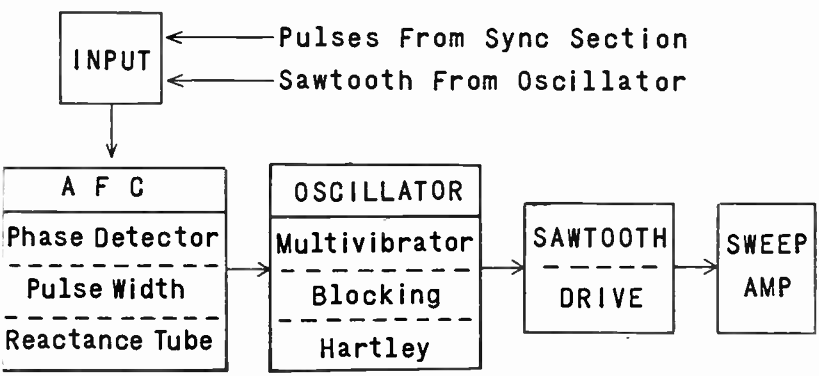


*Fig. 11-28. The trouble shooting tables for horizontal sweep sections are arranged in accordance with this chart.*

Since each type of automatic frequency control is used with a particular kind of oscillator the tables list these two portions of the sweep section together. That is, phase detectors are associated with multivibrator oscillators, pulse width triodes for afc are associated with a blocking oscillator, and a phase detector with reactance tube for afc is associated with a Hartley oscillator and discharge tube.

On the output of the sweep oscillator or discharge tube is a sawtooth capacitor whose rapid discharge and relatively slow recharge produce the sawtooth drive voltage for the following sweep amplifier.

Waveforms shown in preceding pages are characteristic or typical of the various horizontal sweep circuits and components when operating properly. Peak-to-peak voltages will vary with different receivers, but should be within ranges mentioned.

Satisfactory waveforms from the sync input to some certain point in any horizontal sweep section, with unsatisfactory waveforms at points beyond, mean that a fault or faults exist just ahead of the point where waveforms become unsatisfactory.

Examination of the tables shows that a few picture faults are more common than any of the others, and that these common faults usually result from particular circuit troubles. The most common picture faults and the circuits or components most likely to cause them are as follows.

| | |
|---|---|
| 1. Viewing screen dark or brightness lacking. | Oscillator and circuit.<br>Amplifier and circuit.<br>Sawtooth and drive. |
| 2. Sync absent or critical. | Afc tube and circuit.<br>Inputs to afc tube. |
| 3. Width lacking. | Amplifier and circuit.<br>Sawtooth and drive. |
| 4. Folds or split pictures. | Inputs to afc.<br>Oscillator and circuit.<br>Afc tube and circuit. |

## Checking For AFC Operation

The afc system is *not functioning* properly when pictures float to one side or the other, or back and forth, while remaining recognizable and upright, not sloping. Adjustment of a hold control may change the direction of sidewise motion, but will not prevent such motion.

The afc system *is functioning* when the d-c correction voltage varies more or less continually while a TV program is received. Use a VTVM on a low d-c voltage range. Connect the low side of the meter to ground or B-minus and the high side as follows:

**a.** On a multivibrator oscillator to the first or input grid to which connects the noise filter.

**b.** On a pulse width afc triode to the cathode which connects to the filter for correction voltage.

**c.** On a reactance tube to the grid, to which connects the noise filter.

Where the horizontal hold control directly effects oscillator frequency, as in most receivers, varying the hold adjustment will vary the d-c correction voltage at the points mentioned provided the afc system is operating.

## Checking For Oscillator versus Sync Trouble

If the viewing screen shows only sloping lines, wide or narrow, and if hold control adjustment will not produce pictures even momentarily, trouble probably is in the oscillator circuit.

Check for a feedback sawtooth and for synchronizing pulses as follows: Connect the vertical input of the scope to,

**a.** On a twin diode phase detector to the plate and cathode joined together.

**b.** On a triode phase detector to the cathode.

**c.** On a pulse width afc triode to the grid.

If there are sync pulses riding on a sawtooth or approximate sawtooth both the oscillator and the sync section are operative.

If there is only a sawtooth or approximate sawtooth, sync pulses are not reaching the afc tube or are not of correct waveform.

If there are only separated synchronizing pulses, without any sawtooth, the oscillator may be assumed to be in trouble with most types of sweep sections.

## Trouble Location Tables

Faults of circuits and component parts are numbered in the tables. Following the tables are explanatory paragraphs numbered to correspond with numbers in the tables.

Note that the second, third and fourth tables apply in each case to one combination of afc system and oscillator. Obviously, only one of these three tables will be consulted when servicing any one receiver. The first and fifth tables apply to all receivers.

## Notes Relating To Trouble Tables

**6-7.** The two capacitors from plate and cathode of a splitter to a phase detector need not be closely matched in capacitance. Considerable differences do not materially affect sync action.

**8-11.** This is resistor *Rc* of Fig. 11-2, across which appears the correction voltage for a multivibrator.

**12-15.** These are resistors marked *Ra* and *Rb* in Figs. 11-2, 8, 9 and 11. Performance is most satisfactory when the two resistances are matched within 10% plus or minus, and units of this tolerance should be used for replacement.

**17-18.** Pulses from which are derived the feedback sawtooth must be of correct polarity, nearly always positive, and must be of good clean waveform without irregularities or "hash". When there conditions are not obtained there will be shadowy folds moving with movement of objects in pictures.

In the horizontal yoke coils of some receivers there is adjustable direct current for horizontal centering. In this case the pulses for the feedback sawtooth must be taken from a point in the output transformer, damper or yoke circuit that connects to B+. Any other connection usually causes a great deal of hash, critical sync, and shadowy folding.

**34-38.** As a general rule a smaller capacitance to ground requires greater series resistance, and vice versa, in order to preserve good picture quality.

**39.** A tube whose amplifying ability at horizontal line frequency is as little as 50% of normal, for a new tube, usually will operate satisfactorily as a multivibrator. A still weaker tube usually causes loss of brightness before it refuses to oscillate and cause complete failure of high voltage for the picture tube anode.

**42-46.** This is the coupling capacitor from input plate to output or discharge grid of the multivibrator, and is also the capacitor which maintains negative voltage on the discharge grid in connection with the grid resistor or hold control. The capacitor is critical both in value and quality.

| Table 11-A HORIZONTAL SWEEP Inputs To AFC Tube | Bending At Top | Brightness Lacking | Dark, No Raster | Fold, Center | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FROM SYNC SECTION | | | | | | | | | | | | |
| Capacitor (one) In Series | | | | | | | | | | | | |
| 1 Open | | | | | | | | | | • | | |
| 2 Too Small | | | | | | • | | | • | | • | |
| 3 Too great | • | | | | | | | | | | • | |
| 4 Leaky | | • | • | • | | | | | | • | | • |
| 5 Shorted | | | • | | | | | | | | | |
| Capacitors (two) From Splitter | | | | | | | | | | | | |
| 6 Open, too small | | | | | | | | | | • | • | |
| 7 Leaky, shorted | | | • | | | • | | | | • | | |
| Resistor To Ground | | | | | | | | | | | | |
| 8 Open | | | • | | | | | | | | | |
| 9 Too great | | | | | | | | | • | | | |
| 10 Too small | | | | | | | | | | | • | |
| 11 Shorted | | | | | | | | | | • | | |
| Resistors Across Tube Elements | | | | | | | | | | | | |
| 12 Open | • | | | | | | | | | • | • | |
| 13 Too great | | | | | | | | | | • | | |
| 14 Too small | | | | | | • | | | | | | |
| 15 Shorted | • | | | | | • | | • | | • | | |
| Connections From Splitter | | | | | | | | | | | | |
| 16 Reversed | | | | | | • | | | • | | | |

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**Table 11-A**

**HORIZONTAL SWEEP**
**Inputs To AFC Tube**

| | Bending At Top | Brightness Lacking | Dark, No Raster | Fold, Center | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FROM OSC. (OR SWEEP) OUTPUT | | | | | | | | | | | | |
| Capacitor In Series | | | | | | | | | | | | |
| 17 Open | | | | | | • | | • | • | • | • | |
| 18 Leaky, shorted | | | • | | | | | | | • | | |
| Capacitor To Ground | | | | | | | | | | | | |
| 19 Open | | | | | | | • | | | • | | |
| 20 Too small | | | | | | | | | | | • | |
| 21 Too great | | | | | | | | | | • | | |
| 22 Leaky, shorted | | | | | | • | | • | | • | | |
| Resistor In Series | | | | | | | | | | | | |
| 23 Open | | | | | | • | | • | | • | • | |
| 24 Too great | | | | | | | | • | | • | • | |
| 25 Too small | | • | | | • | | | | | • | | |
| 26 Shorted | | • | • | | • | | | | | | | |
| Resistor To Ground | | | | | | | | | | | | |
| 27 Open | | | | | | | | • | | | • | |
| 28 Too great | | | | | | | | • | | | | |
| 29 Too small, shorted | | | | | | | | | | • | | |

**52-53.** Do not fail to check the condition of a hold control potentiometer. A resistance element that is rough from long use will cause much trouble.

**56.** A generally satisfactory method of adjusting the locking control for a multivibrator oscillator is as follows:

**a.** Tune in a program, to make sure it can be done, and let the set warm up for at least 10 minutes. Long warmup is important when some or all of the tubes have seen long use.

**b.** Set the operator's hold control, if other than the locking adjustment, at its mid-position. Some sets have an adjustable

**Table 11-B**

**HORIZONTAL SWEEP**
**Phase Detector AFC and Multivibrator**

| | Bending At Top | Bright Line, Vertical | Brightness Excessive | Brightness Lacking | Dark, No Raster | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Wavy, All Over Or Top | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PHASE DETECTOR | | | | | | | | | | | | | | |
| 30 Weak, defective | | | | | | | ● | | ● | ● | ● | ● | | |
| 31 Leaky, heater to any element | | | | | | | | | | | ● | | ● | |
| NOISE FILTER | | | | | | | | | | | | | | |
| Capacitor In Series | | | | | | | | | | | | | | |
| 32 Wrong Value | | | | | | | | | ● | | | ● | | |
| 33 Shorted | ● | | | | | | | | | | | | | |
| Capacitor To Ground | | | | | | | | | | | | | | |
| 34 Too small, open | | | | | | | | | | | ● | | | |
| 35 Too great | | | | | | | | | ● | | | | | |
| 36 Leaky, shorted | | | | | | | | | | ● | ● | ● | | |
| Resistor In Series | | | | | | | | | | | | | | |
| 37 Too great, open | | | | | | ● | ● | | ● | | | ● | | |
| 38 Too small, shorted | ● | | | | | | | | | | | | | |
| OSCILLATOR TUBE AND CIRCUIT | | | | | | | | | | | | | | |
| 39 Tube weak, defective | | | | | | ● | ● | | | | | | | ● |
| 40 Plate voltage low | | | | | | ● | ● | | | | | | | ● |
| 41 Cathode-heater leak | | | | | | ● | ● | | | | | ● | ● | ● |
| Capacitor, Plate To Grid | | | | | | | | | | | | | | |
| 42 Open | | | | | ● | | | | | | | | | |
| 43 Too small | | | | | | | | | | | ● | | | |
| 44 Too great | | | | | ● | | | ● | | | ● | | | |
| 45 Leaky | | | | | | ● | | ● | | | ● | ● | | ● |
| 46 Shorted | | | | | ● | | | | | | | | | |

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**Table 11-B**

**HORIZONTAL SWEEP**
**Phase Detector AFC and Multivibrator**

| | Bending At Top<br>Bright Line, Vertical | Brightness Excessive<br>Brightness Lacking | Dark, No Raster<br>Fold, Side | Fold, Shadowy<br>Fuzzy Pictures | Jitter Or Jumping<br>Split, Left-right | Sync Absent<br>Sync Critical | Wavy, All Over Or Top<br>Width Lacking |
|---|---|---|---|---|---|---|---|
| **Cathode Resistor** | | | | | | | |
| 47 Open | | | ● | | | | |
| 48 Too great | | ● | | ● | | ● | ● |
| 49 Too small | ● | ● | ● | | | | |
| 50 Shorted | | | ● | | | | |
| **Cathode Bypass Capacitor** | | | | | | | |
| 51 Leaky, shorted | | | ● | | | | |
| **Hold Control Resistance** | | | | | | | |
| 52 Open | | | ● | | | | |
| 53 Too great | | | | | | ● | |
| 54 Too small | | | | | | ● | |
| 55 Shorted | | | ● | | | | |
| **LOCKING CONTROL (Stabilizer)** | | | | | | | |
| 56 Misadjusted | | | | ● | | ● ● | |
| 57 Coil winding open | | | ● | | | | |
| **Capacitor In Parallel** | | | | | | | |
| 58 Open | | | ● | | | ● | |
| 59 Wrong value | | | | | | ● | |
| 60 Leaky, shorted | | | ● | | | | |
| **Resistor To Osc. Plate** | | | | | | | |
| 61 Open | | | ● | | | | |
| 62 Too great | ● | ● | | | | ● ● | |
| 63 Too small | | ● | | | | ● ● | |
| 64 Shorted | | | ● | | | | |

(service) resistor in series with the operator's control. Set both resistances at their middle values, approximately.

**c.** Adjust the frequency control if this is necessary to bring pictures into sync.

**d.** Switch to an idle channel and back to the active channel.

**e.** If pictures do not pull into sync, adjust the frequency control until they just pull in, then continue the adjustment in the same direction for about an additional quarter turn.

**f.** Switch to an idle channel and back again.

**g.** Continue adjustment of the frequency control until pictures pull into sync, when switching from idle to active channels, with the operator's hold control moved as far as possible each way from its mid-position. An adjustable resistor in series with the operator's hold control may be set to obtain satisfactory pull-in without continued adjustment of the frequency control.

**59.** A paper capacitor in parallel with the locking control coil may measure correct capacitance when cold, but may alter its capacitance enough to prevent resonance after warmup. This calls for readjustment of the hold control after the set has operated for a short time. A negative temperature coefficient (NTC) capacitor of any type and of correct value will correct this trouble.

**62-63.** The value of the resistor between the locking control and multivibrator plate is rather critical in most sets. Varying this resistance will cause considerable change of oscillator frequency and difficulty with synchronization.

**67-68.** In Fig. 11-23 this is the capacitor from the bottom of resistor *Rd* to the afc cathode.

**69-70.** In Fig. 11-23 this is resistor *Rd*.

**71.** In Fig. 11-15 this adjustable capacitor is marked *CL*. There may be a fixed capacitor in series. The locking capacitor is not found in all sets using pulse width afc. When not used or disconnected, its effect usually may be compensated for by readjustment of the frequency control.

**Table 11-C**

**HORIZONTAL SWEEP**
**Pulse Width AFC and Blocking Oscillator**

| Table 11-C HORIZONTAL SWEEP Pulse Width AFC and Blocking Oscillator | Bending At Top | Brightness Lacking | Dark, No Raster | Fold, Center | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Wavy, All Over Or Top | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFC TRIODE AND CIRCUIT | | | | | | | | | | | | | | |
| 65 Tube weak, defective | | | | | | ● | | | | ● | ● | | | |
| 66 Cathode-heater leak | | | | | | | | | | ● | | | | |
| Grid Circuit | | | | | | | | | | | | | | |
| 67 Grid-cath cap'r leaky | | | | ● | | | | | | ● | | | | |
| 68 Grid-cath cap'r shorted | | | ● | | | | | | | | | | | |
| 69 Resistor open, too great | | | | | | | | ● | | ● | | | | |
| 70 Resistor small, shorted | | | | | | | | | | ● | | | | |
| 71 Locking capacitor shorted | | | | | | | | | | ● | | | | |
| Plate, Or Hold Control | | | | | | | | | | | | | | |
| 72 Voltage low, zero | | | | | | | | | | ● | | | | |
| 73 Voltage too high | | | | | | | | | | ● | | ● | | |
| 74 Bypass cap'r open | | | | | | | | ● | | | | | | |
| 75 Bypass cap'r leaky, shorted | | | | | | | | | | ● | | | | |
| FILTER FOR CORRECTION VOLTAGE | | | | | | | | | | | | | | |
| Capacitor To Ground | | | | | | | | | | | | | | |
| 76 Open, too small | | | | | | | | ● | | ● | | | | |
| 77 Too great | | | | | | ● | | | ● | ● | ● | | | |
| 78 Leaky, shorted | | | | | | | | | | ● | | | | |
| Capacitor-Resistor To Ground | | | | | | | | | | | | | | |
| 79 Capacitor open, small | | | | | | | | | | | | ● | | |
| 80 Capacitor leaky, shorted | | | | | | | | | | ● | | | | |
| 81 Resistor open, too great | ● | | | | | | | | | | | ● | | |
| 82 Resistor shorted | | | | | | | | | | | ● | | | |

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**Table 11-C**

**HORIZONTAL SWEEP Pulse Width AFC and Blocking Oscillator**

| | Bending At Top | Brightness Lacking | Dark, No Raster | Fold, Center | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Wavy, All Over Or Top | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resistor To Osc. Grid Line** | | | | | | | | | | | | | | |
| 83 Open | | | | | ● | | | | | ● | | | | |
| 84 Too great | | | | | | | | | | | ● | | | |
| 85 Too small | | | | ● | ● | | | | | | ● | | | |
| 86 Shorted | | | ● | | | | | | | | | | | |
| **OSCILLATOR TUBE AND CIRCUIT** | | | | | | | | | | | | | | |
| 87 Tube weak, defective | | ● | ● | | | | ● | | | | | | | |
| 88 Plate voltage zero | | | ● | | | | | | | | | | | |
| 89 Plate voltage too low | | ● | ● | | | | | | | | | | | ● |
| 90 Plate voltage too high | | | ● | | | | | | | | | | | |
| **Resistor, Grid To Ground** | | | | | | | | | | | | | | |
| 91 Open | | | ● | | ● | | | | | | | | | |
| 92 Shorted | | ● | | ● | | | ● | | | ● | | | | ● |
| **Resistor, To Stabilizer "D"** | | | | | | | | | | | | | | |
| 93 Open | | | | | ● | | | | | | | | | |
| 94 Too small | | | | ● | | | | | | | | | | |
| 95 Shorted | | | ● | | | | | | | | | | | |
| **Capacitor, Grid To Freq. Coil** | | | | | | | | | | | | | | |
| 96 Open | | | ● | | | | | | | | | | | |
| 97 Too small | | | | ● | | | | | | ● | | | | ● |
| 98 Too great | | | | | ● | | | | | ● | | | | |
| 99 Leaky, shorted | | | ● | ● | | | | | | ● | | | | |

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**Table 11-C**

**HORIZONTAL SWEEP Pulse Width AFC and Blocking Oscillator**

| | Bending At Top Brightness Lacking | Dark, No Raster Fold, Center | Fold, Side Fold, Shadowy | Fuzzy Pictures Jitter Or Jumping | Split, Left-right Sync Absent | Sync Critical Wavy, All Over Or Top | Width Excessive Width Lacking |
|---|---|---|---|---|---|---|---|
| Frequency (Or Hold) Control | | | | | | | |
| 100 Misadjusted | | | | | ● | ● | |
| 101 Resistor open | | | | | | | |
| 102 Resistor too great | | | | | ● | ● | |
| 103 Resistor too small | | | ● | ● | | | |
| 104 Resistor shorted | | ● | | | | | |
| Stabilizer Control | | | | | | | |
| 105 Misadjusted | | ● | | | ● | ● | |
| 106 Capacitor open | | ● | | | | | |
| 107 Capacitor too small | | | ● | | ● | | |
| 108 Capacitor leaky, large | | | ● | | | | |
| 109 Capacitor shorted | | | | | | ● | ● |

**72-73.** These faults apply to hold control resistances which vary the plate voltage of the afc triode. They apply also to plate voltage of the afc triode where the hold control function is performed by adjustment of the frequency control in the oscillator plate circuit, as in Fig. 11-23.

Excessive voltage on the plate of the afc triode will, in some sets, cause small vertical waves to appear all over the top quarter of the viewing screen.

**76-86.** In Figs. 11-15 and 11-23 the filter for d-c correction voltage consists of capacitors *Ca* and *Cb*, and resistor *Ra*.

**83-86.** In Figs. 11-15 and 11-23 this is resistor *Rb* through which d-c correction voltage from the afc system is applied to the oscillator grid circuit. The ascillator grid circuit includes resistor *Rg* and *Rh*.

**87.** The blocking oscillator tube must be in fairly good condition to have satisfactory operation. A tube which tests as low

| **Table 11-D**<br>**HORIZONTAL SWEEP**<br>**Reactance Tube AFC and Hartley Oscillator** | Brightness Excessive | Brightness Lacking | Dark, No Raster | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Wavy, All Over Or Top | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REACTANCE TUBE AND CIRCUIT | | | | | | | | | | | | | |
| 110 Tube weak, defective | | | | | | | | | ● | ● | | | |
| 111 Plate voltage low | | | | | ● | | | ● | ● | | | | |
| 112 Plate voltage zero | | | | | | | | | ● | | | | |
| 113 Cathode-heater leak | | | | | | | | | ● | | ● | | |
| 114 Grid line open | | | | | | | | | ● | | | | |
| 115 Grid line grounded | | | | | | | | | ● | | | | |
| Capacitor, Plate To Tank | | | | | | | | | | | | | |
| 116 Open | | | | | | | | | ● | | | | |
| 117 Too small | | | | | | | ● | | ● | | | | |
| 118 Too great | | | | | | | | ● | ● | | | | |
| 119 Leaky | | | | ● | ● | | | | ● | | ● | | |
| 120 Shorted | | | | | | | | | ● | | | | |
| Resistor, Cathode To Tank | | | | | | | | | | | | | |
| 121 Open | | | ● | | | | | | | | | | |
| 122 Too great | | | ● | | ● | | | ● | ● | | | | |
| 123 Too small | | | ● | | | | | | | | | ● | |
| 124 Shorted | | | ● | | | | | | | | | | |
| Resistor, Cathode To Ground | | | | | | | | | | | | | |
| 125 Open | | | ● | | | | | | | | | | |
| 126 Too great | | ● | | | | | | | ● | | | | |
| 127 Too small, shorted | | ● | | | | | | | ● | | | | |
| Capacitor, Cathode Bypass | | | | | | | | | | | | | |
| 128 Open | | | | | | | ● | | ● | | | | |
| 129 Too small | | | | | | | | | ● | | | | |
| 130 Leaky, shorted | | ● | | | | | | | ● | | | | |

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**Table 11-D**

**HORIZONTAL SWEEP**
**Reactance Tube AFC and Hartley Oscillator**

| | Brightness Excessive / Brightness Lacking | Dark, No Raster / Fold, Side | Fold, Shadowy / Fuzzy Pictures | Jitter Or Jumping / Split, Left-right | Sync Absent / Sync Critical | Wavy, All Over Or Top / Width Excessive / Width Lacking |
|---|---|---|---|---|---|---|
| **OSCILLATOR TUBE AND CIRCUIT** | | | | | | |
| 131 Tube weak, defective | ● | ● | | | | |
| 132 Plate voltage low, zero | ● | ● | | | | |
| 133 Cathode-heater leak | ● | ● | | ● | | |
| 134 Inductor misadjusted | ● | | | | ● ● | |
| **Grid Capacitor** | | | | | | |
| 135 Open | | ● | | | | |
| 136 Too small | ● | ● | | | | |
| 137 Too great | | | | | ● | |
| 138 Leaky | ● | ● | | | | |
| 139 Shorted | | ● | | | | |
| **Grid Resistor** | | | | | | |
| 140 Too great, open | | | | | ● | |
| 141 Too small | ● | | | | | ● |
| 142 Shorted | | ● | | | | |
| **Plate To Ground Capacitor** | | | | | | |
| 143 Open | | ● | | | | |
| 144 Too small | | | ● | | ● | |
| 145 Leaky | ● | ● | | | | |
| 146 Shorted | | ● | | | | |
| **DISCHARGE TUBE AND CIRCUIT** | | | | | | |
| 147 Tube weak, defective | ● | ● | | | | |
| 148 Plate voltage zero | | ● | | | | |
| 149 Plate voltage low | ● | | | | | ● |
| 150 Plate voltage high | ● | | | | | ● |

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| Table 11-D HORIZONTAL SWEEP Reactance Tube AFC and Hartley Oscillator | Brightness Excessive | Brightness Lacking | Dark, No Raster | Fold, Side | Fold, Shadowy | Fuzzy Pictures | Jitter Or Jumping | Split, Left-right | Sync Absent | Sync Critical | Wavy, All Over Or Top | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capacitor From Osc. Tank** | | | | | | | | | | | | | |
| 151 Open | | | ● | | | | | | | | | | |
| 152 Too small | | ● | | | | ● | | | | | | | |
| 153 Leaky, shorted | | ● | ● | | | | | | | | | | |
| **Grid Resistor** | | | | | | | | | | | | | |
| 154 Open | | | ● | | | | | | | | | | |
| 155 Too great | | | | | | | | | ● | | | ● | |
| 156 Too small | | | ● | ● | ● | | | | ● | | | | |
| 157 Shorted | | | ● | | | | | | | | | | |

as 70% to 75% of normal amplifying ability usually causes no trouble. At 50% of normal performance there still may be oscillation, but picture tube anode voltage will be low and there will be lack of brightness.

**93-95.** In Fig. 11-23 this is resistor *Re*. The principal effect of excessive resistance or an open circuit at this point is horizontal folding.

**96-99.** In Figs. 11-15 and 11-23 this is capacitor *Rg*. It carries alternating feedback voltage from oscillator plate to grid, and blocks B+ voltage at the plate from the grid.

**100** and **105.** A satisfactory method for adjusting the frequency and stabilizer controls is as follows.

**a.** Short out the stabilizer by connecting a jumper between terminals *C* and *D*.

**b.** If there is a horizontal hold control on the plate of the afc triode set this control for maximum positive voltage on the plate, usually by turning the control clockwise.

**c.** Tune in a program and allow the receiver to warm up very thoroughly.

| **Table 11-E** **HORIZONTAL SWEEP** **Oscillator and Amplifier Tubes** | Bright Line, Vertical | Brightness Excessive | Brightness Lacking | Dark, No Raster | Dark Line, Vertical | Fold, Center | Fold, Side | Fuzzy Pictures | Linearity Poor | Sync Absent | Wavy, All Over Or Top | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAWTOOTH SYSTEM | | | | | | | | | | | | | |
| Capacitor | | | | | | | | | | | | | |
| 158 Open | • | | | • | | | • | | | | | | |
| 159 Too small | | | | | | | • | | | | | | |
| 160 Too great | • | | • | • | | | | • | | • | | | • |
| 161 Leaky | | | • | • | | | | | • | | | | • |
| 162 Shorted | | | | • | | | | | | | | | |
| Series (Peaking) Resistor | | | | | | | | | | | | | |
| 163 Open | • | | • | | | | | • | | | | | |
| 164 Too great | | | • | | | | | | | | | | • |
| 165 Too small | | | | | | | | | • | | | | |
| 166 Shorted | | | | | | • | | | • | | | | |
| DRIVE CONTROL | | | | | | | | | | | | | |
| 167 Misadjusted | • | | • | | | | | | • | | | | • |
| Capacitor To Ground | | | | | | | | | | | | | |
| 168 Open, too small | • | | | | | | | | | | | | |
| 169 Too great | | | | • | | | | | | | | | |
| 170 Leaky | | | • | • | | | | | | | | | • |
| 171 Shorted | | | | • | | | | | | | | | |
| AMPLIFIER AND CIRCUIT | | | | | | | | | | | | | |
| 172 Tube weak, defective | | | | | • | | | | • | | | | |
| 173 Cathode-heater leak | | | | | | | | | | | • | | |

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| **Table 11-E HORIZONTAL SWEEP Oscillator and Amplifier Tubes** | Bright Line, Vertical | Brightness Excessive | Brightness Lacking | Dark, No Raster | Dark Line, Vertical | Fold, Center | Fold, Side | Fuzzy Pictures | Linearity Poor | Sync Absent | Wavy, All Over Or Top | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Screen Voltage | | | | | | | | | | | | | |
| 174 Zero | | | | • | | | | | | | | | |
| 175 Too low | • | | • | | | | | | • | | | | • |
| 176 Too high | | | | | • | | | | • | | | • | |
| Screen Bypass Capacitor | | | | | | | | | | | | | |
| 177 Leaky, shorted | • | | • | | | | | | | | | | • |
| Capacitor From Oscillator | | | | | | | | | | | | | |
| 178 Open | | | | • | | | | | | | | | |
| 179 Too small | | | • | • | | | | | | | | | • |
| 180 Too great | • | • | | | | | | | | | | • | |
| 181 Leaky | | • | • | • | | | | | • | | | | • |
| 182 Shorted | | | | • | | | | | | | | | |
| Grid Resistor | | | | | | | | | | | | | |
| 183 Too great, open | | | • | | | | | | | | | | • |
| 184 Too small, shorted | | | | • | | | | | • | | | | |
| Cathode Resistor | | | | | | | | | | | | | |
| 185 Open | | | | • | | | | | | | | | |
| 186 Too great | | | | | | | | • | | | | | |
| 187 Too small, shorted | | | | | | | | | | | | • | |
| Cathode Bypass Capacitor | | | | | | | | | | | | | |
| 188 Leaky, shorted | | | | | | | | | • | | | | |

**d.** If pictures are not now synced adjust the frequency control to bring them into sync. This adjustment usually is on the end of the can opposite the terminal lugs.

**e.** Remove the jumper from stabilizer terminals *C* and *D*.

**f.** Connect the vertical input of the scope to terminal *C* and the low side to chassis ground. Unless the scope has high input impedance use a fixed capacitor of no more than 10 mmf in series with the vertical input.

**g.** Adjust the stabilizer control to obtain the waveform of Fig. 11-21-A, with rounded and sharp peaks as nearly as possible at the same height. A waveform such as in Fig. 11-21-B may make it difficult for pictures to pull in when switching channels or may allow horizontal folding. A waveform such as in Fig. 11-21-C allows noise pulses to destroy synchronization or may allow pictures to drop out of sync quite easily.

**h.** Pictures should pull in quickly when switching stations and should hold with the hold control all or nearly all the way in either direction. To obtain this performance it may be necessary to make slight readjustment of the frequency control.

**107-108.** When the capacitor across the stabilizer coil is of a type which changes capacitance during warmup it may be necessary to readjust the hold control after the set operates for a short time. A capacitor having a negative temperature coefficient (NTC type) will prevent such trouble.

**114-115.** These faults prevent application of d-c correction voltage to the reactance grid.

**121-124.** This resistor carries current between the oscillator cathode and ground.

**125-127.** This resistor carries cathode current for the reactance tube and also for the oscillator. Bias voltage developed across this resistor for the reactance tube grid thus is considerably greater than would be due to reactance cathode current alone.

**128-130.** Some receivers are designed to operate with no capacitor across the cathode resistor on the reactance tube.

**134.** Where the oscillator tank inductor, *L* in Fig. 11-24, is the only horizontal hold adjustment the procedure is to adjust the inductor core for prompt pull-in when switching from idle to active channels. All active channels should be checked for pull-in performance.

Where an operator's hold control consists of an adjustable resistor this control should be set at its mid-position while adjusting the core of the tank inductor. With the afc system operating properly there should be pull-in with a hold control resistor set close to either extreme of its rotation.

**143-146.** In Fig. 11-24 this is capacitor *Cp*. For alternating and synchronizing voltages the plate circuit of a Hartley oscillator must be completed through a capacitance or capacitances back to the bottom of the oscillator inductor. This purpose sometimes is served by decoupling or bypassing capacitors connected on the plate side of any voltage dropping resistor between the plate and a B+ supply line.

**167.** In many receivers there is no adjustable drive control for varying amplitude of sawtooth voltage applied to the grid of the sweep amplifier. In such cases the drive depends on relative values of all capacitors and resistors between the sawtooth capacitor and the amplifier grid. Drive is lessened by smaller capacitances or by greater resistances in series. Drive is increased by smaller capacitances or by greater resistances to ground. In this connection it must be kept in mind that smaller capacitance means greater capacitive reactance and greater opposition to passage of drive voltage either to the amplifier grid or to ground.

Increase of drive voltage at the amplifier grid tends to increase second anode voltage to the picture tube, to increase brightness, and to increase the boosted-B voltage. Greater drive may or may not increase picture width, depending on relative effects of grid swing and picture tube anode voltage.

**172.** An irregular or ragged dark vertical line toward the lefthand side of the viewing screen is caused by Barkhausen oscillation in the output amplifier and its circuit. An amplifier suffering from this trouble in one receiver may prove entirely satisfactory in another. Excessive screen voltage tends to cause Barkhausen oscillation, also a faulty screen bypass capacitor.

**176.** Excessive screen voltage is likely to increase total cathode current to an amount allowing the wattage dissipation limit of the tube to be exceeded. If sweep amplifier tubes have short life, try reducing the screen voltage or, at least measure the total cathode current and compare it with tube ratings.

**178-182.** These faults refer to any capacitor or capacitors in series between the plate of the oscillator or discharge tube and the grid of the sweep amplifier.

# DEFLECTION AND HIGH VOLTAGE

## (SECTIONS 12 THROUGH 16)

Extending from the outputs of the horizontal and vertical sweep amplifiers to the deflecting yoke on the picture tube are several groups of parts so closely related that the performance of any one may be affected by faults in any of the others. These groups are represented by the block diagram of Fig 12-1. For the purposes of trouble location we shall consider these parts and circuits as made up of five groups, to be numbered 12 to 16.

### Group 12. Horizontal Deflection

In this group we have the horizontal output transformer, the horizontal deflecting coils in the yoke, the damper tube, and their circuits. In some receivers this group will include also a width control on the horizontal output transformer and possibly a linearity control in the damper circuits. Actuating voltage (the drive voltage) for this group originates in the grid circuit of the horizontal sweep amplifier and is applied to the horizontal output transformer from the amplifier plate.

### Group 13. Boosted B-Voltage

Boosted B-voltage originates in the damper circuits and passes through the horizontal output transformer to the horizontal sweep amplifier, usually to the vertical sweep amplifier and vertical oscillator, and oftentimes to various other tubes and circuits in the receiver.

### Group 14. High Voltage

In this group is the high-voltage rectifier and its connected circuits. High voltage for the picture tube anode or ultor originates in the horizontal output transformer from pulses produced at the plate of the horizontal sweep amplifier. Although lack of sufficient voltage at the picture tube anode may result from faults in the high-voltage section the more likely causes are in any of the other parts shown by Fig. 12-1. or even further back in the receiver.

## Group 15. Vertical Deflection

Previously considered have been the vertical sweep oscillator and amplifier. The vertical deflection system to be considered now includes the vertical output transformer and the

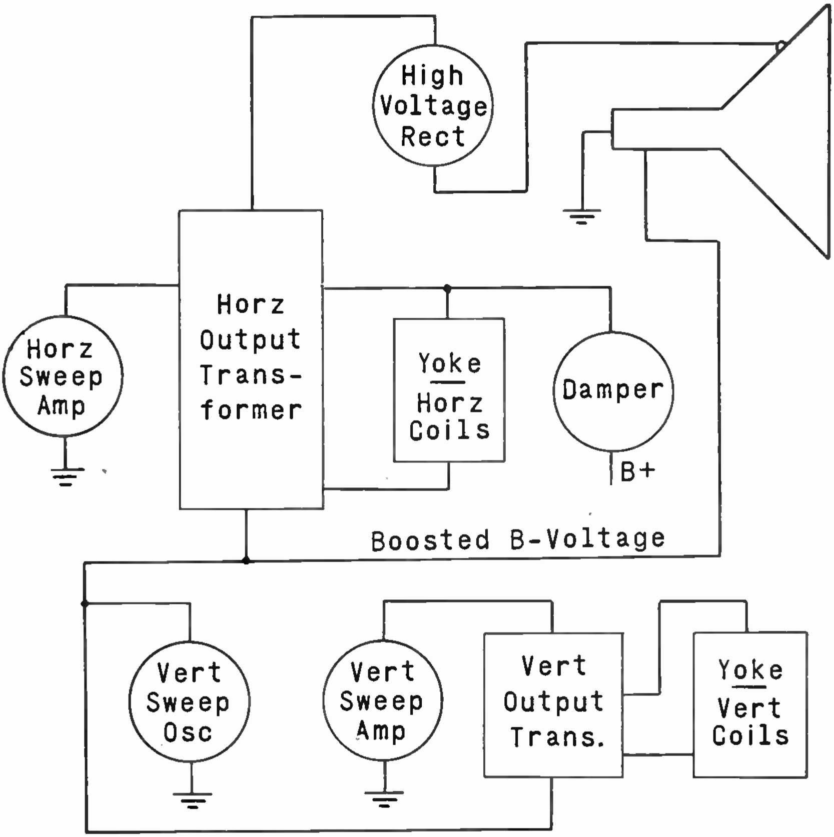


*Fig. 12-1. These are the sections so closely related that performance of any one may be affected by any of the others.*

vertical deflecting coils in the yoke. The vertical deflection group commonly is related to the horizontal deflection group through the boosted B-voltage, but sometimes is entirely independent.

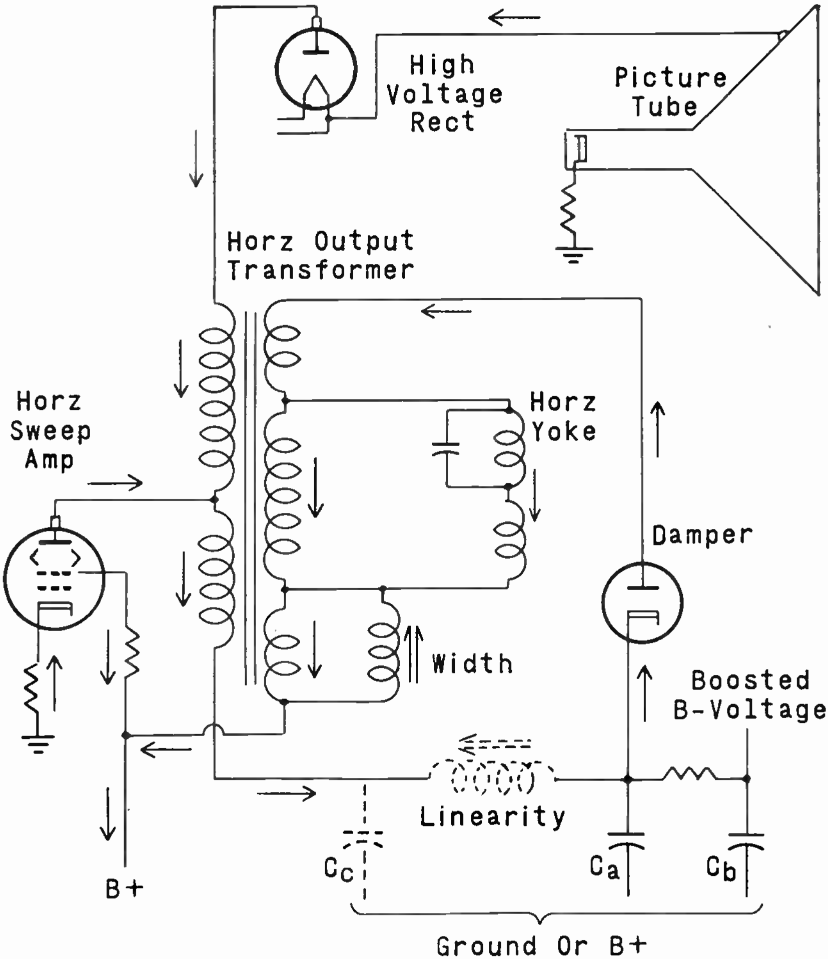


*Fig. 12-2. Electron flows in a system which includes a horizontal output transformer with insulated secondary.*

## Group 16. Deflecting Yoke

The deflecting yoke is considered as a unit, not as separate horizontal and vertical pairs of coils, in relation to troubles due to incorrect positioning and incorrect cable connections.

### Electron Flows

In all of the early receivers and in many later models the horizontal output transformer has completely separate primary and secondary windings insulated from each other within the transformer structure. Such construction and typical circuit connections are shown by Fig. 12-2.

In the great majority of present receivers the horizontal output transformer is an autotransformer with primary and secondary windings connected end to end within the transformer structure. This design and typical connections are shown by Fig. 12-3.

Arrows on these two diagrams show the directions of d-c electron flows. So far as the illustrated circuits are concerned the electron flows begin at the ground connections which lead to the negative side of the low-voltage or B+ power supply, and they end at connections marked "B+", which go to the positive side of the low-voltage power supply.

Consider first the diagram of Fig. 12-2 for an insulated-secondary output transformer. Electrons enter at the ground connection on the cathode of the horizontal sweep amplifier and flow through this tube to its plate. The flow then passes through the transformer primary to the cathode of the damper tube, possibly going through a linearity control inductor between transformer and damper.

The electron flow goes from cathode to plate in the damper, thence through the entire secondary winding of the transformer to a B+ connection.

Note that electron flow from cathode to screen of the sweep amplifier passes through a dropping resistor directly to a B+ connection without going through the output transformer or the damper tube. This is common practice.

Cathode electron flow or current for the picture tube enters from a ground connection and goes through the tube to its high-voltage anode, thence to the filament or cathode of the high-voltage rectifier. After going from filament to plate in this rectifier the flow goes through an extension of the transformer primary and then joins the flow coming from the plate of the sweep amplifier to follow this amplifier electron flow path through the damper, the transformer secondary, and to B+.

To step up the voltage pulses from the plate of the sweep amplifier before they reach the plate of the high-voltage rectifier the extension of the transformer primary forms,

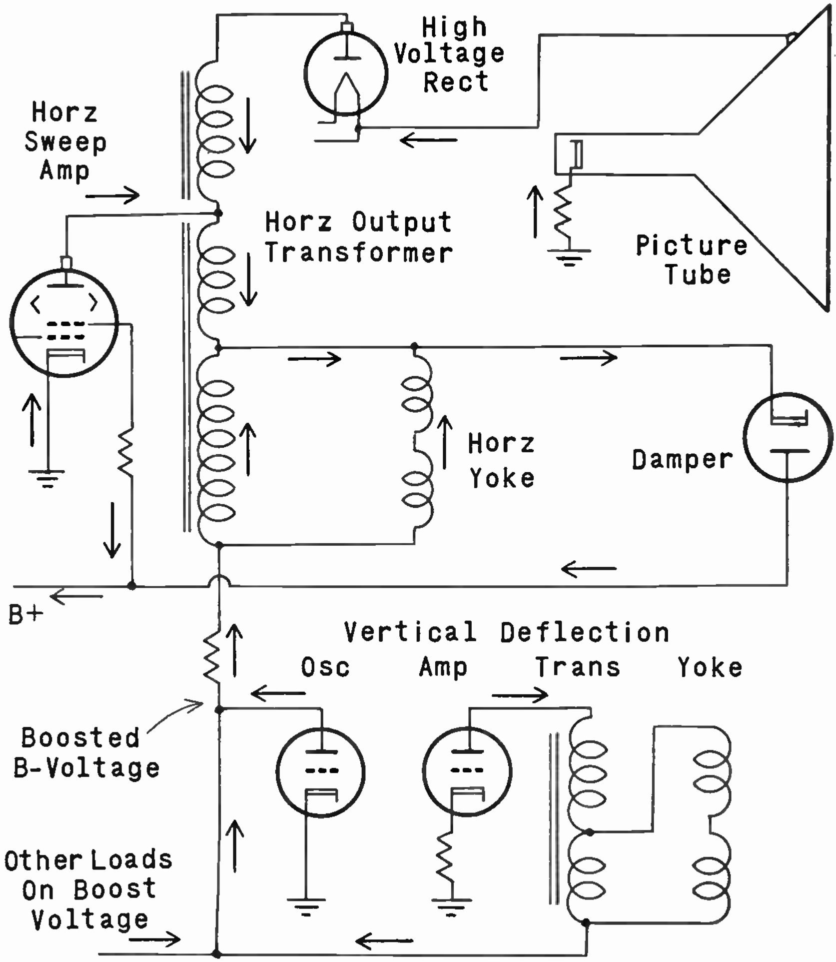


*Fig. 12-3. Electron flows in circuits associated with a horizontal output autotransformer.*

with the main primary winding, an autotransformer. This, however, is not the autotransformer action referred to when distinguishing between the transformer designs shown by Figs. 12-2 and 12-3.

Consider now the circuits of Fig. 12-3 where all the windings of the horizontal output transformer are internally connected together and where we have true autotransformer action.

D-c electron flow from a ground connection goes from cathode to plate of the horizontal sweep amplifier, thence through the middle section of the output transformer and to the cathode of the damper tube. After passing from cathode to plate in the damper, the flow goes to a B+ connection.

Electron flow through the picture tube and high-voltage rectifier is the same as for Fig. 12-2, passing then through the extension of the transformer winding to join the flow coming from the plate of the sweep amplifier.

When boosted B-voltage from the damper circuit is applied to the vertical sweep and deflection circuits, and possibly to other circuits or loads as well, d-c electron flows are as shown in the lower part of Fig. 12-3.

These electron flows in boosted-B circuits enter the tubes from ground or B-minus connections on the tube cathodes and go to tube plate or sometimes to tube screens.

The boosted-B d-c electron flows combine and pass through the lower part of the output transformer to the damper cathode, from which there is a connection to B+.

Keeping in mind the paths followed by d-c electron flows is of great help in locating troubles such as open circuits, high-resistance connections and short circuits. It is to be especially noted that the damper tube carries plate current for the horizontal sweep amplifier, anode current from the picture tube, and currents from all sections and circuits furnished with boosted B-voltage. That is, the damper actually is in series with all these other circuits.

# SECTION 12

## HORIZONTAL DEFLECTION

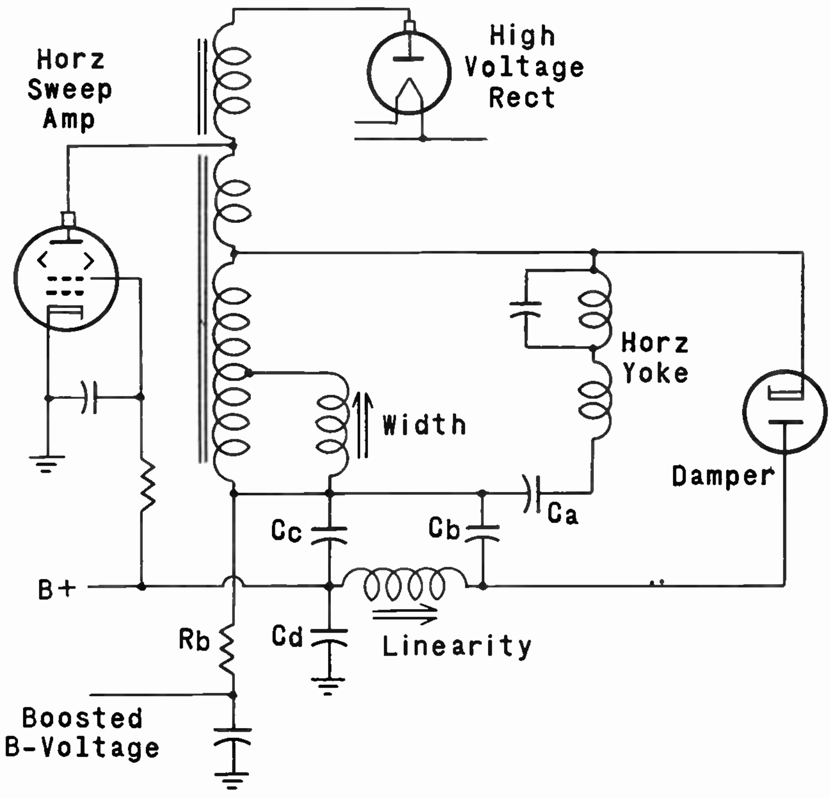


*Fig. 12-4. A horizontal deflection system which includes adjustable inductors for picture width and linearity.*

Although there are not very many components in a horizontal deflection system it will be found that the parts which are commonly used may be connected together in a great variety of circuits. Figs. 12-4 to 12-7 illustrate some of the combinations and connections in general use, but there are many variations and modifications to be found in the service diagrams for particular receivers.

Among the features to be noted in Fig. 12-4 are the following: There is no direct current in the horizontal yoke coils because such current is blocked by capacitor Ca. This capacitor does, however, carry alternating currents between the yoke coils and the transformer winding. There is the usual shunting capacitor across the yoke coil that is directly connected to the high side of the deflecting circuit.

Across part of the turns in the transformer is connected a width control consisting of an adjustable inductor. Another adjustable inductor in series with the damper plate forms a control for horizontal linearity. Such width controls and linearity controls are found with a majority of output trans-

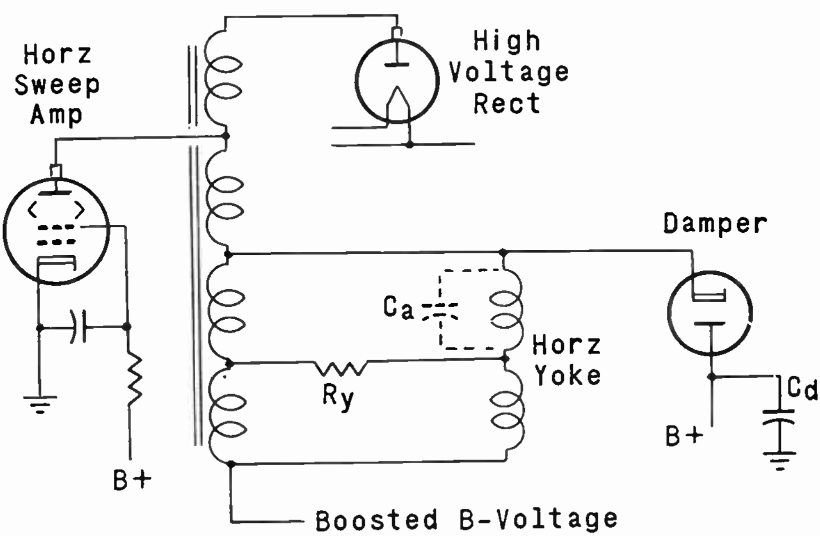


*Fig. 12-5. In this horizontal deflection system a point between the yoke coils is connected to a tap on the transformer.*

formers having an insulated secondary, but are shown here as connected in a design employing an output autotransformer. Capacitors *Cb, Cc* and *Cd* are generally used in connection with a linearity control inductor.

Resistor *Rb* and the capacitor from its lower end to ground are parts of the filter system for boosted B-voltage applied from the low side of the transformer to various sections and circuits.

In Fig. 12-5 there is neither a width control nor a linearity control inductor. Filter elements for boosted B-voltage would be present but are not shown on the diagram. There is direct current in the yoke coils because both the high side and low side of the yoke assembly are conductively connected to the transformer.

From between the yoke coils of Fig. 12-5 and a tap on the transformer winding is a connection containing resistor *Ry*,

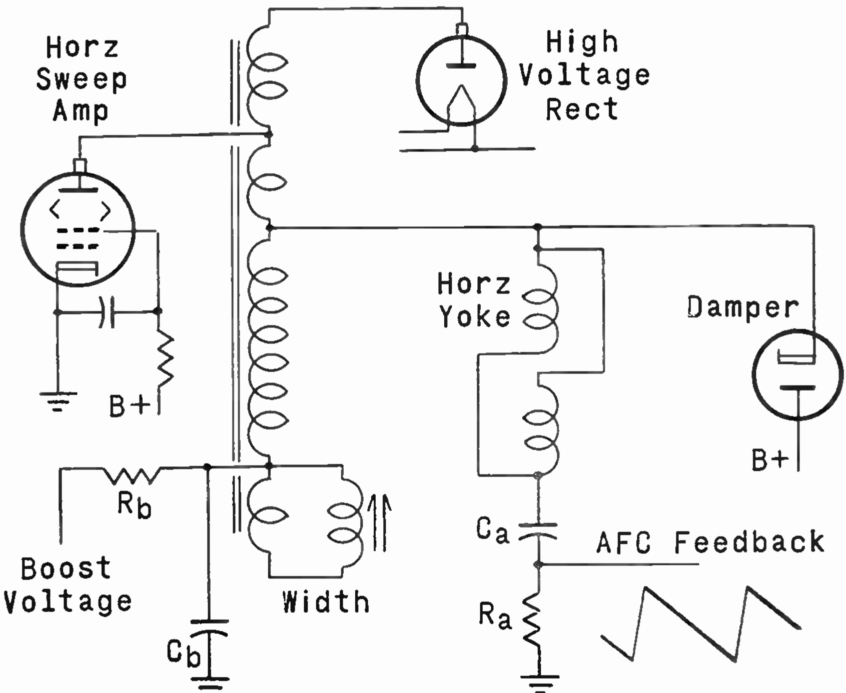


*Fig. 12-6. Here the horizontal coils in the deflecting yoke are in parallel with each other.*

which usually is of about 5,000 ohms. Capacitor *Ca* across the highside yoke coil may or may not be used when there is the center tap connection.

Also to be noted in Fig. 12-5 is capacitor *Cd* from the damper plate to ground. This capacitor usually is of only a few hundred micromicrofarads and is used in addition to larger electrolytic filter capacitors on the B+ lines.

In Fig. 12-6 the two horizontal yoke coils are in parallel with each other instead of being series connected. There is no direct current in the yoke coils because of blocking capacitor *Ca*. The path for alternating currents between yoke and transformer is completed through capacitor *Ca*, resistor *Ra*, ground, and capacitor *Cb* connected to the low side of the transformer winding.

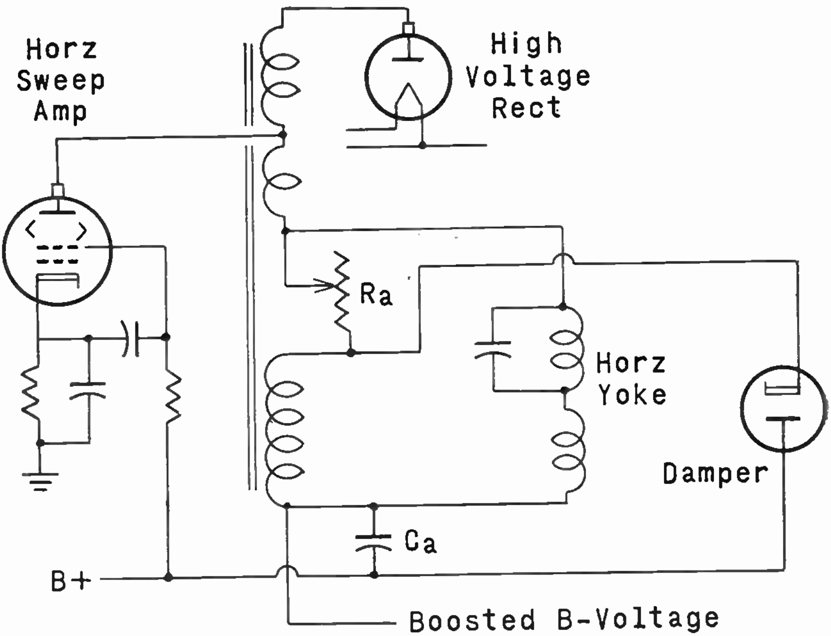


*Fig. 12-7. The adjustable resistor between sections of the horizontal output transformer is a horizontal centering control.*

A sawtooth feedback voltage for the afc section is taken from between capacitor *Ca* and resistor *Ra*. This resistor seldom is of more than 10 to 20 ohms. The waveform of current in this small resistance is the same as that of deflecting current in the yoke coils. Consequently, with this design, an oscilloscope connected from between *Ca* and *Ra* to ground will show the deflecting current waveform. The parallel yoke coils and the afc takeoff have no relation to each other, either feature may be found with or without the other.

Note that the width control inductor of Fig. 12-6 is connected only across turns of the transformer which form an extension from the low side. Boost voltage is taken from above the width inductor. Resistor *Rb* and capacitor *Cb* help filter the boosted B-voltage.

The most noticeable feature in Fig. 12-7 is the resistor *Ra* between sections of the horizontal output autotransformer. When this resistor is adjustable, as shown here, it is used as a horizontal centering control.

The yoke coils of Fig. 12-7 are conductively connected to the transformer winding, which allows direct current to flow in the yoke. Were there an open circuit at the position of resistor *Ra* all plate current from the horizontal amplifier would flow to the damper cathode through the yoke coils. Were there a short circuit at the position of resistor *Ra* the sweep amplifier plate current would go the damper through the short circuit without passing through the yoke. Accordingly, adjustment of resistance at *Ra* varies the value of direct current in the yoke and thereby shifts pictures to the right or left.

A resistor at *Ra* of Fig. 12-7 may be of fixed value rather than adjustable. In still other cases the transformer may be of the same construction, but a direct connection is used instead of a resistance element.

## Inductance Measurements

Relative inductances of the windings in transformers and yokes play important parts in matching these two parts for maximum power transfer from transformer to yoke and for a satisfactorily high voltage to the picture tube anode. An incorrect inductance is one of the few available ways for detecting probable shorted turns in a winding.

Inductances of various components often are shown on manufacturers' service diagrams. In the case of replacement parts the inductances may be learned from the instruction sheets in many cases.

Inductances of windings in horizontal output transformers and horizontal yoke coils, also in vertical yoke coils and in secondaries of vertical output transformers are easily measured with the setup of Fig. 12-8. Primaries of vertical output transformers are difficult to measure, because of their very great inductances.

In Fig. 12-8 a fixed capacitor is connected across any inductance to be measured, thus forming a parallel resonant circuit. An audio generator and a vacuum tube voltmeter are connected across the resonant circuit as shown. The audio generator should be tunable from about 200 cycles per second to 20 or more kilocycles. The VTVM is set for measuring a-c voltage on a low range.

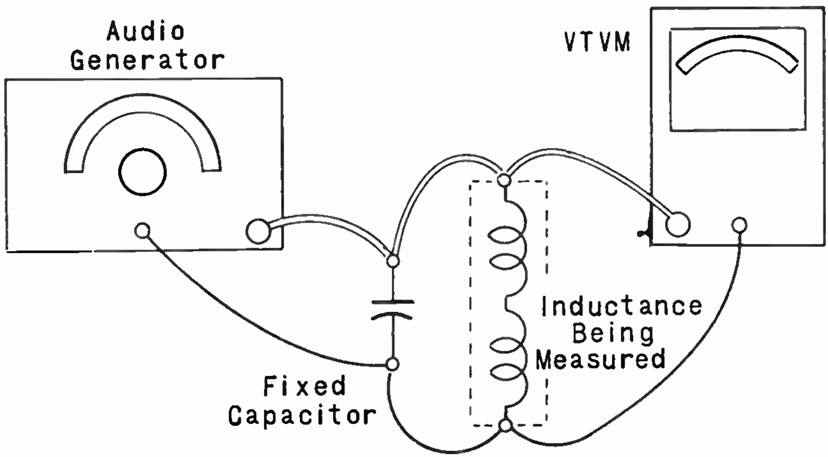


*Fig. 12-8. A method of measuring the inductance of yokes and transformers.*

Tuning the generator through various frequency bands will cause the meter reading to rise or fall. Frequency of resonance is indicated by a peak reading. Knowing the resonant frequency and the value of the fixed capacitor across the inductance allows computing the value of inductance in millihenrys. The formula is,

$$\text{Millinhenrys} = \frac{25.33}{(\text{resonant freq, kc})^2 \times \text{capacitance, mf}}$$

Instead of using the formula, the inductance may be read directly from the chart of Fig. 12-9 when the fixed capacitor has a value of 0.10, 0.05, or 0.01 mf. Following upward from the scale of resonant frequencies to one of the capacitance lines, then to the left will give the inductance in millihenrys. Obviously, the accuracy of the inductance thus arrived at will depend on accuracy of the audio generator as to indicated frequencies and on accuracy of the fixed capacitor. Paper capacitors of 5 per cent or better accuracy are satisfactory.

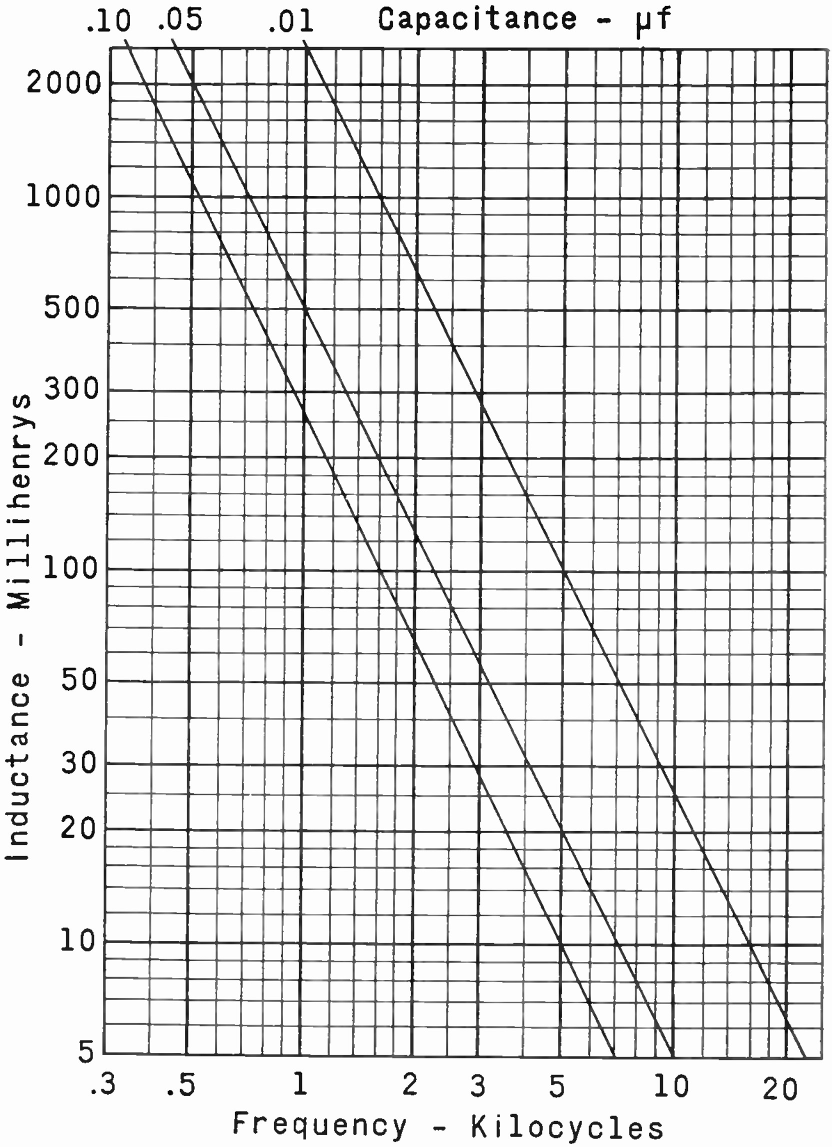


*Fig. 12-9. The chart for determining inductance when resonant frequency and capacitance are known.*

Resonance indications are quite sharp with horizontal output transformers and horizontal yoke coils of good quality. The small capacitances generally used across one or more yoke coils cause no important error, they are swamped by the large fixed capacitor. Resistors shunted across vertical yoke coils cause resonance to be quite broad. It may be necessary to disconnect one end of each shunt resistor.

Fig. 12-10 shows inductances in millihenrys of all windings and all combinations of windings in a typical horizontal output transformer, as measured according to the method just described.

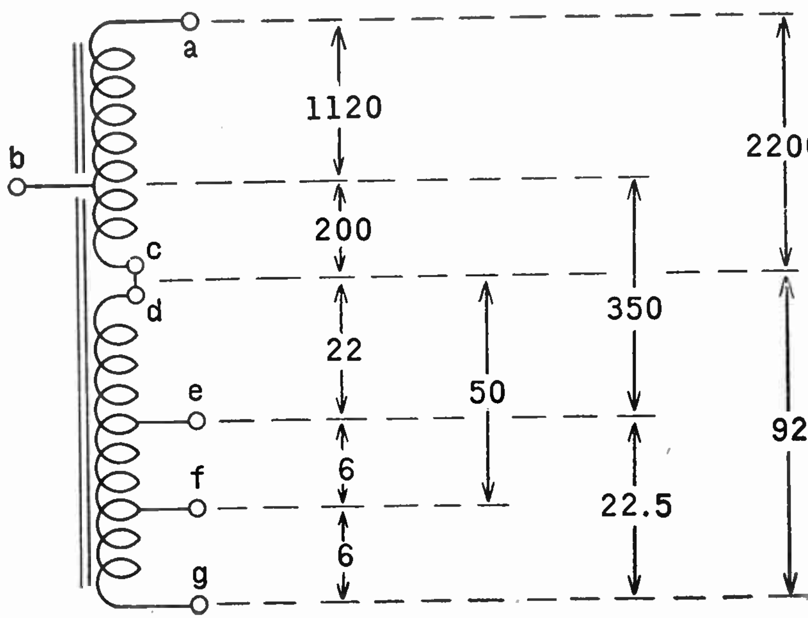


*Fig. 12-10. Inductances of winding sections cannot simply be added to find the overall inductance.*

Note that inductances across two windings or sections of the winding is not the arithmetic sum of the separate inductances, but always is greater. This is because, in any windings which are together on the same core, we have mutual inductance as well as self-inductances. The sum of the square roots of inductances in two sections is very nearly equal to the square root of the overall inductance.

Were this "square root" relation of inductances to be forgotten the inductance measurements of various winding sections and combinations might be confusing.

### OUTPUT TRANSFORMER AND WIDTH CONTROL

Table 12-A lists faults commonly encountered in horizontal output transformers and in width control inductors. Following are notes referring to the faults. The paragraphs of notes are numbered to correspond with numbered faults in the table.

**1.** On some transformers are a number of taps, to any one of which the yoke may be connected so that the yoke is across different numbers of transformer winding turns. When one end of the yoke remains connected to a tap at or near the end of the transformer winding while the other end of the yoke is shifted to cover more and more transformer turns, picture tube anode voltage will increase to a maximum with some certain connection, then decrease as the yoke is connected across still more transformer turns.

**3-4.** Any capacitor connected across any portion of the transformer winding reduces picture tube anode voltage, and thus allows wider pictures. Retrace time is increased. These effects become more pronounced as the value of capacitance is increased.

**5-6.** When a resistor is between sections of the transformer winding with the yoke connected at one end of the resistor and the damper tube at the other end (Fig. 12-7) the amount of resistance determines the amount of direct current in the yoke coils. Such yoke current shifts the pictures sideways to a distance depending on the amount of d-c current in the yoke. Varying the value of resistance has little or no effect on picture tube anode voltage, on width or on linearity.

**8-9.** When a service diagram gives resistances of windings a considerable difference between actual and specified resistance usually indicates internal trouble, but is not likely to indicate only a few shorted turns. When correct inductances are specified there will be noticeable variation in actual measured inductance when there are many shorted turns. Severe over-heating of a transformer often indicates shorted turns. The surest way of determining that a transformer is

**Table 12-A**

**HORIZONTAL DEFLECTION**
**Transformer And Width Control**

| | Anode Voltage Low, Zero (See table 14-B) | Bright Line (Vert) | Brightness Lacking | Centering Difficult | Corona, Arcing (See table 14-C) | Dark, No Raster | Fold, Horizontal | Linearity Poor | Ringing | Speckling | Sync Critical (Horz) | Width Excessive | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TRANSFORMER** | | | | | | | | | | | | | |
| 1 Wrong type for yoke or amplifier | • | | | | | | | • | • | | | | |
| 2 Capacitor-resistor network, any faults | • | | | | | • | • | | | | | | |
| **Capacitor Across Turns** | | | | | | | | | | | | | |
| 3 Too great | • | | | | | | | | | | | | |
| 4 Leaky, shorted | | | | | | • | | | | | | | |
| **Resistor Between Sections** | | | | | | | | | | | | | |
| 5 Open | | | | | | • | | | | | | | |
| 6 Shorted, or wrong value | | | | • | | | | | | | | | |
| **Circuit** | | | | | | | | | | | | | |
| 7 High-resistance joints | | | | | | | | | | | | | • |
| 8 Internal open | • | | | | | • | | | | • | | | |
| 9 Internal shorted turns | | | | | | • | | | | | | | |
| **Core** | | | | | | | | | | | | | |
| 10 Grounded when should be insulated | | | | | • | | | | | | | | |
| 11 Gap too great | | | | | | | | | | | | | • |
| **WIDTH CONTROL INDUCTOR** | | | | | | | | | | | | | |
| 12 Open circuited | | | | | | | | | | | | • | |
| 13 Short circuited | | | | | | • | | | | | | | • |
| **Misadjusted Or Wrong Type** | | | | | | | | | | | | | |
| 14 Too much inductance | | | | | | | | | | | | | • |
| 15 Too little inductance | • | | | | | | | • | | | | • | |
| **Connection To Transformer** | | | | | | | | | | | | | |
| 16 Across too many turns | • | • | • | | | | • | | | | | | • |
| 17 Across too few turns | | | | | | | | | | | | • | |
| **Capacitor Across Inductor** | | | | | | | | | | | | | |
| 18 Capacitance too great | • | | | | | | | | | | | • | |
| 19 Too small, open | | | | | | | | | | | | | • |
| 20 Leaky, shorted | | | | | | • | | | | | • | | |

internally faulty is to temporarily replace it with one known to be good, and to observe performance for any improvement.

**11.** Some of the causes for excessive core gaps are: Loose mounting screws. A gap spacer has become defective. Excessive dirt has collected in the gap.

**14-15.** Width often is varied not by means of an adjustable inductor across turns of the output transformer but by varying the screen voltage on the horizontal sweep amplifier or by varying the peak-to-peak value of drive voltage at the grid of this amplifier. Picture width varies directly with peak-to-peak value of drive voltage.

**16-17.** A width control inductor across transformer turns is an inductance in parallel with part of the transformer inductance and, therefore, reduces the effective inductance of the transformer winding. The greater the number of transformer turns across which the width control is connected the less is the effective inductance. Less inductance decreases picture tube anode voltage and thereby allows increased picture width. One of the symptoms of a control inductor across too many transformer turns is variation of picture brightness when the width control is adjusted one way or the other.

### DAMPER CIRCUIT, LINEARITY CONTROL AND DRIVE

Where the horizontal output transformer is an autotransformer (Fig. 12-3) the cathode of the damper tube is connected to the high point of the transformer winding and either directly or through part of the transformer winding to the high side of the horizontal yoke coils.

Where the horizontal output transformer has an insulated secondary (Fig. 12-2) the plate of the damper tube is connected to the high side of the secondary and, usually through part of the secondary winding, to the high side of the yoke.

With an autotransformer the damper cathode is the high-side element. With an insulated-secondary transformer the damper plate is the high side element. Voltage pulses at the high-side element of the damper, either its cathode or plate,

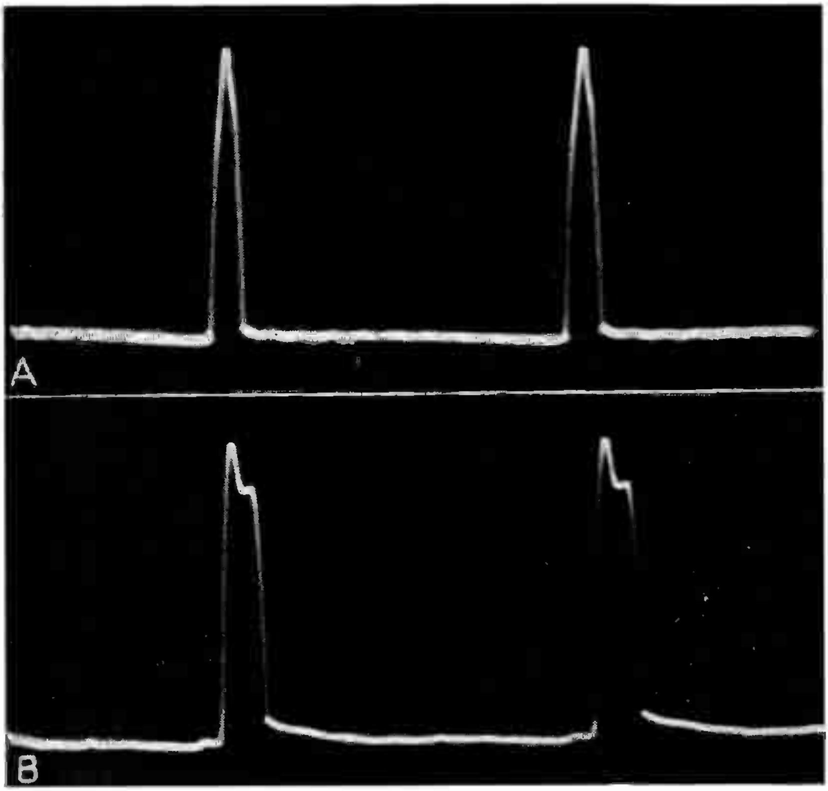


*Fig. 12-11. Pulses observed at cathodes of damper tubes connected to horizontal output autotransformers.*

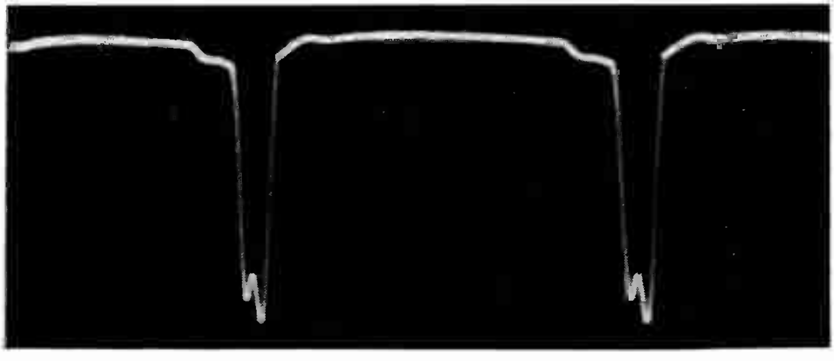

*Fig. 12-12. Pulses at the damper plate connected to an output transformer having an insulated secondary.*

have peak values ranging from 1200 to as much as 4000 volts and may be safely observed on an oscilloscope only by using a high-voltage capacitor type probe on the vertical input of the scope.

Pulses at the damper cathodes of two receivers having autotransformers for horizontal output are shown by Fig. 12-11. This general waveform is characteristic of damper cathodes in all sets having autotransformers for horizontal output.

Fig. 12-12 shows pulses at the damper plate in a receiver having a horizontal output transformer with insulated secondary. The waveform is generally similar to that from high-side cathodes but the polarity is opposite, here being negative. In both cases the vertical input of the oscilloscope was connected through a capacitor probe to the high side element of the damper, the cathodes for Fig. 12-11 and the plate for Fig. 12-12.

The low-side element of a damper connected to an autotransformer is the plate, and of a damper connected to an insulated-secondary transformer it is the cathode. Peak-to-peak voltages on the low-side elements are low enough to observe without a capacitor probe.

There are no generally characteristic waveforms at the low-side elements of dampers. The waveform in any case depends on circuits connected to the damper low side, on whether or not there is a linearity control inductor, on what capacitors and resistors are in circuit, and so on.

Damper current waveforms vary widely with the type of receiver and the damper circuit employed. At *A* of Fig. 12-13 is a trace of damper current from one receiver having an autotransformer for horizontal output and at *B* is a trace from another receiver having an autotransformer. At *C* is a damper current trace from a set having an insulated secondary output transformer. In all these cases the oscilloscope was so connected that increases of damper current are upward and decreases are downward on the traces.

Fig. 12-14 shows features found in some damper circuits. In diagram *A* there is a capacitor, usually less than 100 mmf, from cathode to plate of the damper. Also, between

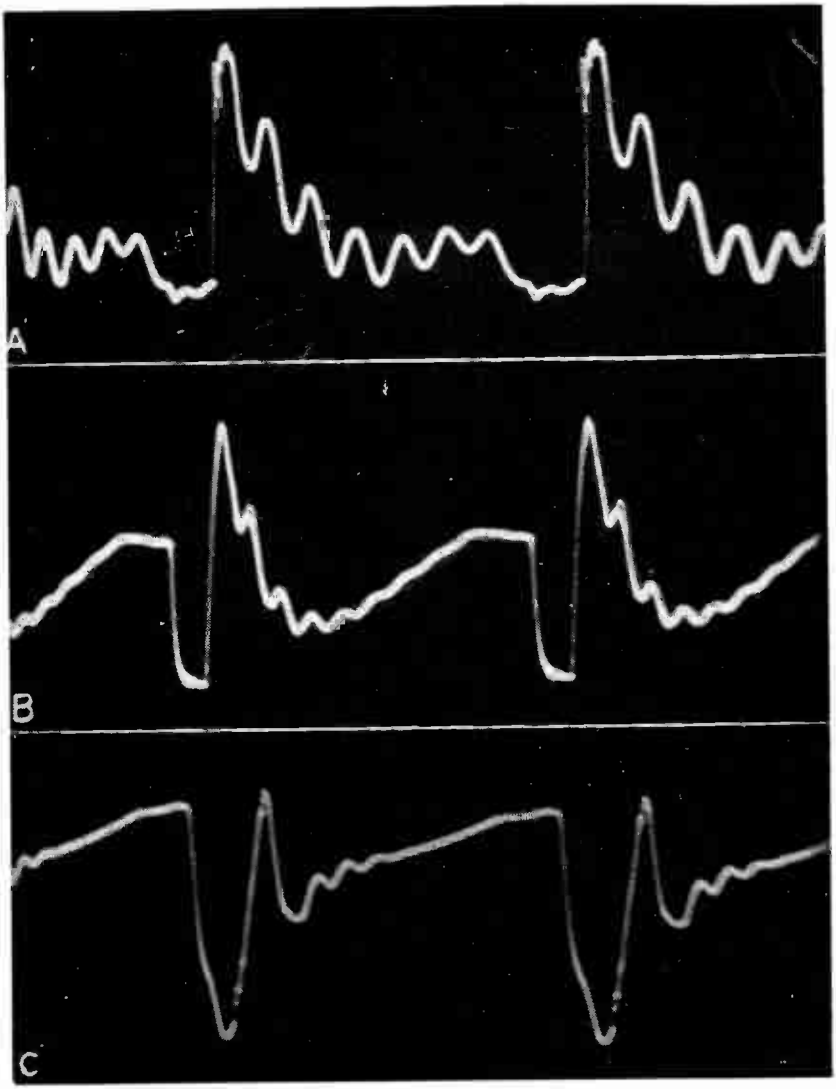


*Fig. 12-13. Waveforms of damper current may vary widely in different receivers.*

the damper plate and B+ is a fuse which usually has a value anywhere from 200 milliamperes or 0.2 ampere up to 3/8 ampere, and frequently is of the slow-blow type.

A fuse in this position protects the output transformer windings from overheating and burnout in case there is excessive current in the horizontal sweep amplifier. The damper carries all plate current from the amplifier, and when there is a connection from above the fuse to the amplifier screen the fuse will carry all current flowing in the amplifier tube.

In diagram *B* of Fig. 12-14 there is one r-f choke on the damper cathode and another on its plate. Chokes may be used in only one of these positions or in both places, as shown. This diagram shows also a capacitor *C* from damper plate to ground. This capacitor is of a few hundred mmf at most.

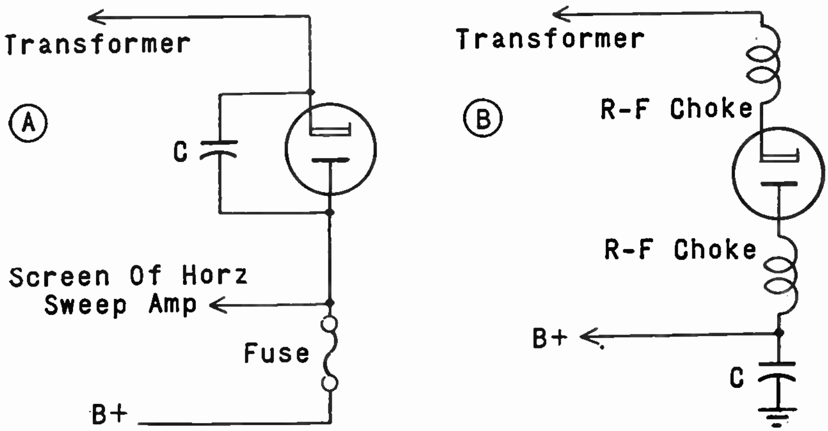


*Fig. 12-14. Circuit elements used in connection with dampers.*

## Horizontal Linearity

Pictures which are non-linear horizontally probably result more often from faults in the damper and its circuits than from any other troubles. When there is a linearity control inductor it may be misadjusted, but since such a control is in the damper circuit the trouble still is associated with the damper.

When pictures are horizontally linear, with no crowding or stretching anywhere, the sawtooth current in the horizontal yoke coils will show on oscilloscope traces as having perfectly straight slopes between retraces. With non-linearity due to faults anywhere in the deflection system the slopes will not be perfectly straight, but irregularities may be too slight to notice on a trace, while reproduced pictures are defective.

Yoke current traces may be observed by connecting in series with the low side of the yoke coils a resistor of from one to five ohms, then connecting the scope vertical input and ground leads to the ends of the resistor. At *A* of Fig. 12-15 is a trace of yoke current which was accompanied by compression at the left and stretching at the right in pictures. At *B* is a trace accompanied by compression at the

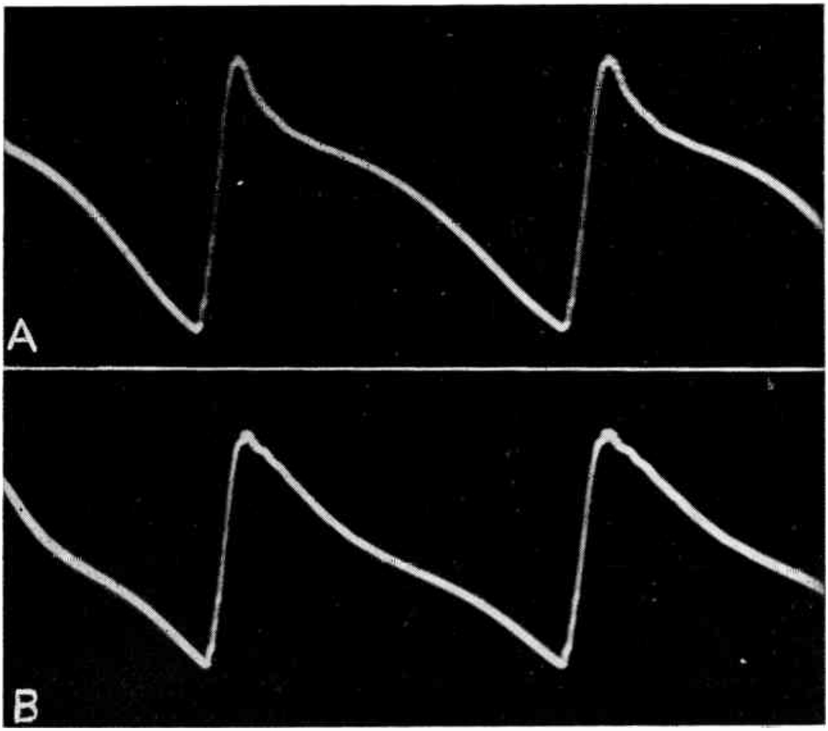


*Fig. 12-15. Horizontal yoke currents causing non-linearity. A, compression at left and stretching at right. B, compression at center and stretching at both sides.*

center and stretching on both sides of pictures. All of these troubles were due to faulty bypassing capacitors on the low side of the yokes, at leads to B+.

In the absence of transmitted test patterns the easiest way to check horizontal linearity or lack of it is with a bar generator capable of furnishing equally spaced lines or vertical rows of dots on the picture tube viewing screen when the generator output is applied to the antenna terminals or to the video amplifier control grid in the receiver.

A square wave generator which will tune as high as approximately 200 kilocycles and which has terminals for a synchronizing input makes an excellent bar generator when used in the setup of Fig. 12-16.

Connect the square wave output of the generator to the grid of the video amplifier through a fixed capacitor *C* which may be as small as 10 mmf for a high-gain amplifier or as

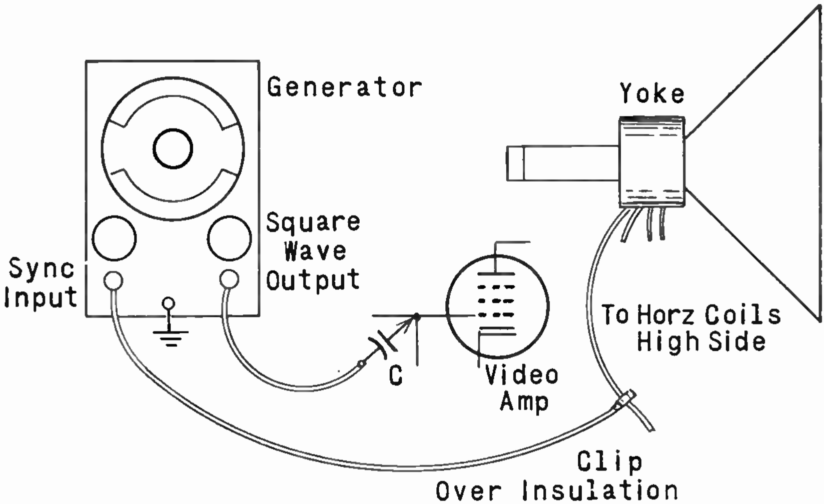


*Fig. 12-16. Using a square wave generator for producing vertical bars used in checking linearity.*

great as 1000 mmf for an amplifier of low gain. On the synchronizing input of the generator use a lead with a spring clip, such as a pee-wee type. Clamp this clip anywhere over the insulation of the lead going to the high side of the horizontal coils in the yoke, without breaking the insulation.

It is not necessary to disconnect the receiver antenna or to disconnect the video amplifier grid from its regular leads. The higher the frequency to which the generator is tuned the greater will be the number of vertical bars on the picture tube screen. Slight waving of the bars may be stopped by adjustment of the vertical hold control. The bars will be evenly spaced across the picture tube when there is horizontal linearity, and unequally spaced when there is nonlinearity.

In cases of faulty horizontal linearity it may be necessary to investigate conditions all the way back to the drive voltage at the sweep amplifier grid. At *A* of Fig. 12-17 is a normal or good waveform as observed at a sweep amplifier grid. Slight irregularities or waviness as at *B* are not likely to cause noticeable non-linearity in pictures. Large waves or bumps should be investigated.

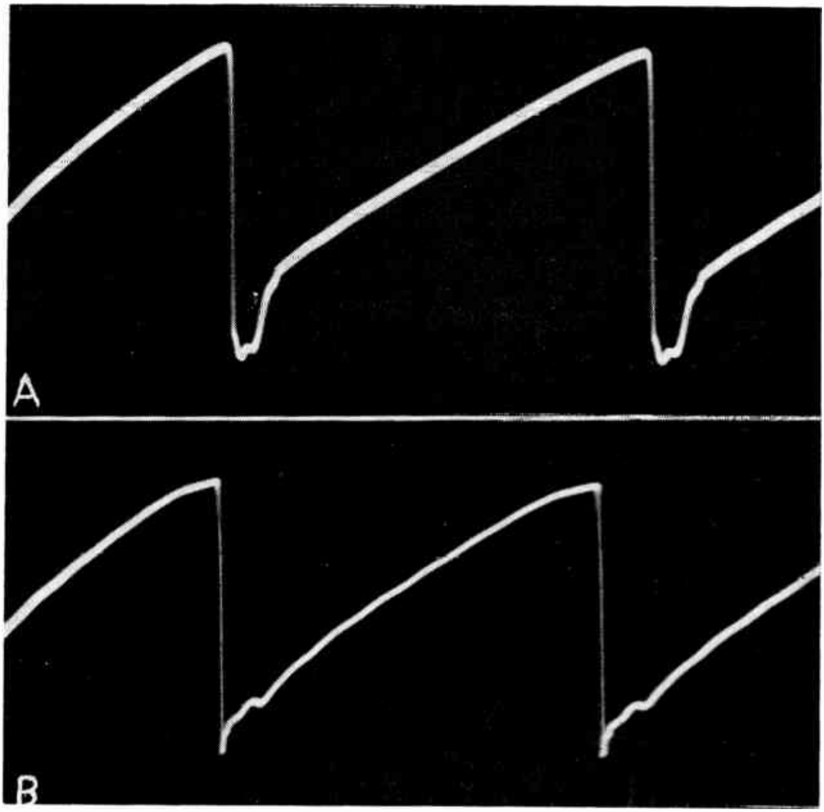


*Fig. 12-17. Voltage waveforms at the sweep amplifier grid. Slight irregularities, as at B, are not likely to cause trouble.*

It is, of course, not possible to observe a waveform at the horizontal sweep amplifier cathode when the cathode is connected directly to ground. If there is a cathode resistor bypassed with large capacitance to ground the cathode waveform should appear as at *A* of Fig. 12-18. Such a wave is characteristic of nearly all circuit points at which there are sawtooth or moderately pulsed voltages and a large bypassing capacitance. The wave indicates only the charging and discharging of the capacitor and tells nothing important about what is happening other than this.

When a horizontal sweep amplifier cathode is connected to ground through a small resistance, something less than 100 ohms, and when there is no bypass capacitor, a trace taken from the cathode end of the resistor shows the waveform of cathode current. A typical example is at *B* of Fig. 12-18.

## Faults And Symptoms

Table 12-B lists common faults in the damper, the linearity control and the drive system together with their associated circuits, and shows picture symptoms which usually accompany the faults. Following are numbered paragraphs which refer to similarly numbered faults in the table.

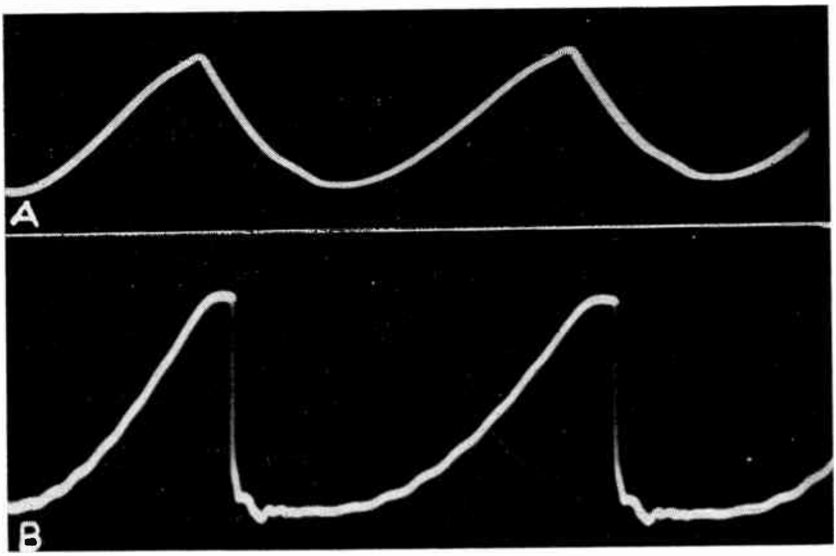


*Fig. 12-18. Waveforms at the cathodes of horizontal sweep amplifiers. A, with large bypass capacitance. B, with an unbypassed resistor to ground.*

**23.** The strong voltage pulses which occur at the damper tube are positive, and they make the cathode strongly positive with reference to the heater as well as the plate. Tubes designed especially for damper service are capable of with-

**Table 12-B**

**HORIZONTAL DEFLECTION**
**Damper, Linearity Control And Drive Voltage**

| | Anode Voltage Low, Zero (See table 14-B) | Anode Voltage High | Boost Voltage Low (See table 13) | Bright Line (Vert) | Dark Line (Vert) | Dark, No Raster | Fold, Horizontal | Jitter (Horz) | Linearity Poor | Ringing | Size Too Small | Sync Critical (Horz) | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DAMPER TUBE AND CIRCUIT** | | | | | | | | | | | | | |
| 21 Tube weak, gassy | • | | | | | • | • | | • | | | | • |
| 22 Plate voltage low | • | | • | | | | | | | | • | | • |
| 23 Cathode-heater leakage | • | | | | | • | | | | | | | • |
| 24 Heater winding excess capacitance | • | | | | | | | | | | | | |
| Connections | | | | | | | | | | | | | |
| 25 High-resistance joints | • | | | | | | | | | | • | | |
| 26 Leads dressed wrongly | | | | | | | | • | | | | | |
| 27 Wrong connections to transformer | | | | | | | • | | • | | | | |
| Series Choke Or Chokes | | | | | | | | | | | | | |
| 28 Shorted or omitted | | | | | • | | | | | • | | | |
| Plate Bypass Capacitor | | | | | | | | | | | | | |
| 29 Open, too small | • | | | | | | • | | • | • | | | |
| **LINEARITY CONTROL INDUCTOR** | | | | | | | | | | | | | |
| 30 Misadjusted or of wrong value | | | | | • | | | | • | • | | | |
| 31 Open circuited | | | | | | • | | | | | | | |
| 32 Short circuited | | | | | | | | | • | | | | |
| **DRIVE VOLTAGE** | | | | | | | | | | | | | |
| 33 Too weak, peak-to-peak | • | | | | | | | | • | | | | • |
| 34 Too strong | | | | | | | • | | | | | | |
| **SAWTOOTH PEAKING RESISTOR** | | | | | | | | | | | | | |
| 35 Too great | | • | | | | | | | | • | | • | |
| 36 Too small | • | | | • | | | • | | | | | • | |
| 37 Bypass capacitor open | | | | | | | | | | • | | | |

standing peak heater-cathode voltages well in excess of 4000 when the cathode is positive with reference to the heater. Consequently there is little trouble from cathode-heater leakage in receivers of recent design. As a general rule a cathode-heater leakage resistance would be less than 100K ohms to cause serious difficulties. The older 6W4 damper tube is directly replaceable with the newer 6AX4 and usually with the 6AU4, although this latter type draws 1.8 ampere for its heater instead of the 1.2 ampere of the other types.

**24.** When using rectifier tubes not especially designed for damper service in receivers having large picture tubes and high pulse voltages it is necessary to limit the potential difference between cathode and heater to minimize the chances for breakdown. As a rule the damper heater is supplied from a separate winding on the power transformer. Then the heater and cathode are connected together directly or through a low resistance.

If the damper heater winding on the power transformer has much capacitance to other windings or to the transformer core there will be a considerable loss of pulse voltage through this capacitance. This loss may be lessened by using between cathode and heater a fixed resistor of about 100K ohms paralleled with a capacitor of about 200 mmf or less, this combination instead of the usual direct connection.

**26.** There is strong radiation of fields due to pulse voltages in the damper high-side leads. These pulses may be picked up by other circuits to cause trouble.

**28.** R-f chokes used in series with the cathode or plate of the damper, or in both places, may have inductances anywhere from 0.5 to 10.0 microhenrys. A number of them are of the self-resonant type, with internal distributed capacitance causing resonance somewhere close to 60 mc.

**29.** The low-side element of the damper, either the cathode or plate, must be bypassed to ground or else to a B+ line on which there is a filter capacitor to ground. With a low-side cathode there may be a rather large capacitance to ground located on the damper side of a linearity control inductor. A low-side plate usually has a direct conductive

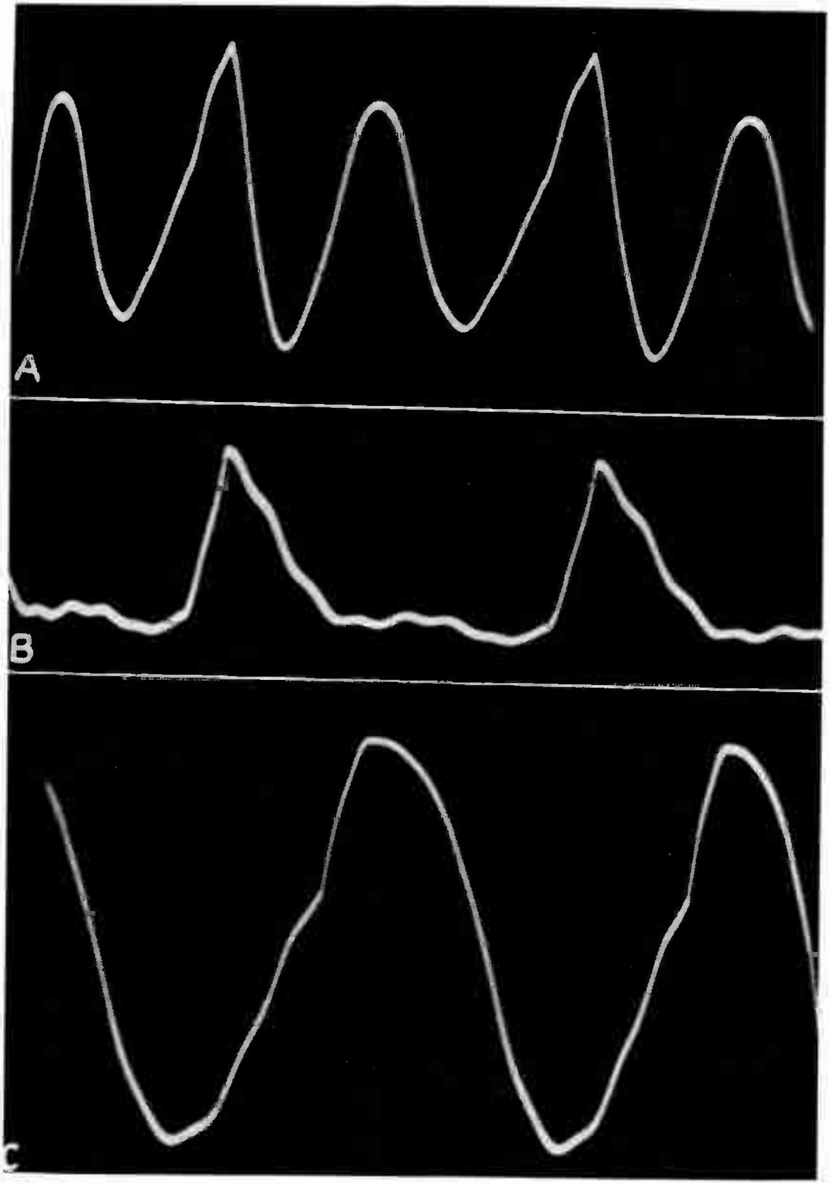


*Fig. 12-19. Adjustment of a linearity control inductor varies the voltage waveform applied through the transformer to the plate of the horizontal sweep amplifier.*

connection to a B+ line on which there is a filter capacitor to ground, but otherwise is provided with a bypass capacitor at the damper plate.

**30.** Varying the adjustment of a linearity control inductor makes large changes in the waveform of voltage at the low side of the damper. This may be the waveform of boost voltage applied through the horizontal output transformer to the plate of the sweep amplifier, or, depending on circuit connections, the voltage waveform at the damper low side may go to the transformer and the sweep amplifier plate through a capacitor. In any case the waveform caused by linearity adjustment affects the sweep amplifier and its output to the horizontal deflecting coils, thus affecting horizontal linearity.

At *A* of Fig. 12-19 is a voltage waveform at the low side of a damper in whose circuit is a linearity control inductor set for its minimum inductance, with the core all the way out of the coil. At *B* is the waveform with the core about half way into the coil, for a medium value of inductance. At *C* is the waveform resulting from maximum control inductance, with the core all the way into the coil.

**33.** Drive voltage at the grid of the horizontal sweep amplifier is a direct control for width, when the drive may be varied. Too little drive voltage usually tends to compress the sides of pictures more than the center, making the entire picture narrower but noticeably cramped only at the sides.

**35-36.** Increasing a negative peaking resistance in series with a sawtooth capacitor adds to the peak-to-peak drive voltage by adding a negative peak, but it does not greatly alter the amplitude of the sawtooth portion of the wave. The negative peak tends to increase picture tube anode voltage, and, within limits, the greater the negative peaking resistance the greater will be the anode voltage. Either too much or too little negative peaking may make horizontal sync critical or difficult to hold unless the hold control has a wide range.

It should be noted that a capacitance voltage divider type of drive control, with an adjustable capacitor from amplifier grid to ground, makes large changes in amplitude of the sawtooth portion of the drive waveform, but does not alter the shape of this portion of the wave.

**35.** Too much peaking resistance and an excessively deep negative peak tend to cause ringing or continued oscillation in the transformer and yoke circuits. This result is alternate light and dark vertical bands in pictures or a raster. A faulty bypass capacitor on all or part of the peaking resistance is likely to cause excessive ringing.

**36.** Too little negative peaking resistance may allow a vertical bright line toward the left, which is a variety of fold, or may allow a wider fold toward the center of pictures. A vertical bright line which cannot be removed by adjustment of a capacitance-divider drive control (Capacitor to ground) often may be removed by slightly more negative-peaking resistance. This is a means for maintaining satisfactory anode voltage on the picture tube where this voltage would be dropped by adjustment of a capacitance-divider drive control in an effort to prevent a vertical bright line.

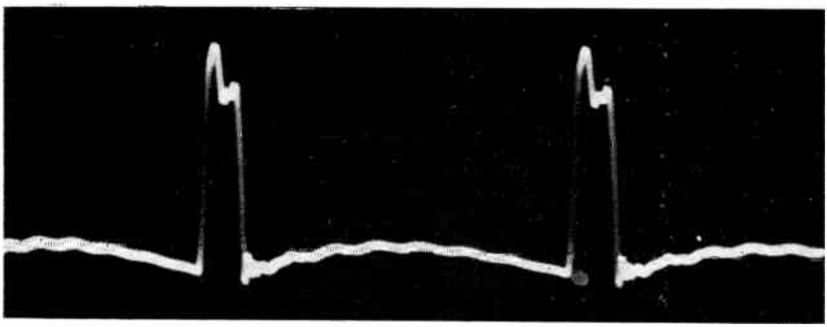

*Fig. 12-20. Voltage waveform at the low side of horizontal yoke coils not connected to the lowest point on the output transformer.*

## HORIZONTAL YOKE COILS

Voltage waveforms at the high side of horizontal yoke coils are very nearly the same as at the high-side elements of dampers in the same receivers. These forms are shown by Figs. 12-11 and 12-12.

Where the low side of horizontal yoke coils is connected to a relatively high-voltage tap on the output transformer, usually above a width control inductor as in Fig. 12-2, there will be strong voltage peaks at the low side of the yoke. Such peaks are shown by Fig. 12-20. These particular traces, measuring 1900 volts, were taken from a receiver having an autotransformer for horizontal output rather than an insulated secondary as in Fig. 12-2. Traces from any yoke so connected should be observed only with a high-voltage capacitor-type probe.

Where a capacitor of large capacitance is connected from the low side of horizontal yoke coils to B+ or ground the voltage pulses are dissipated or absorbed in the capacitance.

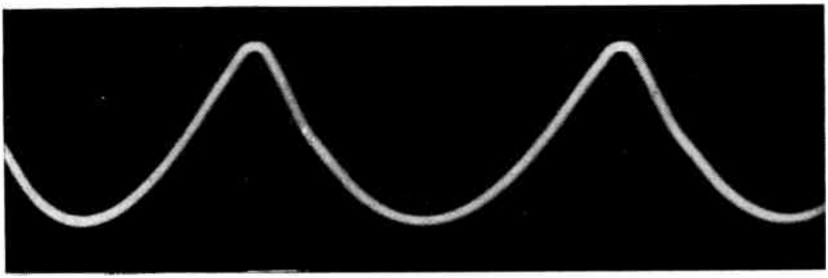

*Fig. 12-21. Voltage waveform at the low side of a yoke on which there is large capacitance to ground.*

Then a trace from the low side of the yoke appears as in Fig. 12-21. This is the general waveform characteristic of any point at which a pulsed or sawtooth voltage connects to a large capacitance going to B+ or ground. Compare Fig. 12-18-A.

## Yoke Inductance

The required relation between inductance of horizontal coils in the yoke and inductance of transformer turns across which the yoke is connected is affected by whether or not there is direct current in the yoke coils. There is direct current when both ends of the yoke coils are conductively connected to the transformer. There is no direct current when a fixed capacitor is in series with the yoke coils, on either end.

When there is no direct current in the yoke its inductance generally is from about 14 per cent to as much as 20 per cent of the transformer winding inductance across which the yoke is connected.

Where there is no direct current in the yoke its inductance usually is somewhere between about 18 per cent and 25 per cent of the transformer inductance across which the yoke is connected. These are merely approximate relations, but they help when checking for trouble where an original yoke has been replaced with one whose inductance may be far from correct.

## Capacitor-resistor Networks On Yokes

In all early receivers and in many current models the high side horizontal coil in the yoke is paralleled with a small capacitor as at *a* of Fig. 12-22 or with a capacitor and

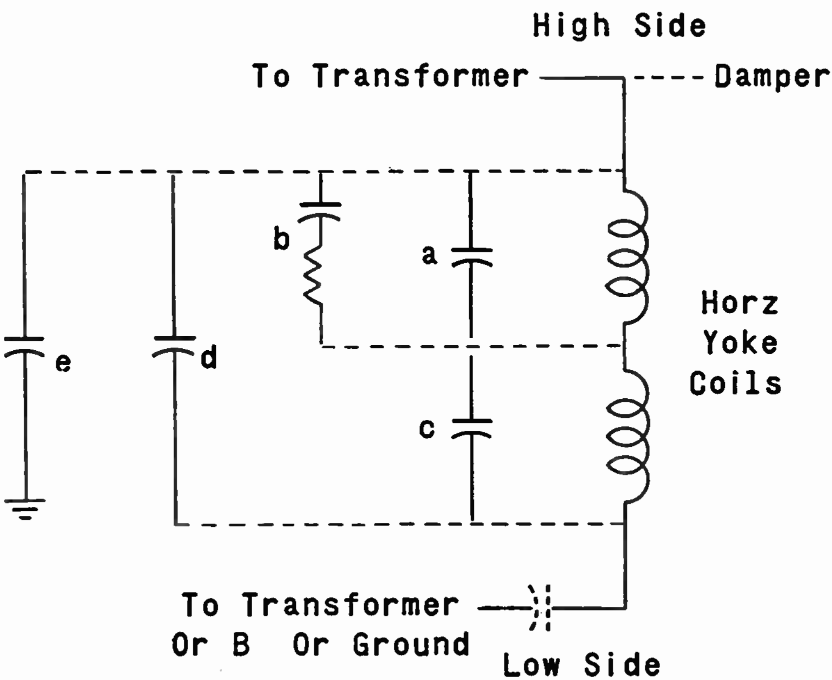


*Fig. 12-22. Some capacitor-resistor networks used with horizontal yoke coils.*

resistor in series as at *b*. A great many later receivers may have an additional capacitor across the low-side coil, at *c*, or capacitors at both *a* and *c*.

Sometimes there may be a single capacitor across both yoke coils, as at *d*, or there may be a capacitor, at *e*, from the high side of the coils to ground. Capacitors *d* and *e* may show on service diagrams as connected to transformer taps.

The values of capacitors shown by Fig. 12-22 may be and often are quite critical, possibly with 5 per cent tolerance or with 10 per cent at most. The purpose of these capacitors and any associated resistors is, in general, to prevent high-frequency oscillation in yoke and transformer elements and to help damp lower frequency oscillation which would be called ringing.

Even were two or more receivers do have transformer windings and yoke coils of equal or nearly equal inductances, the damping requirements introduced by other circuit components might call for different paralleled capacitors. Accordingly there are no general rules for capacitance values; replacements should be with exactly the same types as originally used.

## D-c Centering

One method of centering by variation of direct current in horizontal yoke coils was illustrated in Fig. 12-7. In Fig. 12-23 is shown another method which has been widely used in connections with insulated-secondary output transformers.

Paths of d-c electron flow are shown by arrows on Fig. 12-23. The flow passes from ground to the cathode of the horizontal sweep amplifier, through this tube to its plate, thence through the transformer primary and a linearity control inductor, if such a control is present, and goes to the cathode of the damper.

All plate current from the sweep amplifier goes through the damper and from the damper plate to the junction of the horizontal yoke and the secondary of the transformer. Here the current divides as shown by broken line arrows. Part goes through the transformer secondary and the remainder through the yoke coils and an adjustable resistor, the centering control, in series with the yoke. Currents from yoke and transformer then combine and go to B+.

How much or how little direct current flows in the yoke coils depends on adjustment of the centering control. More resistance and less yoke current shifts pictures toward one side, while less resistance and more yoke current shifts pictures toward the opposite side. Centering control resistors

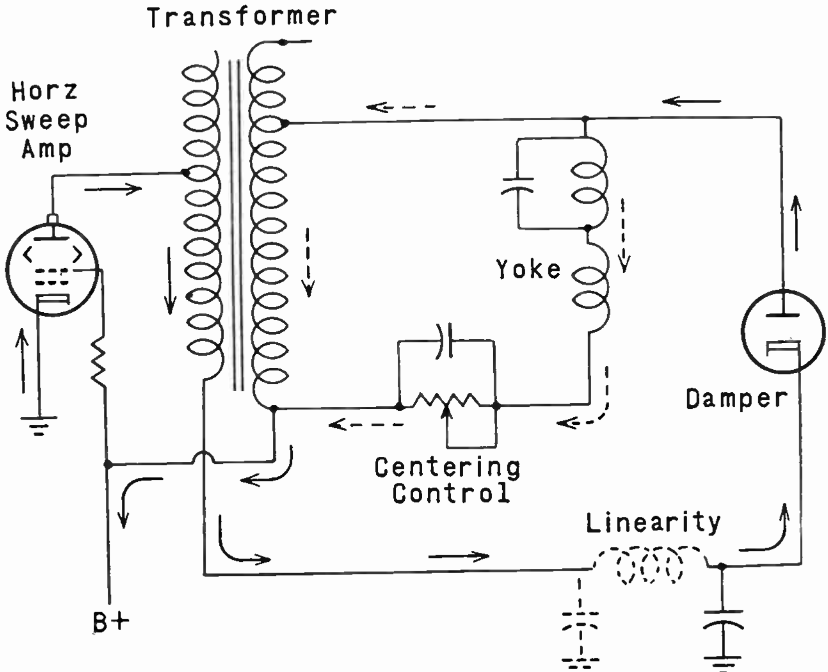


*Fig. 12-23. A centering control that varies the amount of direct current flowing in horizontal yoke coils.*

often are of about 500 ohms. The capacitor across the control may be as small as 0.25 mf or even smaller, or it may be several hundred microfarads in an electrolytic unit.

## Faults And Symptoms

Table 12-C lists faults which commonly occur in the horizontal yoke coils and in their connected components and circuits. The following explanatory paragraphs are numbered to correspond with numbered faults in the table.

**38.** So far as the effect on picture tube anode voltage is concerned there usually may be considerable variation in yoke inductance without seriously lowering this voltage. In many designs it is possible for yoke inductance to vary 30 per cent or more from the optimum value with a drop of less than 10 per cent in anode voltage.

**39.** Excessively long leads to the horizontal yoke coils, especially to the high-side coil, not only allow radiation of

| **Table 12-C**<br><br>**HORIZONTAL DEFLECTION**<br>**Yoke Coils** | Anode Voltage Low, Zero (See table 14-B) | Anode Voltage High | Bright Line (Vert) | Dark, No Raster | Fold, Horizontal | Linearity Poor | Reversed, Left-right | Ringing | Wavy, Horizontal | Wedge Shaped | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|
| YOKE COILS, HORIZONTAL | | | | | | | | | | | |
| 38 Inductance wrong value | • | • | | | • | | | | | | • |
| Connections | | | | | | | | | | | |
| 39 Leads too long | | | | | | • | | | | | |
| 40 High-resistance joints | • | | | | • | | | | | | • |
| 41 Leads interchanged | | | | | | | • | | • | | |
| 42 To wrong taps on output transformer | • | • | | | | | | | | | |
| 43 Center tap to transformer open | • | | | | | | | • | | | |
| Capacitor, Low Side to B+ Or To Ground | | | | | | | | | | | |
| 44 Open | | | | • | | | | | | | |
| 45 Too small | • | | | | | | | | | | • |
| 46 Leaky | • | | | | | | | | | | • |
| 47 Shorted | | | | • | | | | | | | |
| Capacitor Across One Coil | | | | | | | | | | | |
| 48 Open, too small | | | | | | | | • | • | | |
| 49 Too great | • | | | | | | | | | | |
| 50 Leaky, shorted | | | | • | | | | | | • | |
| 51 Too much or too little capacitance | | | | | | • | | • | | | |
| Capacitor Across Both Coils | | | | | | | | | | | |
| 52 Open, too Small | | | | | | | | • | | | |
| 53 Too great | • | | | | • | | | | | | |
| 54 Too much or too little capacitance | | | • | | | | | | | | |

(Continued on following page)

(Continued from previous page)

**Table 12-C**

**HORIZONTAL DEFLECTION**
**Yoke Coils**

| | Anode Voltage Low, Zero (See table 14-B) | Anode Voltage High | Bright Line (Vert) | Dark, No Raster | Fold, Horizontal | Linearity Poor | Reversed, Left-right | Ringing | Wavy, Horizontal | Wedge Shaped | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Internal Faults | | | | | | | | | | | |
| 55 Open circuit | • | | | | | | | | | | |
| 56 One coil shorted, open | | | | | | | | | | • | |
| 57 Graunded to core | • | | | | | | | | | | |
| 58 Core gap too great | | | | | | | | | | | • |
| Yoke Circuit | | | | | | | | | | | |
| 59 Open | | | • | | | | | | | | |
| 60 Grounded | | | | • | | | | | | | |

pulse voltages or fields into other circuits but also cause much loss of picture tube anode voltage. The voltage loss may be as much as 15 per cent.

**40.** With high resistance anywhere in the horizontal yoke circuit the drop of picture tube anode voltage and the decreased in picture width usually are proportional or nearly so.

**41.** When leads to the horizontal yoke coils are interchanged or reversed anywhere from chassis to yoke the pictures will be reversed between left and right but still will be right side up unless leads to the vertical coils are interchanged at the same time.

When the same yoke is used either with an output autotransformer or with an insulated-secondary transformer the yoke leads must be reversed to avoid reversal of pictures. This, in effect, will shift damping capacitors and resistors between the high and low sides of the yoke. To prevent excessive ringing it is necessary to remove a damping capacitor or capacitor-resistor combination from one of the yoke coils and to connect it across the other coil. Failure to change the damping elements may cause the appearance of small horizontal waves over the entire viewing screen of the picture tube.

**43.** A connection from between the horizontal yoke coils to a tap on the transformer (Fig. 12-5) helps reduce the effects of distributed capacitance and in many receivers allows having no capacitor or capacitor-resistor combination across either yoke coil.

**44-47.** A capacitor which is in series with the horizontal yoke coils and which prevents direct current from flowing in the yoke must be capable of carrying the alternating or saw-tooth current between the yoke and transformer. It is this capacitor that completes what may be called the deflecting circuit.

**53.** Too much capacitance almost anywhere in the circuit formed by transformer and yoke windings tends to slow the retrace time between successive horizontal picture lines. This is likely to cause shadowy folding of the kind that moves sideways across pictures when the horizontal hold control is adjusted.

**59.** An open circuit between the horizontal output transformer and yoke coils may, in some cases, allow very strong oscillation in the transformer. This oscillation may so increase the alternating voltage on the filament of the high-voltage rectifier as to burn out the filament.

# SECTION 13

## BOOSTED B-VOLTAGE

Boosted B-voltage is obtained from rectification in the damper tube of strong voltage pulses produced in the horizontal output transformer and yoke circuits. The rectified voltage is filtered and smoothed by inductance in part of the transformer winding and by capacitors and resistors connected to the low side of this winding and/or in the low side of the damper circuit.

Since the low side of the damper always is connected more or less directly to a B+ line, voltage from rectification of pulses by the damper adds to the regular B+ voltage to form the boosted B-voltage or boost voltage.

The additional boost voltage in earlier receivers often was as little as 50 volts, but in recent designs it may be 300 or more volts. As a result, it is possible to have a low-voltage B-supply furnishing somewhere around 250 volts, and in some cases less than 150 volts, while having from the damper circuit a total boosted B-voltage of from 400 to more than 500 volts available for circuits and sections requiring higher voltage than that from the low-voltage B-supply.

Fig. 13-1 shows by heavy lines the parts in which there always is boosted B-voltage and paths in which there may be such voltage. The diagram applies to a receiver having an output autotransformer. Boosted B-voltage is assumed to originate at the cathode of the damper tube, just as ordinary B-voltage is assumed to originate at the cathode or filament of a power rectifier in the low-voltage B-supply.

Boosted B-voltage always is applied through part of the output transformer winding to the plate of the horizontal sweep amplifier. This is the d-c plate voltage for the amplifier. It might be asked how the amplifier can act to produce strong voltage pulses to be rectified and do so before boosted

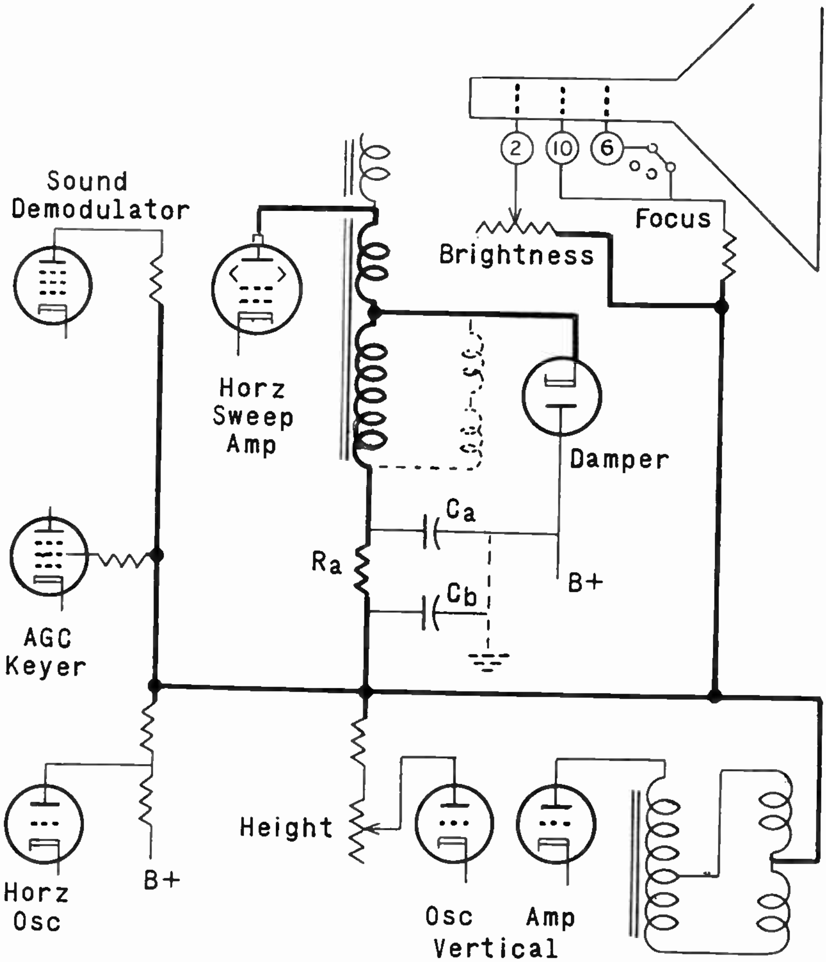


*Fig. 13-1. Boosted B-voltage goes to various sections and subsections through conductors shown by heavy lines.*

B-voltage is developed in the damper circuit for application to the amplifier plate. The answer is that regular B+ voltage acts through the heated damper tube and reaches the plate of the sweep amplifier to begin the action.

Boosted B-voltage acting through the transformer winding is filtered by combined action of capacitors *Ca* and *Cb* and by resistor *Ra* of Fig. 13-1. Filtered boosted B-voltage nearly always is applied to the second grid, (base pin 10) of the picture tube, and in many receivers is applied to the vertical oscillator and vertical output amplifier. Less common uses for boosted B-voltage include the horizontal oscillator, the agc keyer tube, the sound demodulator, and others.

Failure or excessive drop in boosted B-voltage will prevent or impair to a greater or less extend the performance of all circuits and sections operated from this voltage.

Unfiltered boosted B-voltage at the junction of capacitor *Ca* and resistor *Ra* in Fig. 13-1 commonly has such waveforms as in Fig. 13-2.

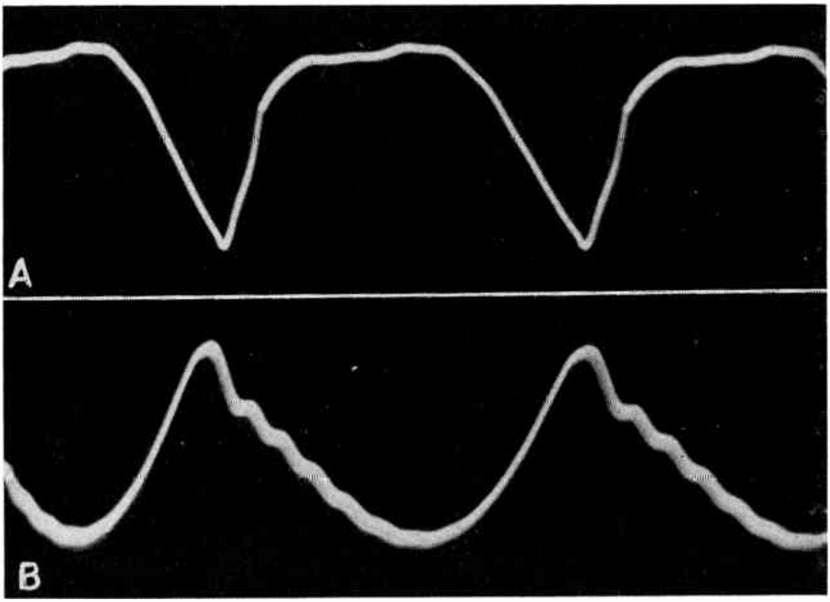


*Fig. 13-2. Waveforms of boosted B-voltage before it is filtered.*

## Faults And Symptoms

Common faults in the boosted B-voltage circuit, together with accompanying picture symptoms, are listed in Table 13. Here are listed also the symptoms due to failure of boosted B-voltage applied to other circuits and sections. Explanatory paragraphs which follow are numbered to correspond with numbered faults in the table.

**1-** When a capacitor in this position is open or too small in value there may be transformer circuit oscillation producing voltages high enough to puncture the insulation of wiring. Peak-to-peak values of 20 to 25 kilovolts have been observed. The oscillation may raise anode voltage to produce a very bright viewing screen with no pictures visible.

**2-** The most noticeable symptom of moderate leakage in this capacitor may be lack of brightness, with the other listed symptoms becoming more evident when leakage resistance drops to only a few thousand ohms.

**7.9-** An electrolytic capacitor of 5 mf or more nearly always is on the boosted B-voltage supply line just beyond the filter resistor. Failure of this capacitor allows pulses at the horizontal line frequency to pass into all sections or tubes operated with boosted B-voltage. This frequency, acting on picture tube anode voltage and brightness, causes a bright or dark area toward one side of pictures and an area of opposite tone on the other side.

**10-** This fuse, whose electrical position is shown by Fig. 12-14-A, carries all plate current for the horizontal sweep amplifier and usually screen current for this amplifier. Various faults in the amplifier tube itself or in its circuits may allow the tube to draw excessive current. This current could burn out the transformer windings were it not cut off by blowing of the fuse.

In the event of a blown fuse a new sweep amplifier should be substituted, at least temporarily, for the original one. Then the fuse may be replaced and power turned on while watching the amplifier for evidences of overheating, such as reddening of its plate. Overheating of the amplifier or blowing of the new fuse is proof of excessive current, usually the result of too little negative bias on the amplifier grid or too little positive voltage at its cathode, or possibly due to shorting of the screen voltage dropping resistor.

A safer procedure is to remove the fuse and connect in its place a d-c current meter on a range of 500 or more milliamperes. If, upon applying power, the current rises above 100 milliamperes it is almost certain proof of trouble in the amplifier tube, or in its grid, screen or cathode circuits. Of course, it is possible but not likely that the fuse has

| Table 13 BOOSTED B—VOLTAGE | Boost Voltage Low | Boost Voltage Zero | Brightness Excessive | Brightness Lacking | Compressed At Top | Dark, No Raster | Dark Area, Vertical | Focus Poor | Fold, Horizontal | Height Lacking | Line (Horz), One | Sync Critical (V Or H) | Width Lacking |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **FILTER FOR BOOST VOLTAGE** | | | | | | | | | | | | | |
| Capacitor, Transformer To B+ Or Ground (Ca of Fig. 13-1) | | | | | | | | | | | | | |
| 1 Open, Too small | | | • | • | | | | | • | | | | • |
| 2 Leaky | • | | | • | | | | | • | | | • | • |
| 3 Shorted | | • | | | | • | | | | | | | |
| Filter Resistor *(Ra)* | | | | | | | | | | | | | |
| 4 Open | | • | | | | | | | | | | | |
| 5 Too great | • | | | | | | | | | | | | |
| 6 Too small, shorted | | | • | | | | | | | | | | |
| Capacitor, Filter Output *(Cb)* | | | | | | | | | | | | | |
| 7 Open, too small | | | | | | | • | • | | | | | |
| 8 Leaky | • | | | | | | | | | | | | |
| 9 Shorted | | • | | | | | | | | | | | |
| **FUSE FROM B+ LINE** | | | | | | | | | | | | | |
| 10 Blown | | | | | | • | | | | | | | |
| **BOOST VOLTAGE LOW OR ZERO TO THESE CIRCUITS** | | | | | | | | | | | | | |
| 11 Picture tube 2nd grid | | | | | | • | | • | | | | | |
| 12 Vertical amplifier and/or oscillator | | | | | • | | | | • | • | • | | |
| 13 Horizontal oscillator | | | | • | | • | | | | | | | • |
| 14 Agc keyer tube | | | | | | | | | | | | • | |

blown because of faults and excessive current in some of the circuits supplied with boosted B-voltage, such as the circuits in Fig. 13-1.

**11-14.** Boosted B-voltage will rise and fall as sweep amplifier grid drive voltage is increased and decreased.

# SECTION 14

## HIGH VOLTAGE SECTION

High voltage for the picture tube anode is secured by adding only a rectifier tube and an extension of the output transformer winding to those parts of the receiver which would be there were no high voltage needed. The high-voltage section is simple in itself, but obtaining satisfactory anode voltage for the picture tube depends also on correct performance and condition of practically everything from the horizontal sweep oscillator to and including the yoke coils.

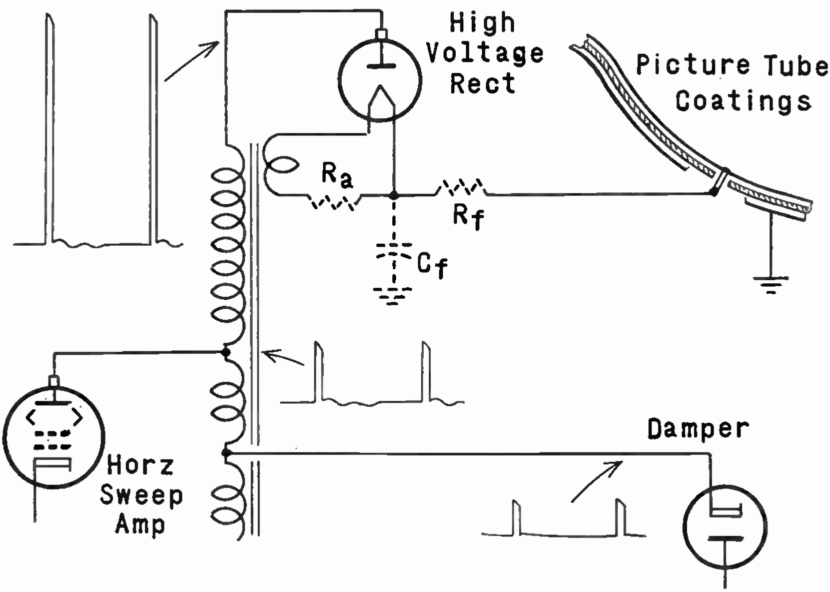


*Fig. 14-1. The high-voltage section and closely related circuits.*

Fig. 14-1 shows the parts to be considered as the high-voltage section and those most closely associated. Voltage pulses which are strong at the plate of the horizontal sweep amplifier are made much stronger by autotransformer action in the extension of the winding from amplifier plate to rectifier plate. The rectified and filtered d-c voltage for the picture tube anode has a potential to ground of approximately the same value as the peak voltage on the rectifier plate.

There may or may not be a resistor at *Ra,* in series with the rectifier filament. There may or may not be a resistor at Rf, in series to the picture tube anode. And there may or may not be a filter capacitor at *Cf.* This capacitor, when used, nearly always is of 500 mmf and is rated at 10,000 to 30,000 volts.

The internal and external conductive coatings of glass picture tubes, with the glass as dielectric between the coatings, act as a filter capacitor for the anode voltage. Capacitance is not uniform from tube to tube, even of the same type, but always is at least 500 mmf and often is as great as 1500 mmf or possibly 2000 mmf. These values are found in glass picture tubes of nominal sizes from 17 to 24 inches.

When a resistor *Ra* is in series with the rectifier filament the resistance value may be anything from less than one ohm to as much as 5.6 ohms, depending on transformer construction and operating voltage or pulse voltages.

Resistor *Rf* is omitted in most receivers of recent design. When used the value may be anything from about 1000 ohms to 2 megohms.

Inductance of the transformer winding between amplifier plate and rectifier plate commonly is between 900 to 1200 millihenrys, but in a few cases may be down around 400 or up around 2500 millihenrys.

Inductance of the winding between amplifier plate and the tap connected to a damper or yoke commonly is almost anything from 30 to 80 millihenrys, but may be smaller or greater.

There is no direct relation between inductance and resistance of the windings. D-c resistance from amplifier plate to rectifier plate quite commonly is between 250 and 330 ohms, but may range from 150 to 600 ohms or even more. Resistance from amplifier plate to the damper or yoke tap is commonly between 10 and 22 ohms and occasionally as great as 30 ohms.

At *A* of Fig. 14-2 are pulses observed at the horizontal sweep amplifier plate and at *B* are pulses at the high- voltage rectifier plate in the same receiver. Peak-to-peak values are, respectively, about 4000 volts and 13,000 volts. Such peaks may be observed with a capacitor probe capable of withstanding very high voltages.

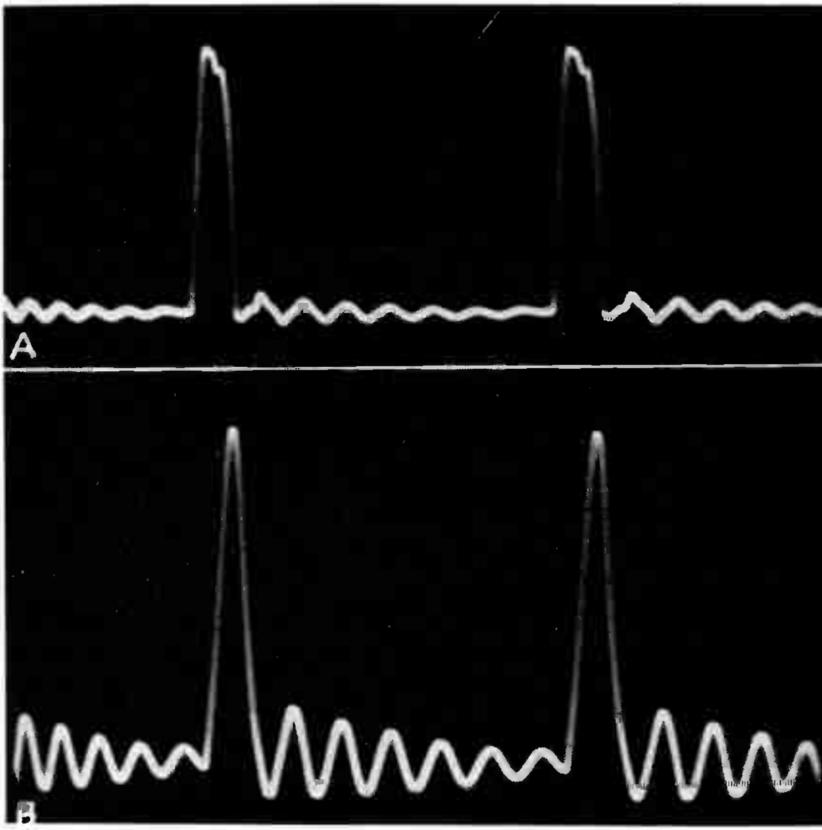


*Fig. 14-2. High-voltage pulses. A, at the sweep amplifier plate. B, at the rectifier plate.*

Fig. 14-3 shows high-voltage pulses from another receiver, at *A* from the sweep amplifier plate and at *B* from the high-voltage rectifier plate. Note that in any case the waveform at the rectifier plate is similar in general to that at the amplifier plate.

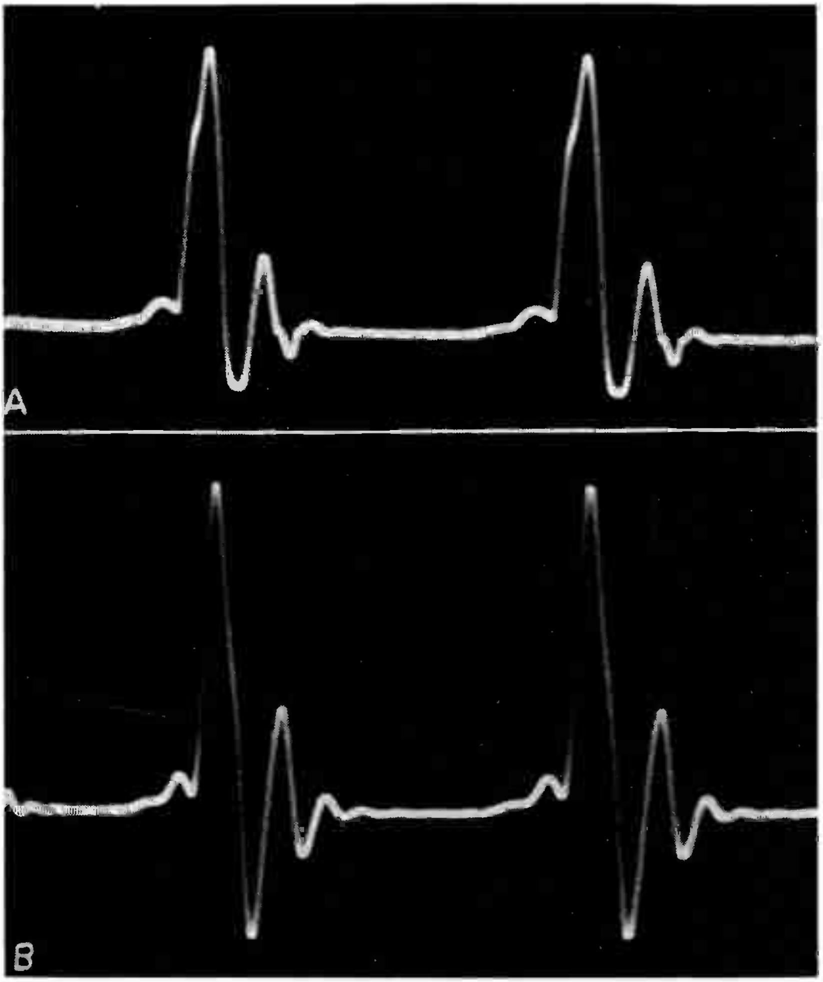


*Fig. 14-3. High-voltage pulses (A) at a sweep amplifier plate and (B) at the rectifier plate.*

## Measuring Anode Voltage

D-c voltage for the picture tube anode, checked anywhere from the filament of the high-voltage rectifier to the anode terminal on the picture tube, may be measured satisfactorily and safely only with a vacuum tube voltmeter fitted with a probe especially designed for such measurements. Methods of using such probes are explained in the instructions accompanying all instruments and will not be described here.

Presence or absence of the high voltage pulses which are the original source of d-c voltage for the picture tube anode is easily detected and traced with a small neon lamp. A 1/25 watt lamp is suitable. The type NE-2 lamp is good because it has extended wire leads instead of a base.

The NE-2 lamp may be held as shown by Fig. 14-4 on the end of a 3/16-inch diameter rod of fibre or plastic which is 8 to 10 inches long. Lay the lamp leads along the rod and hold them with a short length of snug fitting spaghetti (insulating tubing).

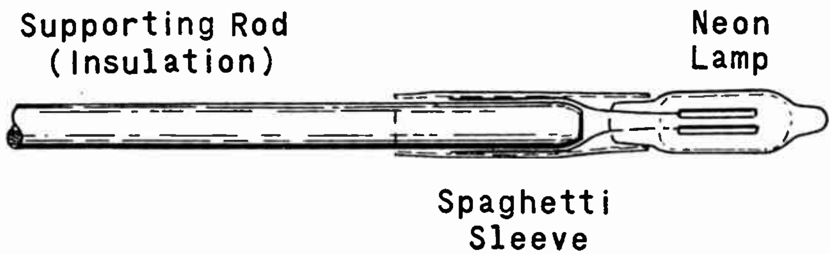


*Fig. 14-4. A probe for detecting presence or absence of high-voltage pulses.*

The neon gas within the bulb will glow red when the lamp is held in any high-voltage alternating field. When high-voltage pulses are present the lamp should glow at the high side of the damper, at the plate cap of the horizontal sweep amplifier, and at the cap of the high-valtage rectifier, also anywhere along the leads connected to these points unless the leads come close to chassis metal. There should be a glow also anywhere around the high-voltage portion of the transformer winding. There will be no glow at the socket for the high-voltage rectifier, none along the cable to the picture tube anode and none at the anode terminal. There should be only d-c voltage at these points.

The stronger the voltage pulses the brighter will be the glow in the lamp, and the closer the lamp is held to conductors carrying pulses the brighter will be the glow. Faults exist where there should be a glow but actually is none.

It is rather common practice to check for high d-c voltage at the picture tube anode by holding the cable connector about a quarter inch from the picture tube terminal, taking good care to hold only the cable insulation and to do this only with extra insulation around the cable. Bright, snappy sparks indicate high d-c voltage.

Spark tests should not be made when any other method is possible with equipment at hand. Jumping a spark more than a very short distance places abnormal stresses on parts of the high-voltage section. Even a weak anode voltage will jump a short distance, so there is little to gain by this method. Spark tests at the sweep amplifier plate, the high-voltage rectifier plate, or at the damper high side are more than likely to cause breakdown in the horizontal output transformer windings.

## Testing Without A Picture Tube

Measuring high voltage from the filament side of the high-voltage rectifier with no picture tube connected will give misleading high voltage readings because there is no load on the rectifier output.

High-voltage performance may be checked and measured without a picture tube by substituting a resistance load. Connect in series with one another a number of 1/2-watt or 1-watt fixed resistors of not more than 12 megohms each. Make up a total resistance which will allow 100 microamperes of current at the anode voltage specified for the receiver. Required megohms of resistance may be found from dividing the specified anode volts by 100. For example, where the specified voltage is 11,000 use 110 megohms of fixed resistance.

Connect the string of resistors from the filament lug on the socket of the high-voltage rectifier to ground. Connect also from this point to ground a standard 20,000- or 30,000-volt capacitor of 500 mmf, because there will be no picture tube coating capacitance in the circuit. Measure the d-c voltage at the filament connection of the high-voltage rectifier, using a VTVM and high-voltage probe in the usual way. The scheme of connections is illustrated by Fig. 14-5.

This method places what amounts to a normal full load or nearly a maximum load on the high-voltage system. Unless the specified anode voltage is for full load conditions the measured voltage will be as much as 20 per cent below that specified, with the high-voltage system in good order.

## Faults And Symptoms

Table 14-A lists faults in the high-voltage parts and circuits shown by Fig. 14-1 and gives symptoms usually associated with the faults.

A high-voltage rectifier whose filament-cathode coating has been damaged by overheating usually will allow d-c anode voltage of something like 1000 volts, but not normal anode voltage.

When the filament of a high-voltage rectifier has burned out, try to locate the cause before replacing the tube. It may be possible to slightly loosen or spread the turns of filament winding on the transformer core as a preliminary precaution, to place the turns in a weaker field and reduce filament voltage. A greater resistance might be used in series with the filament winding. High-voltage rectifiers work well when filament glow is barely visible in normal room lighting.

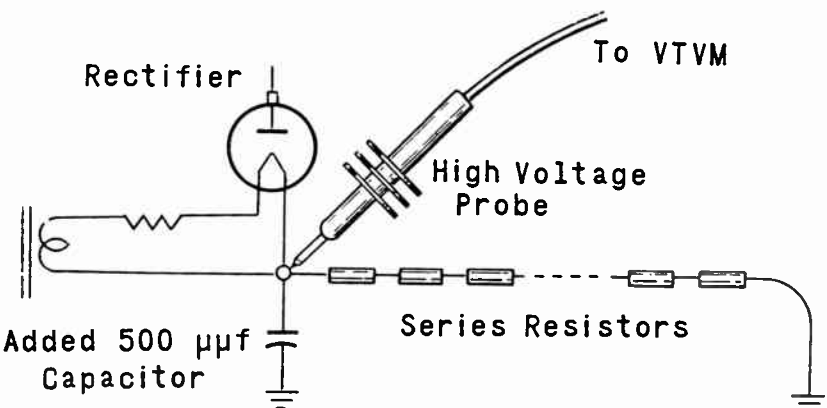


*Fig. 14-5. Measuring high voltage from the rectifier when no picture tube is connected.*

With a glass picture tube the outer conductive coating, if present, usually provides ample filter capacitance, especially when there is no resistor or one of only a few thousand ohms in the line from rectifier to picture tube anode terminal. In this case an open filter capacitor (the 500 mmf unit) drops anode voltage very little.

If the external conductive coating on a picture tube has been flaked off or is coated with a non-conductive film where the ground contact is located a repair may be made. Clean the bared glass with a damp cloth and dry it thoroughly. Then apply a coating liquid prepared for the purpose. Sometimes enough coating may be applied from a very soft lead pencil.

### ANODE VOLTAGE LOW OR ZERO

In many of the tables relating to faults in sweep and deflection sections one of the symptom headings is "Anode Voltage Low Or Zero". While lack of anode voltage is a symptom of various faults it is also a fault in itself and may be the cause of several picture symptoms.

Table 14-B is a summary of most of the faults which, in sweep and deflection sections, may result in picture tube anode voltage being too low or zero. At the top of this table are listed the picture symptoms which usually accompany lack of sufficient anode voltage. These symptoms include blooming, lack of brightness, a dark viewing screen, lack of sharp focus, and pictures of excessive size.

Pictures may bloom or spread in all directions when the brightness control is advanced while anode voltage is too low. The voltage between cathode and viewing screen is not enough to make the electron beam "stiff" and the electrons are deflected too far up, down and sideways.

Low anode voltage reduces brightness because electrons do not strike the viewing screen with enough velocity and energy to properly excite the phosphor.

With anode voltage very low or absent there is little or no excitation of the phosphor, and the viewing screen remains dark under all conditions. There will be no raster.

Poor focus results from low anode voltage because the slowly traveling electrons become diffused before reaching the viewing screen.

Picture size may be excessive for the same reason that blooming occurs, but the trouble is less pronounced.

Keep in mind that there is a direct relation between anode voltage and drive voltage, also between anode voltage

| Table 14-A<br>HIGH-VOLTAGE SECTION | Anode Voltage Low, Zero (See table 14-B) | Corona, Arcing See table 14-C) | Dark, No Raster | Flashes | Size Excessive | Speckling |
|---|---|---|---|---|---|---|
| RECTIFIER | | | | | | |
| 1 Tube weak | • | | | | • | |
| 2 Open filament | | | • | | | |
| 3 Socket defective | | | | • | | • |
| 4 Socket pin contacts poor | | | | | | • |
| FILTER SYSTEM | | | | | | |
| Capacitor | | | | | | |
| 5 Open | • | | | | | |
| 6 Leaky | • | • | • | • | • | • |
| 7 Shorted | | | • | | | |
| Series Resistor To Anode | | | | | | |
| 8 Open | | | • | | | |
| 9 Defective | • | • | | | | |
| Picture Tube Coating | | | | | | |
| 10 Ground contact poor | | • | | | | • |

and peak values of voltages at the damper high side, the sweep amplifier plate, and the plate of the high-voltage rectifier.

The opposites of some of the faults listed in table 14-B provide means for increasing the anode voltage when this is desirable. For example, if insufficient drive voltage at the sweep amplifier drops anode voltage, increase the drive. If low screen voltage on the sweep amplifier lowers the anode voltage, use less dropping resistance to the amplifier screen. In this latter case be sure to check amplifier cathode current to see that it does not exceed the rating for the tube.

Tracing for the location of a fault causing insufficient anode voltage may begin at the picture tube anode terminal and follow back to the grid of the horizontal sweep amplifier,

| PICTURE TUBE ANODE VOLTAGE Low Or Zero | Symptoms: Blooming; Brightness Lacking; Dark, No Raster; Focus Poor; Size Excessive |
|---|---|
| SWEEP AMPLIFIER AND CIRCUIT | Tube |
| | 11 Weak |
| | 12 Screen voltage too low |
| | 13 Plate to wrong terminal on transformer |
| | Peak-To-Peak Drive Voltage |
| | 14 Misadjusted, too much capacitance to ground |
| | 15 Misadjusted, too little series capacitance |
| | 16 Capacitor to ground leaky shorted |
| | 17 Resistor to ground shorted |
| | 18 Negative peaking resistor small, shorted |
| HORIZONTAL OUTPUT TRANSFORMER | 19 Capacitor-resistor network, any faults |
| | 20 Capacitor across turns, too great |
| | 21 Wrong transformer for yoke or amplifier |
| | 22 Core gap excessive |
| | 23 Internal open or shorted turns |
| WIDTH CONTROL INDUCTOR | 24 Misadjusted, too little inductance |
| | 25 Wrong type, too little inductance |
| | 26 Connected across too many transformer turns |
| | 27 Shunt capacitor too great |
| DAMPER AND CIRCUIT | 28 Tube weak, gassy |
| | 29 Plate voltage too low |
| | 30 Cathode-heater leakage |
| | 31 High-resistance connections |
| | 32 Plate bypass capacitor open, too small |
| | 33 Heater winding excess capacitance |
| YOKE COILS HORIZONTAL | Capacitor-resistor Network Faults |
| | 34 Capacitor across one or both coils too great |
| | 35 Capacitor to B+ or ground leaky, too small |

(Continued on following page)

(Continued from previous page)

| **Table 14-B**<br>**PICTURE TUBE ANODE VOLTAGE**<br>**Low Or Zero** | Symptoms<br>Blooming; Focus Poor<br>Brightness Lacking; Size Excessive<br>Dark, No Raster |
|---|---|
| YOKE COILS HORIZONTAL | Connections |
| | 36 High-resistance joints<br>37 Lead too long<br>38 Connected to wrong tap on transformer<br>39 Center tap to transformer open |
| | Internal Faults |
| | 40 Inductance wrong value for transformer<br>41 Internal open circuit<br>42 Ground to core<br>43 Core gap excessive |
| HIGH-VOLTAGE SECTION | Rectifier |
| | 44 Filament open<br>45 Weak emission |
| | Capacitor To Ground Or Damper Plate |
| | 46 Open, disconnected<br>47 Leaky, shorted<br>48 To ground instead of damper plate with insulated secondary transformer |
| | Resistor To Anode |
| | 49 Open, defective |
| CORONA, ARCING | 50 Anywhere from rectifier socket to picture tube anode terminal |
| PICTURE TUBE | 51 Gassy |

or begin at the amplifier grid and proceed to the picture tube anode terminal. Checks may be made in either direction with methods shown by Fig. 14-6.

At the grid of the horizontal sweep amplifier use an oscilloscope to observe the waveform and the peak-to-peak value of the drive voltage.

Use the neon lamp of Fig. 14-4 to check for presence or absence of high-voltage pulses at the plate of the horizontal sweep amplifier, around the windings of the horizontal output transformer, and at the plate cap of the high-voltage rectifier.

Use the vacuum tube voltmeter with a high-voltage probe for measurement of anode voltage at any point from the rectifier socket to the picture tube anode terminal.

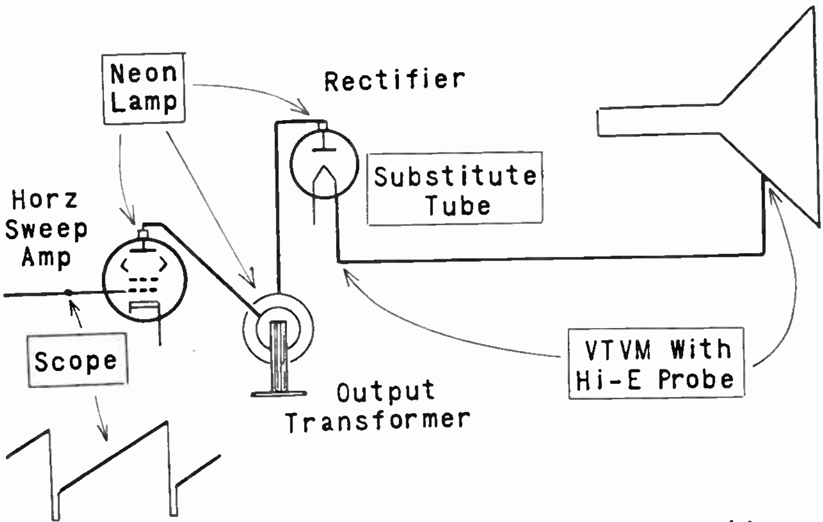


*Fig. 14-6. Within the blocks are names of instruments or parts used for tracing the cause of insufficient anode voltage.*

## CORONA OR ARCING

Any of three forms of electrical discharge (corona, sparking or arcing) are symptoms of various faults in the high-voltage section or in the horizontal output transformer. At the same time any of these discharges are the causes for various symptons at the picture tube viewing screen.

Table 14-C lists, at the top, the picture symptoms which may accompany electrical discharges, and down below lists the faults most often responsible for the discharges.

The corona is an electrical discharge evidenced on positive conductors by a continual bluish-white glow, and on negative conductors by reddish tufts at the conductor surface. There will be strong odor of ozone when corona occurs, and often a slight hissing sound. A corona discharge may change intermittently to sparking, which causes snapping

| Table 14-C<br><br>**CORONA OR ARCING** | Symptoms<br>Anode Voltage Low / Snow In Pictures<br>Dark, No Raster / Speckling<br>Flashes / Sync Critical<br>Jumpy Pictures / Tear Out |
|---|---|
| HIGH-VOLTAGE SECTION | Connections And Joints |
| | 44 Sharp points protruding<br>45 Wire strands protruding<br>46 Too close to other metal<br>47 High-resistance joints, from rectifier socket to picture tube. |
| | Filter Capacitor |
| | 48 Leaky or defective |
| | Insulation Faulty |
| | 49 Cable to picture tube anode terminal<br>50 Rectifier filament winding turns |
| | Rectifier Socket |
| | 51 Poor soldering to lugs<br>52 Tube pin contacts faulty<br>53 Socket of low dielectric strength |
| | High-voltage Cage |
| | 54 Grommets lacking around wires<br>55 Dirt and dust excessive |
| | Anode Voltage Too High |
| | 56 Sawtooth peaking resistor too great<br>57 Yoke connections faulty |
| HORIZONTAL OUTPUT TRANSFORMER | 58 Defective insulation on windings<br>59 Core grounded when should be insulated |
| PICTURE TUBE, METAL TYPE | 60 Metal support not grounded<br>61 Dirt on glass between shell and yoke |

sounds. An arc is a steady discharge causing a bright yellow-red glow and a sizzling sound. An arc carries enough current to cause burnouts in the apparatus.

Sparking and arcing are easily seen on normal room light. Corona is best observed where suspected parts are in the dark or well shaded from all surrounding light. Listening for the sounds mentioned in the preceding paragraph sometimes helps to locate the point at fault.

Causes and remedies for corona, sparking and arcing are much the same, for either kind of discharge may change to one of the others intermittently. Oftentimes there will be sparking before a corona occurs, especially where conductors are close together.

Remedies for most of the faults which allow electrical discharges are evident from the faults themselves. For example, sharp points should be smoothed, a cable with defective insulation should be replaced or covered with high-voltage tubing, and so on.

Additional insulation may be applied in various ways such as: (1) A plastic coating, sprayed on to form several coats, with each one dry before the next. (2) High-voltage insulating tubing, a variety of spaghetti. (3) Electrical plastic tape, in one or more layers. (4) High-temperature wax, melted and applied.

The following numbered notes refer to faults correspondingly numbered in table 14-C.

**44-46.** Clearance between bare conductors and adjacent metal of any kind should be at least one inch for each 10,000 volts of anode potential.

**44.** Sharp points most often exist on solder joints at the high-voltage rectifier socket. Such solder may be drawn off with a hot iron to make way for a smooth, well-rounded joint.

**45.** Loose wire strands must be removed, melting away the solder if necessary and then making a new joint.

**46.** If neither the high-voltage conductor nor adjacent metal can be moved, apply insulation as described earlier.

**47.** Solder joints may be loose or corroded. If a cold-solder joint is suspected, heat it well while applying a very little additional flux-cored solder. Spliced high-voltage leads should not be tolerated, the cable should be replaced with a continuous run.

**48.** High-voltage filter capacitors cannot be satisfactorily checked for leakage with an ordinary capacitor tester, not enough voltage can be applied. The test is to temporarily substitute a new capacitor.

**49.** Insulation sometimes hardens and cracks on very old cables. These cables are not difficult to replace, even for the rectifier filament winding. Use only high-voltage cable designed for this use.

**51.** Solder joints on high-voltage conductors must be smooth and rounded. Faulty joints should be resoldered until of good shape.

**56.** When the trouble exists between windings of the horizontal output transformer, or between windings and core, and when it is not desired to replace the transformer, the anode voltage may be reduced by lessening the drive voltage. As a rule the pictures still will be quite satisfactory with anode voltage 10 to 20 per cent lower than recommended for the receiver.

**59.** Metal supports around the insulation at the face-plate end of metal picture tubes tends to collect a static charge that escapes as a corona or as occasional slight sparks. Such metal usually is grounded to the chassis through a fixed resistor of about ½ megohm. The resistor may be bypassed with a capacitor of a few hundred mmf.

**60.** There is a high potential difference between the metal shell of a picture tube and the coils in the yoke, across the glass at the rear of the shell. In case of persistent trouble, after cleaning the glass, the yoke coils may be protected with electrical tape.

# SECTION 15

## VERTICAL DEFLECTION

Various circuit connections found with vertical output transformers and vertical coils in the deflecting yoke are illustrated by Figs. 15-1, 15-2 and 15-3. It cannot be said that any one of the circuit connections is much more typical of general practice than the others. All of them are in common use for receivers of recent design.

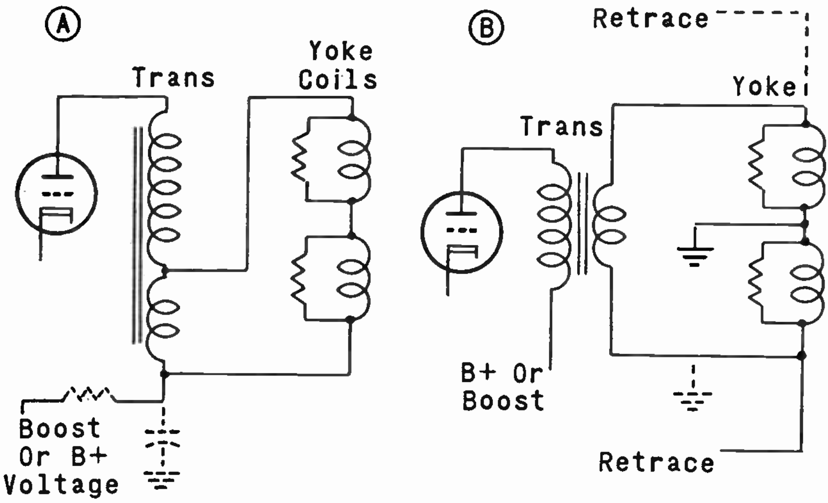


*Fig. 15-1. Some common types of vertical deflection sections. A, with an autotransformer. B, with a transformer having insulated secondary.*

At *A* of Fig. 15-1 there is an autotransformer wherein the entire winding acts as the primary, with the lower section, across which the yoke coils are connected, acting as the secondary. Either boosted B-voltage or regular B+ voltage is applied to the bottom of the transformer and the low side of the yoke coils.

Diagram *B* of Fig 15-1 shows a vertical output transformer with insulated secondary. As with any such transformer, boost or B+ voltage is applied to the low side of the primary. The secondary and the yoke coils always must be grounded when the secondary is insulated from the primary. Here the ground is from between the two yoke coils. Since neither end of the yoke circuit is directly grounded, pulses for vertical retrace blanking may be taken from either end of the yoke or either end of the transformer secondary, depending on required retrace polarity.

Diagram *A* of Fig. 15-2 illustrates application of B+ or boost voltage to an intermediate tap on an output autotrans-

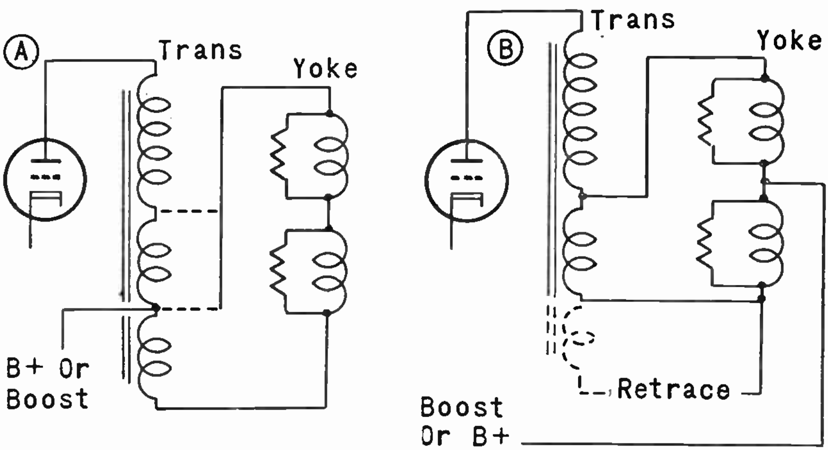


*Fig. 15-2. Vertical deflection sections in which there are extensions at the low end of autotransformer windings.*

former. The high side of the yoke coils may be connected to the same transformer tap as the B-voltage or to the end of an extension on the transformer winding.

At *B* of Fig. 15-2 the boost voltage or B+ voltage is applied between the vertical yoke coils, with plate current for the amplifier tube passing through the transformer and both coils. Pulses for vertical retrace blanking are taken from the low side of the transformer and yoke coils or else from an extension on the low side of the transformer winding.

On all but a very few vertical yoke coils there are two damping resistors, one across each coil. Fig 15-3 shows some methods of using damping elements on the windings of the output transformer. At *A* there is a capacitor across the secondary section of the transformer winding. Capacitance usually is anything from 0.05 mf to 1.0 mf. In addition to the capacitor across the secondary there is a resistor across the upper part of the transformer winding in some receivers.

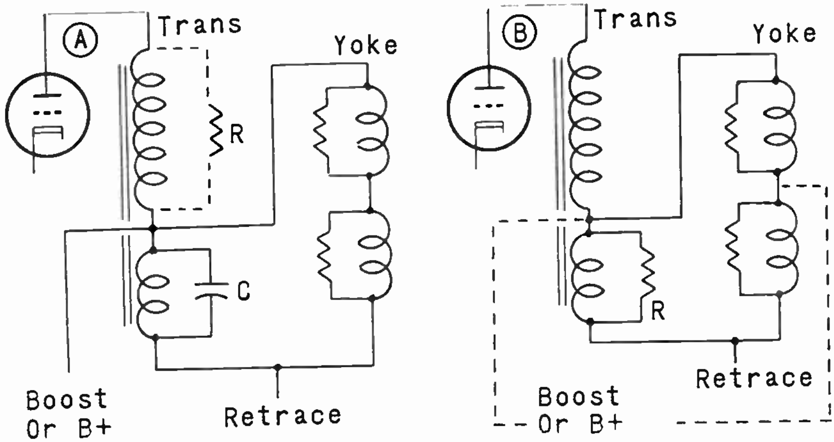


*Fig. 15-3. Vertical deflection sections in which damping elements are connected to the output transformer.*

At *B* of Fig. 15-3 the boost or B+ voltage may be applied either to the top of the secondary section of the transformer or else to a point between the two vertical yoke coils. There is a damping resistor across the transformer secondary section in addition to resistors across each of the yoke coils.

Note that in none of the circuits is a connection for retrace blanking pulses at the point where boosted-B or B+ voltage is applied. On any of the B-voltage lines there would be a filter or decoupling capacitor of large capacitance which would absorb the pulses.

When boosted B-voltage is applied to a point between the vertical yoke coils, and is taken from the low side of a horizontal output transformer, it appears on service diagrams that the horizontal transformer is connected to the vertical coils. This may be confusing unless it is recalled that the connection is merely for handling plate voltage and current for the vertical output amplifier.

Figs. 15-1 to 15-3 do not, of course, show all the combinations of connections which may be found in vertical deflection systems. The same circuit components may be combined in various other ways.

Damping resistors across the vertical yoke coils are from 500 to 600 ohms in the majority of cases. Sometimes, however, the resistance of each unit may be less than 200 ohms or more than 2000 ohms.

D-c resistances in the secondary sections of vertical output autotransformers commonly range from 4 to 16 ohms, and in the portion of the winding above the secondary from about 400 to as much as 1600 ohms or even more. D-c resistance of the two vertical yoke coils in series, including the effect of damping resistors, may be as little as 25 ohms or as much as 65 to 70 ohms.

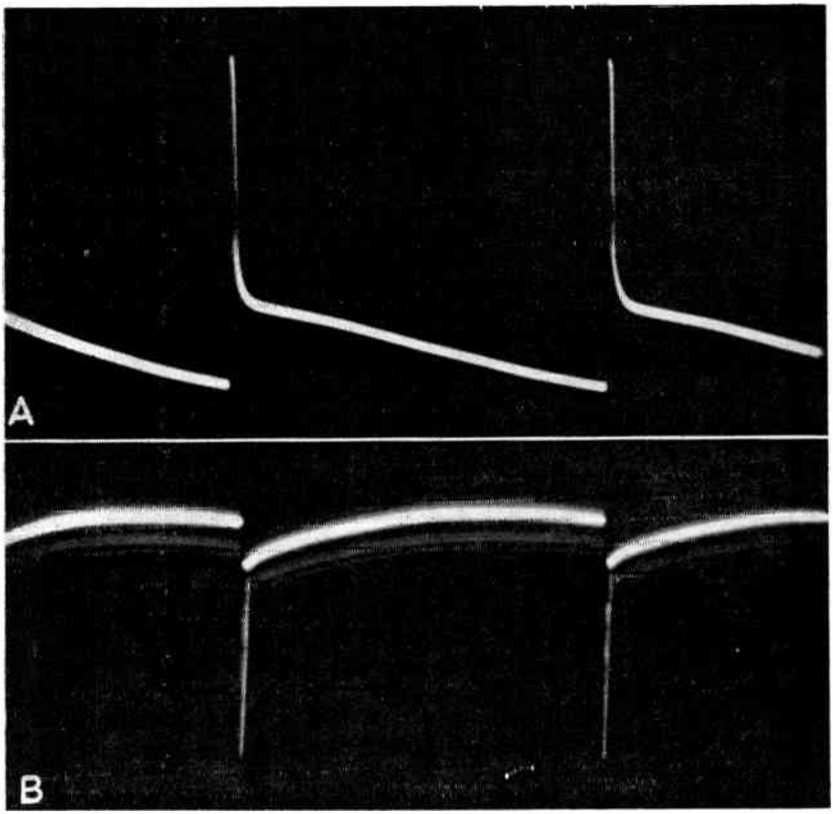


*Fig. 15-4. Vertical deflection voltages. A, at the plate of the output amplifier. B, at the high side of the vertical yoke coils.*

The voltage waveform at the plate of a vertical output amplifier is typically as at *A* of Fig. 15-4. Peak-to-peak voltage in different receivers varies from a few hundred volts less than 1000 to something on the order of 2000, and should be observed with a high-voltage capacitance probe on the oscilloscope.

Voltage at the high side of the vertical yoke coils and at their connection to the transformer is typically as at *B* of Fig. 15-4. Peak-to-peak values are small enough for measurement without a high-voltage probe.

The cathode of the vertical output amplifier usually is connected directly or otherwise to an adjustable resistor for vertical linearity control, and is bypassed to ground or B-

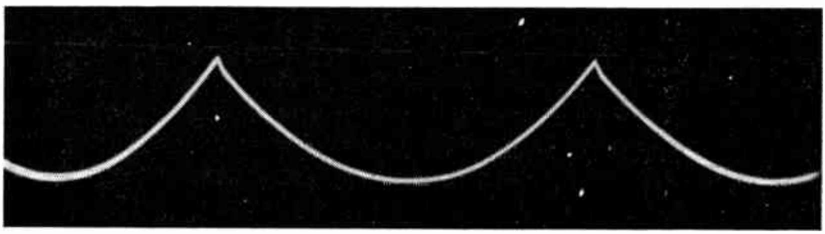

*Fig. 15-5. Voltage waveform at a vertical output amplifier cathode bypassed to ground with large capacitance.*

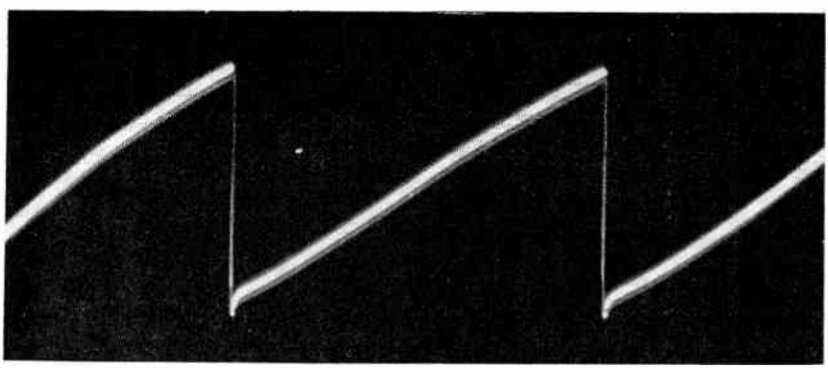

*Fig. 15-6. Typical current waveform in the vertical coils of a yoke.*

minus with large capacitance. Then the voltage waveform at the amplifier cathode is of the general form shown by Fig. 15-5. This waveform always is observed where pulsed or sawtooth voltage is absorbed by large capacitance.

Current in the vertical yoke coils should be of sawtooth waveform. Fig. 15-6 is an example observed with the scope connected across one ohm resistance in series with the yoke. In this case there is satisfactory vertical linearity. Non-linearity is accompanied by bending or waving along the sloping portion of the sawtooth.

## Faults And Symptoms

Table 15 lists faults which are more or less common in vertical output transformers, vertical yoke coils, and their connections. Numbered paragraphs which follow refer to similarly numbered faults in the table.

**5.** When an insulated secondary and connected yoke coils are not grounded directly or through large capacitance there is likely to be strong oscillation in the ungrounded inductances. The picture tube will show a bright blur over the entire viewing screen with no evidences of pictures or of a good raster.

**8.** Insufficient inductance in vertical yoke coils, or too much inductance in the transformer turns across which the yoke is connected, causes too little deflecting current in the yoke. Pictures may be of good detail, but lacking in height, or there may be severe folding at the top.

**10.** When leads to vertical yoke coils are interchanged the pictures will be upside down but not reversed from left to right unless leads to horizontal yoke coils are interchanged at the same time.

**11.** When a retrace blanking connection is to the wrong point on the vertical output transformer or vertical yoke coils, and this point is not connected to ground or to a B+ line, the pulse polarity usually is the opposite of that needed. Then vertical retrace lines become very bright, far brighter than with no retrace pulses.

**14-16.** Note that with an insulated-secondary vertical output transformer the secondary and connected yoke coils must be grounded, while with an autotransformer the yoke coils must not be grounded.

**17.** Damping resistors which are open or of excessive resistance usually allow severe oscillation in yoke coils.

| Table 15 VERTICAL DEFLECTION | Bright Bar, Top | Brightness Lacking | Compressed At Top | Dark, No Raster | Fuzzy Pictures | Height Lacking | Line (Horz), One | Raster, No Pictures | Retrace Lines Appear | Reversed Pictures (Vert) | Wavy, Horizontal | Wavy, Vertical | Wedge Shaped |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRANSFORMER Autotransformer | | | | | | | | | | | | | |
| Grounds | | | | | | | | | | | | | |
| 1 Direct | | | | • | | | | | | | | | |
| 2 High-resistance | | • | | | | | | | | | | | |
| Internal Faults | | | | | | | | | | | | | |
| 3 Open circuit | | | | | | | • | | | | | | |
| 4 Shorted turns | | | | | | • | | | | | | | |
| TRANSFORMER Insulated Secondary | | | | | | | | | | | | | |
| 5 Secondary not grounded | | | | | • | | | • | | | | | |
| Internal Faults | | | | | | | | | | | | | |
| 6 Open circuit | | | | | | | • | | | | | | |
| 7 Shorted turns | | | • | | | • | • | | | | | | |
| YOKE | | | | | | | | | | | | | |
| 8 Too little inductance | • | | | | | • | | | | | | | |
| Connections | | | | | | | | | | | | | |
| 9 Defective joints | | | | | | | • | | | | | | |
| 10 Leads interchanged | | | | | | | | | | • | | | |
| 11 Retrace pulses from wrong end | | | | | | | | | • | | | | |
| 12 One coil shorted | | | | | | • | | | | | | | • |
| 13 Both coils shorted | | | | | | | • | | | | | | |
| Grounds, With Autotransformer | | | | | | | | | | | | | |
| 14 Direct ground | | | | • | | | • | | | | | | |
| 15 High-resistance ground | | • | | | | | • | | | | | | |
| Grounds, With Insulated Secy | | | | | | | | | | | | | |
| 16 Ground lacking | | | | | • | | | • | | | | | |

(Continued on following page)

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| **Table 15** **VERTICAL DEFLECTION** | Bright Bar, Top | Brightness Lacking | Compressed At Top | Dark, No Raster | Fuzzy Pictures | Height Lacking | Line (Horz), One | Raster, No Pictures | Retrace Lines Appear | Reversed Pictures (Vert) | Wavy, Horizontal | Wavy, Vertical | Wedge Shaped |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resistor Across Coil | | | | | | | | | | | | | |
| 17 Open, too great | | | | | • | | | | • | | | • | |
| 18 Too small | • | | • | | | | | | | | | | |
| 19 Shorted | | | | | | | | | | | | | • |
| Internal Faults | | | | | | | | | | | | | |
| 20 Open circuit | | | | | | | • | | | | • | | |
| 21 Shorted turns | • | | | | | | • | | | | | | |

**19.** A shorted damping resistor, which means a shorted yoke coil, will make pictures smaller at either the left or right than on the opposite side, depending on which resistor or coil is shorted. Maximum height of pictures will be about one-half normal.

**20.** An open circuited vertical yoke coil may cause horizontal waviness because of pulses at the horizontal frequency being induced in the open-circuited vertical coils.

# SECTION 16

## DEFLECTING YOKE

When it is suspected that a fault may exist in either the horizontal or vertical coils of the yoke, or that the yoke as a whole has been damaged by abuse, it may be worth while to temporarily connect another yoke of generally similar characteristics to the yoke leads from chassis circuits. Although this substitute yoke will not allow production of pictures, since it need not be mounted on the picture tube, it may eliminate some troubles such as lack of anode voltage and thus show that the original yoke actually is faulty.

The yoke should be checked for resistances of the vertical coils and of the horizontal coils when such resistances are specified in service literature, also for shorts between horizontal and vertical coils.

The core of most of the yokes in recent receivers is in two semicircular pieces held together by an external clamp. Loosening of the clamp may allow an excessive gap or gaps between the core pieces. Improper clamping in a yoke mounting may have cracked off the edges of the core and allowed broken pieces to get into the gap. Insulation may be preventing the yoke parts from coming close enough together.

Table 16 lists faults in positioning of the yoke with respect to the picture tube neck and faults which may affect both the horizontal and vertical coils.

**1.** In black-and-white receivers the yoke as a unit must be as close as possible to the flare of the picture tube or directly against the flare. This usually is a matter of adjusting the yoke after loosening the screw or nut that secures the yoke in its mounting bracket.

**3-4.** When a yoke is properly positioned against the flare of the picture tube the yoke usually will be well centered around the tube neck. However, the bracket fastenings or adjustments may have been twisted or jammed in the wrong

| Table 16<br>DEFLECTING YOKE<br>As A Unit | Centering Difficult | Focus Poor | Reversed Pictures | Skew Or Tilt | Spot Only | Wavy (Vert) All Over | Wedge Shaped |
|---|---|---|---|---|---|---|---|
| POSITION OF YOKE | | | | | | | |
| 1 Too far back from flare | • | • | | | | | |
| 2 Rotated around tube neck | | | | • | | | |
| 3 Tilted on tube neck | • | | | | | | |
| 4 Not concentric with neck | | | | | | | • |
| CONNECTIONS TO YOKE | | | | | | | |
| 5 Leads interchanged, both horizontal and vertical | | | • | | | | |
| 6 Open circuits, both horizontal and vertical | | | | | • | | |
| 7 Coupling between vertical and horizontal | | | | | | • | |

positions. The imaginary center line of the yoke should be exactly in line with the center of the tube neck, with equal clearance between the interior of the yoke and the outside of the tube neck all the way around, and at front and back of the yoke.

**5.** If leads are interchanged to both the horizontal and vertical coils the pictures will be upside down and backward from left to right at the same time.

**6.** A single bright spot near the center of the picture tube viewing screen indicates that there is anode voltage but neither horizontal nor vertical deflection. Since production of anode voltage depends on horizontal deflection voltages and currents, a single bright spot would be a rare symptom.

**7.** Troublesome coupling between vertical and horizontal yoke circuits would occur in circuits external to the yoke. Examine all filter and decoupling capacitors, especially those on the boosted-B lines when boosted voltage goes to the vertical system.

# SECTION 17

## LOW-VOLTAGE POWER SUPPLY

The low-voltage power supply section furnishes B-voltages and currents for plates, screens and grid biasing in all small tubes not handled by boosted B-voltage. It furnishes also the heater voltages and currents for all small tubes and for the picture tube.

Fig. 17-1 is a schematic diagram of the type of low-voltage power supply longest in use. On the primary of the power transformer is the on-off switch for the receiver and

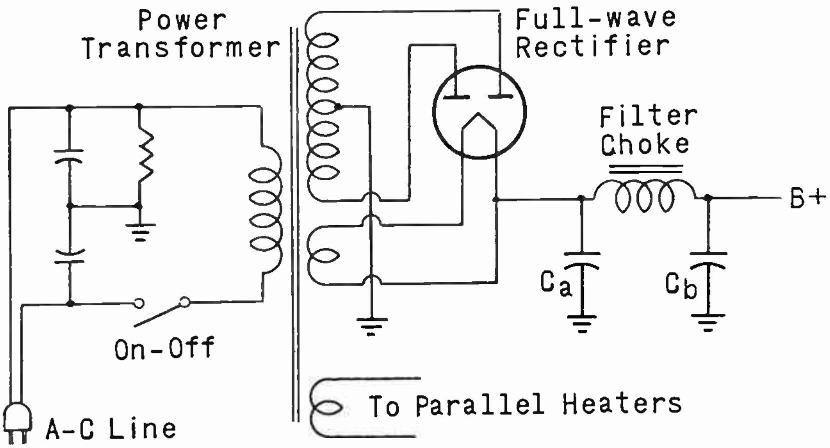


*Fig. 17-1. Low-voltage power supply with one full-wave rectifier tube.*

sometimes a fuse in series with the primary. It is common practice to have on the transformer primary some arrangement of capacitors (usually of 0.01 mf capacitance) and a resistor of 100K ohms or more for reduction of power line interference which otherwise might pass through internal capacitances of the transformer to receiver circuits.

Connected to a center-tapped "high-voltage" secondary winding of the transformer is a full-wave vacuum tube rectifier whose filament-cathode is heated from a separate secondary. The filament-cathode is the most positive d-c point of the B-voltage system.

The center tap of the high-voltage secondary is the most negative d-c point of the B-voltage system. This tap may be connected directly to ground as shown, or else connected to ground through a fuse having current capacity of 200 ma or more, as required for the particular receiver.

There will be one or more low-voltage secondaries for tube heaters, pilot lamps and other accessories. Tube heaters are connected in parallel with one another, with one side to ground.

The power filter consists of two electrolytic capacitors, *Ca* and *Cb*, with between them an iron-cored choke. Capacitances usually are 40 to 100 mf in each capacitor. Choke inductance is commonly one henry or thereabouts. In some receivers the field coil of an electromagnetic speaker is used for the power filter choke.

At the filter output of most recently designed sets there is 250 to 350 volts, positive to ground. A value around 270 volts is common. Greater B-voltages are provided, where needed, by boosted B-voltage.

## Parallel Rectifier Tubes

In receivers requiring greater total B-current than can be furnished by ordinary standard rectifier tubes used singly, two such tubes may be connected in parallel as in Fig. 17-2. In the left-hand diagram the two plates of each tube are connected to opposite ends of the transformer secondary. Each tube acts as a full-wave rectifier.

In the small diagram at the right the two plates of each tube are connected together and to one end of the secondary. Each tube acts as a half-wave rectifier, with the combination forming a full-wave rectifier.

Two paralleled rectifier tubes of the same type are capable of handling approximately twice the d-c current that could safely be handled by one tube. Output voltage is about the same as from a single tube, but may be slightly greater because internal resistances of the two tubes are in parallel.

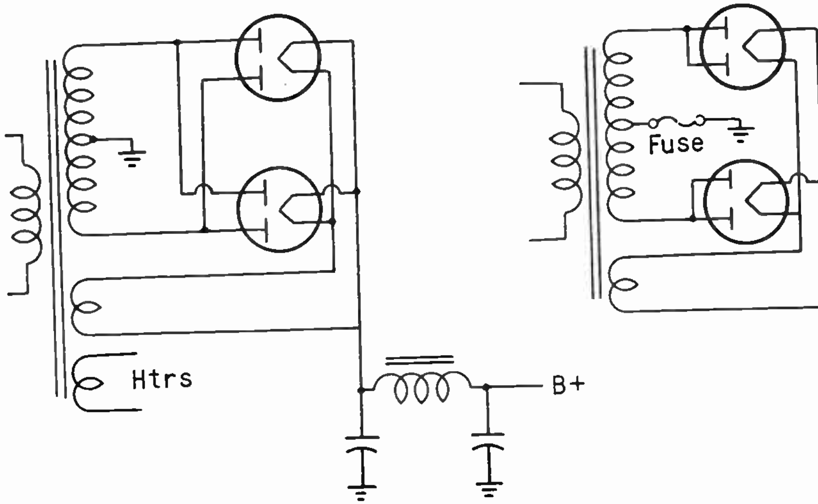


*Fig. 17-2. Two methods of connecting rectifier tubes in parallel.*

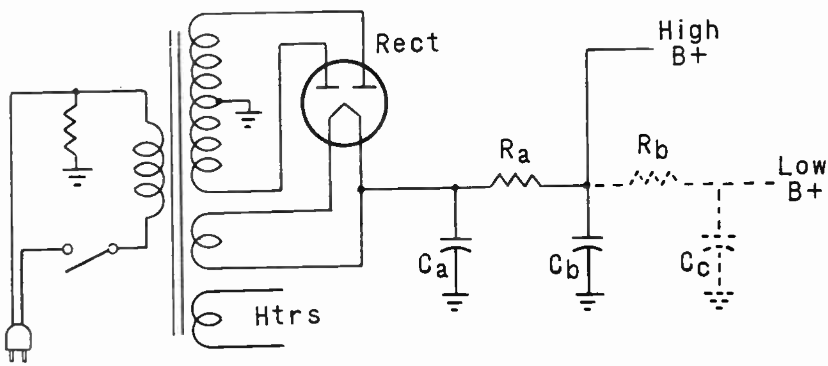


*Fig. 17-3. A resistor-capacitor filter for low-voltage B-power.*

## Resistor-Capacitor Filters

In the power filter of Fig. 17-3 a fixed resistor *Ra* is used instead of the filter choke of Figs. 17-1 and 17-2. This resistor is of small value, possibly 100 to 200 ohms, in order to lessen the drop of B-voltage. The electrolytic filter capacitors *Ca* and *Cb* may be of 60 to 100 mf each.

Although a filter resistor does not oppose all *changes* of alternating current, as does a choke, there is a resistance-capacitance time constant effect that slows the discharges of the first filter capacitor. There is, of course, additional filtering or smoothing action in all resistor-capacitor decouplings of the receiver.

Ripple voltage at the filter output drops proportionately to increase of filter resistance, also proportionately to increase of filter capacitance.

If there is a second filter resistor and capacitor, *Rb* and *Cc* of Fig. 17-3, the second resistor usually is much greater than the first. The resulting lower output voltage is better filtered and has less ripple.

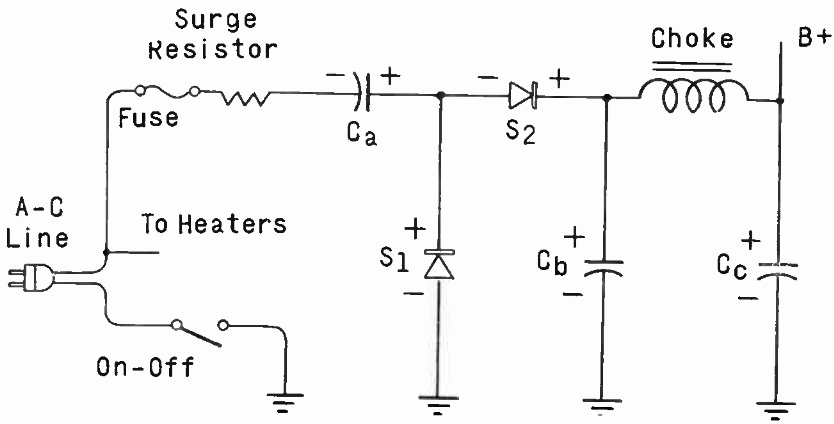


*Fig. 17-4. A selenium doubler system for low-voltage B-power.*

## Selenium Doubler Rectifiers

Fig. 17-4 illustrates a widely used B-power supply employing two selenium rectifiers in a voltage doubling circuit. The rectifiers are marked *S1* and *S2*. Electron flow is in a direction against the arrowhead of the symbol, being from cathode to anode within the rectifier. Cathodes may be marked with a positive (+) sign, with a red dot, or may have such lettering as *K*, *CATH*, or *POS*. As a rule the anode, the negative terminal, has no special marking.

The purpose of the surge resistor is to limit the peak voltage which otherwise would act on the rectifiers during initial charging of capacitors and also later on were there short circuits. When an ordinary resistor is used there usually is a fuse in series, as in the diagram. A shorted rectifier could carry enough current to heat wiring red hot and start a fire.

Instead of using an ordinary resistor and series fuse many receivers have a fusible resistor designed to burn out on heavy current overloads. It is a general rule that the smaller the current capacities of the selenium rectifiers the greater is the surge resistance in any type of resistor unit. In many television receivers the resistance is something from 5 to 8 ohms.

Values of the three capacitors, *Ca*, *Cb* and *Cc* of Fig. 17-4 commonly range from 120 to 200 mf each, with usually somewhat greater capacitance at *Ca* than in the other two positions. Rated working voltages may be 150 to 200 at *Ca*, with 300 or 350 volts in the other positions.

Normal d-c voltage across either one of the rectifiers is a little less than rms line voltage. D-c voltage measured across either of the filter capacitors *Cb* and *Cc* is double or somewhat more than double the rms line voltage.

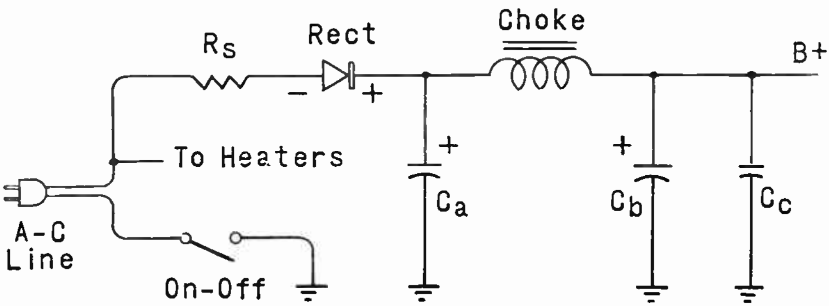


*Fig. 17-5. Connections for a single selenium rectifier.*

## Selenium Single Rectifiers

Fig. 17-5 is a circuit diagram for a B-voltage supply using a single selenium rectifier unit as found in television receivers. The surge resistor *Rs* is directly followed by the rectifier. D-c voltage at the filter output ranges from 130 to 150, measured to ground.

Filter capacitors *Ca* and *Cb* are electrolytics in values of 200 to 300 mf and working voltage of 150 in practically all cases. The second filter capactor may be bypassed for high frequencies by a fixed capacitor *Cc* of anything from less than 1000 mmf to as much as 0.25 mf.

## Selenium Rectifier Tests

Other than trying a new unit where a fault is suspected the most satisfactory way to test a selenium rectifier is with an instrument made for the purpose. One kind of testing circuit is shown by Fig. 17-6. The 5-ohm surge resistor is of 10-watt rating. Rectifiers must be connected with their cathodes to the clip marked "+".

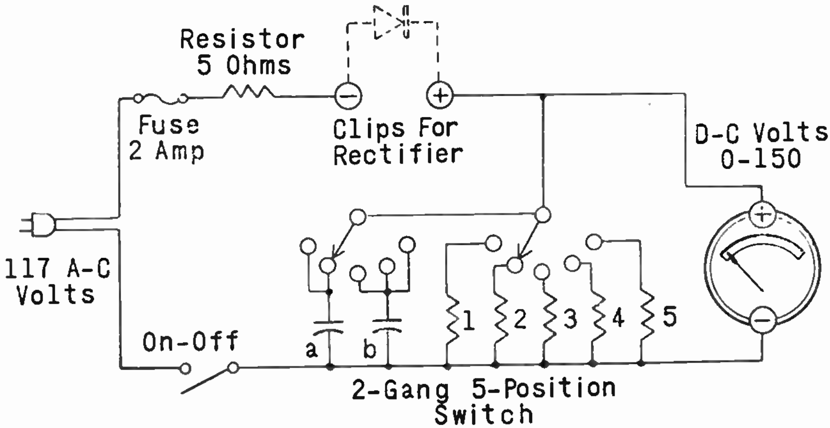


*Fig. 17-6. Circuits in a tester for selenium rectifiers.*

Switch positions identified by numerals *1* to *5* connect into the circuit the following capacitors and resistors, and are used for testing rectifiers of listed current ratings. Both electrolytic capacitors are rated for 150 d-c working volts.

| SWITCH | RECTIFIER | CAPACITOR | RESISTOR |
|---|---|---|---|
| 1 | 200 ma | (a) 120 mf | (1) 680 ohms, 50 watts |
| 2 | 250 ma | (a) 120 mf | (2) 510 ohms, 60 watts |
| 3 | 300 ma | (b) 300 mf | (3) 430 ohms, 75 watts |
| 4 | 350 ma | (b) 300 mf | (4) 360 ohms, 100 watts |
| 5 | 450 ma | (b) 300 mf | (5) 300 ohms, 100 watts |

With 117 rms volts from the a-c power line applied to a good rectifier the d-c voltmeter should indicate 120 to 130 volts within 5 minutes after closing the switch to the line. Normal d-c voltage with the larger rectifiers will be slightly less than with the smaller units.

The lower the d-c voltage the less efficient is the rectifier on test. A rectifier which is shorted or has very low resistance will blow the fuse. A 2-ampere circuit breaker may be used instead of the fuse.

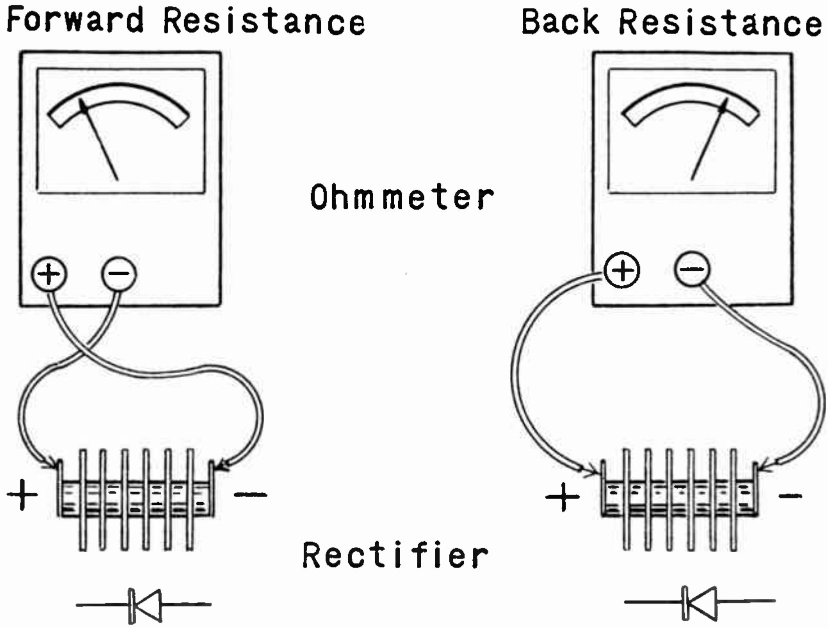


*Fig. 17-7. Checking a selenium recifier with an ohmmeter.*

A rough check which will show serious faults in a selenium rectifier is illustrated by Fig. 17-7. Forward resistance is measured as at the left, with positive of an ohmeter to negative (anode) of the rectifier and with negative of the meter to positive (cathode) of the rectifier. Back resistance is measured as at the right, with ohmmeter leads reversed to the rectifier terminals, with positive to positive and negative to negative.

Forward resistance of a good rectifier may measure almost anything from 10K to 30K ohms or even more. Back resistance should measure more than 10 times the forward resistance, and up to 40 times as much. A great deal depends on the type of ohmmeter and on how much d-c voltage it applies to the rectifier. Types of resistance testers which apply pulsating or alternating voltage give no distinct indications on selenium rectifiers.

## Other Selenium Rectifier Circuits

Fig. 17-8 shows one method of using a resistor-capacitor filter or filters with selenium doubler rectifiers. The first filter capacitor is marked *Cb*. There are three separate filter resistors, *R1, R2,* and *R3*. In connection with the three filter resistors are used three separate filter capacitors marked *C1, C2* and *C3*. This arrangement allows taking three different B-voltages from the power supply, and provides effective decoupling of each B-voltage from the other two.

It is also possible to use the resistor-capacitor filter system of Fig. 17-3 in connection with selenium doubler or single selenium rectifiers.

With receivers employing the selenium rectifier circuits of Figs. 17-4, 17-5 and 17-8 the chasses are "hot". One side of the a-c power line is connected to chassis ground. Fig. 17-9 shows a method of using a selenium doubler system with one side of the a-c line connected to the chassis only through an electrolytic capacitor at *Cb*.

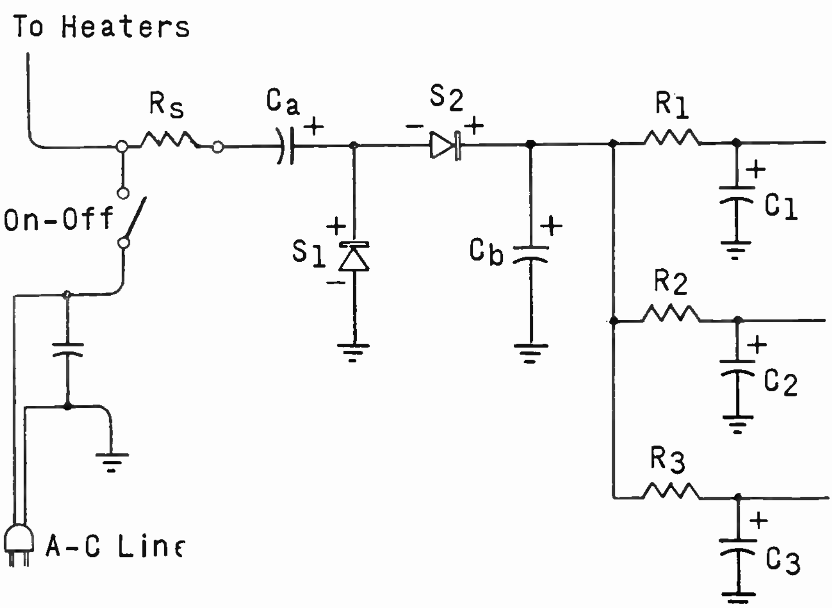


*Fig. 17-8. A three-section resistor-capacitor filter system with selenium doubler rectifiers.*

In Fig. 17-9 there is no capacitor between the surge resistor and the rectifier units. An ordinary surge resistor unit may be used in connection with a fuse, as shown, or there may be a fusible resistor without the fuse. Otherwise a circuit breaker may be used instead of the fuse. Capacitors

*Ca* and *Cb,* in series with each other to ground, usually are of 150-volt rating each. The second filter capacitor, *Cc* is of 300-or 350-volt rating.

Selenium rectifiers, either singly or in a doubler circuit, most often are found in receivers having series heaters. In Fig. 17-9, however, there is a separate step-down transformer for the heaters of all tubes. The heaters then are connected in parallel with one another.

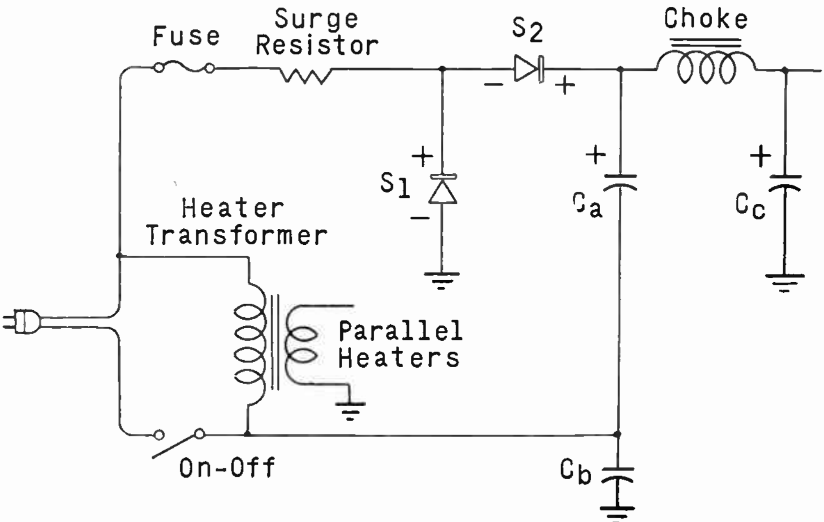


*Fig. 17-9. Selenium doubler system not grounded to chossis, with tronsformer for parallel heaters.*

## Series-Parallel B-Voltages

In Fig. 17-10 the audio output amplifier is in series with a number of other tubes so far as plate voltage and current are concerned. In this particular "power distribution" diagram the other tubes are the r-f oscillator-mixer in the tuner, all three i-f amplifiers, the sync tube, and the audio detector or demodulator. Plate and screen currents pass from ground (B-minus) to the cathodes of these other tubes, then from their plates and screens to the cathode of the audio output tube, and from its plate and screen the combined currents go to positive of the B-power supply.

This general method of B-power distribution may be called "series-parallel" or "plate current series" or "series plate-cathode" and by other descriptive names. It provides

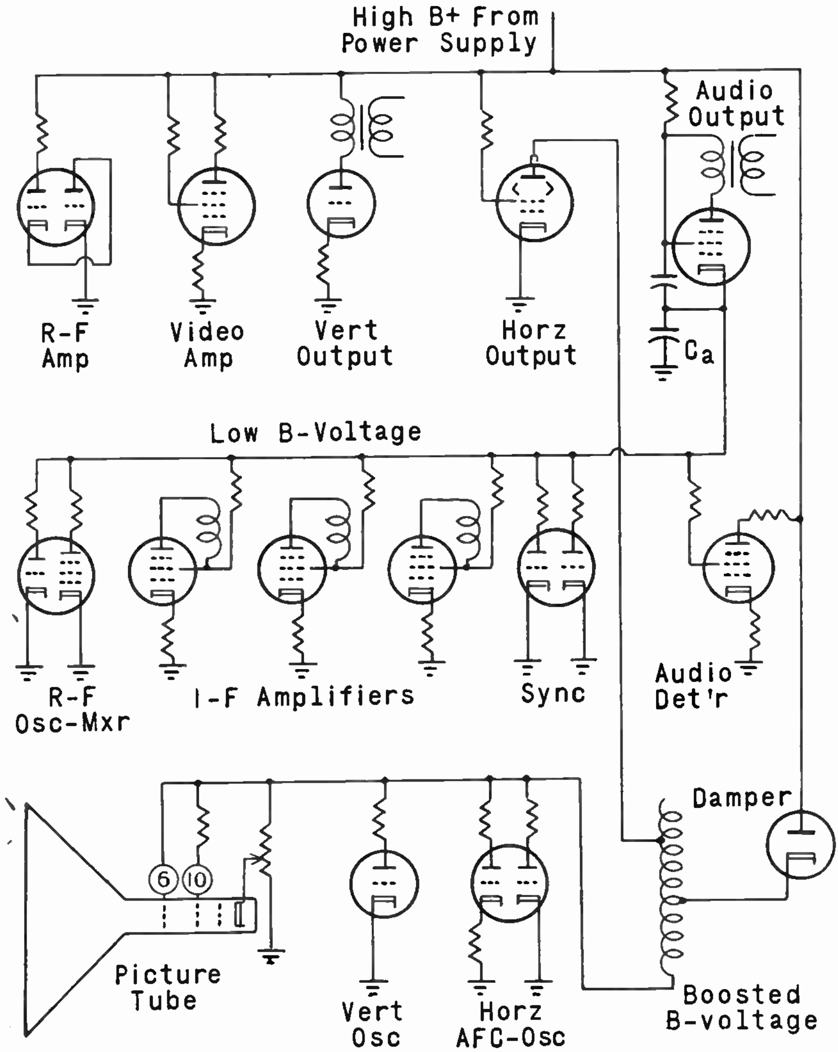


*Fig. 17-10. An example of series-parallel distribution of B-voltage and current.*

a high B-voltage and a low B-voltage from a single power supply without requiring high wattage resistors for voltage dropping. The drop between high and low B-voltages occurs in the audio output tube.

The total of plate and screen currents in all tubes on the low B-voltage line is equal or approximately equal to cathode current in the audio output amplifier. If tube currents are not exactly equal there will be resistors to ground for carrying any difference between the currents. Sometimes other tubes are in parallel with the audio output tube, their cathodes being connected to the audio output cathode and their plates to the high B-voltage line.

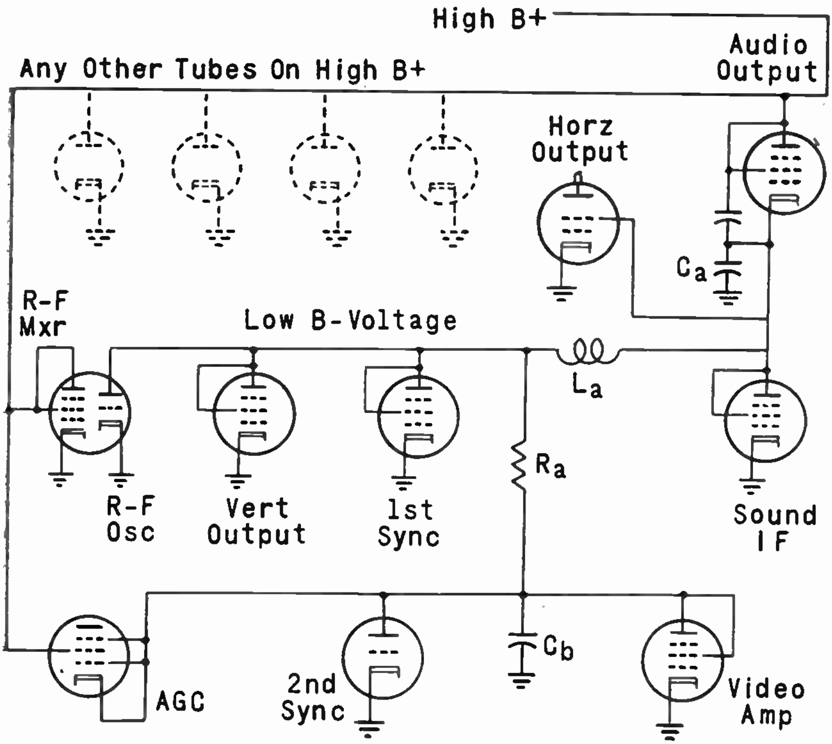


*Fig. 17-11. Series-parallel B-voltage distribution with additional decoupling.*

In a typical distribution system there will be 250 to 270 volts to ground on the B+ line from the power supply. This voltage acts through any dropping resistor on the plate and screen of the audio output tube. In the resistor and amplifier there will be a drop of about 110 volts, leaving something like 150 volts at the amplifier cathode. This 150 volts becomes the low B-voltage of Fig. 17-10 and is, of course, the drop through resistors and tubes on this line.

Pairs of tubes or tube sections may be in series with each other between high B+ and ground, as in the r-f amplifier of Fig. 17-10. Sometimes the plate of one i-f amplifier connects to high B+, its cathode connects to the plate of another amplifier, and the cathode of this second amplifier goes to ground.

Fig. 17-11 shows another series-parallel power distribution system. The diagram is simplified by omitting the dropping resistors, also the boosted B-voltage circuits shown in Fig. 17-10.

In any series-parallel system the audio signal voltages which exist at the cathode of the audio output amplifier must be kept out of the low B-voltage lines. The decoupling in Fig. 17-10 is performed by capacitor *Ca*, a large electrolytic, and by the dropping or decoupling resistors for the low-voltage tubes.

There are two decouplings in Fig. 17-11. The first consists of an electrolytic capacitor *Ca* and choke *La*. The second decoupling occurs in resistor *Ra* and electrolytic capacitor *Cb*. The drop in *Ra* ordinarily is no more than 5 to 10 volts. Always there will be one or more decoupling capacitors and sometimes a series resistor or choke on the low B-voltage lines from the cathode of the audio output amplifier.

Since the grid of the audio output amplifier may be only about 10 volts negative to its cathode, this grid will be about 140 volts positive to ground. It must be kept in mind that the grid as well as the cathode will be highly positive to ground in any tube at the high end of a series-parallel distribution system.

Whether or not a receiver employs a series-parallel distribution system may be determined by measuring the voltage to ground or to B-minus at the grid of the audio output tube. Voltage in excess of 100 would indicate a series-parallel distribution system.

Screens of some tubes may receive low B-voltage, as in the audio detector of Fig 17-10, while the plates receive high B-voltage. In Fig. 17-11 the r-f mixer section of a tuner tube works on high B-voltage while the oscillator section receives low B-voltage. Also, the agc keyer tube receives both high and low B-voltages.

Where there is series-parallel power distribution any fault in the audio output amplifier or its circuits may cause trouble in receiver sections whose tubes are in series with the audio output tube. This fact must be considered when locating the real cause for trouble symptoms.

## Faults And Symptoms

Faults in the B-power supply cause, at the filter output, either low B-voltage, zero B-voltage, or excessive ripple or hum voltage. Certain picture symptoms result from these incorrect voltages. Picture symptoms, and faults which usually cause the incorrect B-voltage, are listed in tables 17-A through 17-D. Following numbered paragraphs give additional information relating to faults similarly numbered in the tables.

Low or zero B-voltage may be recognized by measurement with a d-c voltmeter, and comparison with known correct voltages shown on a service diagram or in a service listing of proper voltages.

Ripple or hum voltage may be measured with an a-c voltmeter in which a series capacitor blocks d-c voltage. Ripple or hum voltage may be located with an oscilloscope.

Vacuum tube rectifiers in B-power supplies are full-wave rectifiers. Therefore, ripple voltage at the filter output will be of 120-cycle frequency, or twice the line frequency. Selenium rectifiers, either single or doubler types, are half-wave rectifiers, and ripple voltage at the filter output will be of 60-cycle frequency. Selenium rectifiers may be used in full-wave circuits, but this is not customary in television B-power supplies.

**1.** Approximately 105 rms volts from the a-c power line is about the lowest which allows satisfactory picture reproduction. A-c line voltage below 100 causes serious trouble.

**3.** When one parallel rectifier is out the remaining one carries a heavy current overload and usually will give out quite soon. The remaining rectifier gets filament voltage somewhat higher than normal, allowing greater emission and less internal resistance. B-voltage may drop no more than 10 to 15 per cent. When one rectifier has been carrying the total load for some time it is advisable to replace both tubes.

| **Table 17-A B-VOLTAGE LOW At filter output** | Symptoms: Blooming; Dark, No Raster; Brightness Lacking; Size Lacking |
|---|---|
| LINE VOLTAGE | 1 Less than 105 volts rms. |
| RECTIFIERS | Single Tube<br>2 Weak |
| | Parallel Tubes<br>3 One weak, or open filament |
| | Selenium Doubler System |
| | Series Capacitor (**Ca** Fig. 17-8)<br>4 Old, small capacitance<br>5 Leaky |
| | Series Rectifier (**S2** Fig. 17-8)<br>6 Weak, small back resistance |
| | Shunt Rectifier (**S1** Fig. 17-8)<br>7 Open |
| | Selenium Single Unit<br>8 Weak, small back resistance |
| POWER FILTER | 1st Capacitor<br>9 Open<br>10 Old, small capacitance<br>11 Leaky |
| | 2nd Capacitor<br>12 Leaky |
| WIRING | 13 Defective joints |

| Table 17-B<br>B-VOLTAGE ZERO<br>At filter output | Symptoms<br>Dark, No Raster |
|---|---|
| LINE VOLTAGE | 14 Zero |
| POWER TRANSFORMER | 15 Fuse blown, on primary or secondary<br>16 Winding open internally |
| RECTIFIERS | Single Tube<br>17 Open filament<br>18 Plate-filament short |
| | Selenium, Doubler Or Single |
| | Surge Resistor Or Fuse<br>19 Open |
| | Series Capacitor (**Ca** Fig. 17-8)<br>20 Open<br>21 Shorted. A fuse will blow. |
| | Series Rectifier (**S2** Fig. 17-8)<br>22 Open<br>23 Shorted. A fuse will blow. |
| | Shunt Rectifier (**S1** Fig. 17-8)<br>24 Shorted. A fuse will blow. |
| POWER FILTER | 25 Either capacitor shorted<br>26 Choke or series resistor open |
| WIRING | 27 Open connections |

| **Table 17-C RIPPLE OR HUM EXCESSIVE At filter output** | Symptoms: Hum Bars, 60 Or 120 Cycle; Wavy, Vertical; Vertical Sync Critical |
|---|---|
| POWER TRANSFORMER | 28 Shorted turns |
| RECTIFIERS | Selenium Doubler System |
| | 29 Either rectifier weak, small back resistance |
| POWER FILTER | 1st or 2nd Capacitor |
| | 30 Open |
| | 31 Old, small capacitance |
| | Choke Or Series Resistor |
| | 32 Shorted |

| **Table 17-D SERIES-PARALLEL B-VOLTAGE SYSTEM** | Brightness Lacking | Contrast Lacking | Focus Poor | Raster Only, No Picture | Sound Bars |
|---|---|---|---|---|---|
| AUDIO OUTPUT TUBE | | | | | |
| 33 Heater open | | | | • | |
| 34 Weak | • | • | | • | |
| 35 Cathode-heater leakage | • | | • | | |
| DECOUPLING CAPACITOR | | | | | |
| 36 Open, or old with small capacitance | | | | | • |
| 37 Leaky or shorted | • | • | | • | |

**4.** A series capacitor which is old, or has small capacitance for any reason, usually causes more trouble from low B-voltage than from ripple.

**6-8.** The life of a selenium rectifier is shortened by operation at temperatures in excess of 170° F. Such rectifiers are mounted close to chassis metal, which helps carry away excess heat. Current overloads, which may result from shorts and accidental grounds on wiring, will seriously damage a selenium rectifier, as well as a vacuum tube type. A defective selenium rectifier may overheat, make popping noises, and emit a disagreeable odor.

**9-10.** To check for opens or small capacitance temporarily connect across the suspected capacitor a good unit of equal or greater nominal capacitance Be sure to observe polarity of electrolytics. Improved performance indicates a fault in the original capacitor.

An old electrolytic capacitor may have much less than rated capacitance, with a high power factor, but with only normal or less than normal leakage.

**13.** Check such possible locations for defective joints or connections as: The power cord and power cord plug for the a-c line receptacle. Interlock contacts on the receiver and cord. The on-off switch in the receiver. Interconnection plugs and sockets between the chassis and other components.

**14.** Check for voltage at the a-c receptacle with a lamp. A fuse in the building power line may be blown.

**17.** If a rectifier tube burns out suddenly, with a bright flash in the tube, it indicates a severe current overload. Locate the cause before replacing the tube.

**23-24.** A shorted selenium rectifier may not show zero resistance on an ohmmeter test. Resistance may be around 100 ohms.

**27.** Check the points mentioned in preceding paragraph *13*. Look also for a blown fuse on either the primary or secondary side of the power transformer. A combination switch, such as TV-Phono, may be in the wrong position. On older sets in which a focusing coil carries B-current check the coil and its connections.

**28.** Shorted secondary turns in a power transformer displace the electrical center to cause successive voltage waves of unequal amplitudes such as those in Fig. 17-12, or worse. The inequality is more than can be smoothed by the filter.

Shorted turns reduce the winding resistance by too little for detection with an ohmmeter. Other than excessive ripple, the most noticeable result of shorted turns is severe overheating. When this happens, temporarily disconnect all circuits from the transformer secondaries, including the heaters.

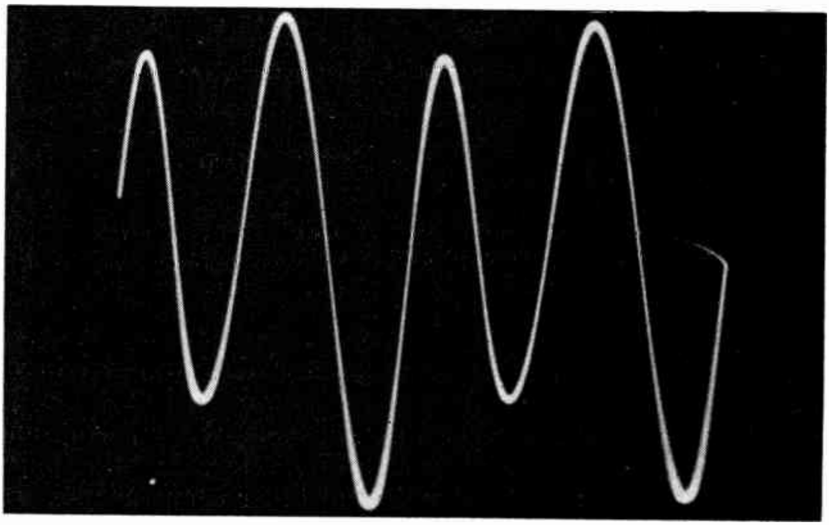

*Fig. 17-12. Unequal amplitudes in voltage from a power transformer having displaced electrical center.*

Turn on the power and allow the transformer primary to be energized for as much as one hour. Excessive temperature (too hot to touch for more than a second or two) indicates shorted turns or other serious internal trouble.

Ripple voltage at 60 cycles and sometimes at 120-cycles may result from loose core clamps or screws on the power transformer. The vibration may cause microphonic effects in various tubes, giving picture symptoms similar to those from ripple.

**29.** Ripple voltage from a television B-power supply employing selenium rectifiers, either singly or in a doubler circuit, is of 60 cycle frequency. The waveform of voltage

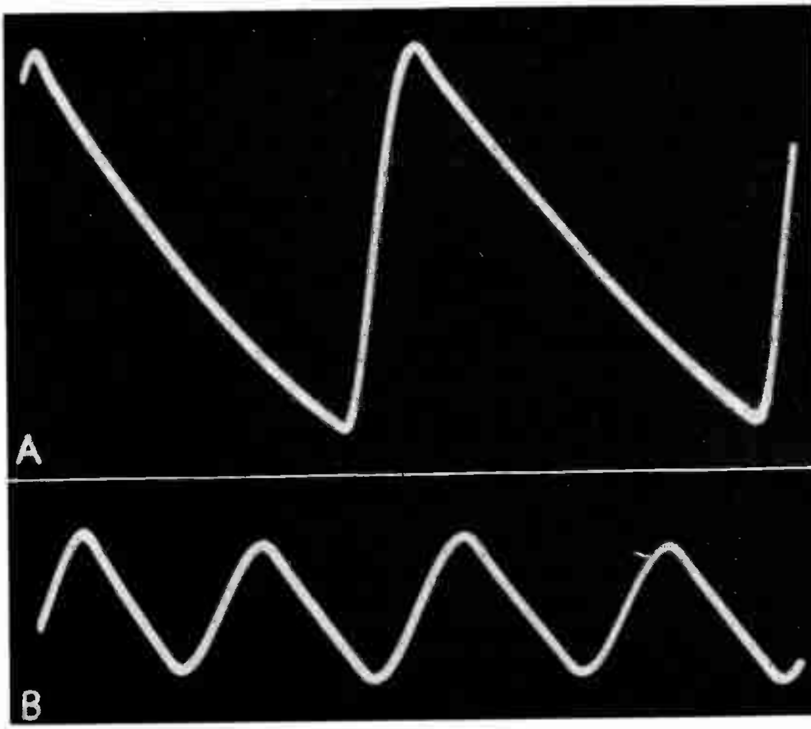


*Fig. 17-13. Typical voltage waveforms from half-wave (A) and full-wave (B) rectifiers as observed at the filter input.*

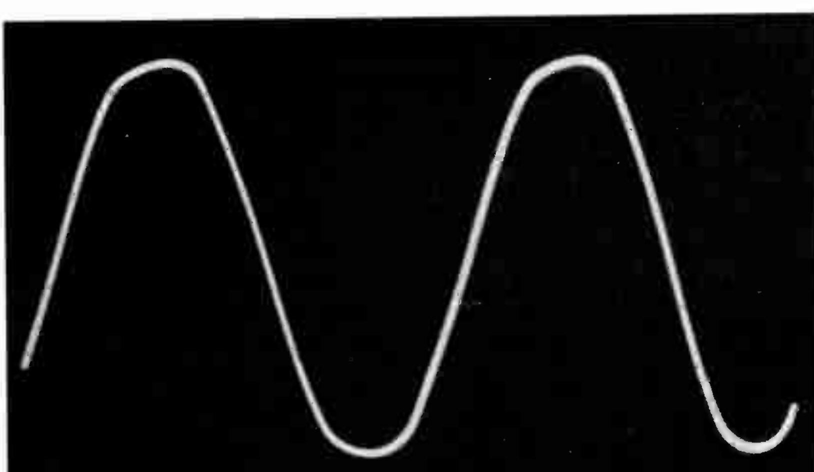

*Fig. 17-14. Voltage waveform at the junction of two rectifiers in a selenium doubler system.*

from a rectifier or rectifiers at the input to the filter choke and first filter capacitor is as at *A* of Fig. 17-13. Input from a full-wave vacuum tube rectifier to the filter is as at *B*. Frequency at *A* is 60 cycles and at *B* is 120 cycles per second.

Voltage waveform at the junction of the two rectifiers in a doubler circuit is practically a 60-cycle sine wave, as shown by Fig. 17-14. In Fig. 17-8 this would be the voltage at the positive side of series capacitor *Ca*.

If back resistance is low in a shunt rectifier of a selenium doubler (*S1* of Fig. 17-8) there will be bad ripple voltage but there may not be a great drop of B+ voltage from the filter.

**30.** An open second filter capacitor will allow a large ripple voltage, but will drop the B+ voltage from the filter output only relatively little.

**33.** An open heater in the audio output tube would prevent reproduction of sound, which would lead to investigation of the sound section. The fact that there is a raster but no picture would point to faults in the audio output amplifier of a series-parallel system.

**35.** Cathode-heater leakage in the audio output amplifier usually must be equivalent to less than 20K ohms to cause serious picture symptoms. It would cause decided trouble with sound reproduction.

## Series Heaters

Fig. 17-15 shows fairly typical connections for series heaters in a television receiver. Tubes used in these series strings are designed for such applications. Warmup time is very nearly equal in all the tubes so that all begin drawing cathode current together. Actual time from turning on the power to having picture reception with new or fairly new tubes will run about 45 seconds or slightly more. This is a little longer than for a receiver having parallel heaters and equally good tubes. All tubes take the same heater current, 0.6 ampere or 600 ma, which has been standard for picture tubes over a long period. The various "controlled warmup" tubes have various voltage drops in their heaters, such as 2.35 volts, 4.2 volts, 4.7 volts, 6.3 volts, 12.6 volts and 25 volts.

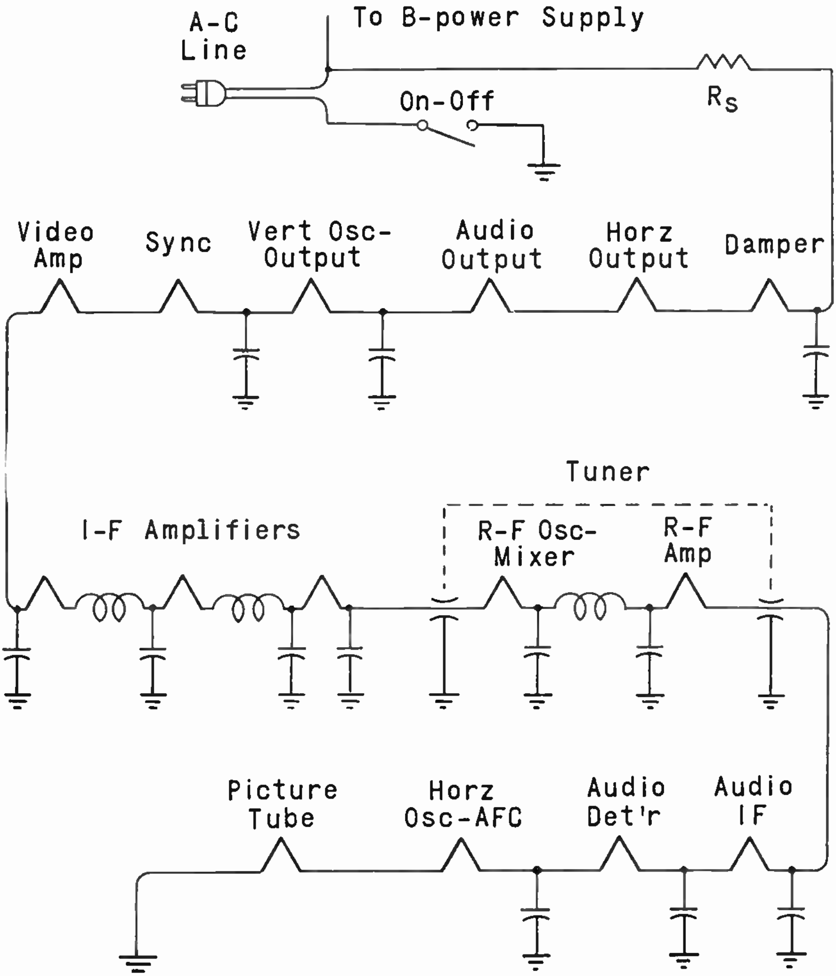


*Fig. 17-15. Schematic diagram for series heaters of the controlled warmup type in a television receiver.*

A surge resistor, as at *Rs* of Fig. 17-15, most often has resistance of 30 to 50 ohms and power rating of 20 or 25 watts. Such large units are easily recognized in the chassis. Some sets have Thermistors or negative temperature coefficient (NTC) resistors whose resistance is high, several hundred ohms, when cold and drops to something like 10 to 20 ohms when hot. In some cases a Thermistor is in series with an ordinary resistor.

There is no standard order of tubes from a-c line to ground. However, practically always the damper and horizontal output amplifier will be at the high end or line end of the string, and often the audio output amplifier will be near this end. Toward the ground end of the string will usually be the picture tube, horizontal oscillator, audio detector or demodulator, and sound i-f (4.5 mc) amplifier.

Decoupling capacitors and chokes are necessary on a series heater string. Decoupling chokes will be in the tuner and nearly always in the i-f amplifier section, also in other sections of some receivers. Decoupling capacitors always are used in the tuner and the i-f amplifier section, also quite commonly at the audio detector or demodulator and the sound i-f amplifier. Capacitances range from 470 to 1500 mmf or more in some cases. Feed-through capacitors may be found where the heater line enters and leaves the tuner, also in other shielding partitions.

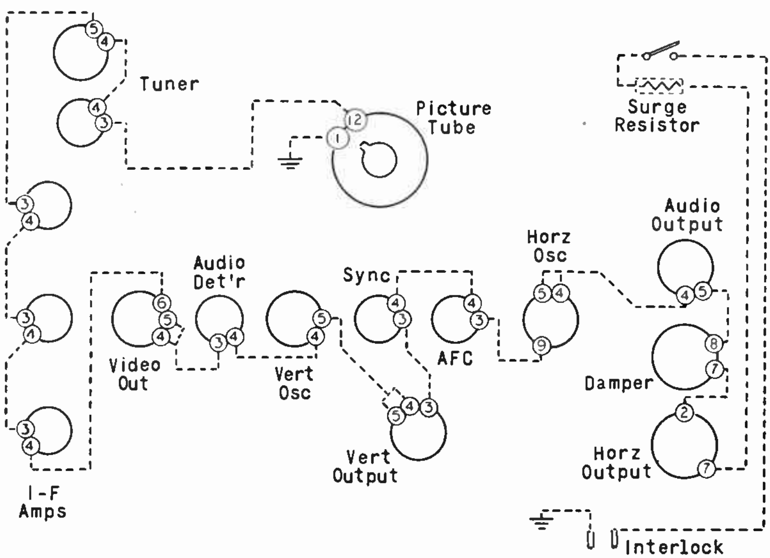


*Fig. 17-16 Tube layout on a television receiver chassis, with connections for series heaters.*

Heater-cathode shorts or leakage of very low resistance will place a ground connection at an intermediate point along the heater string. Then full line voltage will be applied to only a few tubes. One of these will suffer a burned out heater, which cuts off the line voltage. The difficulty is that the cathode-heater short will be in some tube not burned out.

## Locating An Open Heater

For reasonably fast location of a tube with an open heater in a series string it is necessary to have a heater connection diagram of the particular receiver. Fig. 17-16 is an example.

The usual method is to remove the tube which is at or near the center of the string, such as the vertical oscillator or the audio detector of the diagram. Check the heater of this tube with an ohmmeter or other circuit or continuity tester.

If the heater of this tube is good, check for continuity from ground to the heater opening toward the ground end on the socket of the removed tube. If there is continuity, check next from the other heater opening to the surge resistor.

If either of these continuity tests shown an open circuit, check the heaters of all tubes in the portion of the string showing an open.

Should neither continuity test show an open circuit, check the surge resistor. It is possible but not probable that a fault exists between the resistor and the on-off switch.

# SECTION 18

## TELEVISION SOUND

The sound section of a television receiver includes circuits and components represented by the block diagram of Fig. 18-1. Frequency-modulation inter-carrier sound signals at a center frequency of 4.5 mc are taken from any point following a video detector. This point may be immediately after the detector, or from the video amplifier output, or, with a reflex system, from the output of an i-f amplifier.

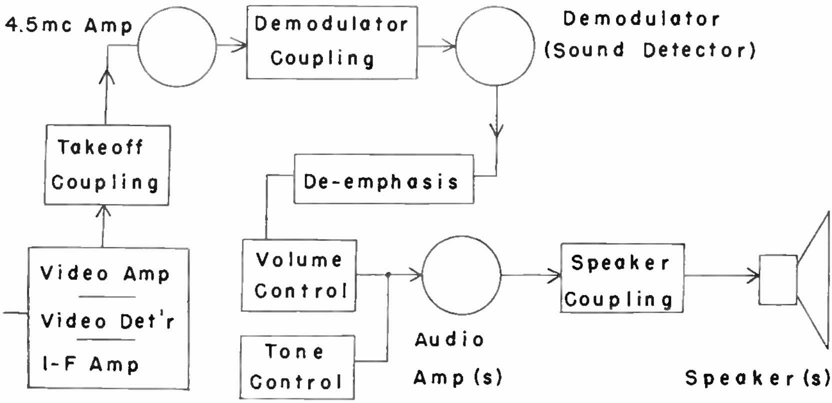


*Fig. 18-1. The sound section of a television receiver.*

A sound takeoff coupling aligned for 4.5 mc furnishes signals to the first or only 4.5-mc amplifier, sometimes called a sound or audio i-f amplifier. If there are two 4.5-mc amplifiers an interstage coupling transformer will be between them. This will be a second point for 4.5-mc alignment. One of these two 4.5-mc tubes may act as a limiter, especially when the demodulator is a discriminator type. Sometimes a crystal diode is used as limiter, bypassing any excessive peaks of amplitude modulation.

The demodulator may be a gated beam type or a ratio detector or a discriminator. A coupling transformer or impedance coil from a 4.5-mc amplifier to a gated beam demodulator usually has only one adjustable slug, but for a ratio detector or a discriminator the coupling transformer will have separate alignment slugs for primary and secondary windings.

At the output of the demodulator is a de-emphasis filter consisting of one or more series resistors, with capacitors to ground. This filter reduces strength of high audio frequencies which are emphasized at the transmitter.

A volume control, and sometimes a tone control, are on the input or output of an a-f voltage amplifier or first a-f amplifier, or on the grid circuit of the audio output amplifier.

An a-f voltage amplifier usually is a triode, quite commonly part of a duodiode-triode tube. The audio output most often is a beam power amplifier. Push-pull audio amplification is used in some receivers. There may be one, two or more than two speakers when the receiver employs either single or push-pull audio output tubes.

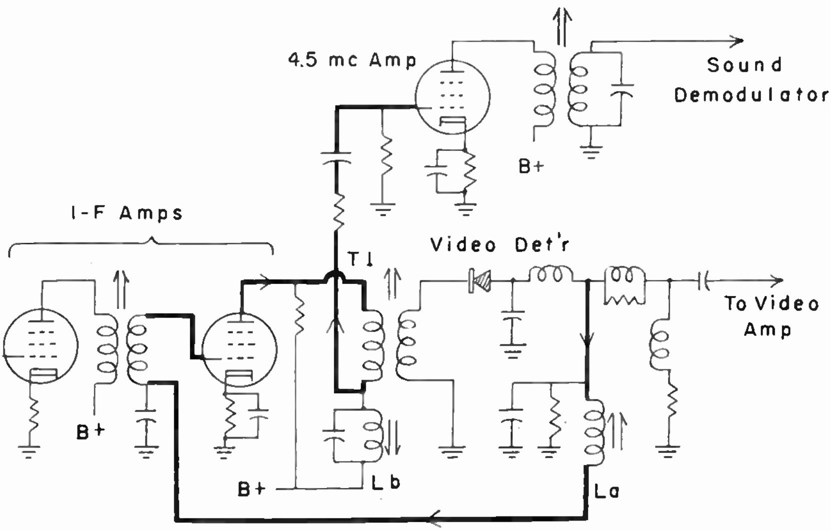


*Fig. 18-2. Reflexing 4.5-mc sound signals through an i-f amplifier.*

## Reflex Sound Takeoff

A reflex system is one in which the same set of elements in a tube simultaneously amplifies signals at two widely different frequencies. In Fig. 18-2 the final i-f amplifier handles signals at intermediate frequencies and also at the 4.5-mc sound frequency. The path of 4.5-mc sound signals is shown by heavy lines.

Sound signals are taken from the output of the video detector through inductor *La*, aligned for 4.5 mc, to the low side of the secondary of an i-f transformer which is aligned for intermediate frequencies. The 4.5-mc signals go through the i-f transformer secondary to the grid of the i-f amplifier, and from the plate of this amplifier through the primary of transformer *T1* to a line leading to the grid of the 4.5-mc amplifier.

Transformer *T1* is aligned for intermediate frequencies, but inductor *Lb* is aligned for 4.5 mc. Consequently, *Lb* is an impedance coupler for 4.5-mc signals. The 4.5-mc sound signals meet little opposition in transformers tuned for intermediate frequencies because these transformers are quite sharply resonant for the intermediates and have little impedance at 4.5 mc.

## Takeoff Alignment With VTVM

When the sound takeoff is from the secondary of a transformer whose primary is in series with the video amplifier plate, or for a takeoff coupling transformer or impedance coil on the grid of a 4.5-mc amplifier, alignment is made thus:

**1.** Connect an r-f signal generator through a capacitor of about 0.001 mf to the grid of the video amplifier. The generator is used unmodulated and tuned to exactly 4.5 mc, preferably with crystal control for this frequency.

**2.** Connect a VTVM to the audio output point of the demodulator, immediately following the de-emphasis filter but ahead of any capacitor going to the volume control. Set the meter on its d-c voltage function.

Note: Should the meter read in the neighborhood of 150 d-c volts positive when first connected, the receiver has a series-parallel B-voltage system. In this case connect the low side of the VTVM to a line from the cathode of the audio output amplifier. A metal cased meter must be insulated from chassis ground.

**3.** Adjust the takeoff coupling for maximum meter voltage, with generator output low enough that the meter reading does not exceed 2 or 3 volts. If a coupling transformer has separate primary and secondary adjustments, work back and forth between them for maximum meter reading.

For aligning a reflexed takeoff such as that of Fig. 18-2 proceed thus:

**1.** Use an r-f generator as in step *1* of preceding instructions.

**2.** Connect a VTVM, on its d-c voltage function, to the grid of the first or only 4.5-mc amplifier.

**3.** Adjust inductors *La* and *Lb* of Fig. 18-2 for peak voltage on the meter while keeping signal generator output low enough that the meter indicates only about one volt above the noise level voltage.

## 4.5 Mc Interstage Coupling Alignment

A 4.5-mc interstage coupling transformer should be aligned immediately after alignment of a takeoff coupling, using the same setup of a-f signal generator and VTVM. Adjust the interstage coupling for peak meter reading.

Still using the same instrument setup it will be convenient now to align the primary of the input transformer for a

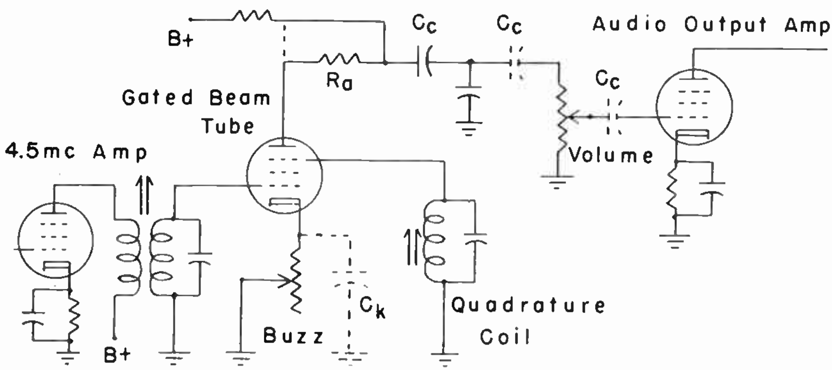


*Fig. 18-3. Gated beam demodulator with buzz control on cathode.*

ratio detector, or the single adjustment of the coupling to a gated beam demodulator. Adjust these couplings for maximum meter reading, always with generator output only great enough for meter reading of no more than 3 or 4 volts.

## Gated Beam Demodulators

Fig. 18-3 illustrates circuits commonly used for a gated beam tube used as a television sound demodulator. The coupling from a preceding 4.5-mc amplifier, shown as a transformer, may be an impedance coupler with a single inductor.

The adjustable resistor on the demodulator cathode often is called a buzz control. This potentiometer may or may not be paralleled with a capacitor to ground. Between the third grid of the gated beam tube and ground is a resonant circuit consisting of an inductor with adjustable slug and a paralleled capacitor. This is called the quadrature control.

Audio output is taken from the plate of the gated beam tube. A B+ connection may be to the demodulator plate or following a series resistor *Ra*. Coupling or blocking capacitor *Cc* may be in any of the positions shown.

Fig. 18-4 illustrates other connections for a gated beam demodulator. Here the demodulator cathode resistor is not adjustable. In series with the quadrature coil are a paralleled

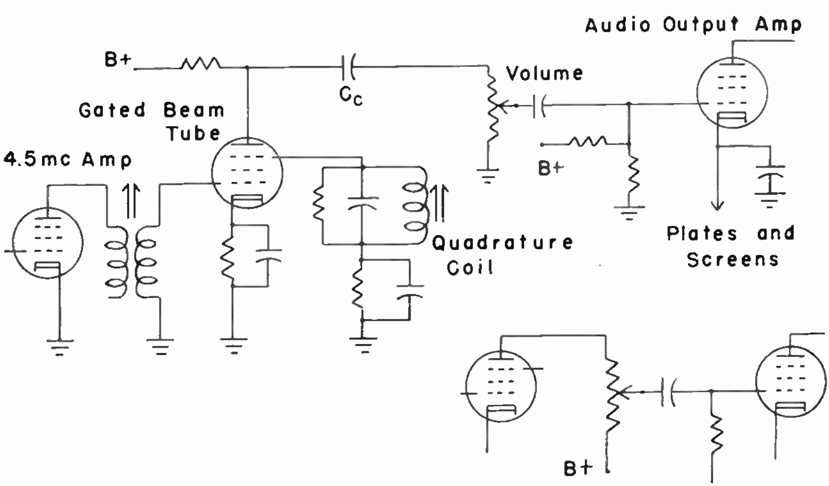


*Fig. 18-4. Gated beam demodulator without buzz control potentiometer.*

resistor and capacitor to ground. The low side of the volume control usually goes to ground, with a blocking and coupling capacitor at *Cc*. However, as shown by the small sketch, the low side of the volume control may go to B+, then carrying demodulator plate current.

## Gated Beam Demodulator Adjustments

To use a received signal for adjustment of the quadrature coil and buzz control proceed as follows:

**1.** Adjust receiver controls, especially the fine tuning, for best possible pictures.

**2.** Set the buzz control, if used, to the center of its range.

**3.** Adjust the quadrature coil for strongest, clearest sound, with minimum buzz.

**4.** Weaken the input signal by disconnecting one or both sides of the transmission line, then supporting the end of the transmission line near the antenna terminals of the receiver. Otherwise use an attenuation pad or other convenient means to lower the received signal level. In any case, reduce the received signal until there is a hissing sound from the speaker.

**5.** Adjust the buzz control for minimum hissing sound.

**6.** Reconnect the transmission line and try the fine tuning control at different positions. Slightly readjust the quadrature coil for least buzz and clearest sound.

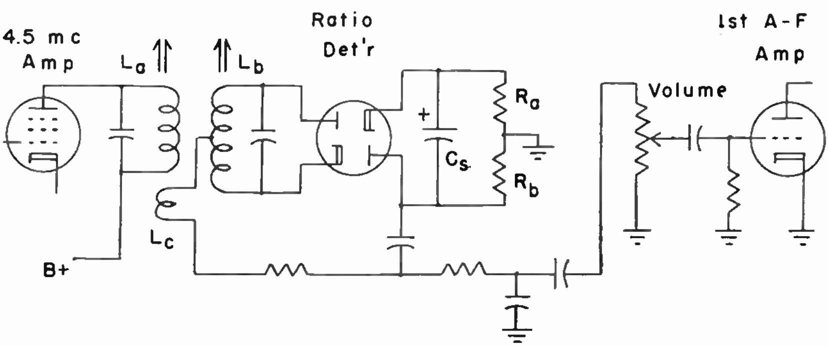


*Fig. 18-5. Ratio detector demodulator with divided resistor on load side.*

## Ratio Detector Demodulators

One of the circuits used for a ratio detector demodulator is illustrated by Fig. 18-5. The detector itself consists of two diodes, which may be in a twin tube or may be two crystal diodes. A characteristic feature of ratio detector demodulators is the storage capacitor *Cs,* which is an electrolytic of from one to as much as 10 mf capacitance. The positive side of this capacitor is connected to the cathode of one diode.

The ratio detector input transformer has three windings, a primary *La* and a secondary *Lb*, which have individual alignment slugs, also a third winding *Lc* connected to the audio output, and through the de-emphasis filter to the volume control. In Fig. 5 note the two resistors, *Ra* and *Rb*, which are across the storage capacitor, with a mid-connection to ground.

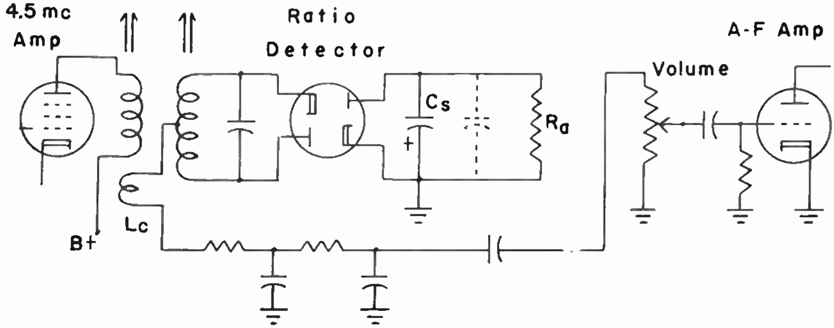


*Fig. 18-6 Ratio detector demodulator with ground on load side.*

The ratio detector demodulator of Fig. 18-6 is quite similar except that only a single resistor, *Ra,* is across the storage capacitor *Cs*, with one side of both these elements and the cathode of one diode conected to ground. Here is shown also a two-section de-emphasis filter.

## Ratio Detector Alignment

A ratio detector demodulator transformer may be aligned with either a generator signal or else a received transmitted signal, using a VTVM in either case. The method for using a generator is as follows:

**1.** Connect the r-f signal generator through about 0.001 mf capacitance to the video amplifier grid. Alignment may be easier with received signals kept from the amplifier. This may be done by disconnecting the transmission line and grounding both antenna terminals of the receiver, and possibly grounding the grid of an i-f amplifier. Some tuners can be set between channels, for the same effect. Use the generator unmodulated, tuned for exactly 4.5 mc, preferably with crystal control.

**2.** Connect two 5% tolerance 100K ohm resistors in series from an ungrounded side of the storage capacitor to ground.

**3.** Connect the high side of the VTVM to the junction of the two 100K ohm resistors and the low-side to an ungrounded side of the storage capacitor. A metal-cased VTVM must be insulated from ground. Alternately, the VTVM may be connected from an ungrounded side of the storage capacitor to ground. Use the meter on its d-c voltage function.

Note: If the receiver employs a series-parallel B-voltage system, consider ground, as referred to for VTVM connections, as a line from the cathode of the audio output amplifier.

**4.** Adjust the primary of the ratio detector transformer for maximum VTVM reading, or else adjust the secondary and then the primary for maximum reading.

**5.** Connect the VTVM from the junction of the 100K ohm resistors to the audio output just beyond the de-emphasis filter. Insulate the meter from ground.

**6.** Adjust the secondary of the ratio detector transformer for zero meter reading, so that a slight turn of the slug either way causes the meter to read positive or negative.

**7.** Repeat the primary adjustment, steps *4* and *5*, then recheck the secondary adjustment.

**8.** Disconnect the instruments, restore conditions altered in step *1*, tune in a station, and touch up the takeoff coupling for best sound.

When making a complete sound alignment, steps *1*, *2* and *3* of the preceding instructions may be performed, then the takeoff, also any interstage coupling, may be adjusted before adjusting the ratio detector transformer primary.

For ratio detector alignment with a received signal and a VTVM proceed thus:

**1.** Perform steps *2* and *3* of the preceding instructions.

**2.** Tune for the best possible picture from a received signal.

**3.** Perform steps *4* through *8* of the preceding instructions.

## Reflexing For Audio Amplification

Fig. 18-7 shows one method of using a 4.5-mc sound amplifier as a reflexed a-f voltage amplifier, thus avoiding the need for a separate a-f voltage amplifier between demodulator and audio output amplifier.

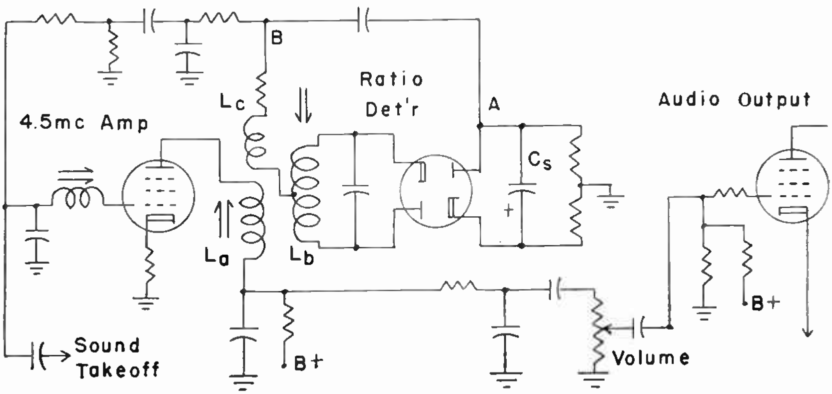


*Fig. 18-7. Reflexing audio signals through a 4.5-mc amplifier.*

Audio output is taken from the ratio detector at *A* and *B*, the usual points, and goes through a filter network at the top of the diagram to the grid of the 4.5-mc amplifier. Amplified audio signals from the 4.5-mc amplifier plate go through the transformer primary *La* and the re-emphasis filter to the volume control.

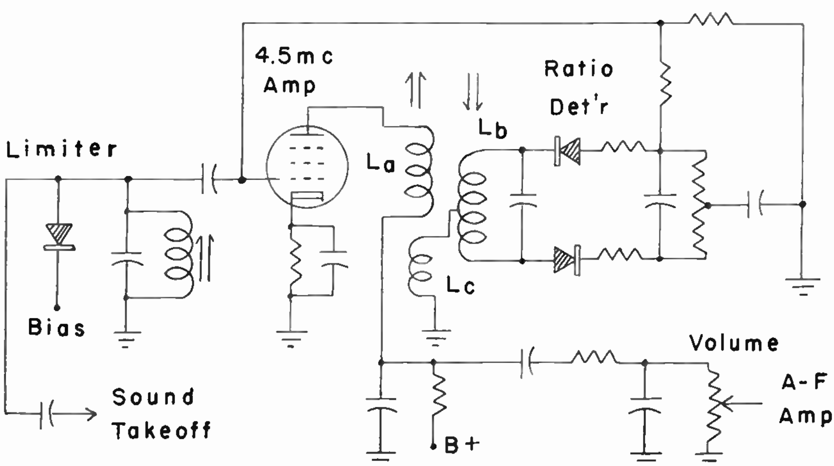


*Fig. 18-8. Another circuit for reflexing audio signals through a 4.5-mc amplifier.*

Fig. 18-8 shows another method of reflexing the audio output of a ratio detector through a 4.5-mc amplifier. Here the ratio detector elements are crystal diodes instead of a twin-diode tube.

## Discriminator Demodulators

Fig. 18-9 shows two methods for using pairs of crystal diodes as a discriminator type demodulator. At the left the 4.5-mc sound signals are put into the discriminator transformer secondary through two small capacitors connected to the amplifier plate. At the right the discriminator transformer has three windings like those used in ratio detector transformers.

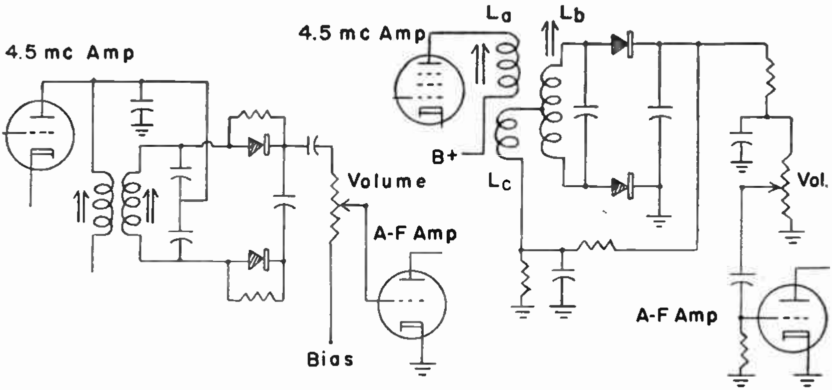


*Fig. 18-9. Discriminator demodulators employing pairs of crystal diodes.*

A discriminator transformer may be aligned thus:

1. Tune in the best possible picture from a received signal.

2. Disconnect the transmission line from receiver antenna terminals, and support the line near the terminals, or otherwise provide a weak signal.

3. Adjust the transformer primary for maximum sound and minimum hiss.

4. Reconnect the transmission line.

5. Adjust the transformer secondary for maximum or best sound with the volume control advanced only part way.

6. Readjust the primary on a weak signal.

## Tone Controls

Various tone control circuits in general use are illustrated by Fig. 18-10. The simplest type, at *A*, consists of an adjustable resistor and a capacitor in series to ground from a line carrying audio signals. The capacitor bypasses higher audio frequencies to ground, thus emphasizing the lows. The less the series resistance the greater is the loss of high frequencies and the more the lows stand out.

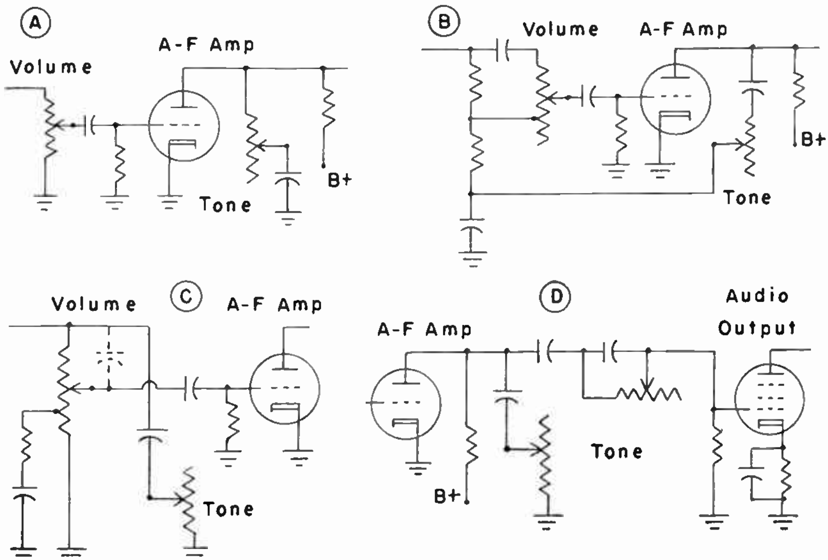


*Fig. 18-10. Tone control circuits, also some compensated volume controls.*

At *B* a generally similar tone control circuit is connected to a compensated volume control. A compensated volume control helps maintain proper balance between high and low audio frequencies, as they affect the ear, with volume reduced to a low level. Such volume controls often are found without a tone control. In diagram *C* a tone control and compensated volume control are both on the grid circuit of an a-f voltage amplifier.

Diagram *D* of Fig. 18-10 shows two tone controls. The one consisting of a capacitor and adjustable resistor in series to ground attenuates high audio frequencies as previously explained. It may be called a treble control. The other tone control consists of an adjustable resistor across a small coupling capacitor to the grid of the output amplifier. It may be called a bass control. Reducing the paralleled resistance allows more of the lower frequencies to reach the output amplifier.

## Push-pull Audio Amplifiers

Features found in many push-pull audio amplifiers are illustrated by Fig. 18-11. The a-f voltage amplifier takes signals from the demodulator through the volume control and delivers its plate signals to the grid of one beam power output amplifier. Part of the a-f amplifier output signal goes through a resistor-capacitor network to the grid of the inverter, from whose plate are taken signals to the grid of the other output amplifier. The network shown is called a self-balancing inverter system. The purpose is to apply to the inverter grid

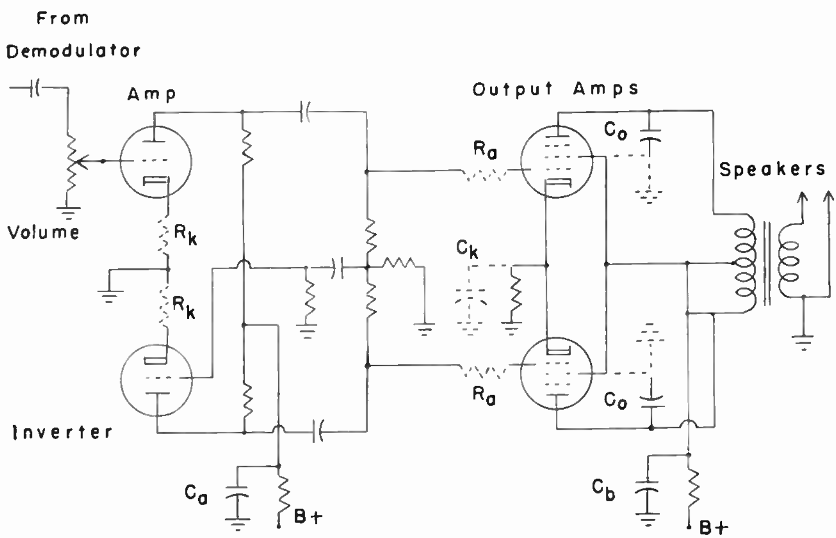


*Fig. 18-11. A typical push-pull audio amplifier circuit as used in television receivers.*

an audio signal of the same strength as applied to the grid of the a-f amplifier. Cathode bias resistors *Rk-Rk* may or may not be used.

Distortion is reduced by using output amplifier tubes whose characteristics are approximately equal. The usual check is to measure their d-c plate currents while no signals are applied and while grid biases are equal. Plate currents should differ by no more than about 10 per cent.

Output amplifier cathode bias capacitor *Ck* may or may not be used. Using a bypass of 100 mf or more helps reduce distortion when output amplifier tubes are unbalanced in performance.

Output amplifier oscillation, which causes whistles or squeals, may be reduced or prevented by series grid resistors *Ra-Ra* whose value usually is around 500 ohms but which may be several thousands of ohms. Whistles or squeals may be prevented also by small capacitors *Co-Co*, usually 0.002 to 0.005 mf, connected from output amplifier plates to ground or to B+ or sometimes to the amplifier cathodes.

Decoupling capacitors at *Ca* and *Cb* reduce the chances for hum introduced at a-f amplifier plates or at output amplifier screens from B-voltage containing considerable ripple. The value at *Ca* usually is 20 mf or more, and at *Cb* is 100 mf or more.

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Tables which follow list faults which commonly cause faulty sound output from the speaker or speakers. Each table covers a certain symptom or related symptoms. Paragraphs following the table give additional information on some of the faults. These paragraphs are numbered to correspond with faults listed in the tables.

| Table 18-A | Sound Absent Or Weak<br>Pictures And Raster OK |
|---|---|
| CONTROLS | A1 Fine tuning misadjusted<br>A2 Volume control potentiometer defective, open.<br>A3 Tone control, any element wrongly grounded. |
| TUBES | Audio output amplifier. 1st a-f amplifier, if used. Demodulator. 4.5-mc amplifier(s)<br>A4 Check with tester or by substitution.<br>A5 Examine socket contacts.<br>A6 Measure element voltages. |
| ALIGNMENTS ADJUSTMENTS | A7 Demodulator input transformer or coupler.<br>A8 Takeoff coupling.<br>A9 4.5-mc interstage coupling, if used.<br>A10 I-f alignment for sound too low on response. |
| | Gated beam demodulator<br>A11 Quadrature coil misadjusted<br>A12 Buzz control misadjusted, if used.<br>A13 Cathode circuit open. |
| CIRCUIT ELEMENTS | A14 Any coupling transformer, coil or capacitor open or disconnected. |
| SPEAKER SYSTEM | A15 Connection plug loose, defective, not in place.<br>A16 Transformer or voice coil leads open, loose or broken.<br>A17 Transformer internally open, shorted<br>A18 Speaker cone or spider loose, broken |

**A5.** Removing and replacing sound section tubes while receiver is turned on may clear the trouble.

**A7-9.** See instruction for alignments in preceding pages of this section.

**A10.** When rotating the fine tuning control allows either good pictures or good sound, but not both at same time, the i-f amplifier section may be poorly aligned.

**A11-12.** See instructions for adjustments in preceding pages of this section.

| Table 18-B | Sound Absent Or Weak<br>No Pictures. Raster OK. |
|---|---|
| CONTROLS | B1 Fine tuning misadjusted.<br>B2 Contrast control potentiometer open, when on video amplifier.<br>B3 Channel selector switch contacts dirty, loose, bent, broken. |
| ANTENNA | B4 Transmission line or antenna open, grounded. |
| TUBES | Audio output tube, in series-parallel B-voltage system.<br>B5 Cathode circuit open.<br>B6 Cathode bypass-decoupling capacitor shorted, leaky. |
| | Video amplifier. Video detector. I-f amplifiers. R-f amplifier or oscillator-mixer in tuner.<br>B7 Check with tester or by substitution.<br>B8 Examine socket contacts.<br>B9 Measure element voltages. |
| ALIGNMENTS ADJUSTMENTS | B-10 R-f oscillator in tuner aligned for sound too low on frequency response.<br>B11 I-f alignment for sound too low on response, or two couplers aligned for frequencies so close together as to cause regeneration.<br>B12 Agc voltage too negative. |
| CIRCUIT ELEMENTS | B13 Any coupling transformer, coil or capacitor open or disconnected in circuits preceding the video amplifier. |

**B5-6.** The audio output amplifier cathode carries current from i-f and r-f amplifiers, and sometimes other tubes.

**B8.** Removing and replacing tubes with set turned on may clear the trouble.

**B10-12.** See instructions for alignments in preceding pages of this section.

**B11.** If i-f alignment allows sound too low on the response, rotating the fine tuning control usually allows either good sound or good pictures, but not both. Regeneration or possibly oscillation in i-f amplifiers is indicated by high, sharp

| Table 18-C | Intermittent Sound<br>Pictures OK |
|---|---|
| TUBES | 4.5-mc amplifier(s). Demodulator. A-f amplifier. Audio output amplifier.<br>C1 Socket contacts loose.<br>C2 Heater or other internal element connections are opening and closing with changes of temperature. |
| CIRCUIT ELEMENTS | At or following the sound takeoff.<br>C3 Coupling capacitor opening and closing its internal connections with changes of temperature.<br>C4 Resistor internal element or pigtail connection opening and closing with temperature changes.<br>C5 Insulating coatings have penetrated switches or other contact members. |
| WIRING | In sound section<br>C6 Rosin joints, cold solder, corrosion.<br>C7 Loose wire strands making temporary contact at terminals.<br>C8 Insulation broken or gone.<br>C9 Wire conductor broken inside its insulation. |

peaks on a frequency response trace observed with the oscilloscope.

**B12.** Check the setting of any sensitivity adjustment, also condition of any agc amplifier.

**C1.** Removing and replacing tubes may clear the trouble.

**C2.** Replace all sound section tubes. If trouble disappears, put back original tubes one at a time until trouble does appear.

**C5.** Insulating cement may have been carelessly applied. Remove with sharp tool, or first soften the cement with a prepared solvent or lacquer thinner.

**C6-9.** Move suspected wires or pull them gently. Press or tap suspected joints while listening for sounds. Clean around suspected joints and resolder with hot iron while touching with rosin-core solder to provide flux. Pay especial attention to terminals or lugs where two or more wires join.

| Table 18-D | **Hum**<br>A low-pitched rather soft or semi-musical sound at 60- or 120-cycle frequency. To be distinguished from the trouble classified as "Buzz", which is a sharp, disagreeable sound. |
|---|---|
| TUBES | Video amplifier or any tube in sound section. 60-cycle hum.<br>D1 Heater voltage excessive<br>D2 Heater-cathode leakage. |
| CIRCUIT ELEMENTS | Video amplifier or any tube in sound section.<br>D3 Cathode bypass capacitor old, open, leaky.<br>D4 Plate, screen or grid decoupling capacitor faulty. |
| | Series-parallel B-supply system.<br>D5 Output amplifier cathode decoupling-bypass capacitor old, open, leaky. |
| LOW-VOLTAGE POWER | 120-cycle hum.<br>D6 Filter capacitor old, open, leaky.<br>D7 Filter choke or resistor shorted, wrong value.<br>D8 Either of two selenium rectifiers weak, low back resistance.<br>D9 Power transformer internal short. |
| WIRING | 60-cycle hum.<br>D10 Heater wiring too close to capacitors, inductors or B+ wires in plate, screen or grid circuits of video amplifier or any sound section tube.<br>D11 Wiring from a-c line to switch or fuse too close to wires in video amplifier or sound section circuits. |
| | 120-cycle hum.<br>D12 Any B+ line which should connect to power filter output actually connected ahead of a filter choke or resistor. |

**D1.** Excessive heater voltage, and current, may be the cause of heater-cathode leakage, or may make such leakage worse.

**D3-4.** A defective cathode bypass capacitor causes hum that increases in intensity with large values of grid bias and of cathode resistors. Check for an old or open capacitor by temporarily paralleling it with a good capacitor of equal or greater value. If hum stops, replace the original capacitor.

Note that hum introduced ahead of a push-pull stage is not cancelled by push-pull action.

**D5-6.** Follow instructions in preceding paragraph D3-4.

**D7.** Measure ripple voltage at input and output of filter choke or resistor. Ripple should be much less at output than at input. Measure with voltmeter or oscilloscope as explained at the end of these paragraphs.

**D9.** An internally shorted power transformer runs excessively hot. Disconnect the transformer secondary from the rectifier, let the transformer cool, then turn on a-c power and keep it on for about 30 minutes. If the transformer heats abnormally there probably is an internal short.

**D12.** B+ lines to plates of audio output tubes often are connected ahead of a filter choke or resistor. If any other B+ lines are so connected, check with a service diagram for the receiver.

## VTVM for Locating Hum

**1.** Use the VTVM on its a-c voltage function. Make sure there is a capacitor of 0.25 mf or more capacitance in series with the high side lead, to prevent indication of d-c voltages.

**2.** Disconnect the transmission line and set the channel selector where there are no transmitted programs.

**3.** Check for a-c voltage at plates, screens and grid returns of sound section tubes. Ripple voltage should be too little to measure except, possibly, at the plates of push-pull audio output amplifiers.

## Oscilloscope For Locating Hum

**1.** Adjust the internal sweep of the scope to show one or two waves at 60 cycles, by connecting the vertical input to any

| Table 18-E | **Buzz**<br>Sharp, disagreeable and usually continued sound, somewhat like that of a bee or from rubbing the edge of a paper across saw teeth. To be distinguished from hum, which is softer and semi-musical. |
|---|---|
| CONTROLS | E1 Fine tuning misadjusted.<br>E2 Contrast control advanced too far, when operates on video amplifier. |
| TUBES | Demodulator<br>E3 Defective tube, wrong element voltages.<br>Video amplifier, if ahead of sound takeoff.<br>E4 Weak, low emission<br>E5 Overloaded. Plate or screen voltage too low. Grid bias not sufficiently negative. |
| | E6 Limiter, if used, defective or wrong element voltages.<br>E7 Agc tube defective, or faults in agc circuit. |
| ALIGNMENTS ADJUSTMENTS | Gated beam demodulator<br>E8 Buzz control misadjusted, when used.<br>E9 Quadrature coil misadjusted, open, shorted. |
| CIRCUIT ELEMENTS | E10 Demodulator input transformer.<br>E11 Sound takeoff, 4.5-mc amplifier input.<br>E12 4.5-mc interstage coupling, if used.<br>E13 I-f aligned for sound too high on frequency response.<br>E14 R-f oscillator in tuner aligned for sound too high on frequency response. |
| | E15 Sound takeoff coupling capacitor open. leaky, shorted. |
| | Gated beam demodulator<br>E16 Cathode bypass capacitor shorted, leaky.<br>Ratio detector demodulator<br>E17 Storage capacitor leaky, open.<br>E18 Resistors or capacitors of a balanced pair decidedly different in values. |

(Table continued on page following)

| Table 18-E (Continued) | Buzz |
|---|---|
| LOW-VOLTAGE POWER | E19 Transformer mounting screws, core clamp screws, or laminations loose.<br>E20 Leads from transformer to rectifier, or from rectifier to filter, dressed close to audio wiring, volume control or tone control. |
| VERTICAL OUTPUT | Transformer<br>E21 Mounting screws, core clamps, or laminations loose.<br>E22 Coil loose on core.<br>E23 Capacitor from secondary to ground old, open, otherwise defective.<br>E24 Internal short. |
| | E25 Vertical output leads dressed too close to audio circuit leads. |
| HIGH VOLTAGE | E26 Poor ground contact on outer coating of picture tube.<br>E27 High-voltage filter capacitor defective. |

heater line or to a 6.3-volt output on the scope. Remember the number of waves shown.

**2.** Use a shielded cable on the vertical input. With the shield clip connected to chassis ground and the high side prod to the chassis, advance the vertical gain and note any indication of voltage on the scope. Such voltage should be neglected in following tests.

**3.** Touch the scope prod to plate, screen and grid terminals on sockets for tubes in the sound section, beginning at the audio output amplifier or amplifiers and working back to the grid of the video amplifier. Negligible ripple voltage should be at any elements other than possibly at plates of push-pull output amplifiers. Ripple at i-f or tuner tubes is not likely to cause bad audible hum, although it may affect pictures.

**E3.** Even though a demodulator tube is defective, weak or noisy sound still may be heard.

**E8-12.** See instructions for alignments in preceding pages of this section. It is advisable to check the demodulator tube

| Table 18-F | Motorboating<br>Rapid or slow "putt-putt" sound caused by blocking and cutoff of amplifiers at regular intervals. |
|---|---|
| TUBES | F1 Audio output or first a-f amplifier grid bias too negative. |
| CIRCUIT ELEMENTS | Audio output or first a-f amplifier circuits.<br>F2 Grid resistor too great, open.<br>F3 Coupling capacitor to grid, too much capacitance.<br>F4 Decoupling capacitor on plate or screen, old, open, too little capacitance. |
| WIRING | F5 Tone control wires to front panel dressed too close to other wires. |

| Table 18-G | Hiss<br>Continual or intermittent. |
|---|---|
| HIGH VOLTAGE | G1 Corona or arcing in high-voltage power supply. |
| ADJUSTMENT | G2 Gated beam demodulator buzz control misadjusted, if used. |
| TUBES | Audio output or a-f amplifier.<br>G3 Overheated, due to excessive screen or plate voltage, and current, or to grid bias not sufficiently negative.<br>G4 Gassy. |
| WIRING | G5 Joints loose, cold solder, corroded. Especially in B+ lines.<br>G6 Resistor overheated, cracked, pigtail loose in body. |

and its element voltages, or demodulator crystals, before aligning or adjusting the circuits.

**E13-14.** When either of these faults is present, rotating the fine tuning control may allow either good pictures or good sound, but not both together.

**E19.** Buzz sometimes may be prevented by tightening some screws and loosening others.

**E23.** A shorted transformer affects pictures also.

| Table 18-H | Rasping Or Crackling<br>Not having any definite audio frequency. Either continual or intermittent. |
|---|---|
| HIGH VOLTAGE | H1 Flashover from terminals or conductors. |
| CONTROLS | H2 Volume control defective.<br>H3 Contrast control defective, when on video amplifier.<br>H4 Channel selector, tone switch, or TV-Radio-Phono switch. Contacts dirty, loose, bent. |
| TUBES | H5 Socket contacts loose, dirty.<br>H6 Shields loose, not grounded to chassis. Check other shielding for looseness. |
| POWER LINE PICKUP | Building wiring elements.<br>H7 Lamps or lamp holders defective.<br>H8 Switches in walls or lamp holders defective.<br>H9 Any terminal connections loose, dirty. |
| | Appliances with brush-type motors.<br>H10 Vacuum cleaners.<br>H11 Food and drink mixers.<br>H12 Sewing machines.<br>H13 Hair dryers, electric razors, etc. |
| | Machines with switches<br>H14 Office machines, cash registers, elevators.<br>H15 Flashing signs, welders, etc. |
| SPEAKER | H16 Neon signs with defective elements. |
| CIRCUIT ELEMENTS | H17 Dirt in voice coil gap.<br>H18 Voice coil not centered in gap.<br>H19 Cone loose, torn.<br>H20 Spider loose, broken. |
| | In Sound section.<br>H21 Resistor cracked, overheated, pigtail loose in body.<br>H22 Capacitor pigtail or terminal loose.<br>H23 A-c line filter elements defective. Between line cord and input to low-voltage power supply. |

**E24.** An open or defective capacitor may allow vertical sync pulse voltage to get into B+ lines.

**E25.** This and other vertical output faults may be checked by temporarily removing or disabling the vertical oscillator or amplifier. The buzz will cease if the fault is in the vertical system.

**G1.** Refer to Table 14-C in the section of this book on "High Voltage".

**G5.** Press or tap suspected joints and carefully press or pull connected wires while listening for hissing sound. Resolder doubtful joints, using a hot iron and rosin-core solder.

**H1.** Watch for visible flashes with room darkened or receiver shaded. Coat the points of flashover with plastic insulation after smoothing sharp wire ends and rough solder joints as much as possible.

**H4.** Apply a contact cleaning liquid with brush or spray while moving the switch contacts.

**H5.** Removing and replacing a tube may correct the trouble.

**H7-16.** Disconnect the transmission line from the receiver and ground both antenna terminals at the tuner. If noise disappears it was coming through the antenna or transmission line. If noise continues, temporarily operate the receiver from an isolation transformer with its core grounded to chassis. Less noise indicates pickup from power line. If noise remains, trouble probably is in receiver or is picked on receiver wiring.

**H10-16.** The best remedy is an interference filter at the offending appliance or machine. Filtering at the receiver is less effective. Filters for all applications are available from supply houses.

**H17.** Work out dirt or any foreign matter with a piece of stiff paper, a thin card, or thin brass or aluminum. A jet of compressed air, if available, is still better. Dirt may have entered because a dust cover is missing or torn. This cover usually is a piece of thin felt cemented at the center of the cone.

**H18.** The voice coil can be recentered only with the cone and spider loosened from the frame. Use commercially available

| **Table 18-I** | **Ringing Whistling Howling Squealing**<br>The sound may be like that from a small bell struck far away, or a whistle or howl, usually rather high pitched. The sound may be continual or intermittent, or may rise and fall in intensity. |
|---|---|
| TUBES | Oscillator-mixer. R-f amplifier. A-f amplifier. I-f amplifier. Video amplifier. Audio output.<br>I1 Microphonic.<br>I2 Loose in socket.<br>I3 Shield loose on tube or chassis. |
| TUNER | I4 Shaft or control knob touching against cabinet opening.<br>I5 Frame touching cabinet.<br>I6 Mounting bracket loose. |
| SPEAKER | I7 Anti-vibration mounting defective.<br>I8 Capacitor on output amplifier plate, or capacitor or resistor across transformer primary, open or defective.<br>I9 Transformer of poor quality, excessive leakage reactance. |
| CHASSIS | I10 Excessive vibration in cabinet, mountings defective. |
| CIRCUIT ELEMENTS | Audio output amplifier.<br>I11 Plate bypass capacitor to ground, B+ or tube cathode. Open, too little capacitance.<br>I12 Cathode bypass electrolytic capacitor old or of too little capacitance.<br>I13 Cathode bypass electrolytic may require paralleling with ceramic or mica capacitor of about 0.001 mf.<br>I14 Resistor in series with grid, at the grid, shorted, too small in value. |
| | I15 Any interstage coupling or blocking capacitor vibrating because of poor supports. |

centering shims, or wrap the central magnet pole with paper or brass shim stock to form a tube longer than the voice coil support. The voice coil is placed over this tube. Strip shims may be inserted with the cone in place. The edges of spider and cone are cemented while the voice coil is held centered.

**H20.** Replace a defective spider with one of the same shape and diameter. Some are cupped or corrugated, others are flat.

**I-1.** Tap each suspected tube with a finger nail, pencil eraser, or rod with rubber tip. Have the receiver in its cabinet, all shields in place, volume turned fairly high. There is microphonic trouble when the sound continues after each tap. Try removing and replacing a suspected tube in its socket. Try interchanging the microphonic tube with another of the same type from a different position. Microphonism is worse in some positions than others.

**I-8-14.** These faults may allow parasitic oscillation. One check for oscillation is measurement of plate current from a suspected tube. Current varying erratically, or remaining unusually high or low, may indicate oscillation. A better check is made with an oscilloscope connected to the plate of a suspected tube while output from an audio-frequency signal generator is fed through a capacitor to the video amplifier grid. The high oscillation frequencies sometimes may be seen on the trace, or very high-frequency oscillation may cause abnormal thickening or widening of the trace. Try feeding various audio frequencies at various generator attenuator settings and receiver volume control settings.

**I-12.** Temporarily parallel the capacitor with a good one of the same or greater capacitance. Reduction of trouble indicates the original capacitor is old or open.

**I-14.** This grid stopping resistor may be increased in value to several thousands of ohms if oscillation is thereby prevented.

**J3.** Low voltage on plate or screen, or grid bias not sufficiently negative may allow overloading and production of harmonics.

**J5-8.** See instruction for alignments in preceding pages of this section.

| Table 18-J | Distortion<br>Generally disagreeable or unnatural reproduction of sound, not characterized by any particular kind of noise. |
|---|---|
| CONTROLS | J1 Fine tuning misadjusted. |
| TUBES | Audio output amplifier, possibly the voltage amplifier.<br>J2 Tube weak.<br>J3 Element voltages wrong.<br>J4 Push-pull output amplifiers unbalanced. |
| ALIGNMENTS ADJUSTMENTS | J5 Demodulator input transformer.<br>J6 Gated beam demodulator quadrature coil.<br>J7 Sound takeoff or coupling to grid of 4.5-mc amplifier.<br>J8 4.5-mc interstage coupling, if used. |
| CIRCUIT ELEMENTS | J9 Gated beam demodulator cathode bypass capacitor open, leaky.<br>J10 De-emphasis filter or demodulator output capacitor leaky, wrong value. Series resistor wrong value.<br>J11 Audio output amplifier cathode bypass capacitor too large, leaky.<br>J12 Audio output amplifier plate or screen decoupling capacitor faulty. |
| SPEAKER | J13 Voice coil or cone binding.<br>J14 Speaker transformer not matched to output amplifier, voice coil, or both.<br>J15 Speaker of too small rating for audio power applied. |

**J11.** A cathode bypass of moderate or small capacitance may be used to allow a certain amount of degeneration.

**J13.** The voice coil and cone center must move quite freely for a considerable distance for good reproduction of lows. Clearance between coil support and magnet core normally is very small.

**J14.** Primary impedance should be within 90% to 125% of load resistance specified for the audio output amplifier. Secondary impedance should be no greater than nominal impedance of the voice coil.

**J15.** The speaker power rating in watts should exceed the maximum undistorted power output rating of the audio amplifier.

## Distortion Test With Oscilloscope

**1.** Connect the output of an audio-frequency generator or the audio output of any signal generator directly to the vertical input of the oscilloscope. If possible, tune the generator for about 1,000 cycles and adjust internal sweep of the scope to show a trace of one or two cycles. The trace should be a good sine wave, or variations in form should be noted.

**2.** Connect the audio output of the generator to the high side of the volume control. Remove the demodulator tube.

**3.** Connect the vertical input of the oscilloscope to the following points, in the order listed. Keep the generator output power at a level of one or two volts and adjust vertical gain of the scope as necessary for trace height.

a. Voice coil lead, ungrounded side.

b. Audio output amplifier plate.

c. Audio output amplifier grid.

d. A-f voltage amplifier plate.

e. A-f voltage amplifier grid.

Vary the volume control with each connection of the scope. Listen to sound reproduction from the speaker. Trouble exists between the last connection showing a distorted sine wave and the first one showing a good sine wave. Various audio frequencies may be checked if the generator is tunable.

# INDEX FOR TROUBLE TABLES


A

Afc, input to, 194-195
  phase detector, multivibrator, 196-197
  pulse width, 199-201
  reactance tube, 203-204
Agc, 49-51
Anode voltage, 261-262
Antenna, 8
Arcing, 264
Audio, 314-326

B

Blocking oscillator, horizontal, 199-201
    vertical, 156
Boost voltage, 251
B-voltage, low-zero. 290-291
  series-parallel distribution, 292
Brightness, 79

C

Cathode coupled multivibrator
    horizontal, 196-197
    vertical, 156
Centering magnets, 97
Clippers, sync, 124
Corona, 264

D

Damper circuit, 235
D-c restoration, 81
Drive, horizontal, 235

F

Filter, integrating, 154
  noise, horizontal, 196
  power supply, 290
Focus magnet or coil, 97

H

Hartley oscillator, 202-204
Height control, 158
High voltage, picture tube, 261-262
    section, 260
Hold control, horizontal
    multivibrator, 197
    pulse width, 201
  vertical, 158
Horizontal, deflection, 225, 235, 244
  linearity, 235
  output transformer, 225
  sweep section, 194-204
  yoke coils, 244-245
Hum voltages, 292

I

I-f amplifier, 28
Integrating filter, 154
Ion trap magnet, 97

L

Linearity, horizontal, 235
  vertical, 159
Locking control, multivibrator, 197
Low voltage, too low, zero, 290-291

M

Multivibrator, horizontal
    cathode coupled, 196-197
Multivibrator, vertical
    cathode coupled, 156-157
    plate coupled, 154-155

N

Noise filter, horizontal, 196

O

Oscillator, horizontal
    blocking type, 199-201
    Hartley type, 202-204
    multivibrator, 196-197
Oscillator, vertical
    blocking type, 156
    multivibrator, cathode coupled, 156-157
    multivibrator, plate coupled, 154-155

P

Pattern, picture, XI
Phase detector afc
    multivibrator, 196-197
    reactance tube, 202-204
Picture, pattern, XI
Picture tube, 85
    accessories, 97
    input circuits, 79-81
Plate coupled multivibrator, 154-155
Pulse width afc, 199-201

R

Restoration, d-c, 81
Retrace blanking, vertical. 80-81
Ripple voltage, 292

S

Sawtooth system, vertical, 158
Separator, sync, 124
Series-parallel B-voltage, 292
Signal, picture tube, 79
Sound, 314-326
Stabilizer, multivibrator, 197
  pulse width, 201
Sync section, 124
Synchroguide, afc, 199-201

T

Transmission line, 8
Tuner, 15

V

Vertical, deflection, 273
  hold control, 158
  linearity, 159
  output, transformer, 273
    tube, 157
  retrace blanking, 80-81
  sawtooth system, 158
  sweep section, 154-159
  yoke coils, 273-274
Video amplifier, 57-60
  detector, 39

W

Width control, 225

Y

Yoke, as a unit, 276
  coils, horizontal, 244-245
    vertical, 273-274

# INDEX


A

Afc
  checking operation of, 191-192
  input to, table of troubles, 194-195
  phase detector, diodes, 162-166
    multivibrator, table of troubles, 196-197
    triodes, 170-177
  pulse width, 177-185
    table of troubles, 199-201
  reactance tube, 186-189
    table of troubles, 203-204

Agc, 41-52
  clamp tube action, 42-43
  gated or keyed, 45-47
  principles of, 41-42
  rectifiers for, 45
  table of troubles, 49-51
  troubles and remedies, 48-52
  video detector as source, 44
  voltage tests, 47-48

Alignment, i-f, 29-32
  tuner, adjustments for, 13-16
    oscilloscope connections, 17-18

Amplifier, i-f. See *I-f amplifier.*
  sync, 103-104
  video. See *Video amplifier.*

Anode voltage. See *High voltage.*
    table of troubles, 261-262

Antenna, 8-11
  built-in or indoor, 9
  directivity of, 10
  height and location of, 8-9
  impedance mismatch, 10
  orientation of, 8-9
  signals too strong, 9-10
  table of troubles, 8

Arcing, 263-266
  table of causes, 264
  audio systems, 301-327

Automatic frequency control. See *Afc*
  gain control. See *Agc*

Autotransformer, horizontal output, 214-215
  vertical output, 267-268

B

Bandwidth, i-f amplifier, 30

Bar generator, square wave generator used as, 232

Barkhausen oscillation, 208-209

Base pin resoldering, picture tube. 90-91

Beat frequency traps, 56, 58

Blanking, vertical retrace.
  circuits for, 67-72
  filters for, 74-75
  pulse observation, 80-82
  table of troubles, 80-81

Blocking oscillator.
  horizontal, 177-185
    table of troubles, 199-201
  vertical, cathode feedback, 134-136
    plate feedback, 131-134
    table of troubles, 156
    types of, 127

Boost voltage, 247-251
    table of troubles, 251

Boosters, picture tube, 93

B-power supply. See *Low voltage*

Brighteners, picture tube, 93

B-voltage, low-zero, table of causes, 290-291
  series-parallel, table of troubles, 292

Brightness control, 75-76
    circuits for, 67-72
    tests of, 76
    table of troubles, 79

Built-in antenna, 10

Burning out shorts, picture tube, 92-93

B-voltage, boosted, 247-251
    table of troubles, 251
  series-parallel distribution, 285-289
    table of troubles, 292

C

Capacitance divider probe, 146-148

Capacitor coupled multivibrator, 128, 140-145

Capacitors, decoupling, test of, 62
  negative temperature coefficient, 24
  tuner, testing methods, 21-23

Cathode coupled multivibrator.
horizontal, 166-170
table of troubles, 196-197
vertical, 136-140
table of troubles, 156-157
Cathode feedback blocking oscillator, 134-136
Cathode-heater leakage, picture tube, effects and prevention, 88-89
Centering, correction of, 96
d-c method of, 242-243
horizontal, in transformer, 220
magnets, table of troubles, 97
Checks, preliminary, 7-8
Clamp tube, agc, action of, 42-43
Clippers, sync (separators).
horizontal and vertical, 110-116
pentagrid or heptode, 117-121
single stage, 105-109
table of troubles, 124
two stage, 109-110
Coil, focus, adjustment and positioning, 96
Contrast controls, 56
connections for, 67-72
Controlled warmup. *See Series heaters.*
Corona or arcing, 263-266
table of causes, 264
Crystal diode, agc rectifier, 45
video detectors, 36, 38
Current waveforms, scope observation, 149

D

Damper, circuit, 226-230
table of troubles, 235
tubes for, 234-236
D-c centering, 242-243
restoration, 72-73
table of troubles, 81
Decoupling capacitors, test of, 62
Deflecting yoke, See *Yoke.*
Deflection, horizontal, 216-246
circuit types, 216-220
current flows, 212-215
fuse in circuit, 229-230, 250
tables of troubles, 225, 235, 244
yoke current observation, 231
vertical, 267-274
circuit types, 267-269
table of troubles, 273
Detectors, phase. See *Phase detectors.*
Detector, video, 36-40
agc source from, 44
crystal types, 36-38
table of troubles, 39
tube types, 37-38
Diode, clamp tube action, 42-43
crystal, agc rectifier, 45
video detector, 36, 38
Doubler rectifiers, selenium, 280-281
Drift, frequency, in tuner, 23-24
Drive, horizontal, 226-230
table of troubles, 235

E

Electrostatic focus, voltage effects ,88
Emission, picture tube.
increase with brightener, 93
measurement of, 84-87

F

Filters, integrating, 129-130
table of troubles, 154
noise, table of troubles, 196
power, resistor-capacitor, 279-280, 284
table of troubles, 290
Fine tuning, effect on carrier frequencies, 23-24
First anode, picture tube, voltage effects, 87
Focus, magnet or coil
adjustment, positioning, 96
table of troubles, 97
electrostatic
effects of voltage, 88
Frequency controls, horizontal.
multivibrator, 168
adjustment of, 195-196
pulse width, 182-184
adjustment of, 204-207
Frequency drift, tuner, 23-24
Frequency response.
i-f, carrier markers, 23-24
observation of (VTVM), 32-33
video amplifier, observation, 65-66
Fringe area adjustments.
i-f amplifier, 41-42
sync section, 120-121
Fuse, horizontal deflection, 229-230, 250

G

Gain, i-f amplifier, increase of, 34-35
testing, 33-34
tuner, increase of, 25-26

Gated or keyed agc. 45-47
sync, 116, 117-121

Generator, bar, square wave generator used as. 232

H

Hartley oscillator, afc with, 186-189
table of troubles, 202-204

Heater-cathode leakage, picture tube, effects and prevention. 88-89

Heaters, series. 296-299
open heater location, 299
order of tubes, 298
surge resistor for, 297

Height control, table of troubles, 158

Heptode sync separator, 117-121

High voltage, 252-266
low, causes for, 259-263
measurement of, 255-258
neon lamp detection of, 256
oscilloscope observation, 146-148
spark tests for, 256-257
tables of troubles. 260-262, 264

Hold controls, tables of troubles.
horizontal, multivibrator, 197
pulse width. 201
vertical, 158

Horizontal centering, transformer, 220

Horizontal deflection, 216-246
circuit types, 216-220
current flows. 212-215
fuse in circuit, 229-230, 250
tables of troubles, 225, 235, 244
yoke current observation, 231

Horizontal drive. 226-230
table of troubles, 235

Horizontal frequency controls.
multivibrator, 168
adjustment of, 195-196
pulse width, 182-184
adjustment of, 204-207

Horizontal hold controls, tables of troubles.
multivibrator, 197
pulse width. 201

Horizontal linearity.
controls. effects of. 237-238
trouble with, 226-230
faulty, 230-234
table of troubles, 235

Horizontal output transformer.
autotransformer type, 214-215
centering in, 220
current flows in, 212-215
insulated secondary type, 212-214
troubles in, 224-226

Horizontal sweep section, 160-209
tables of troubles, 194-204

Horizontal yoke coils, See *Yoke*.
table of troubles, 244-245

Hum voltage, table of causes, 292

I

I-f amplifier, 27-35
agc trouble in, 48
alignment troubles, 29-32
bandwidth, 30
couplings in, 27
frequency response (VTVM), 32-33
gain, increase methods, 34-35
tests, 33-34
signal circuit continuity, 33-34
table of troubles, 28
traps in, 27, 29, 33

Impedance, antenna, mismatch, 10

Incremental tuners, 14-16

Inductances, measurement of, 220-224
series connected, values, 223
yoke, required values, 240-241

Integrating filter. 129-130
table of troubles, 154

Intermediate-frequency amplifier. See *I-f amplifier.*

Ion trap magnet, adjustment, 94-95
strength of, 95
table of troubles, 97

K

Keyed or gated afc, 45-47
sync, 116, 117-121

L

Limiting, sync pulse, 102

Line, transmission, 9-12
mismatch of, 11
routing of, 10-11
table of troubles, 8
Linearity, horizontal.
control, effects of, 237-238
trouble with, 226-230
faulty, 230-234
table of troubles, 235
Linearity, vertical.
controls for, 149-151
table of troubles, 159
Local-distant adjustment, i-f, 41-42
sync section, 120-121
Locking control.
multivibrator, 168
adjustment of, 195-196
table of troubles, 197
pulse width, 182-184
adjustment of, 204-207
Low voltage section, 277-299
filters, resistor-capacitor, 279-280
rectifiers, selenium, 280-285
selenium, tests of, 282-283
tube, parallel, 278-279
series-parallel distribution, 285-289
tables of troubles, 290-292

M

Magnet, focus, adjustment-positioning, 96
ion trap, adjustment, 94-95
strength required, 95
Mismatch, antenna-line, 11
Multivibrator, horizontal.
action of, 166-170
locking control, 168
adjustment of, 195-196
table of troubles, 196-197
Multivibrator, vertical.
cathode coupled, 136-140
table of troubles, 156-157
plate coupled, 128, 140-145
table of troubles, 154-155
types of, 128
Neon lamp, high voltage checks, 256
Noise filter, table of trouble, 196
gate, adjustment of, 120-121

O

Open elements, picture tube, tests, 89-91
Orientation of antenna, 8-9
Oscillation, Barkhausen, 208-209
Oscillator, blocking. See *Blocking oscillator.*
Hartley. See *Hartley oscillator.*
Oscillator, horizontal sweep.
blocking type, 177-185
table of troubles, 199-201
Hartley type, 186-189
table of troubles, 202-204
multivibrator, action of, 166-170
locking control, 168
locking control adjustment, 195-196
table of troubles, 196-197
Oscillator, r-f. See *Tuner.*
Oscillator, vertical sweep.
blocking, cathode feedback, 134-136
plate feedback, 131-134
table of troubles, 156
types of, 127-128
multivibrator, cathode coupled, 136-140
cathode coupled, trouble table. 156-157
plate coupled, 126, 140-145
plate coupled, trouble table, 154-155
types of, 128
sync pulse observation, 132, 142
triggering polarities, 130-131
Oscilloscope, high-voltage probe, 146-148
Overload, video amplifier. 102

P

Parallel rectifier tubes, 278-279
Peakers, video amplifier, 53-55
connections for, 67-72
Peak-to-peak voltages, sync, 123
Pentagrid sync separator, 117-121
Phase adjustment, pulse width afc, 182-184
Phase detectors. afc.
action of, 163-166
diodes, to multivibrator
table of troubles, 196-197
with splitter, 162-163
without splitter, 171-172
diodes, to reactance tube, 186-189
table of troubles, 202-204
triodes, to multivibrator
table of troubles, 196-197
with splitter, 170-171
without splitter, 172-177

Picture tube, 83-97
accessories, table of troubles, 97
base pin resoldering, 90-91
brighteners for, 93
cathode-heater leakage, effects and prevention, 88-89
centering adjustment, 96
electrostatic focus tests, 88
elements, connections to, 67-72
table of troubles, 85
voltage measurements, 87
emission measurement, 84-87
input circuits, 67-81
table of troubles, 79-81
types of circuits, 67-72
open element tests, 89-91
reactivation-rejuvenation, 93-94
second grid voltage, effects, 87
shorted elements, burning out, 92-93
tests for, 91-92
table of troubles, 85
Pictures absent, also raster, 4
also raster and sound, 3
raster present, 4
Plate coupled multivibrator, 128, 140-145
table of troubles, 154-155
Plate current series distribution, 285-289
Power supply. See *Low voltage*
Probe, high-voltage, scope, 146-148
Pulse width afc, 177-185
frequency control, 182-184
adjustment of, 204-207
table of troubles, 199-201
Pulses, high voltage, observation, 146-148
Pulses, sync.
limiting of, 102
oscillator effect on, 121-122
vertical oscillator, observation, 132, 142

## R

Raster, absent, 4
also pictures, 4
also pictures and sound, 3
observation of, 2-2
Reactance tube, afc, 186-189
Reactivation, picture tube, 93-94
Receiver, section of, 2
Rectifiers, agc, 45
doubler, selenium. 280-281
selenium. power supply, 280-285
tests of, 282-283
single, selenium, 281
tubes, parallel, 278-279
Rejuvenation, picture tube, 93-94
Resistor-capacitor filters, power, 279-280, 284
Resistors, surge, selenium rectifier, 280-281
series heater, 297
tuner, test methods for, 21-23
Response, frequency
i-f, carrier markers on, 23-24
observation (VTVM), 32-33
video amplifier, observation, 65-66
Restoration, d-c, 72-73
table of troubles, 81
Retrace blanking, vertical.
circuits for, 67-72
filters for, 74-75
pulse observation, 80, 82
table of troubles, 80-81
R-f oscillator, See *Tuners.*
Ringing coil, multivibrator, 168
adjustment of, 195-196
Ripple voltage, table of causes, 292

## S

Sawtooth system, vertical, table of troubles, 158
Second grid, picture tube, voltage effects, 87
Selenium rectifiers.
doubler circuit, 280-281
power supply, 280-285
single unit circuit, 281
surge resistor for, 280-281
tests of, 282-283
Sensitivity adjustments, 41-42
Separators, sync.
horizontal and vertical, 110-116
pentagrid or heptode, 117-121
single stage, 105-109
table of troubles, 124
two-stage, 109-110
Series heaters, 296-299
open heater location, 299
order of tubes, 298
surge resistor for, 297
Series-parallel distribution, 285-289
table of troubles, 292

Shorted elements, picture tube.
burning out, 92-93
tests for, 91-92
Signals, paths in receiver, 2
picture tube, table of troubles, 79
Smearing, analysis of causes, 6
Soldering base pins, picture tube, 90-91
Sound absent, analysis, 4
only, analysis, 4
sound systems, 301-327
Spark tests, high voltage, 256-257
Sparking, high voltage, 263-266
Square wave generator, use as bar generator, 232
Square wave tests, video amplifier, 63-64
Stabilizer, multivibrator, 168
adjustment of, 195-196
table of troubles, 197
pulse width, 182-184
adjustment of, 204-207
table of troubles, 201
Surge resistors, selenium rectifier, 280-281
series heater, 297
Sweep, horizontal, 160-209
tables of troubles, 194-204
vertical, 127-159
scope check of, 151-153
tables of troubles, 154-159
Sync (synchronizing), 100-126
amplifiers, 103-104
circuit elements, 100-103
feedback from oscillator, 121-122
fringe area adjustments, 120-121
gated or keyed, 117-121
local-distant adjustments, 120-121
oscilloscope tracing for faults, 122-123
peak-to-peak voltages, 123
pulses, limiting of, 102
oscillator effect on, 121-122
vertical, observation of 132, 142
separators, horizontal-vertical, 110-116
pentagrid or heptode, 117-121
single stage, 105-109
table of troubles, 124
two stage, 109-110
signals, tracing with scope, 122-123
table of troubles, 124
Synchroguide afc. See *Pulse width.*

T

Transformer, horizontal output.
autotransformer type, 214-215
centering in, 220
current flows in, 212-215
insulated secondary type, 212-214
troubles in, 224-226
Transformers, inductance measurement, 220-224
vertical output, autotransformer, 267-268
Transmission line, 9-12
mismatch of, 11
routing of, 10-11
table of troubles, 8
Traps, beat frequency (4½ mc), 56-58
i-f amplifier, 27, 29, 33
ion, magnet adjustment, 94-95
magnet strength, 95
Triggering polarities, vertical oscillator, 130-131
Tube, picture. See *Picture tube.*
Tuners, 12-26
alignment adjustments, 13-16
scope connections, 17-18
capacitors in, tests of, 21-23
cleaning and lubricating, 19-20
frequency drift in, 23-24
response, faults indicated, 18, 19
gain, increase of, 25-26
incremental type, 14-16
inductors, squeeze-spread of, 20
mechanical faults in, 19-20
NTC capacitors in, 24
resistors in, tests of, 21-23
table of troubles, 15
turret type, 12-14
Tuning, fine effect on carrier frequencies, 23-24
Turret tuners, 12-14

V

Vertical deflection, 267-274
circuit types, 267-269
tables of troubles, 273
hold, table of troubles, 158
integrating filter, table of troubles, 154
linearity controls, 149-51
table of troubles, 159

Vertical oscillators.
blocking, cathode feedback, 134-136
plate feedback, 131-134
types of, 127-128
multivibrator, cathode coupled, 136-140
plate coupled, 128, 140-145
types of, 128
sync pulse observation, 132, 142
triggering polarities, 130-131
Vertical output, transformer, table of troubles, 273
tube, table of troubles, 157
voltage, scope observation, 146-148
Vertical retrace blanking.
circuits for, 67-72
filters for, 74-75
pulse observation, 80, 82
table of troubles, 80-81
Vertical sawtooth, table of troubles, 158
Vertical sweep section, 127-159
scope check of, 151-153
tables of troubles, 154-159
Vertical yoke coils. See *Yoke.*
Video amplifier, 53-56
bias sources, 60
frequency response observation, 65-66
overload in, 102
peakers in, 53-55
connections of, 67-72
picture tube connections, 67-72
square wave tests, 63-64
table of troubles, 57-60
Video detector, 36-40
agc source from, 44
crystal diode types, 36-38
table of troubles, 30
tube types, 37-39
Voltage, agc, tests of, 47-48
boost, 247-251
table of troubles, 251
doublers, power supply, 280-281
peak-to-peak, sync, 123

W

Warmup, controlled. See *Series heaters.*
Waveform control, pulse width afc, 182-184
adjustment of, 204-207
Waveforms, current, scope observation, 149
Width control, 224-226
table of troubles, 225

Y

Yoke
as a unit, 275-276
table of troubles. 276
current, observation of, 231
horizontal coils, 239-240
capacitor-resistor networks, 241-242
table of troubles, 244-245
inductance, measurements, 220-224
required, 240-241
vertical coils, 272-274
table of troubles, 273-274