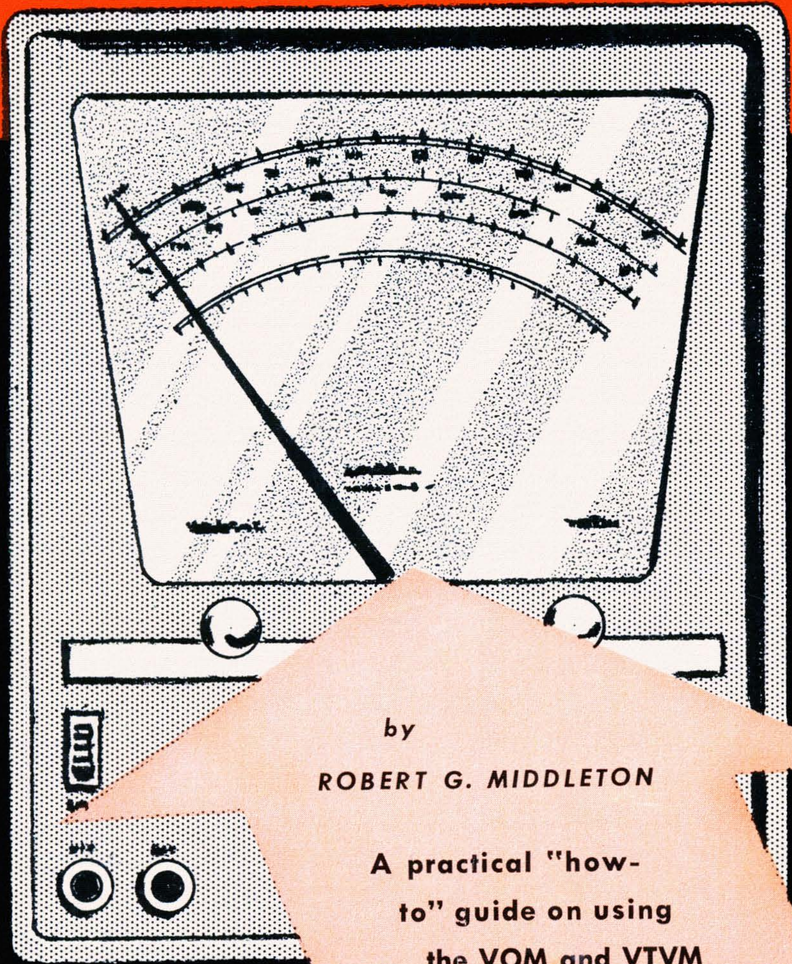
A Howard W. Sams PHOTOFACT PUBLICATION

TROUBLESHOOTING WITH THE VOM AND VTVM



by

ROBERT G. MIDDLETON

A practical "how-to" guide on using the VOM and VTVM in TV servicing.

$2.50

Cat. No. TWV-1

Troubleshooting with the VOM and VTVM

by Robert G. Middleton

HOWARD W. SAMS & CO., INC.
THE BOBBS-MERRILL COMPANY, INC.
Indianapolis • New York

FIRST EDITION

FIRST PRINTING — AUGUST, 1962

TROUBLESHOOTING WITH THE VOM AND VTVM

Library of Congress Catalog Card Number: 62-19649

Preface

Most troubleshooting of modern electronic circuits is accomplished on the basis of voltage and resistance measurements—both DC and AC. Yet, the use of such instruments can be a drawback unless the technician knows which measurements to make, the order in which to make them, how to make them accurately, and how to interpret their meanings.

For example, suitable probes are required for measuring DC voltages in the presence of high-frequency AC voltage and for measuring peak and peak-to-peak voltages. Also, circuit loading is an important consideration, both in signal-level measurements and sometimes in DC voltage measurements. A measuring instrument inevitably becomes a part of the circuit under test, imposing a certain impedance load and altering operation to some degree.

The practical explanations of these considerations, as well as step-by-step procedures for analyzing TV circuit operation, will show you how to avoid many of the common pitfalls awaiting the unwary meter user.

BOB MIDDLETON

July, 1962

Table of Contents

CHAPTER 7

CHAPTER 8

CHAPTER 9

CHAPTER 10

CHAPTER 11

CHAPTER 1

Operation of Voltage, Current, and Resistance Measuring Instruments

A volt-ohm-milliammeter (VOM) is used chiefly to measure resistance, DC and AC voltages, and DC current. Although some VOM's can measure AC current directly, with others it is necessary to use accessory probes or adapters. A feature of the VOM is that it usually has a decibel scale for measuring AC-power levels. Also, the ohmmeter function of a VOM can be used for ballistic measurements of capacitance values from about 0.25 mfd to 40 mfd.

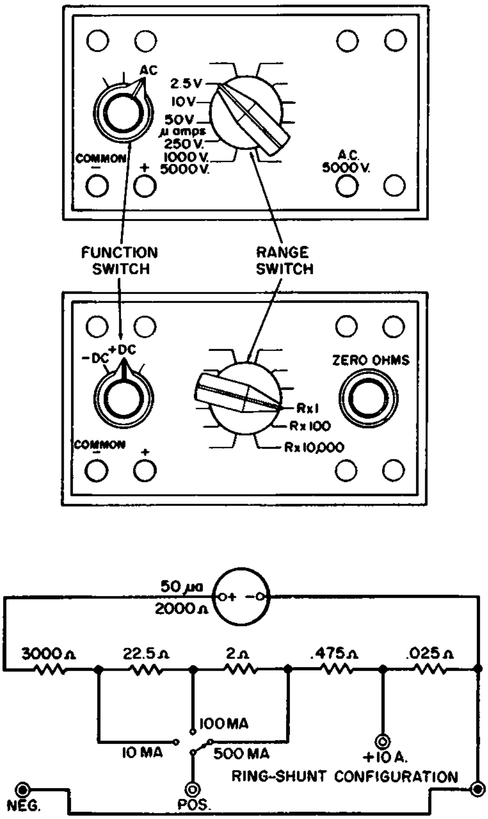
The vacuum-tube voltmeter (VTVM) has the same general fields of usefulness as the VOM, except that only a few VTVM's have provision for measuring AC current. On the other hand, most of them can measure peak-to-peak voltage values and peak RF values directly, which is difficult or impossible with a VOM. In addition, a VTVM has higher resistance ranges and a higher input resistance than a VOM, which extends its useful limits of measurement. In fact, some VTVM's (audio types) are extremely sensitive and can be used to measure very low-level voltages.

VOLT-OHM-MILLIAMMETER FUNCTIONS AND FEATURES

In the order of their importance and degree of usefulness, the various functions and features of the VOM will be presented in this chapter. Where needed, circuit descriptions are given as an aid in better understanding the instrument.

The Range and Function Switches

As seen in Fig. 1-1A, a range switch is provided to accommodate various levels of voltage; and the function switch is used to change the instrument circuitry for indication of either DC or AC voltages. The range switch also has some of the properties of a function switch, inasmuch as it can be rotated from the voltage sector to the DC-current, or the resistance sector. When the range switch is set to a position in the resistance sector (Fig. 1-1C), the zero-ohms control becomes functional. The highest DC and AC voltage ranges are brought out to separate jacks on the VOM panel, because of insulation requirements. In some instruments, one also finds that the lowest DC-current range is brought to a separate jack. This is often true also of the highest DC-current range (Fig. 1-1C),



(A) Settings for measurement of AC voltage.

(B) Settings for measurement of resistance.

(C) The 10-amp input is brought out to a separate jack to avoid switch-contact resistance.

Fig. 1-1. Examples of range- and function-switch settings for a VOM.

in order to avoid passage of large currents through rotary-switch contacts.

Many modern VOM's have a choice of +DC or −DC positions on the function switch. This is a considerable convenience, which makes it unnecessary to reverse the test leads in DC voltage measurements. As we shall subsequently find, the polarity switch is also useful in checking capacitance values on the resistance ranges of a VOM. In most cases, the red test lead is positive and the black lead negative on the ohmmeter function when operating on the +DC setting. However, this is not true of all VOM's—some operate with the black test lead positive on the ohmmeter function. This is a matter to be taken into consideration when checking out semiconductor diodes and transistors.

Scales

A scale plate for a typical VOM is seen in Fig. 1-2. The DC scales are linear; that is, the intervals are practically uniform over the entire range. The same DC scale is used on all DC voltage and current ranges. You must observe the range-switch setting, and read the indication with respect to the appropriate full-scale value marked on the scale plate. The resistance (ohms) scale is highly nonlinear because of the instrument circuitry on its resistance-measuring function. The cramping of the scale divisions at the left-hand end of the scale makes it advisable to choose a resistance range which brings the pointer position to the center of the meter face.

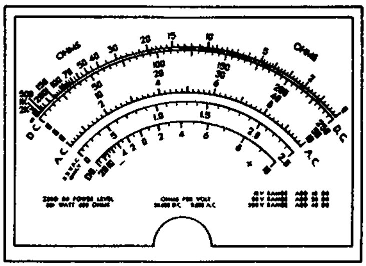


Fig. 1-2. Typical VOM-scale plate.

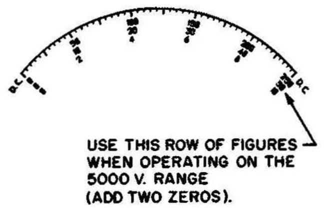
The decibel scale is also highly nonlinear. This is not the consequence of instrument circuitry, but is due to the logarithmic nature of the decibel value. This consideration, as well as the meaning and use of positive and negative db values, are explained in detail. The low AC-voltage scale is appreciably nonlinear toward the zero region, while the high AC scale is less nonlinear. The nonlinearity is a result of the instrument-rectifier characteristics.

Sometimes we must use a scale factor in reading the full-scale values. For example, when operating on the 5000-volt range, the pointer indication is read on the "50" scale (Fig. 1-3A). In this case, mentally place two zeros after the "50" to obtain the full-scale value. Again, when operating on the 2.5-volt range, the pointer indication is read on the "250" scale.

Here, we mentally shift the decimal point two places to the left in the full-scale marking. As shown in Fig. 1-3B, a few VOM's have rotating scales coupled to the range switch so that only the scale of interest is visible at any one time—in such case, scale factors are not necessary.

Overload Protection

Unless the operator has adequate experience, there is always danger of damaging a VOM. This can be done by applying too much voltage or current on a given range; using a current range to check voltage; or using a resistance range to measure voltage. Also, the meter may be damaged by attempting to measure AC ripple voltage from a power supply on the AC-voltage function when, actually the output jack of the instrument should be used. If used improperly to check this ripple, the high DC component from the source voltage may permanently damage the meter.



(A) Single scale as seen on VOM.

Courtesy B & K Manufacturing Co.

(B) Individual scale drops in place as selector knob is rotated.

Fig. 1-3. VOM scales.

A few VOM's, such as the one in Fig. 1-4, contain a built-in overload relay and protective fuse to eliminate the danger of meter burnout on any function; while others have zener-diode protection for the meter movement. An ideal semiconductor would have one of the characteristics depicted in Fig. 1-5A and B. However, silicon-junction diodes are not ideal but have a characteristic as seen in Fig. 1-6. The departure from perfection is fortunate in this instance. We are particularly concerned with the zener region of the reverse portion of the characteristic. At a certain reverse voltage, the hitherto small reverse current suddenly increases very rapidly, and the internal resistance of the silicon diode becomes very small. (Zener diodes are commercially available in a wide range of zener-voltage values.)

The zener characteristic is put to use as shown in Fig. 1-7. The current through the meter movement is always in the

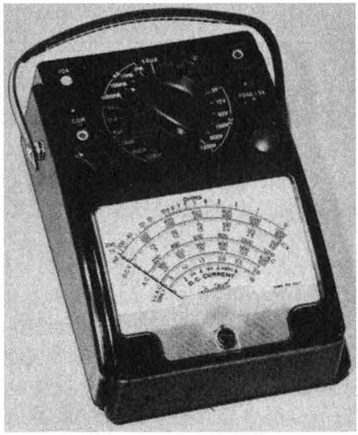


Fig. 1-4. A typical VOM with built-in overload protection.

Courtesy Hickock Electric Instrument Co.

same direction (from negative to positive in Fig. 1-7); while the voltage drop across the zener diode is always in the reverse-current direction. Resistor *R* is merely a calibrating resistance which is chosen at the factory to compensate for meter manufacturing tolerances. As long as the pointer is on-

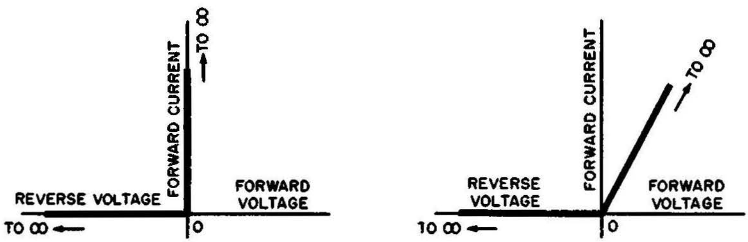


Fig. 1-5. Ideal diode characteristics.

scale, the reverse voltage across the zener diode does not extend to the breakdown (zener) region. However, soon after the pointer might be accidentally driven off-scale, the voltage drop across the diode falls in the zener region, and practically no more current can then enter the meter movement; the diode is now a low-resistance shunt (almost a short circuit) around

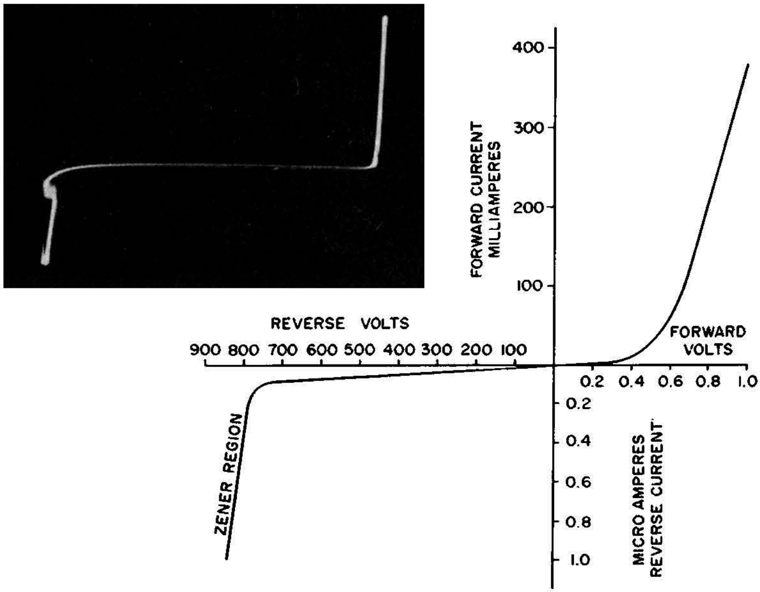


Fig. 1-6. Characteristic of a typical silicon-junction diode.

the meter movement. While a zener diode effectively protects a meter movement from damage or burnout, it cannot protect the multiplier resistors in the meter circuitry. However, since

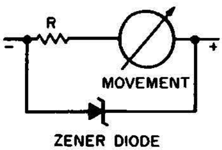


Fig. 1-7. A zener diode protects the meter movement from overload damage.

precision resistors are much less expensive than meter movements, zener diodes avoid much of the usual costs involved in overload damage. As shown in Fig. 1-8, on different ranges,

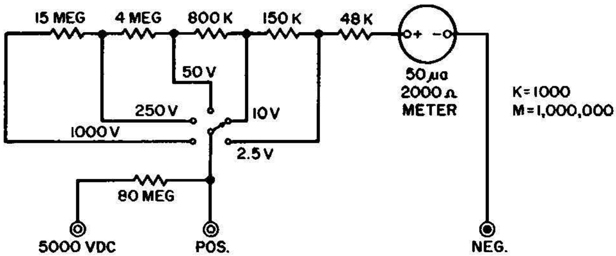


Fig. 1-8. DC-voltmeter configuration.

multiplier resistors are switched in series with the meter movement to obtain various full-scale indication values.

Range Circuitry

The coil in the meter movement has a low resistance, and cannot be used directly in measurement of appreciable voltages. However, when a multiplier resistance is connected in series with the movement, any desired full-scale voltage indication may be obtained. The values shown in Fig. 1-8 are for a 20,000 ohms-per-volt instrument. This simply means that the input resistance of the DC voltmeter is equal to the full-scale value multiplied by 20,000. A high-input resistance is desirable to minimize circuit loading, which can lead to false low-voltage indications when testing high-resistance circuits.

Multiplier resistors must not only be precision types (having close tolerance) but must also be rated for the voltage drop on the given range. Thus, the 80-megohm resistor in Fig. 1-8 must be rated for operation at 5000 volts. However, the 48-K resistor need withstand only 2.5 volts. The permissible tolerance on a multiplier resistor depends on the rated accuracy of the VOM. Thus, if the meter movement has a tolerance of 1%, and the multiplier resistors have a tolerance of 1%, the over-all accuracy of the instrument is 2%. In this case it is obvious that the tolerance on multiplier resistance adds to the tolerance on the meter movement. On the other hand, if two 1% multiplier resistors are connected in series (or in parallel), their tolerance is still 1%. This is perhaps a rather tricky point which must be kept in mind when calculating VOM accuracy. Some VOM's are rated at 100,000 ohms per volt, in which case the multiplier resistances have correspondingly higher values, and are used with a meter movement which has 10 microamperes full-scale sensitivity. Again, some VOM's are rated at 1% over-all accuracy, which imposes tighter tolerances on both the meter movement and the multiplier resistors.

AC voltages are measured by switching an instrument rectifier in series with the meter movement as seen in Fig. 1-9. Two diodes are used in this typical instrument rectifier; however, only the series diode passes current into the meter movement. The shunt diode provides a low-resistance path around the movement during negative half-cycles to minimize back voltage across the series diode and provide more accurate scale indication with respect to diode tolerances. Resistors R1 and *R* are calibrating resistors which are selected at the factory.

The calibrating resistors also serve as *swamping* resistances which help to linearize the AC scales in spite of the nonlinear

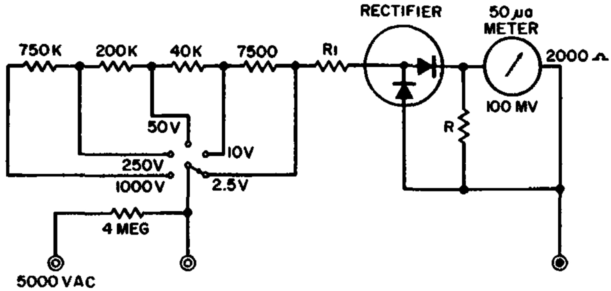


Fig. 1-9. AC-voltmeter configuration.

characteristic of the series diode. In turn, there is a voltage and current loss, which imposes a lower ohms-per-volt rating on the AC function. Thus, a VOM rated at 20,000 ohms-per-volt on its DC ranges customarily has a rating of 1000 ohms-per-volt on its AC ranges. However, VOM's with bridge rectifiers have a typical rating of 5000 ohms-per-volt on their AC ranges.

It is interesting and helpful to note the current relations in an AC meter. These are shown for a half-wave rectifier in Fig. 1-10. Half sine waves of current flow through the meter movement which constitute pulsating DC current. This current has an average value which can be seen on a scope, and is 0.318 of the peak value. The meter movement responds to this average value. On the other hand, the AC scales of the VOM are calibrated in rms values. Hence, the AC scales indicate 2.22 times the average value. This fact has considerable practical significance. To demonstrate this relationship, one can connect a 1.5-volt dry cell to a VOM and switch the instrument to its AC-voltage function. If the polarity is suitable, the scale indicates 1.5 times 2.22 or 3.33 volts. The practical meaning of this response is that a VOM is dependent on the form factor of an AC voltage in order to indicate accurately.

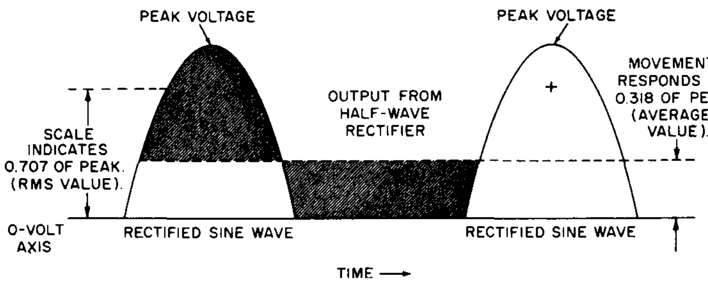


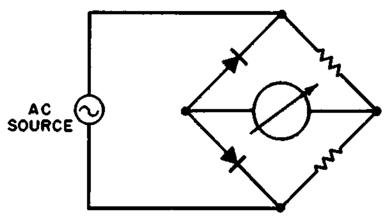
Fig. 1-10. Current relations in a half-wave VOM.

As long as sine-wave voltages are applied to the instrument, the indication is correct. However, if a square-wave voltage (for example) is applied, the scale indication is incorrect. The scale reads 0.9 of the true square-wave voltage. The error is much greater for a sawtooth wave, or a pulse; therefore this limitation must be kept in mind when troubleshooting TV receivers, or other equipment in which AC voltages are not necessarily sinusoidal.

When a half-bridge is used, as illustrated in Fig. 1-11, the meter movement works out of a full-wave rectifier, and the average value of the rectified current is 0.636 of the peak. Since the AC scales are calibrated to read rms values of a sine wave, this type of AC voltmeter reads 1.11 times the value of an applied DC voltage. The same considerations of form factor must be observed as discussed before. A half-bridge causes an AC scale indication of 0.9 the true value of a square wave, and large errors for various other waveforms. A VOM should be used to measure AC values of sinusoidal waves only.

A complete circuit for a 20,000 ohms-per-volt VOM is shown in Fig. 1-12. Note the 0.1-mfd series capacitor which is inserted in series with the AC multipliers when the output jack is used. This capacitor blocks the flow of DC but permits passage of AC. Hence, AC voltage can be measured in the presence of DC voltage on the output function of the VOM. The basic half-bridge circuitry in Fig. 1-11 appears also in Fig. 1-12.

Fig. 1-11. Half-wave bridge rectifier.



Ohmmeter Function

The 1.5- and 6-volt batteries in Fig. 1-12 are utilized on the ohmmeter function. Voltage is applied across the component under test when measuring resistance values. However, when the polarity switch is thrown, this voltage across the component is reversed; thus making it convenient to check the forward and back resistances of junction devices such as semiconductor diodes and transistors. It also makes ballistic tests of capacitance values possible.

The following is an example of capacitance measurement: If a 0.25-mfd capacitor is connected across the test leads and the

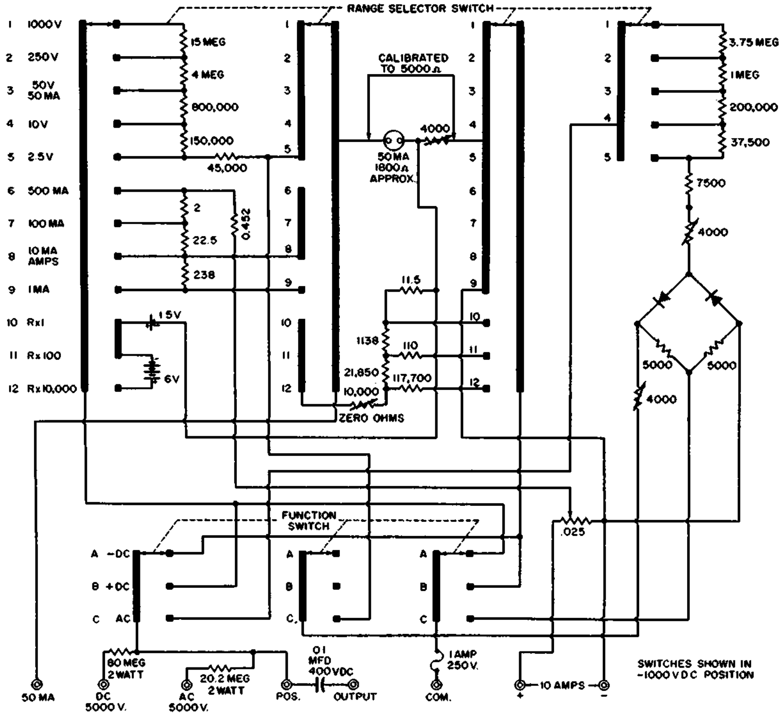


Fig. 1-12. A typical VOM circuit.

ohmmeter is operated on its R × 10,000 ohms function, and if any serious leakage is indicated, the capacitor may be discarded. On the other hand, if the ohmmeter scale indicates infinity, we may proceed to capacitance measurement. When the polarity switch is thrown, if the pointer does not move, the capacitor is open and is discarded. But if it has its full 0.25-mfd value, the pointer deflects about ¼ of full scale and falls back rapidly. When one becomes familiar with the VOM, he can check capacitance values with reasonable accuracy.

The 1-amp fuse in Fig. 1-12 is a protective fuse for the R × 1 ohmmeter range. In case the test leads are accidentally applied across a voltage source while the ohmmeter is set to its R × 1 range, the fuse will blow; and the 11.5-ohm resistor will not burn out. Note the 50-microammeter jack—ordinarily used for measuring very small DC currents, this jack can also be used to measure voltages up to 0.25 volt. In other words, the meter scales have full-scale values of either 50 microamperes or ¼ volt on this range. The input resistance is comparatively low—only 5000 ohms.

Power Measurements

A VOM does not read power directly. Power is equal to voltage times current, with the product given in watts; and since both voltage and current can be measured, it is fairly simple to determine the power being taken by a DC circuit. Current need not be measured if there is a series resistor present, if one measures the voltage drop across it. The current flow is figured by Ohm's law—this is a convenient method of determining current, because the circuit does not need to be opened.

There are additional considerations when measuring AC power. Voltage and current are measured in rms values. The product of rms volts times rms current is equal to AC power in watts. Thus far, the situation is basically the same as determination of DC power; rms values in AC circuits are equivalent to DC values. On the other hand, AC loads are often reactive; that is, an AC load may contain capacitance or inductance, as well as resistance. In this case, a simple measurement of AC voltage and AC current gives the power in volt-amperes. The presence of inductance or capacitance causes the volt-amperes to actually consist of real and reactive power. Real power is of chief interest, however, because it represents useful power, or power that does work. Reactive power merely surges back and forth in and out of the reactance and is wasted for all practical purposes. To take an extreme example where an audio amplifier is terminated in a capacitor which has a reactance of 500 ohms at 1000 cycles. If one measures 10 volts across the capacitor, the power is equal to 0.2 watt. This is all reactive power, and no work is being done on the load.

Again, if the amplifier is terminated in a 500-ohm resistor, the 10 volts across the resistor corresponds to 0.2 watts of real power ($W = E^2/R$). All this power now does work in heating the resistor. Now, suppose that the amplifier is terminated with a 250-ohm resistor in series with an inductor which has a reactance of 250 ohms at 1000 cycles. It is found that the 10 volts is split across the resistor and capacitor, with 7.07 volts across each (Fig. 1-13). The explanation is simple: voltage across resistance adds at right angles to voltage across reactance. In the same manner, reactive power adds to real power at right angles. Thus, for the example cited, the volt-amperes in this circuit equal 0.283, the power in the resistor equals 0.2 watt, and the power in the inductor equals 0.2 watt. However, only the real power in the resistor does work (by heating the resistor). The reactive power in the inductor merely takes energy from the circuit and returns it again to the circuit 1000 times a second. The bearing of this situation on power supplied to substandard output transformers and speakers is obvious.

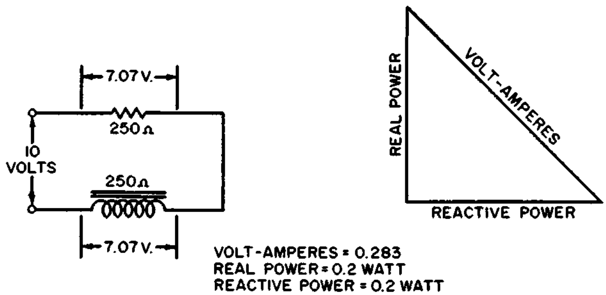


Fig. 1-13. Relationship of real and reactive power to volt-amperes.

Measurements of Nonlinear Resistance

Semiconductor diodes and transistors are important examples of nonlinear resistance. Although an ohmmeter test indicates the polarity of a diode, the resistance readings themselves do not give much other information, except to indicate whether the diode is definitely bad.

The reason for this is that the electrical characteristic of a diode is curved, as we have seen earlier, and the resistance reading will depend on the voltage that the ohmmeter happens to apply across the diode. The same limitations apply to ohmmeter tests of transistors. However, if a transistor test adapter similar to the one illustrated in Fig. 1-14 is available for a VOM, meaningful measurements can be made. The adapter circuit is seen in Fig. 1-15. The VOM indicates the cutoff current of the transistor (I_{co}), and the common-emitter current amplification (beta). The adapter circuit is basically a bridge that is balanced at a collector current of 1 milliampere. The three positions of the beta switch insert resistance into the base circuit and unbalance the bridge. In turn, the

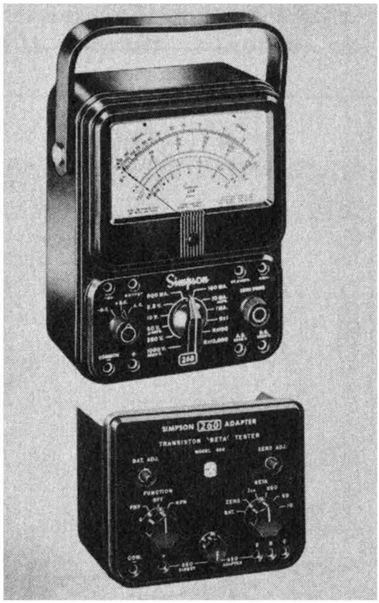


Fig. 1-14. Transistor test adapter for a VOM.

Courtesy Simpson Electric Co.

beta value is read from the VOM scale corresponding to the range setting. Cutoff current is read on the low-current scale when the range switch is set to the I_{co} position.

Thermistors have a nonlinear resistance characteristic which is a function of their temperature. Thus, if you measure the cold resistance of a thermistor, a much higher value is indicated by an ohmmeter than when the hot resistance is measured. Thermistors, having a negative temperature coefficient of resistance, are used in series heater strings, and as stabilizers in transistorized power amplifiers. Unlike the thermistor, the filament in a vacuum tube has a positive temperature coefficient; its cold resistance is much lower than its hot resistance.

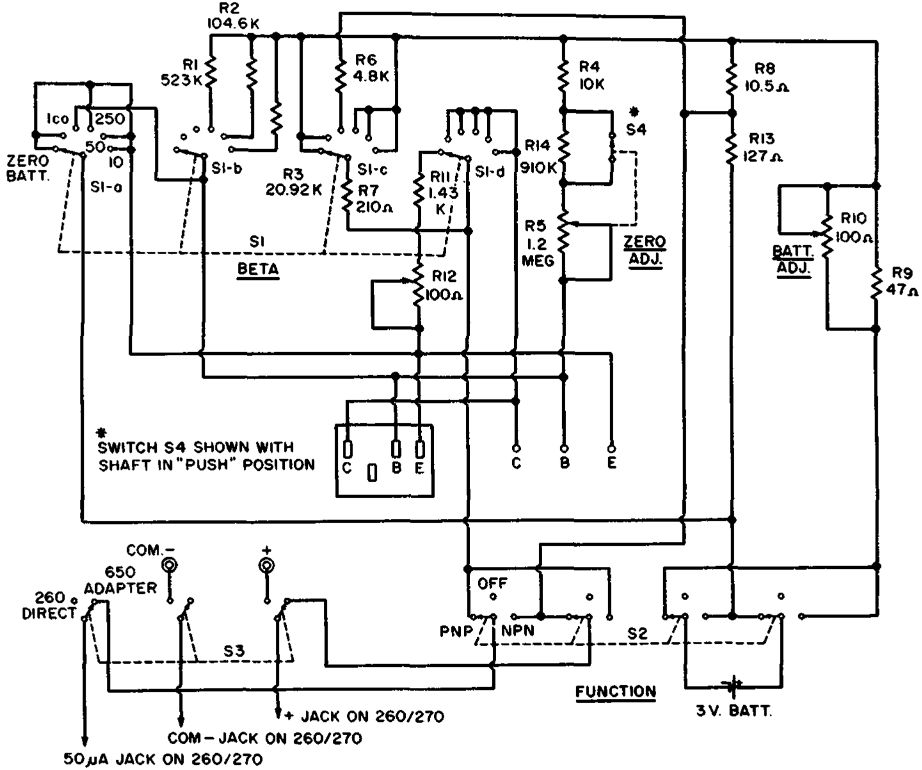


Fig. 1-15. Circuit of transistor-test adapter.

VACUUM-TUBE VOLTMETER FUNCTIONS AND FEATURES

The functions of a service-type VTVM, such as that illustrated in Fig. 1-16, are similar to VOM functions, with several important differences. The input resistance of a VTVM is comparatively high, e.g., 10 megohms on all DC voltage ranges. It is practically immune to overload damage, because the tubes in the instrument saturate quickly after the pointer is driven off-scale. Higher resistance values can be measured on a VTVM than on a VOM. Capacitance scales are occasionally provided having a choice of zero-left or center-zero indication—the latter indication is useful in checking FM detectors, as shall be explained subsequently.

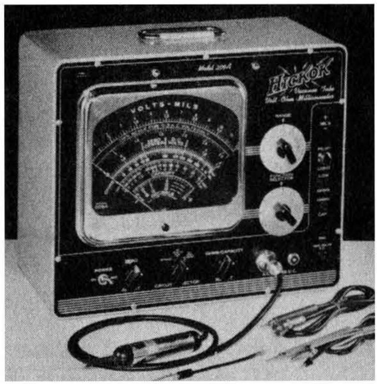


Fig. 1-16 Typical large-size service VTVM.

Courtesy Hickock Electric Instrument Co.

In addition to indicating the rms voltages of sine waves, most modern VTVM's also provide for measurement of peak-to-peak voltages of any waveform. This is an important function, since receiver service data provides a wealth of information concerning the normal peak-to-peak voltages in a TV chassis. It must be noted that the input impedance of a VTVM is not as high on its peak-to-peak voltage function as it is on its DC function. This limits peak-to-peak voltage measurements to circuits with low or medium internal impedance. Nevertheless, its utility is considerable, as is seen in the following chapters.

While a VOM is commonly used with a pair of simple direct test leads, a VTVM supplements these with probe-type leads.

Those who may be unfamiliar with VTVM isolating probes, peak-to-peak probes, and RF-peak probes are referred to the final chapter of this book. Due to the high sensitivity of a VTVM, all voltage-measuring functions respond to stray fields. Thus, when the beginner touches a test probe with his finger and the pointer is driven off-scale, he is usually disconcerted. This stray-field response is normal, however, as even a good VOM shows some scale indication on its AC-voltage function when one touches a test lead.

Unlike a VOM, the zero setting of a VTVM tends to drift and requires occasional resetting of the zero-adjust control. Over a period of time, this happens because of aging in the VTVM bridge tubes. Although this is sometimes cited as a disadvantage of the VTVM, its inconvenience is not great, and it

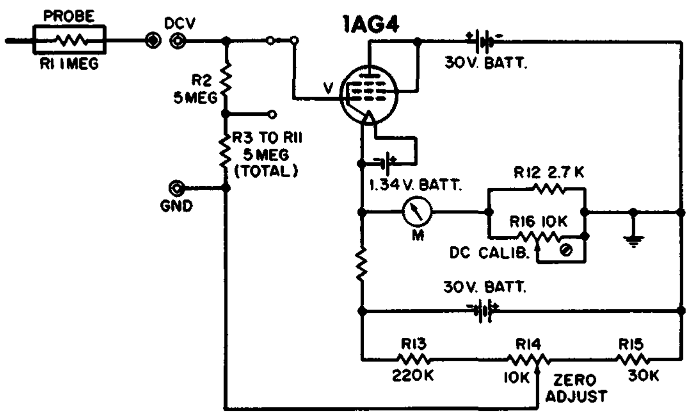


Fig. 1-17. VTVM-adapter configuration.

is far outweighed by the greater range of measurements provided by the instrument.

Ground-Return Considerations

Since a VOM has no power supply, and in turn has no ground reference in its circuitry, either one of the test leads can be used as a hot lead, and the other as a ground lead. This, however, is not the case with a service-type VTVM, due to its built-in AC-power supply which necessarily references one of the instrument's input terminals to ground. Accordingly, the VTVM is less flexible than a VOM on occasion. For example, a conventional VTVM cannot be connected from plate-to-plate of a push-pull amplifier to check for balance—there are exceptions, however. Elaborated VTVM's are available which have differential input, and provide the same freedom from ground as a VOM. Another exception is found in a VTVM adapter for a VOM, such as shown in Fig. 1-17. The adapter is powered by self-contained batteries, which give the same freedom from ground as a VOM. The test leads can be applied at will in any circuit, and either test lead can be used as a ground lead. In the case of a conventional service-type VTVM, the ground return does not have to be made to the true ground in the circuit under test, provided there is not more than a few volts difference to true ground. If the case of the VTVM is operated at a substantial DC voltage above ground, an objectionable scale error often occurs. In some cases, one will find that this error tends to drift, and to change when the instrument is touched. Hence, a VTVM must be applied judiciously in such situations.

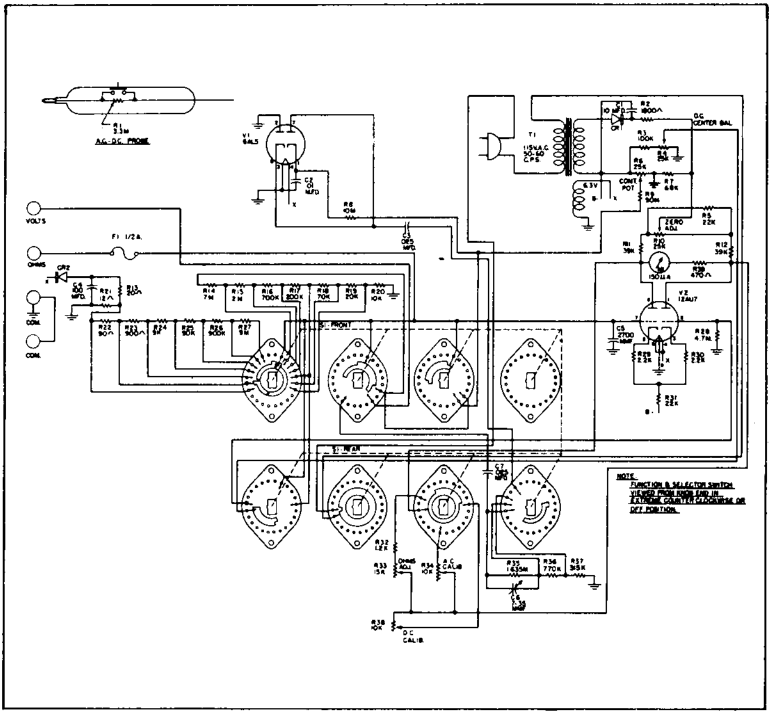
Although the input impedance to the hot lead of a VTVM is very high, the opposite holds true for the ground lead as it has a very high input capacitance. If one tries to measure the AC voltage across the coupling capacitor in an audio amplifier by connecting the VTVM leads across the capacitor, the circuit action is killed. Instead, a pair of measurements must be made. The ground lead of the VTVM must be connected to the amplifier chassis, and the AC voltage measured first on one end of the coupling capacitor, and then at the other end. The difference between the two scale readings is the voltage drop across the capacitor.

Polarity-Reversing Switch

All VTVM's have polarity-reversing switches which operate on the DC voltage function of the instrument. The switch does not operate on the ohmmeter function. Therefore, it is not possible to check capacitance values on the ohmmeter function by throwing the polarity switch—since there is no response. Instead, it is necessary to reverse the test leads across the capacitor. A VTVM gives a ballistic indication of capacitance values which is much more sensitive than for a VOM. In other words, it may be less convenient to make ballistic tests, but much smaller capacitance values can be checked with the VTVM.

Meter Bridge

A complete circuit for a typical service-type VTVM is seen in Fig. 1-18. Note twin triode V2 which is the active element in the meter-bridge circuit. The plate resistances of the two triodes are arms in the bridge, and are very critical. Unless they are approximately equal, the bridge cannot be balanced (zero setting cannot be obtained). Again, unless the plate resistances are stable, the pointer will drift objectionably on the meter scale. In this event, a replacement tube is usually selected by checking each section individually on a tube tester. (The two sections of the tube must have about equal plate resistances.) Good practice dictates that the tube be aged for a day or two before using it in the instrument. It is only necessary to energize the heater during the aging period to activate the getter.



Courtesy Hickock Electric Instrument Co.

Fig. 1-18. Circuitry of a typical service-type VTVM.

There is another consideration regarding contact potential. Although a tube might have equal plate resistances and be adequately aged, one may still discover that there is excessive pointer shift when switching from a low DC-volts range to a higher DC-volts range. In such a case, there is excessive contact potential in the grid circuit. (There might also be a trace of gas in the tube, or noticeable grid emission.) This will usually show up on a tube tester which provides for a sensitive grid test. While such tubes will operate satisfactorily in low- and medium-impedance circuits, they are unsuitable for VTVM bridge-circuit application.

The bridge tube in a VTVM is frequently operated at reduced heater voltage. This is not an indication of trouble in the instrument; but is a design measure adopted to ease the problem of grid-current flow. Also, the bridge tube is often operated at reduced plate voltage. This feature not only helps to stabilize tube operation, but also insures that saturation occurs at a suitable level to avoid overload damage. In spite of all design precautions, a warm-up period must be observed in practice; since the pointer usually drifts excessively when the instrument is first turned on.

CHAPTER 2

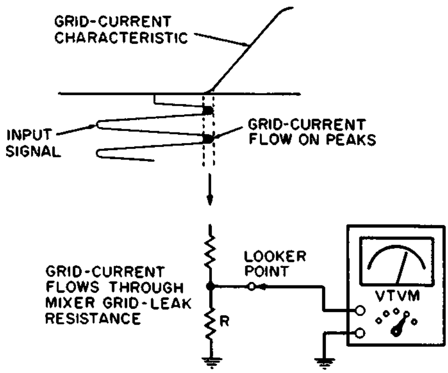
Signal Tracing in the RF, IF, and VIDEO AMPLIFIERS

Signal tracing is an effective troubleshooting method. The presence or absence of an applied signal voltage is checked stage-by-stage through the signal channels of a TV receiver. Strength or weakness of the signal at each stage is significant; for example, if you measure only 1/4 volt at the picture detector output when the receiver is driven normally, the weakness of the signal is a trouble indication. Similarly if you measure 20 volts at the picture-detector output, the abnormal voltage is again a trouble indication.

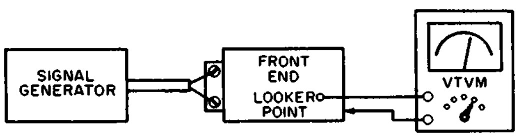
TROUBLESHOOTING THE RF AMPLIFIER

When the TV receiver has a raster, but no picture or sound, the place to start signal tracing is at the RF amplifier. Before anything, be sure to check for a defective tuner on all channels. For example, the high-band channels may be operative, while the low-band ones are dead. Inspect the switch contacts for visible defects and make sure that there is continuity from the twin-lead section to the tuner terminals. After making these checks, apply an RF-signal voltage of suitable frequency to the antenna-input terminals of the receiver. It is advisable to use the output from an AM (or a pattern) generator, instead of a regular TV station signal, as a generator signal steady and adjustable which makes the evaluation of measurements much easier. Why start signal tracing at the front end? Because it is most likely that an absence of both picture and sound will be traced to a defect there. After confirming that plate voltage is present in the tuner, check for signal-developed bias at the looker point. A substantial negative-bias voltage appears at the mixer grid during normal operation. This voltage is generated by grid-current flow on positive peaks of the local-oscillator signal (which is injected into the mixer-grid circuit). A functional diagram of this injection-voltage test is shown in Fig. 2-1A and 2-1B.

In case there is no injection voltage at the mixer grid, a small negative voltage (a fraction of one volt) will still be measured at the looker point. The reason for this unexpected indication is *contact potential.* Contact potential appears because the grid of the mixer tube is in a space charge of electrons; and an occasional electron strikes the grid and charges it negative. Another



(A) Voltmeter measures the IR drop across *R*.



(B) Voltmeter reading rises slightly when generator is switched on.

Fig. 2-1. Functional diagram of injection-voltage test.

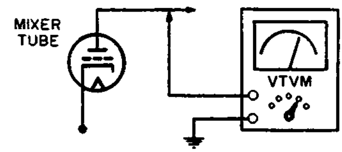
fact shown in Fig. 2-1A is the rectifier action in the mixer-grid circuit. In the unlikely event that the mixer grid should be biased to a Class-A operating point (due to a circuit defect), no rectification would occur, and no injection voltage would be measured at the looker point.

Next, if local-oscillator operation is confirmed by the presence of injection-bias voltage, measure the AGC voltage to the RF amplifier, as AGC trouble can bias off that stage. (A VTVM should be used to measure AGC voltage; a VOM has too low an input resistance.) In case the signal is passed normally by the RF amplifier, it adds to the oscillator drive at the mixer grid, and one can confirm the presence of signal by watching the voltage indication at the looker point as the generator is switched on and off. For example, in a typical receiver the oscillator develops an injection voltage of −2 volts at the looker point; and when a fairly strong RF-input signal is applied to the receiver, the looker-point voltage rises to about −2.05 volts. Since this is only a small change, one must observe the pointer indication carefully, but it is a definite signal-tracing test. What is a "fairly strong" generator signal? This term implies a signal level which produces a high-contrast picture when applied to a normally-operating receiver. Hence, if one is not familiar with his generator, it is advisable to determine reference attenuator settings by using a normally-operating receiver. Unless a signal generator is operated at a suitable output level, false conclusions may be drawn in signal-tracing tests. For example, an input signal, which is ten times as strong as required for normal operation, is certain to feed through a dead circuit and produce a signal output where none exists in realistic tests.

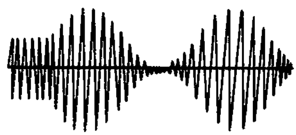
In general, a signal generator would be operated on modulated-RF output in signal-tracing tests. Even if the modulation is not essential to the particular test, it will give a bar indication on the picture-tube screen when the trouble is cleared. On the other hand, a CW (unmodulated RF) signal produces no indication on the picture-tube screen other than eliminating snow. Hence, set the function switch to the modulated-RF output, and adjust the attenuator(s) to a suitable output level.

So far, the procedure up to this point has established that (1) the RF amplifier is working; (2) the mixer-grid circuit responds to a signal; and (3) adequate oscillator-injection voltage is present. Of course, to arrive at this, one may need to close in on a faulty component. Resistors can be measured for correct value on an ohmmeter; capacitors can be roughly checked for leakage with the ohmmeter, tested on a capacitor checker, or by substitution. Coils can be tested for continuity with the ohmmeter. With satisfactory circuit action as noted in the foregoing three points, lack of picture and sound points to trouble past the mixer-grid circuit. Occasionally, an open capacitor in the oscillator circuit will cause an excessive rise in the oscillating frequency. In this event, the output from the oscillator may be about normal, but the beat frequency in the mixer is not accepted by the IF amplifier. To check this possibility, connect the receiver to an antenna, and couple the output from the signal generator through a small capacitor (50 mmf is satisfactory) to the tuner-input terminals. Using a fairly high generator output, tune the generator frequency about 40 mc above the picture-carrier frequency. If there is now a picture and sound, the local oscillator is undoubtedly operating off-frequency.

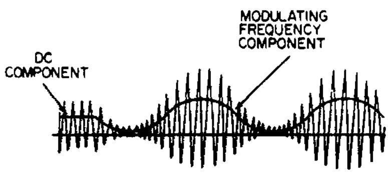
Lack of picture and sound may also be due to trouble past both the local oscillator and the mixer-grid circuits. If such is the case, proceed to trace the signal at the plate of the mixer tube. This test may require hooking a short length of insulated wire to the plate pin, and bringing the wire up through a captive shield. A functional diagram of mixer-plate–circuit action is shown in Fig. 2-2. Remember that the mixer operates as a rectifier (or partial rectifier). Hence, the DC-plate voltage is expected to rise slightly when the signal generator is turned on.



(A) Voltmeter reading should rise slightly when signal is present.



(B) Modulated-RF input to mixer.



(C) Partially-rectified output contains the modulating frequency.

Fig. 2-2. Functional diagram of mixer plate-circuit action.

This possibility of signal tracing by DC-voltage measurement is dependent on the presence of a series resistor in the mixer-tube plate circuit. Although most receivers have a series resistor in the circuit, there are exceptions. Hence, check the receiver circuit diagram. In case a series resistor is not present, one must use a VTVM and an RF probe to signal-trace past the looker point, as depicted in Fig. 2-3. A VOM cannot be used to much advantage in this application. If the mixer-plate circuit is operative, the test in Fig. 2-3 shows a substantial voltage even with no input signal to the receiver. The oscillator-injection voltage passes into the mixer-plate circuit, and some of this voltage drops across the mixer-plate inductor.

Next, with the signal generator turned on, expect to see a substantial rise of voltage. The RF-generator signal is normally amplified through both the RF and mixer stages. In a typical signal-tracing test, the VTVM reading would be 1 volt at the mixer plate without an input signal, and 1.3 volts with the signal generator turned on. Do not suppose that the full signal level is being measured, because the input capacitance of the RF probe somewhat detunes the mixer-plate circuit. In the event that no RF voltage is found at the mixer plate, check the possibility of a shorted mixer coil. A shunt capacitor may be shorted, for example. Sometimes a splash of solder on a coil produces an effective RF short-circuit. Alignment should be checked last. There is an off-chance that the mixer-plate inductor is tuned far off resonance (perhaps because a do-it-yourselfer has been at work behind the scenes). If the mixer circuit is badly out of alignment, some rise of RF voltage will be found when the signal generator is turned on, although the rise will be small. Under these conditions, a weak picture will probably be visible when a strong TV signal is applied from an antenna or a pattern generator.

When signal tracing, if one does not have a VTVM available, remember that a VOM when used with a signal-tracing probe

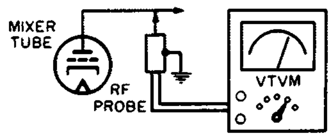


Fig. 2-3. Signal tracing with an RF probe at the mixer output.

can be used to check for the presence or absence of RF or IF voltages. For example, suppose a quick check of the local oscillator is desired. A simple method is to lift the shield up slightly on the oscillator-mixer tube, and touch a signal-tracing probe to the glass tube envelope. A reading of a volt or two indicates that the oscillator is working.

Signal-Injection Test

The signal-tracing tests which have been described here can be supplemented by signal-injection tests. If a modulated-RF signal applied to the tuner-input terminals produces no indication on the picture-tube screen, try injecting the same signal at the looker point. If the RF amplifier only is inoperative, bars will be seen on the picture-tube screen, as shown in Fig. 2-4. In the same way, if the mixer-grid circuit only is defective, bars will be seen when the signal is injected at the mixer plate.

Note that there is no DC voltage present at the tuner-input terminals. Hence, no blocking capacitor is required. However, when injecting signals at the looker point or at the mixer plate, be sure to connect a small-series capacitor in the generator-output lead. A 250-mmf capacitor is satisfactory. Also, do not forget to tune the generator to the receiver's IF frequency when injecting a signal at the mixer plate.

Cascode Tuner Voltages

Besides the pentode-RF amplifier used in some sets, many tuners use a twin triode in a cascode configuration as shown in Fig. 2-5. When measuring DC voltages in a cascode circuit, the beginner is sometimes puzzled by the presence of voltage on the floating cathode and plate. Voltages are present because of the plate resistances of the tube, as seen in Figs. 2-5A and B. This same situation is occasionally encountered in other sections of the receiver. It is well to note that if a cascode amplifier tube is pulled and the socket voltages are measured, only one plate will show B+.

Robbing the Space Charge

Another basic point to keep in mind is that the plate voltage falls as grid bias is reduced, but only down to a certain point—as the grid bias passes zero and becomes positive, the grid cur-

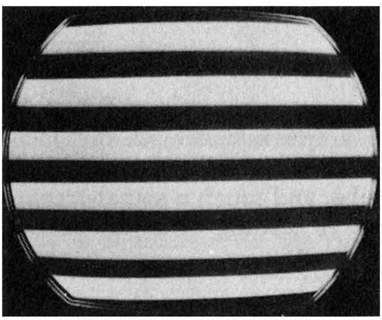


Fig. 2-4. Bar display produced by an AM generator.

rent rises excessively. When the grid current robs the space charge of electrons, the plate resistance of the tube and the DC-plate voltage rises. Thus, a leaky coupling capacitor may cause the normal plate voltage to rise instead of falling. This, of course, causes the tube to run very hot. Leaky coupling capacitors often cause associated trouble in RF tuners, by overheating plate-decoupling resistors. This results in an increase of resistance value, or sometimes even a burning out of the resistor. Hence, if a leaky coupling capacitor has been replaced, and the plate voltage is low, look for a damaged plate-decoupling resistor.

Body Capacitance as Noise Generator

In a normally-operating receiver, the snow level on the picture-tube screen increases if one lifts the mixer-tube shield. This is a quick-test made to determine whether receiver operation is normal past the mixer-grid circuit. The basis of the test is injection of IF noise voltages picked up body capacitance to electromagnetic fields in the shop. Of course, an AM-generator signal can also be injected at a floating tube shield over the mixer tube to perform the same task.

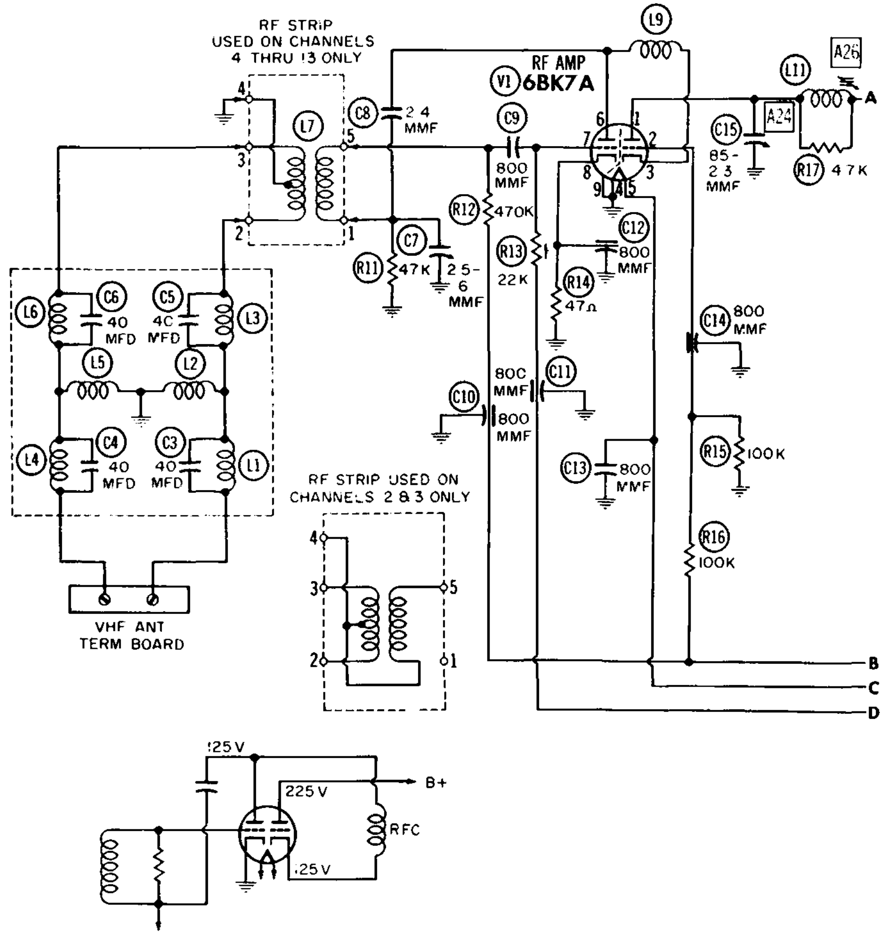
Line-Voltage Stabilization

You will occasionally find that the voltmeter reading fluctuates up and down during signal-tracing tests due to line-voltage variations. In general, a VTVM is more stable in this regard than a TV receiver. To minimize the annoyance of line-voltage fluctuation, both the receiver under test and the VTVM can be powered from an automatic line-voltage regulating transformer such as that illustrated in Fig. 2-6. This type of transformer operates on a saturable-core principle, and must be properly rated for the load.

Signal-Tracing Transistorized Front Ends

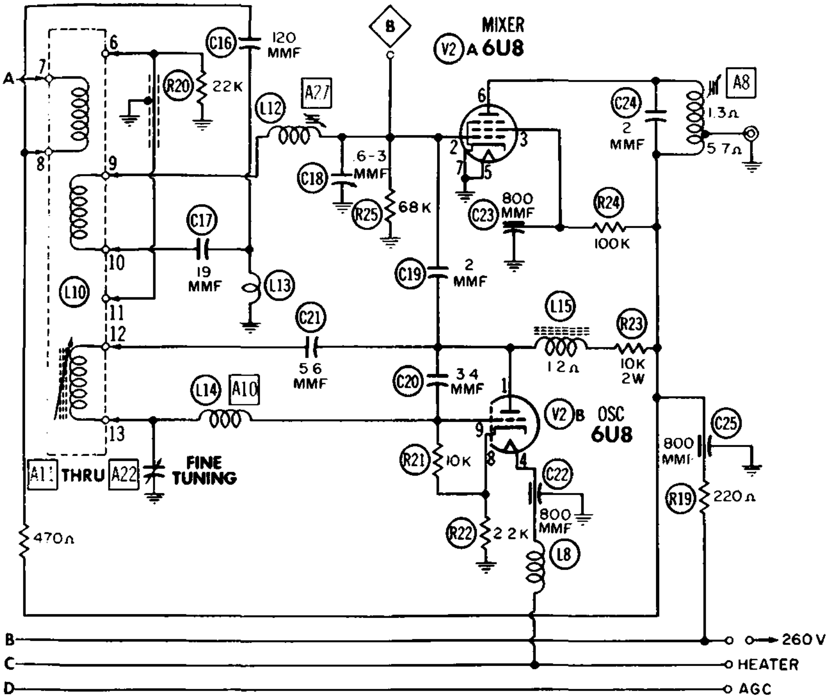
As in troubleshooting tube-type front ends, DC-circuit voltages are measured first to eliminate defects associated with incorrect DC distribution. A transistor is much less likely to fail than a vacuum tube. However, the DC voltages should be measured first, and then the transistors tested, if the voltage measurements do not indicate circuit trouble. It may be difficult to remove a transistor from the circuit for test. Therefore, signal-tracing tests are helpful to localize a defective transistor, as well as circuit faults which do not show up on DC checks.

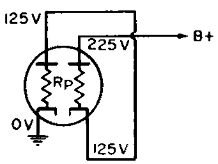
The typical circuit shown in Fig. 2-7 has considerable resemblance to a tube-type front end. If one regards the base electrode as a grid, the collector as a plate, and the emitter as a cathode, the similarity is evident. The analogy must not be pressed too far, however, because the base of a transistor draws appreciable current, while the grid of a tube seldom draws current. The DC-voltage levels are also much lower; thus, the plate of a triode-RF amplifier ordinarily operates at +200 volts or more, while the collector of a transistor operates at only a



(A) Partial circuit.

Fig. 2-5. Schematic diag





(B) Partial circuit equivalent.

ram of a cascode tuner.

few volts. Signal tracing in a transistorized front end, however, is basically the same as in a tube-type front end, i.e., the stage gains are approximately the same in both cases. The area-selector switch (Fringe, Suburban, Local) must be set to accommodate the test-signal level (or vice versa) because front ends such as shown in Fig. 2-7 do not have AGC control of the RF amplifier. The reason is that transistors can be effectively controlled by AGC bias only if forward AGC is used (as in transistorized IF amplifiers). Forward AGC simply means that the stage gain is reduced by increasing the collector current, and running the transistor into saturation for reduction of gain. Unfortunately, forward-AGC control does not work unless there is appreciable series resistance in the collector circuit and this is not practical in RF-amplifier circuits such as depicted in Fig. 2-7. Appreciable series resistance reduces the maximum available gain objectionably. Since triode transistors are employed, the RF amplifier must be neutralized to avoid regeneration, which will make the RF response curve excessively narrow and peaked. In turn, there

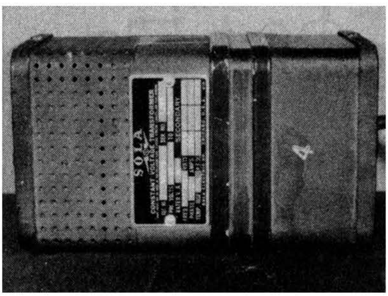


Fig. 2-6. A constant-voltage line transformer.

results a separation of sound and picture—best picture quality is obtained at one setting of the fine-tuning control, while the best sound reproduction is obtained at another setting.

SIGNAL TRACING IN THE IF SECTION

In the IF-amplifier, plate- and screen-DC voltages are checked first. In the event the values are within 20% of those specified in the receiver service data, check out the cathode and grid (AGC) voltages next. These preliminary tests serve to localize basic defects such as leaky coupling capacitors, faulty resistors, or lack of power-supply voltage. Attention to these points may restore picture and sound. If not, proceed to make signal-tracing tests with a VTVM and RF probe.

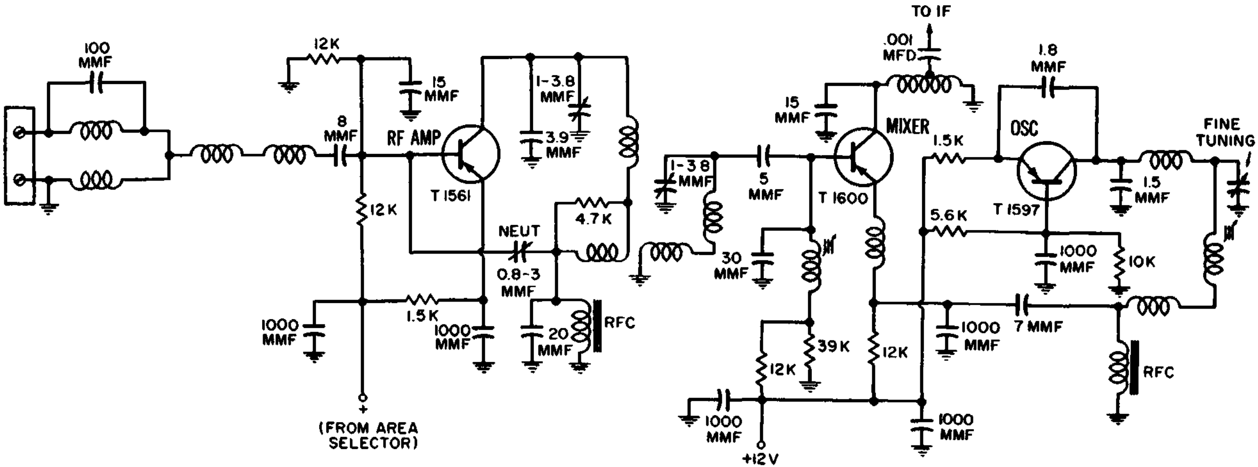


Fig. 2-7. Typical transistorized front-end.

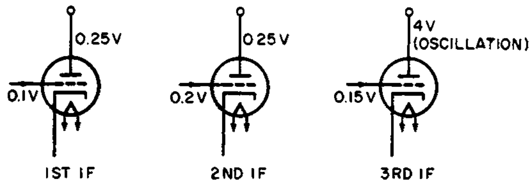


Fig. 2-8. Typical series of IF-voltage measurements.

A typical series of IF-signal voltages is given in Fig. 2-8. At first glance, it may appear that the values do not make sense. However, the important point is that an IF voltage appears at each grid and plate terminal. In other words, signal voltage is not absent at any test point. The erratic pattern of IF voltages results from the input capacitance to the RF probe, which detuned the IF circuit at each test point. The sudden appearance of a 4-volt reading at the plate of the third IF during this test is the result of stage oscillation. Detuning of the third-IF plate circuit happens to bring its resonant frequency about equal to that of the grid circuit, with the result that the stage operates as a tuned-plate tuned-grid oscillator.

In case zero indication is found at a grid or plate terminal, look for a defective component in the associated circuit. When coupling capacitors are employed, an open capacitor is to be anticipated. In such a case, a check is made of signal voltage at both ends of the capacitor, as shown in Fig. 2-9. If signal voltage is present at the input end but not at the output end, the capacitor is open. Since the measured levels are often rather low in such tests, it is advantageous to use a VTVM with a low-range scale, such as 0 to 0.5 volt. Since some IF strips employ small capacitors in shunt with the IF coils (Fig. 2-10), absence of signal at a test point throws suspicion on a shorted capacitor. Inasmuch as the coil resistance is quite low, it is necessary to disconnect one end of the shunt capacitor to check

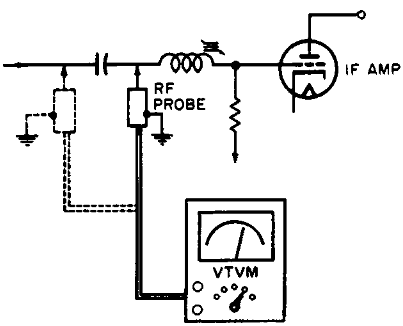
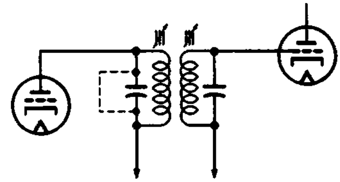


Fig. 2-9. Checking signal voltage at both sides of suspected open capacitor.

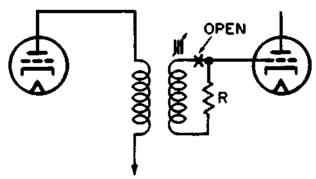
Fig. 2-10. A shorted-shunt capacitor kills the IF signal.



it for a short circuit. Other IF strips also utilize damping resistors in shunt with IF-coil windings, as depicted in Fig. 2-11. In case the coil is open, the DC voltage measures correctly at the grid terminal, but the signal is stopped. Since a typical value for a damping resistor is 82 K, an ohmmeter check will disclose the defect without any circuit disconnections.

The possibility of splashed solder on a coil has been noted previously, and a quick visual inspection may uncover this obvious signal killer. In the receivers of older models also look for broken tuning slugs which may be resting in pieces at the bottom of the coil. This results in an excessively-high resonant frequency which can simulate a dead circuit. If there is reasonable doubt that the IF strip is in workable alignment, a frequency-response check should be made with a sweep and marker generator, and an oscilloscope. Assume the operating complaint is a weak picture, instead of no picture: This now causes additional considerations in the testing procedure. The IF signal is passing through, but the gain is subnormal. Inasmuch as obvious defects such as incorrect DC voltages have been eliminated, look for high-frequency failures. The first step is to make a progressive stage-by-stage gain check. Con-

Fig. 2-11. Damping resistor used in IF circuit.



nect a DC voltmeter at the picture-detector output, as shown in Fig. 2-12, clamp the AGC bus to −2 or −3 volts, and inject a 43-mc signal at each grid in turn.

Do not overload any stage while making gain measurements. Connect the generator output to the third IF grid, and adjust the attenuator for a reading of about 2 volts. Then, transfer the generator output to the input of the picture detector. The meter reading will drop to a small fraction of a volt, if the gain of the third stage is normal. On the other hand, if the third

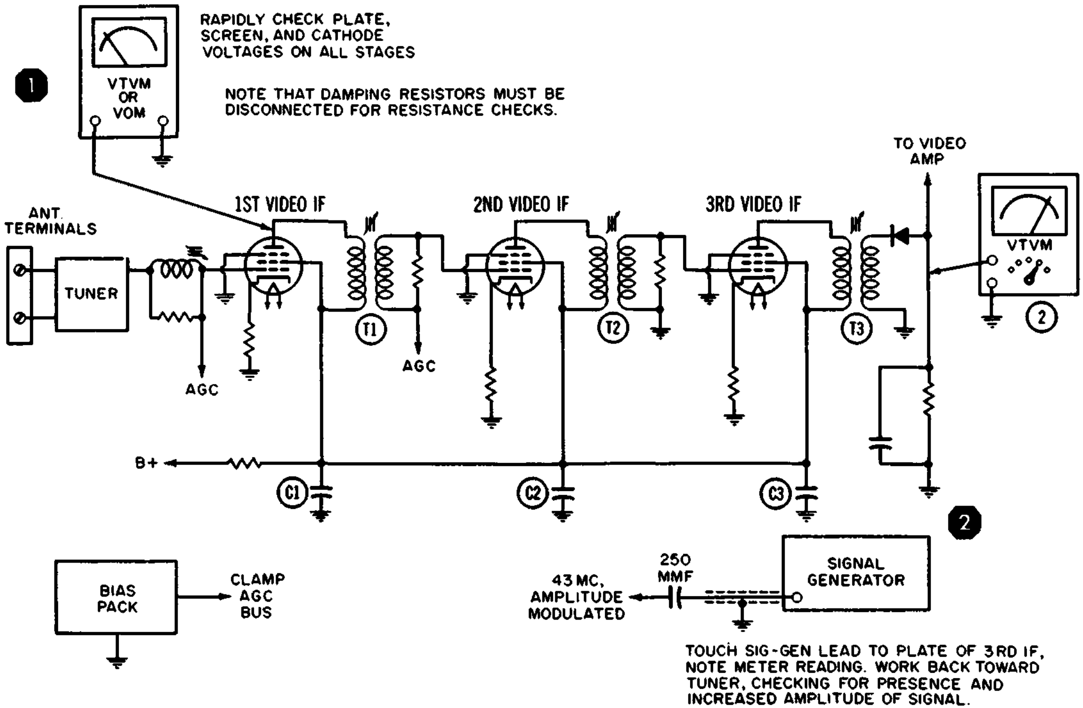


Fig. 2-12. Basic IF-amplifier testing procedures.

stage has low gain, suspect either an open decoupling capacitor (C3), or an inoperative transformer (T3). If the third stage works, proceed to measure the gain of the second stage. Connect the generator output first to the third IF grid, and adjust the attenuator for a reading of about 0.25 volt on the meter. This insures that the third stage will not be overloaded in the next test. Now, transfer the generator output to the grid of the second stage. The meter should now read much higher, although the exact gain depends on the over-ride bias value and the tube type. With a bias of −2 volts, the meter should read at least 1 volt. However, in the event the meter reading increases only a small amount, a low gain in the second stage is indicated. The same trouble possibilities as were noted for the third stage must then be checked out. From this it is evident that gain-measuring procedures serve to localize the trouble to a specific stage, thereby eliminating an aimless search. The first IF stage is checked out in the same manner, with reduced output from the generator to avoid overloading the following stages.

Oscillating Stage

When an IF strip is unstable and breaks into oscillation, it can be stopped by advancing the AGC over-ride bias until a DC voltmeter connected at the picture-detector output suddenly indicates a decrease in voltage to nearly zero. In this manner, the circuits can be temporarily stabilized for measurement of DC voltages which have basic correspondence to values specified in the receiver service data. In some cases, the DC-voltage measurements will indicate the trouble area; for example, a screen-grid voltage may be very low. In other cases, the oscillatory condition is due to a high-frequency fault which will show up only in a signal-tracing test.

By advancing the output from the signal generator, one may be able to drive a signal through the over-biased IF amplifier, provided the front end does not go into overload first. In the event of front-end overload, the IF test signal must be applied directly at the grid of the first IF tube. In tracing the signal, don't only measure the grid- and plate-signal levels, but also pay close attention to readings which may appear across the decoupling capacitors (Fig. 2-13). If an IF-signal voltage is measured across this capacitor, the screen grid becomes hot and does not have its normal shielding action. This permits excessive feedback of signal from plate to control grid, and often results in stage oscillation. An open decoupling capacitor does not always cause stage oscillation; sometimes the circuit reactance is such that the signal voltage feeds back to the control grid out-of-phase, instead of in-phase, with the incoming signal. In this instance, there is a low gain throughout the stage. Thus, an open decoupling capacitor might cause a weak-picture symptom, instead of a no-picture symptom. While picture-and-sound analysis is useful up to a point, reliance must be placed on instruments to resolve the various possibilities in a given situation.

The foregoing troubles are occasionally simulated by misalignment of the IF strip. If the grid and plate coils of a stage

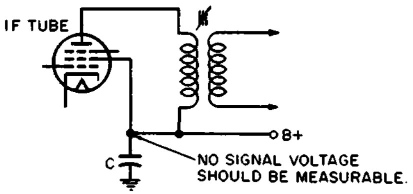


Fig. 2-13. Decoupling capacitor can cause stage oscillation if open.

are not stagger-tuned, but are resonated to the same (or nearly the same) frequency, there is sufficient residual feedback in a 43-mc circuit to cause serious regeneration and narrowing of bandwidth. At lower values of AGC bias, such a stage will break into uncontrollable oscillation. On the other hand, if one or more of the IF coils is tuned far off its correct frequency, the stage gain will fall accordingly.

Transistorized IF Strips

Some transistorized TV receivers have three IF stages, as shown in Fig. 2-14, while others have four. The common-emitter-amplifier configuration shown here is standard, since it provides good gain and gives a fairly good impedance match between stages without unduly complicated circuitry. Why make use of the current-amplification factor in a transistorized stage? Simply because the beta current gain of a transistor is fairly constant over most of the operating range, whereas the voltage relation between base and collector is far from constant. To put it another way, the beta (β) of a transistor is an uncomplicated gain factor, just as mu (μ) is an uncomplicated gain factor for a tube. Otherwise, there is no reason why one would not discuss a common-emitter circuit in terms of its voltage amplification. The first two transistors in Fig. 2-14 have forward-AGC bias. In other words, as the input-signal level is increased, one can expect to find a larger current flow in the collector circuit. This drives the transistor progressively into collector saturation, and reduces the stage gain. When the collector *is* saturated, there is a large voltage drop across the

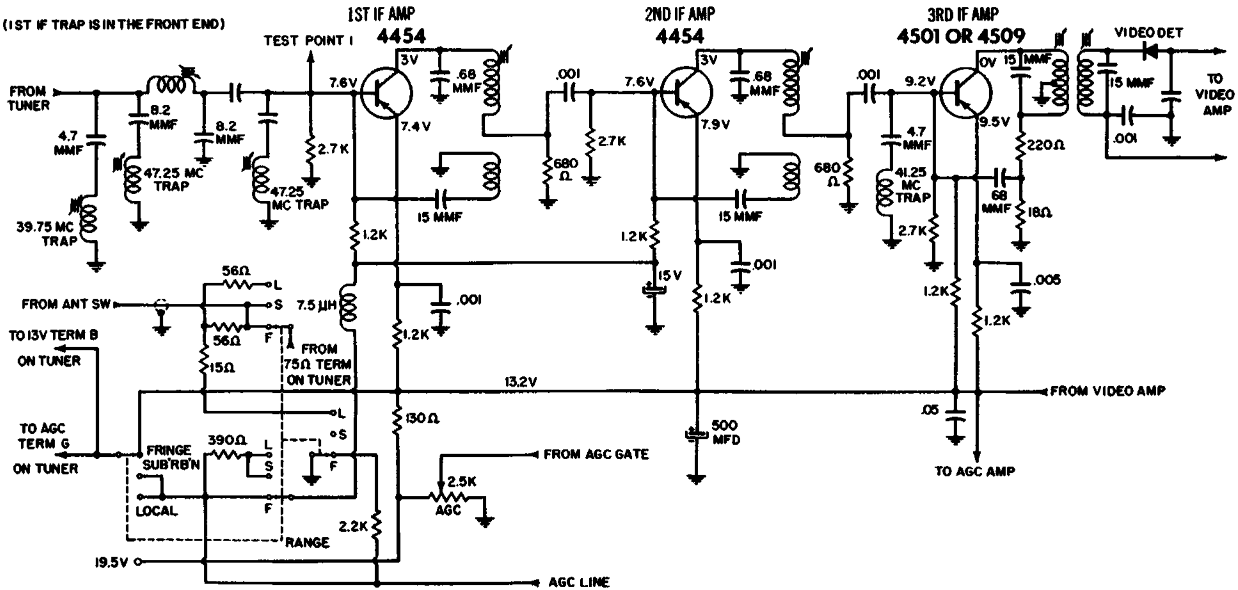


Fig. 2-14. Typical transistorized IF amplifier.

680-ohm resistors, and a corresponding decrease in the DC voltage measured from the collector to the emitter. Hence, preliminary DC-voltage measurements should be made for the operating conditions specified in the receiver service data.

Signal-tracing is done in the same manner as for a tube amplifier—use the same methods to locate a dead stage. Signal-injection procedure provides measurement of stage gains and over-all gain; and open capacitors are localized on the same principles as in the vacuum-tube counterpart. Remember that electrolytic capacitors have a low working-voltage rating; and that modern capacitor checkers sometimes have special facilities for testing these capacitors.

Because triode transistors are utilized, neutralizing circuits are employed to avoid regeneration and/or oscillation. Thus, in case a 15-mmf capacitor is open in one of the neutralizing circuits, the familiar symptoms of instability will be present. In the event that regeneration or oscillation might be due to misalignment, the same general procedure is used to realign the IF strip as for a vacuum-tube configuration. Because of the comparatively large number of traps in the transistorized arrangement, there are a few additional adjustments. These traps have a marked effect on the shape of the over-all frequency response curve.

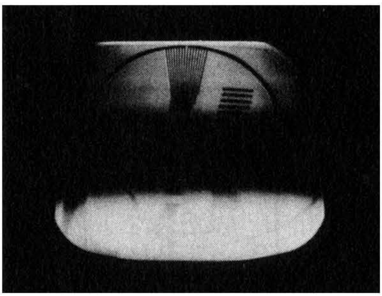


Fig. 2-15. Hum bars in the picture.

Hum Bars

A complaint of hum bars in the picture (Fig. 2-15) is less likely in a transistorized receiver, but it can happen. When it does, it is the result of poor filtering in an AC-power supply. This trouble is indicated by a high reading on the output function of a VOM, or a high reading on the AC-voltage function of a VTVM. The B+ line is never completely free from ripple; however, the ripple voltage should not exceed the limit specified in the receiver service data.

A possible source of simulated hum bars is due to faulty decoupling of the vertical-output stage from the power supply. The current demand of this stage is high, and without normal decoupling the power-supply output becomes modulated at the vertical-sweep rate. Hence, the measurement of an excessively high-ripple voltage does not necessarily indicate defective filtering. The vertical-sweep circuit can be temporarily disabled to see if this expedient reduces the ripple voltage to a normal value. In some receivers, simulated hum bars are also associated with horizontal-AGC trouble. When the picture is pulled over a given region, there is a lack of coincidence between the horizontal-sync pulses and the flyback pulses at the keyed-AGC tube. In turn, the AGC voltage varies over the vertical-scan interval, and produces an appearance of hum bars in the pulled regions. Clamping the AGC line clears up the simulated hum but not the pulling symptom.

Ground Loops

When is a ground not a ground? There is a different ground potential at each stage in a 43-mc amplifier. As depicted in

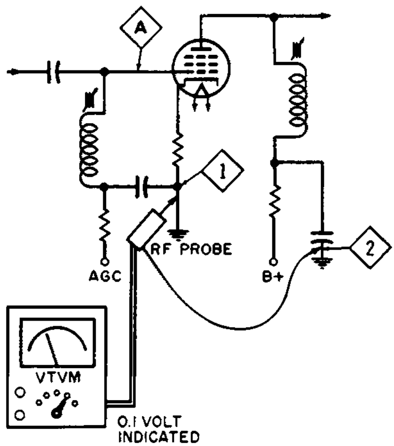


Fig. 2-16. Grounds 1 and 2 are at different 40-mc potentials.

Fig. 2-16, one can connect an RF probe between two separated ground points in an IF amplifier, and often observe a scale deflection. In a typical instance, when this was tried, 0.1 volt was indicated when the RF probe was grounded at the output point in the amplifier, but zero volts was indicated when the probe was grounded at the input. When checking the action of a bypass or decoupling capacitor, it is essential to ground the probe to the capacitor lead, and not to a chassis point removed

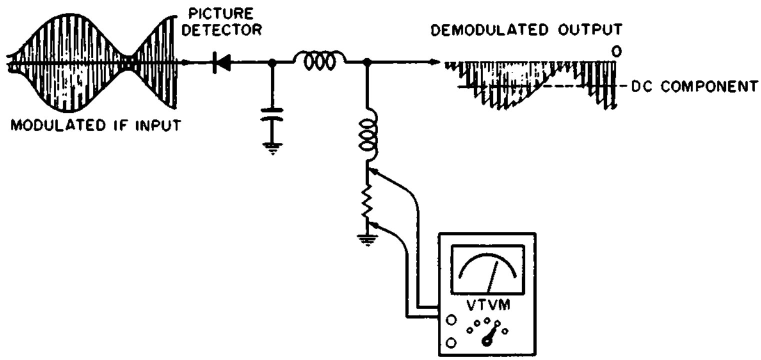


Fig. 2-17. Metering the DC component at the picture-detector output.

from the lead. This is one of the basic distinctions between DC-voltage measurements and high-frequency voltage measurements. The difference in ground potentials at successive IF stages is a consequence of the inductive reactance present in a few inches of wire or metal at 43 mc. When one forces the probe ground-return to pass through the output-point ground potential during measurement of an input-signal voltage, the potential difference between the two ground points will accordingly be indicated by the meter.

SIGNAL TRACING IN THE VIDEO AMPLIFIER

Several different voltage values can be measured at the picture-detector output (video-amplifier input). As shown in Fig. 2-17, the detector action produces a demodulated wave which has a DC component. If the picture-detector output signal is checked with a DC voltmeter, the voltage of the DC component is indicated. On the other hand, if a peak-to-peak VTVM is used, the peak-to-peak voltage of the envelope is indicated; this can be less than the DC component when the modulation percentage is small, as shown in Fig. 2-18. By measuring the

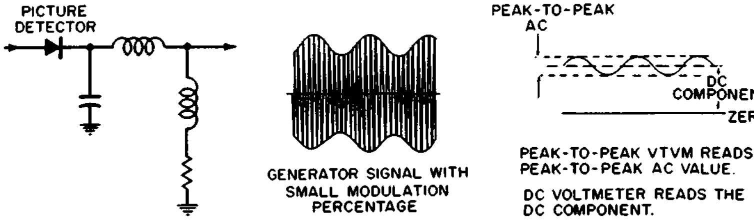
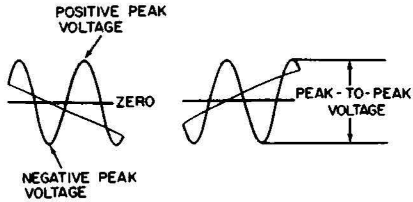


Fig. 2-18. Detector-output-envelope voltage is less than the DC component.

(A) Sine-wave (equal peak voltages).



(B) Pulse-wave (unequal peak voltages).

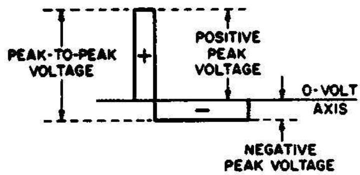


Fig. 2-19. Peak-voltage waveforms.

picture-detector output with a peak-reading probe, the probe indicates zero when polarized in one direction, and reads half the peak-to-peak indication when polarized in the other direction. A peak-reading probe reads half the peak-to-peak voltage in this instance, because the modulating waveform in Fig. 2-18 is symmetrical, or, its positive-peak voltage is equal to its negative-peak voltage. If a complex waveform is to be measured, the situation is altered as shown in Fig. 2-19.

Troubleshooting Procedures

As noted previously, troubleshooting procedures start after good tubes have been plugged in and do not restore the operation to normal. DC voltages are measured and compared with the values specified in the receiver service data to assist in preliminary localization. In many cases, this suffices to eliminate a defective component. On the other hand, one may need to try another tactic to localize the cause of smeared picture reproduction, similar to that shown in Fig. 2-20.

For the circuit shown in Fig. 2-21, the most likely cause of the picture symptom is an open peaking coil (L1). Circuit

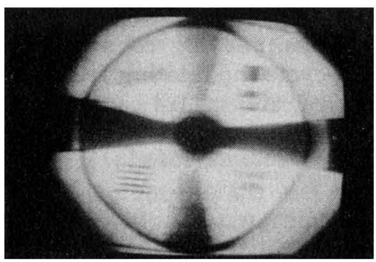


Fig. 2-20. Smeared TV picture.

continuity is maintained by the shunt-damping resistor, but high video frequencies undergo attenuation and phase shift through the resistor. This particular defect would be indicated by an ohmmeter check of the peaking coil. Circuit disconnection is not required in this case; since the ohmmeter will read the resistance of the damping resistor, which is much higher than the resistance of a peaking coil.

This trouble will not show up clearly on a conventional signal-tracing test. Most AM generators have a fixed-modulation frequency of about 400 cycles—this comparatively low frequency will appear at the grid of the video amplifier without appreciable attenuation. A definitive signal-tracing test in this example requires a modulating frequency of 1 or 2 mc.

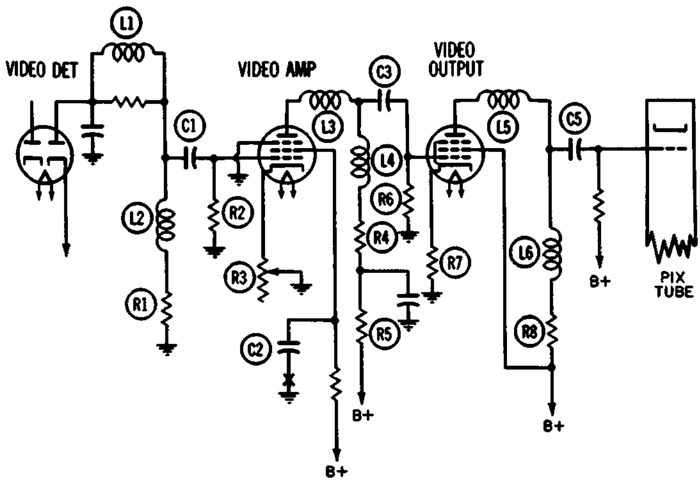


Fig. 2-21. Video-amplifier circuit.

On the other hand, if coupling capacitor C1 should be open (or nearly open), a conventional signal-tracing test will spot the trouble clearly. In making signal-tracing tests through the video amplifier, use the peak-to-peak AC function of a VTVM. Although the input capacitance of the probe is considerable, and the peaking coils are detuned, a good indication of the 400-cycle modulating frequency from the AM generator is obtained, and useful conclusions can be made.

Gain Measurements

When the output voltage from the picture detector is normal, as determined from peak-to-peak voltages in the service data, but the picture has low contrast, gain measurements are in order. The gain of a video-amplifier stage is easily measured by simply transferring the peak-to-peak probe from the grid to the plate of the video-amplifier tube. Low gain can be caused by an open-screen bypass capacitor (C2 in Fig. 2-21). In such a case, appreciable AC voltage will be measured across C2 in the signal-tracing procedure. Low gain can also be caused by coupling capacitors which have lost a large proportion of their capacitance. This shows up in a signal-tracing test as a substantial voltage drop from the input end to the output end of the capacitor. There is also an off-chance of a grid-leak resistor being reduced in value or shorted. This defect, of course, will not show up in DC-voltage measurements but can be easily spotted with an ohmmeter.

Normal gain at high frequencies critically depends on the inductances of the peaking coils. Some technicians may replace

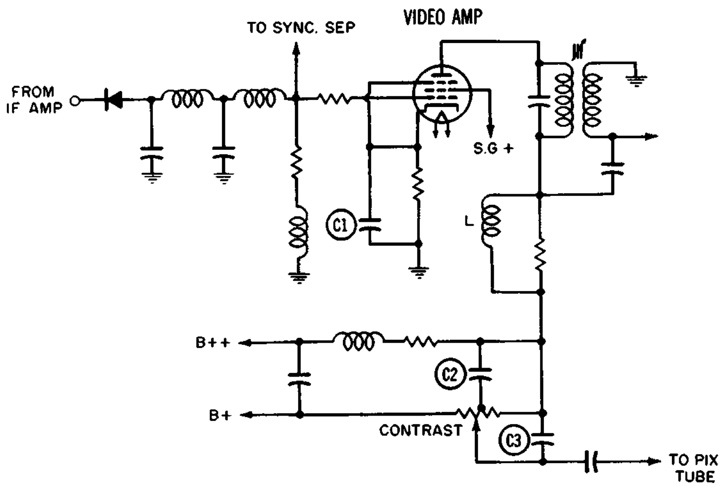


Fig. 2-22. Frequency response being partially controlled by C1, C2, and C3.

a defective peaking coil with just any peaking coil that is readily available. This is a serious error, and often leads to a baffling poor-picture problem. Consult the receiver service data for correct replacements.

Both excessive low-frequency gain and poor high-frequency gain result when a plate-decoupling capacitor, such as C4 in Fig. 2-21 is open. DC voltages remain normal, but one will find an appreciable voltage drop across the capacitor in a signal-tracing test. Low frequencies are amplified excessively because the effective plate-load resistance is much too high. On the other hand, high frequencies are attenuated because the peaking coils work into too high a load.

It is interesting to note that low video frequencies produce practically no drop across a peaking coil such as L2, since all the low-frequency signal drops are across load resistor R1. On the other hand, at high-video frequencies, the larger portion of the signal drops are found across L2. To put it another way, there is an effective crossover of high- and low-video frequencies in a peaking-coil circuit, and equal gain through the video band requires a suitable balance of inductive and resistive values.

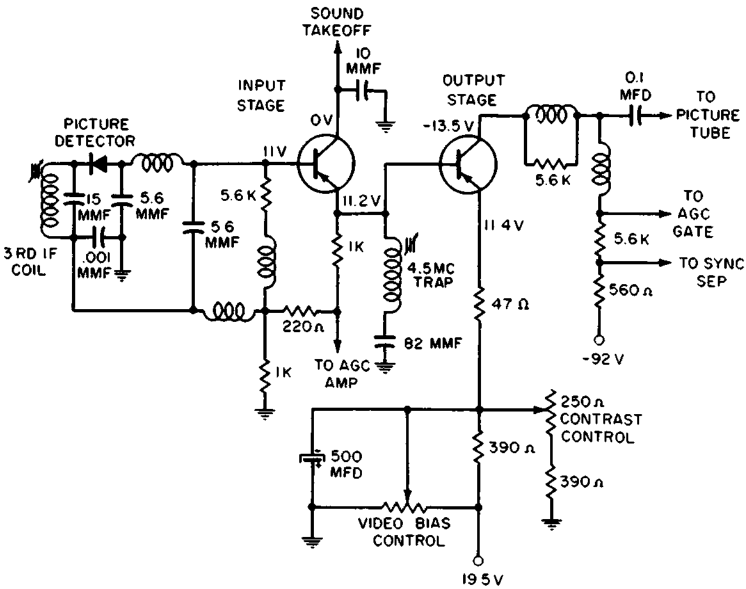


Fig. 2-23. Typical transistorized-video amplifier.

Cathode Bypassing

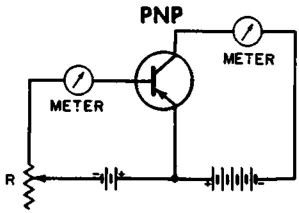
Some video amplifiers utilize cathode bypassing, as at C1 in Fig. 2-22. This is not a large capacitor, and has only partial bypassing action. Hence, one can measure signal voltage at the cathode of the tube, particularly if a 400-cycle test is made. The result of partial bypassing is increased stage gain at high-video frequencies. In case C1 is open, the picture lacks full definition. C2 is also a partial bypass capacitor which increases passage of high-video frequencies when the contrast control is at the midpoint of its range. It can be compared with a compensated volume control. In some receivers, C2 is made larger than in others to obtain overcompensation. This permits reduction of high-frequency response during the reception of weak signals, and reduces snow visibility. C3 operates in conjunction with C2. The values of all three capacitors are somewhat critical, just as peak-coil inductances are critical. The only guide in troubleshooting these circuits is to disconnect the capacitors, measure their values, and compare the values specified in the receiver service data.

TRANSISTORIZED VIDEO AMPLIFIERS

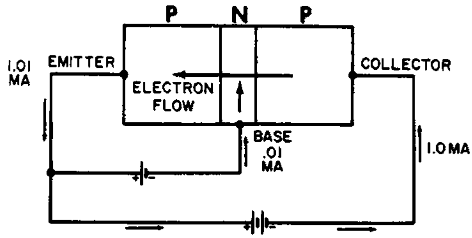
Transistorized video amplifiers operate with substantial DC voltage, in order to drive the picture tube to full contrast. Hence, the types of transistors in this section are different from those in the IF section. As shown in Fig. 2-23, a typical video-output stage operates from a 92-volt supply. At first glance, it might be supposed that this is a cascaded common-emitter amplifier. However, the input stage operates as an emitter follower (analogous to a cathode follower in tube amplifiers). An emitter follower provides a fairly high-input impedance, and a low-output impedance. Thus, it matches the output impedance of the picture detector to the input impedance of the output-video stage. There is no gain through the input stage, on the basis of signal-tracing voltage measurements. (There is a power gain, but power in signal-tracing tests is not measured). Thus, it *is* a normal condition to measure about the same values of input- and output-signal voltage at the input-video stage.

The output stage has a comparatively low input impedance because it operates over a large dynamic range at high collector voltage. This is a common-emitter circuit which gives voltage amplification. The input circuit (base circuit) contains a series 4.5-mc trap which has a low impedance at the intercarrier-sound frequency. Therefore the trap effectively shorts the 4.5-mc signal to ground, preventing sound interference from entering the video-output stage. At the same time, the 4.5-mc signal appears at the collector of the input stage, due to its operation as a common-emitter amplifier at this frequency. These are the essential points to keep in mind when making signal-tracing tests.

A visualization of the current flow in a common-emitter circuit is shown in Fig. 2-24. A test of a typical transistor shows that a base current of .01 ma corresponds to a collector current of 1 ma—the collector current is always much larger than the base current in a normally-operating common-emitter cir-



(A) Schematic.



(B) Pictorial.

Fig. 2-24. Common-emitter current flow.

cuit. The reason for this (Fig. 2-24) is that the current in the collector circuit also flows through the emitter of the transistor. Only a small base current is then needed to control the flow of a large collector current.

You will also encounter video amplifiers which have *NPN* transistors instead of a *PNP* type. The same considerations apply, with opposite supply-voltage polarities, as seen in Fig.

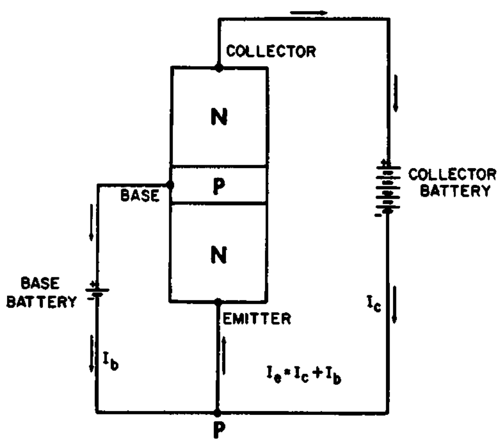


Fig. 2-25. Current in the emitter is the sum of the currents in the base and collector.

2-25. The emitter current is still the sum of the collector- and the base-currents in a common-emitter configuration. Service data sometimes refers to the common-emitter circuit as a grounded-emitter circuit. Actually, the two terms mean the same thing; however, it is better to use the term *common emitter* because the physical ground connection can be (and sometimes is) made to some circuit point other than the emitter electrode. This arbitrary selection of a physical ground point does not, however, change the configuration from a common-emitter arrangement.

CHAPTER 3

Sync-Section Testing

The sync section of a TV receiver is a signal channel. That is, an input signal from a pattern generator, or antenna must be applied to the receiver in order to make signal-tracing tests. The sync separator is a branch off the video channel whose function is to clip the sync tips from the composite video signal. If the separator does not operate properly, the picture falls out of sync, as seen in Fig. 3-1. Horizontal sync is affected more often than vertical-sync lock, although both troubles can arise in the sync-separator circuitry.

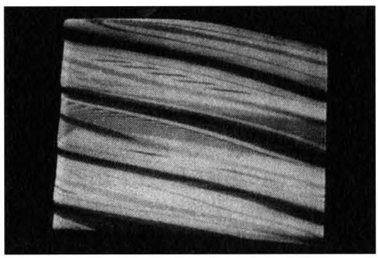


Fig. 3-1. Loss of horizontal sync.

PRELIMINARY TESTS

When the substitution does not restore proper sync action, it is best to make DC-voltage and resistance measurements. These tests serve to localize most defects other than high-frequency difficulties.

Sometimes the input signal to the sync section lacks sync pulses, due to clipping or compression in the IF or video amplifier (rarely in the front end). When this fault exists, the sync separator cannot operate properly. It is thus necessary to localize the section causing the basic difficulty. In most cases,

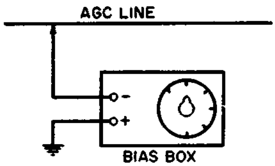


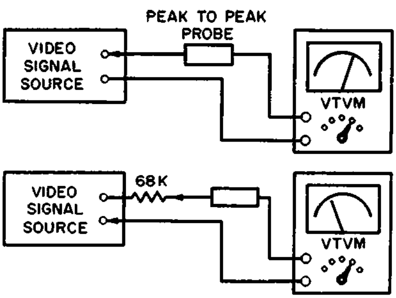
Fig. 3-2. Applying over-ride bias to the AGC line.

the picture can be analyzed, even though it is out of sync. Clipping or compression of sync tips is usually accompanied by a filled-up or muddy appearance of the picture, inasmuch as the grays in the video signal are also compressed into the black region.

If the sync pulses are being compressed in the IF amplifier, the trouble may be in the IF strip, but there may also be a defect in the AGC section which biases the IF tubes incorrectly. In such cases, it is pointless to signal-trace the sync section until normal sync pulses are being fed to the sync separator. If you suspect that the AGC section is causing sync compression in the IF amplifier, apply override bias, as illustrated in Fig. 3-2.

CIRCUIT-LOADING CONSIDERATIONS

Peak-to-peak voltage values are specified in the receiver service data and will be measured in a normally-operating circuit, provided the test method is one which does not seriously load the circuit. The meaning of circuit-loading is seen in Figs. 3-3A and B. Here a peak-to-peak probe is used with a VTVM. Using typical service equipment, the VTVM reading dropped to one-half of the true voltage indication when the source resistance was 68 K. Source resistance is simply the internal resistance of a circuit under test. It is equivalent to connecting a resistor in series with the peak-to-peak probe, as in Fig. 3-3B. The meter indication is too low when the 68-K resistance is



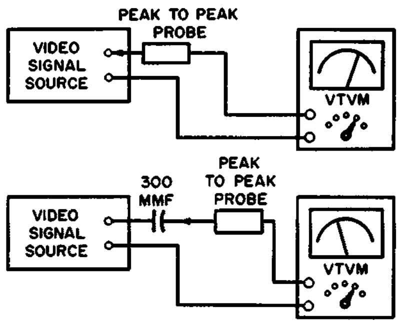
(A) Reference reading from a low-impedance source.

(B) Reading drops to one-half when the source resistance is 68 K.

Fig. 3-3. Difference reading with a source resistance.

in series with the peak-to-peak probe, because its input capacitance is comparatively high. Hence, the 68-K series resistance working into the shunt-input capacitance of the probe forms an integrating circuit, or low-pass filter. Consequently, the higher video frequencies become attenuated.

When circuit loading becomes a problem in signal-tracing procedures, it is advisable to use an RF probe. If necessary, the internal resistance (source resistance) can be made much higher without seriously impairing the indication accuracy. Thus, when a series resistance of 68 K is used, the meter reading is 15% low. The reading does not reach a 50% error until the source resistance is about 300 K. Of course, most RF probes are peak-reading probes. As a rough rule of thumb, one can multiply a video-signal peak-voltage reading by 2, and assume that the product is the peak-to-peak voltage. While this



(A) Reference reading from low-impedance source.

(B) Reading drops to one-half with 300-mmf series capacitance.

Fig. 3-4. Source reactance reduces voltage indication.

assumption is not strictly correct, it provides a rough working basis. The same general considerations of circuit loading apply when checking through source reactance, such as a coupling capacitor. Fig. 3-4 shows how the reading obtained with a peak-to-peak probe drops to one-half when working through a source reactance corresponding to 300 mmf. On the other hand, an RF probe gives only a slightly subnormal reading when working through a 300-mmf capacitor; and if the capacitance value is reduced to 50 mmf, the RF probe then reads one-half of the actual video voltage. An RF probe has much less input capacitance than a peak-to-peak probe—the capacitive-voltage division which occurs when working through a capacitor is less with an RF probe. It is possible to avoid the majority of circuit-loading difficulties by using probes which have a cathode-follower input; however, these are not in general use at service shops.

FORM FACTOR OF STRIPPED SYNC

If the amplitude of the input-signal to the sync separator is measured with a peak-to-peak probe, the VTVM indicates the peak-to-peak voltage, provided the circuit under test is not substantially loaded. On the other hand, if circuit loading is appreciable, it becomes necessary to use an RF probe. Then, the VTVM reads either the positive- or negative-peak voltage, depending on the polarity of the probe configuration (most RF probes read the positive-peak value). Since the positive- and negative-peak voltages of video waveforms are roughly equal, one can multiply the peak reading by 2 to approximate the peak-to-peak voltage of the waveform. Next consider the out-

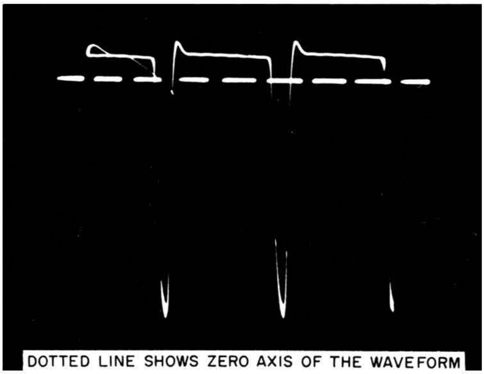


Fig. 3-5. The positive- and negative-peak voltages of stripped sync are widely dfferent.

put signal voltage from the sync separator. If the sync separation is complete, only stripped sync appears at the output of the sync-separator stage. Stripped sync is a pulse waveform (Fig. 3-5) having a form factor widely different from that of a sine wave. Consequently, when this signal voltage is measured with an RF probe, the reading can be greatly in error.

If the probe responds to the positive peak of the signal voltage in Fig. 3-5, the VTVM reading is a reasonable approximation to the peak-to-peak voltage, although the reading is distinctly low. On the other hand, if the probe responds to the negative-peak voltage, it will appear that a normal signal voltage is greatly attenuated. Hence, it is advisable to always use a peak-to-peak probe—unless circuit loading is excessive.

TYPICAL CIRCUIT-LOADING SITUATIONS

TV technicians must be able to "size up" a circuit to make a reasonable estimate of how much loading will be imposed by a peak-to-peak VTVM probe. For example, in Fig. 3-6, only 50% of the grid signal is indicated by the VTVM. However, practically 100% of the plate signal is indicated. Why the difference? The reason is the loading effect is dominated by the 330-K resistor and the 270-mmf capacitor. These components are the chief consideration in the estimation of loading effects. Each by itself will cause the VTVM reading to be somewhat less than half of the actual voltage. In parallel, they will cause the VTVM reading to be about 70% of the actual voltage. Or, approximately 30% of the signal voltage which normally appears at the grid will not be indicated by the VTVM because of the source impedance represented by the 330-K resistor and 270-mmf capacitor.

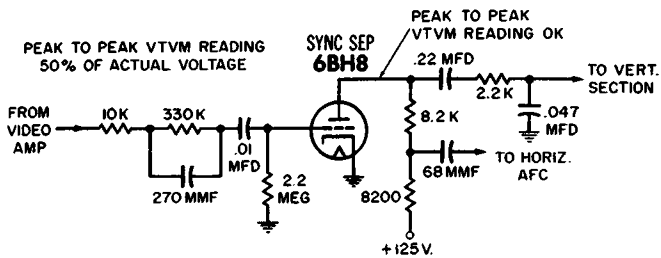


Fig. 3-6. Grid circuit is heavily loaded by peak-to-peak probe—plate circuit is not.

Further consideration shows that although the minor source impedances have been disregarded in order to focus attention on the major source impedance, there is also the sum of the minor source impedances with which to contend. To put it another way, when the sum of the video-amplifier source impedance is considered, plus the 10-K series resistor and .01-mfd coupling capacitor, the sum is not to be disregarded. It causes the VTVM reading to fall another 20%, or the total source impedance causes a 50% error in the reading. Notice in Fig. 3-6 that the source impedance is a parallel combination of the tube-plate resistance, the 16,400-ohm plate load, and the branch circuit to the vertical section. The branch circuit to the horizontal-AFC section can be disregarded because the 68 mmf is a low capacitance value. A 6BH8 has a plate resistance of approximately 5000 ohms. Paralleled with the plate load and the branch to the vertical section, however, the effective source resistance is seen to be much less than 5000 ohms. Hence, there is a negligible loading effect when the peak-to-peak probe is applied at the plate of the 6BH8.

DC-VOLTAGE ANALYSIS

Often, DC voltage measurements alone suffice to disclose a defective component. Fig. 3-7 shows a sync-amplifier circuit which can be the cause of poor vertical locking. It is assumed that a good tube is in the socket. Suppose that the plate voltage is measured and it is found to be low—perhaps 50 volts instead of the 65 volts specified in the receiver service data; inasmuch as vertical lock only is affected, and horizontal lock is all right, this reading is not interpreted as stemming from a low grid-bias voltage. Instead, the experienced technician will turn his attention to the plate circuit. If C3 and C4 should become leaky, an effective voltage-divider circuit would be formed, which could reduce the plate voltage. Hence, one should check for a voltage drop across R2. If 50 volts is measured at one end, and 10 volts at the other end, for example, it is known that C3 and C4 are leaky. Disconnect the grounded end of C3, and check for DC voltage across the disconnection. If the VTVM pointer swings upscale, it is known that C3 is defective. On the other hand, if C3 is all right, disconnect C4 from R5, and check for DC voltage across the disconnection.

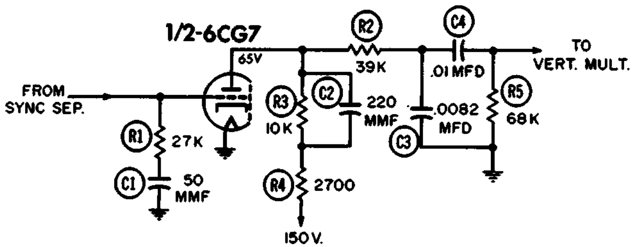


Fig. 3-7. Leakage in C3 or C4 can cause poor vertical-sync locking.

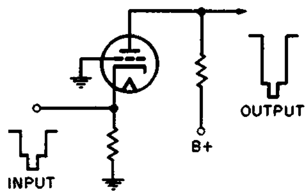
This typical job illustrates how a capacitor can be tested for leakage without clipping it completely out of the circuit, and connecting it to a capacitor tester. Whenever appreciable voltage is applied to one end of a capacitor in its circuit, all that one needs to do is to disconnect the other end of the capacitor and check for voltage from B— to the open lead.

COMBINED SYNC-SEPARATOR AND NOISE-LIMITER

In a circuit coupling a separate tube section for noise limiting and sync separation, the cathode of the noise limiter is driven by a signal from the picture detector. This signal voltage therefore appears in the same phase at the noise-limiter output, as depicted in Fig. 3-8. The signal is fed to the grid of the sync separator—its amplitude is determined by the setting of the noise-limiter control, which adjusts the grid bias of the noise limiter. The sync separator also has a grid input from the video amplifier. Because the video amplifier reverses the polarity of the picture-detector signal, this signal is 180° out of phase. The two inputs to the sync separator tend to cancel out. In normal operation, the output from the noise limiter is too small to cancel the signal from the video amplifier—this condition is established by the noise-limiter control setting. On the other hand, if a high-amplitude noise pulse appears in the signal channel, the noise-limiter tube is driven into its high-gain region, and its output then cancels the video-amplifier signal for the duration of the noise pulse.

It is apparent that signal voltage must be present at the noise-limiter cathode in order to obtain noise-cancellation ac-

Fig. 3-8. Cathode drive causes input and output signals to have the same phase (polarity).



tion. Thus, if a signal voltage at the cathode is not found, it is necessary to trace back through the circuit to find the defect. There can be an apparent lack of cathode signal due to leakage or a short in the 10,000-mmf grid capacitor; this brings the grid of the noise-limiter tube to (or near to) ground potential, while the cathode operates at −2 volts. This is the same as a +2 volt bias on the grid, and heavy grid current is drawn (although the active bias is on the cathode). This flow of grid current produces a very-low input impedance which practically kills the signal in the noise-limiter circuit.

Many modern receivers combine the functions of noise-limiting and sync-separation in the same tube section (Fig. 3-9). The other section of the 'BU8 tube (or equivalent type) serves as a keyed-AGC system. Although this configuration may appear confusing at first glance, the separation and limiting functions take place in the same manner as explained above for the case of separate tubes. The first grid of the 'BU8 is driven by a signal voltage from the picture detector. The suppressor grid is driven by a signal from the video amplifier. These two signals are in opposite polarity. The screen grid of the separator is an effective bias electrode which operates in combination with the control-grid bias to set the operating level of the noise-limiting circuitry. The bias is normally set so that the signal from the picture detector (a negative-going signal) produces little output at the plate of the separator. The suppressor grid is driven with a strong signal from the video amplifier (a positive-going signal), and in turn stripped sync normally appears at the separator plate.

In case a strong noise pulse appears in the signal channel, the control grid of the tube is driven appreciably negative, and

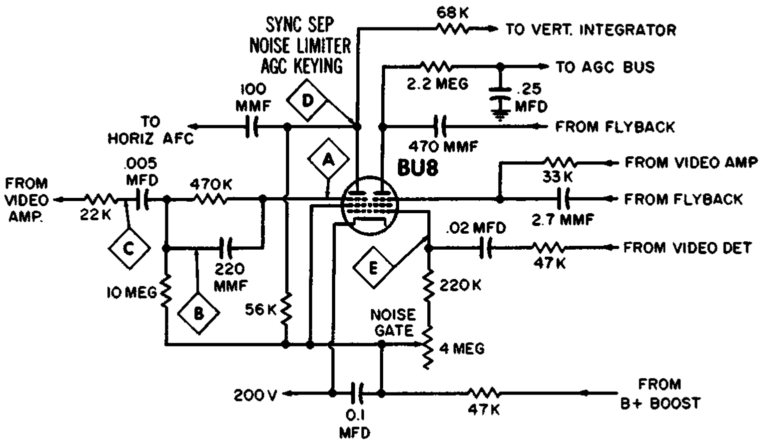


Fig. 3-9. Noise limiter and sync separator are in left-hand section of the tube; keyed AGC is in right.

since the control grid has a higher-amplification factor than the suppressor, output from the plate is cancelled for the duration of the noise pulse. Proper cancellation, of course, depends on a suitable setting of the noise-gate bias control. Effectively, a hole is punched in the separator output during the noise-pulse interval. This momentary killing of separator output has much less disturbance on sync lock than if the noise pulse were passed.

RESISTIVE ISOLATION OF AC SIGNAL

During analysis of sync circuitry, high-resistance bias paths are often encountered which have no signal-current flow. A simple illustration of this is seen in Fig. 3-10. Here, the grid bias, developed from the 1-meg resistor, is obtained from a tap on the cathode resistance. Beginners are sometimes confused by this type of circuitry, and expect at least a portion of the AC-input signal to appear in the cathode circuit via the 1-megohm resistor—actually, there is no such signal transfer. To see why this is so, first observe that the 1-megohm resistor feeds into a low-resistance cathode circuit. The resulting voltage-divider action causes only 1% of the grid signal to appear across the 2-K resistor. Moreover, the cathode circuit has substantial input capacitance—even a very small capacitance will make the AC signal transfer so small that it cannot be measured. More clearly, when high-series resistance works into shunt capacitance, a low-pass filter action occurs which kills AC signals. The reverse circuit action is similar; in other words, the signal voltage in the cathode circuit does not feed into the grid circuit through the 1-megohm resistor. The grid circuit has input capacitance, and from the cathode-driving end the 1-megohm resistor *looks into* a capacitance of 0.1 mfd. There is a low-pass filter action which makes signal transfer from cathode to grid impossible.

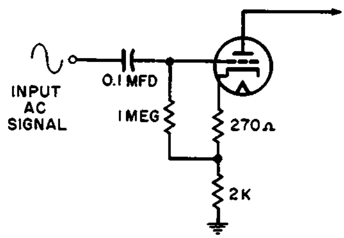


Fig. 3-10. The input AC-signal does not appear in the cathode circuit.

Notice in Fig. 3-9 that the progressive check points are lettered. It is assumed, of course, that a good tube has been plugged into the socket, and that DC voltages agree with those specified in the receiver service data (within reasonable tolerance). In case sync action is still absent or unsatisfactory, check first at point *A* with a peak-to-peak probe and a VTVM. The signal voltage at *A* will be contributed in about equal portions to the probe through the 200-mmf capacitor and the 470-K resistor. A typical probe and VTVM will indicate about half the signal amplitude specified in the receiver service notes, if operation is normal. In case the reading is too low, the 200-mmf capacitor may be open. A quick test can be made by bridging the circuit with a known good capacitor. But in the event that signal voltage is absent at *A*, check next at *B*. Absence of signal voltage at *B* indicates that the .005-mfd coupling capacitor is probably open—again, a bridging test will provide a quick-check. These signal-tracing tests provide information that cannot be obtained in DC-voltage and resistance measurements, since the DC-grid voltage does not change substantially when a capacitor is open.

If the suppressor-grid circuit has been restored to normal operation, practically the full signal voltage specified for point *D* will be measured—unless there is a plate-circuit fault. If there is a shorted- or leaky-shunt capacitor in the vertical-integrator circuit, for example, the signal amplitude at *D* will be subnormal. This type of defect, however, does not show up in DC voltage and resistance measurements. Finally, a signal-voltage check should be made at *E*. Absence of signal here points to an open .02-mfd coupling capacitor.

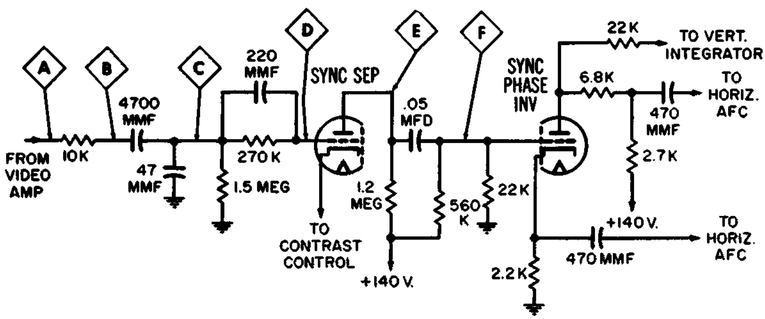


Fig. 3-11. Sync-separator and phase-inverter circuit.

PHASE-INVERTER CONFIGURATION

Quite a few receivers have a sync-phase inverter following the separator, as illustrated in Fig. 3-11. The progressive signal-tracing test points are lettered. One may expect to find a somewhat weaker signal voltage at *C*, e.g. than at *A* or *B*, because the effective source impedance increases toward the separator tube. A very substantial drop in the reading occurs from *C* to D, because of the large effective source impedance between these two points. Lack of signal at *C* points to either an open 4700-mmf, or a shorted 47-mmf capacitor. If the grid is normally operative, practically all the specified signal-voltage amplitude at *E* will be measured. At first glance, it might appear that point *E* is a high-impedance signal source, but rather low impedance is maintained by the combination of the .05-mfd coupling capacitor and the 22-K grid resistor of the phase-inverter stage.

With signal voltage normal at point *E*, but circuit action still unsatisfactory, one should next check the signal voltage at *F*. Weak or no signal at *F* indicates that the .05-mfd coupling capacitor is low in value, or open. Note that the same general trouble symptom could be caused by a load resistor which is greatly reduced in value; however, this type of defect is much less likely than capacitor trouble. The final signal-voltage measurements in the sync section are made at *G* and *H*. Here, one usually finds considerable sawtooth voltage from the AFC circuit which follows, and this masks the stripped-sync voltage. Therefore, the AFC circuit should be disabled temporarily. It is important to have equal stripped-sync voltages at *G* and *H;* otherwise, the AFC circuit cannot function properly. As before, defective capacitors are the most likely cause of incorrect signal voltages.

TRANSISTORIZED SYNC CIRCUITRY

The general plan of a transistorized-sync section is the same as its vacuum-tube counterpart, as seen in Fig. 3-12. In detail,

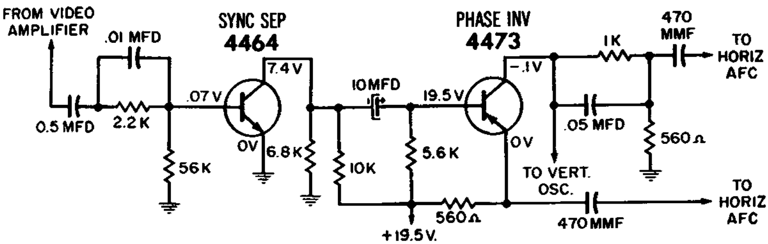


Fig. 3-12. Typical transistorized sync-section of a TV receiver.

however, there are considerable differences. Coupling capacitors are 10 to 20 times higher in value, because of the lower circuit impedance demands. The same general time-constants are thereby maintained. Since the time-constant of a circuit is equal to RC seconds, it is evident that the same time-constant can be obtained in a low-resistance circuit by using a larger value of capacitance.

Fig. 3-13 shows how a common-emitter circuit reverses the signal polarity from input to output. Thus, the common-emitter configuration has the same phase relations as a grounded-cathode vacuum-tube circuit. An *NPN* transistor is used in the sync-separator stage of Fig. 3-12. The small positive DC bias at the base is not signal-developed, as might be expected from analogy with tube circuits. Instead it is an IR drop across the 56-K resistor due to the base component of the reverse collector-current flow. When a transistor is biased from collector to emitter, the reverse-current flow is much larger than if the transistor is biased from collector to base. Now, if the base has a DC path to the emitter, as in Fig. 3-12, the reverse current is greatly diminished. It is apparent that this circuit action entails current flow from base to emitter, and it is this current that develops the .07-volt IR drop across the 560-K resistor.

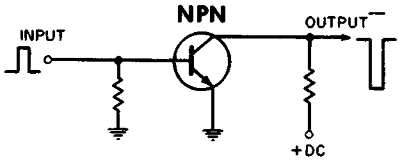


Fig. 3-13. A common-emitter circuit reversing the signal polarity.

Signal tracing is straightforward in a transistorized-sync circuit, due to the low source resistances in the system. A peak-to-peak probe does not load the circuits appreciably—up to the 470-mmf capacitors.

CHAPTER 4

Troubleshooting Horizontal AFC and Oscillator Circuits

Loss of (or unstable) horizontal lock is the most common sync complaint in TV receivers today. If vertical lock is also unstable or absent, the trouble is likely to be in a sync stage or at a previous point in the signal-flow path. On the other hand, if only horizontal lock is affected, one should direct his attention first to the horizontal AFC and oscillator circuits. Horizontal-sync troubles include symptoms of squealing, squegging, ripples in the picture, and the "Christmas-tree effect," in addition to the familiar breaking up of the picture into diagonal bars. If the diagonal bars slant uphill to the right, the oscillator frequency is too low (less than 15,750 cps), and if the bars slant downhill, the oscillator frequency is too high.

GENERAL CONSIDERATIONS

The AFC system can bring the oscillator back on the correct frequency (within certain limits) as its natural frequency drifts up or down. Outside these limits, control is lost and the picture breaks up into diagonal bars. If the AFC system is operating normally, but the oscillator is out of its limits, the diagonal bars will remain in a fixed position (locked) on the screen. Suppose, however, that the oscillator is operating near 15,750 cycles, but the AFC system is dead—no diagonal bars will be seen; instead, the picture will "float" or run horizontally. In this instance, the picture can be free-wheeled into frame momentarily by adjusting the horizontal-hold control (Fig. 4-1). When the AFC system is operating normally but oscillator drift is excessive, the entire picture first pulls off-center, then exhibits pulling and finally breaks up into diagonal bars which lock in sync. Squegging involves high-frequency motorboating between various receiver sections, and may include the horizontal-sync section. The symptoms are varied and may or may not include audible-sound output, however,

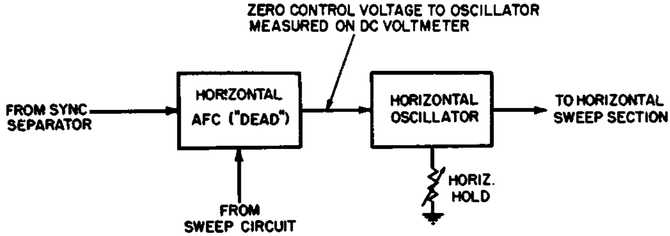


Fig. 4-1. Localization of a dead horizontal-AFC section.

the picture is always out of sync and may even be absent. In addition, spurious AC voltages often enter the picture tube and produce odd patterns.

PRELIMINARY CHECKS

The first step in localizing horizontal-sync trouble is to check the tubes and semiconductor diodes (Fig. 4-2). Next, adjust the service controls to bring the oscillator back on frequency. If this can be done with the controls set within the middle third of their range, the oscillator and AFC circuits are operating properly. If not, a detailed investigation of these circuits is in order.

As shown in Fig. 4-3, the AFC-oscillator configuration is a servo system in which a signal is fed back from output to input,

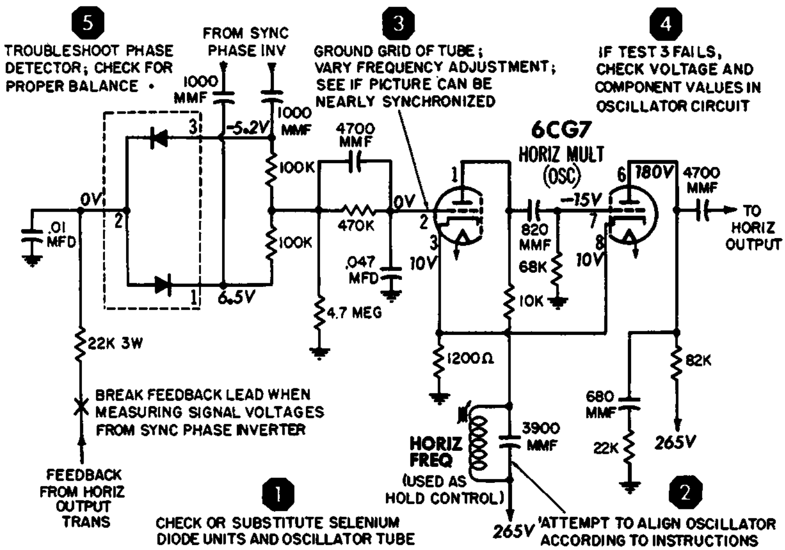


Fig. 4-2. Localizng horizontal-sync trouble.

forming a closed-loop. In this sense, it can be compared to an AGC system. A failure in any portion of the system can upset operation in all its circuits and give rise to confusing symptoms. Moreover, the problem of interaction must be contended with. It may be difficult to determine whether off-frequency operation of the sweep section is due to a faulty oscillator or a defective AFC circuit. The preliminary approach is to break the closed loop by interrupting the feedback path as follows:

Disable the AFC circuit, to see whether the picture can be framed temporarily by adjustment of the hold control and frequency slug, as indicated in Fig. 4-2. If the picture cannot be framed, there is a defect in the oscillator circuit. Another

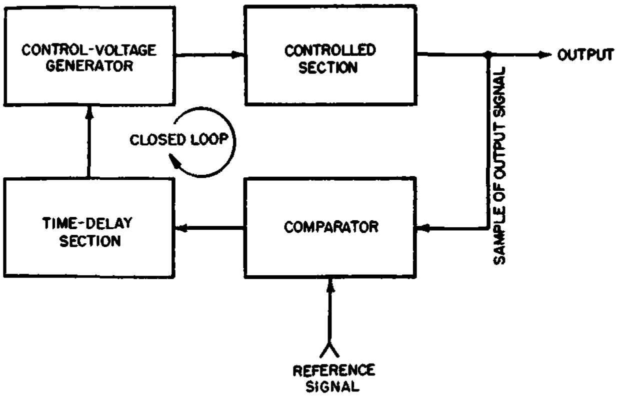


Fig. 4-3. Functional plan of a servo system.

helpful test of AFC operation is to rotate the hold control and to check (with a voltmeter) for a variation in the AFC-output voltage. If the DC voltage on the output side of the AFC stage remains the same or fluctuates nonlinearly, the AFC circuit is not operating properly. When the horizontal oscillator is a cathode-coupled multivibrator preceded by a phase-detector AFC circuit, the oscillator can usually be made free-running simply by grounding the grid of the oscillator-tube input section. Even with no control voltage applied, it should still be possible to frame the picture momentarily without rotating the hold control and horizontal-frequency slug past the middle third of their respective ranges. In case this isolation test convinces you that the AFC-circuit action is abnormal, consider the possibility of unbalance between the two halves of the phase-detector circuit. This requires checking both the positive and the negative sync-pulse outputs of the sync-phase inverter with a peak-to-peak probe and a VTVM; both should have approximately the same amplitude. (Open the feedback lead from the sweep circuit, as indicated in Fig. 4-2). Some phase-detector circuits, particularly in late-model chassis, are not designed to supply exactly zero control voltage when the oscillator is locked-in at the sync frequency. If the AFC stage is disabled in such circuits, the frequency or hold control will have to be turned toward one end of its range in order to frame the picture momentarily.

COMPARATOR ACTION

The AFC circuit is basically a waveform comparison configuration, as shown in Fig. 4-3. The incoming sync pulses are mixed with a sawtooth wave from the oscillator; the mixed waveform is then fed to the AFC diodes, and rectified (Fig. 4-2). This rectified DC voltage is fed to the grid of the first tube in the multivibrator (oscillator) circuit. When this DC-bias voltage is positive, the oscillator speeds up; when it is negative, the oscillator slows down.

The polarity of the DC-output voltage from the AFC diodes depends on the phase of the sawtooth wave with respect to the sync pulses. Phase change takes place when the operating frequency (pulling) causes the sync pulses to ride lower on the sawtooth in one diode circuit; the opposite is the case for the other diode circuit. The DC output from the AFC diodes will swing positive or negative, depending on which way the oscillator is pulling; that is, whether it is tending to run too fast or too slow.

If you have localized a fault to the AFC section, measure the DC voltages and resistances. Test the capacitors on a capacitor checker, or by substitution. In Fig. 4-4 the 1N60 AFC-diodes may become defective, and cause waveform changes. These diodes can be checked out for front-to-back ratio with an ohmmeter, or a substitution test can be made. If you should use a VTVM with capacitance scales to check out the capacitors, be sure to make a leakage test first. In case a capacitor has appreciable leakage, its apparent capacitance value may be very high when measured with some VTVM's, as shown for a typical situation in Fig. 4-5. On this basis, it is evident that a capacitor which has lost most of its capacitance, and which also has substantial leakage, could appear to be all right on the basis of a capacitance measurement alone.

Avoiding Oscillator Disturbances

In the circuit of Fig. 4-4, the comparison voltage is fed back to the AFC circuit from the output of the oscillator. One can-

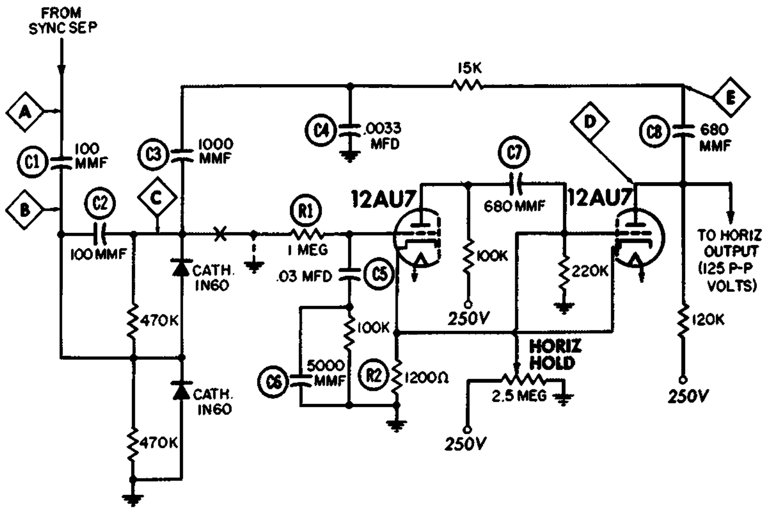


Fig. 4-4. Freewheeling test is made in this circuit by breaking the lead at *X* and grounding the 1-meg resistor.

not make a simple short-circuit to ground for a free-wheeling test—the oscillator will be seriously disturbed. Hence, break the AFC lead at *X*, and ground the free end of the 1-meg resistor.

Why AFC Is Necessary

The beginner sometimes regards the AFC section as an unnecessary complication, inasmuch as a horizontal oscillator can be triggered directly by the output pulses from the sync

(A) Correct reading.

(B) Incorrect reading.

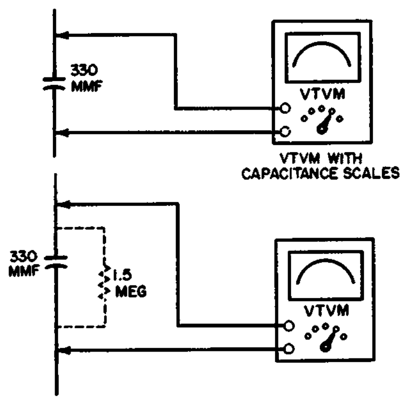


Fig. 4-5. Shunt resistance causes incorrect indication of capacitance value.

separator. As a matter of fact, many early-model TV receivers had no horizontal-AFC section. However, noise immunity was poor, with frequency picture-tearing due to ignition interference and other noise voltages, man-made or natural. Hence, all modern receivers have the basic arrangement shown in Fig. 4-2; the time-delay circuit averages out noise pulses which may not have been removed by the noise limiter.

Notice the RC time-delay circuit (R1-C5 and C6-R2) in Fig. 4-4: the AFC circuit feeds its DC-control voltage through a 1-meg resistor into a capacitor followed by a 5000-mmf capacitor and 100-k resistor. Every AFC-output circuit has an equivalent delay circuit. It can be compared with a shock-absorber which averages out the sharp bouncing of a wheel to which it is attached.

COMPONENT CHECKS

Although a horizontal-oscillator and -AFC circuit may look complex, it is merely an assembly of basically simple components. Therefore, the attack on a defective circuit is first of all a check of the individual components. Note here too that Ohm's law applied to reactance and impedance in the same general manner as to resistance.

In case C1 is open, horizontal-sync lock becomes extremely touchy in Fig. 4-4. When C2 is open, sync lock becomes unstable on weak channels. If C3 is open, it is impossible to frame the picture without disabling the AFC section. An open C4 impairs sync lock, in which event an abnormally high signal amplitude is present at *C*. If one suspects that C1 is open, he may wish to make a signal-voltage test at *B*. To do so, unplug the multivibrator tube to kill the comparison voltage which is fed back at *C* (use a dummy tube in a series-heater type of chassis). Observe that the signal voltage measured at *D*, when the multivibrator is operating, is the drive voltage to the horizontal-output tube. When the horizontal oscillator is inoperative, the screen is dark because there is no drive to the horizontal-output tube, and therefore no high voltage is supplied to the picture tube. Faults other than oscillation failure also cause a dark screen. For example, when C5 is open, the oscillator continues to function, but at an incorrect frequency. When the drive to the horizontal-output tube is considerably off-frequency, the high-voltage output falls so low that the screen becomes dark. Also, when C5 is open, the grid-circuit impedance of the multivibrator-input tube becomes very high, and spurious feedback occurs through the AFC section. This spurious feedback oscillation is audible, and is called squegging. Squegging may also generate excessive spurious voltages which can break down some components.

When C8 in Fig. 4-4 is open, the symptom here too is a dark screen picture-tube. If C8 is leaky, the picture is present but horizontal sync is unstable. In this case, the oscillator can usually be adjusted to operate temporarily at 15,750 cycles, but continual drift necessitates frequent resetting of the horizontal-hold control. An open C8 shows up in a signal-tracing test with no reading at *D*.

In addition to defective capacitors, off-value resistors or incorrect B+ supply voltage can cause trouble in horizontal-oscillator operation. However, incorrect resistance values are easy to localize, once the defective circuit has been isolated by troubleshooting.

SYNCHROGUIDE CIRCUIT

The *synchroguide* circuit shown in Fig. 4-6 uses a pulse-width method of generating control bias to the horizontal-blocking oscillator. The AFC tube is biased beyond cutoff. In other words, the grid is held highly negative with respect to the cathode (−15 volts is typical). A sawtooth voltage is fed back from the blocking oscillator and combined with the sync pulse at the control-tube grid. The positive peak of this combination waveform reduces the DC-grid bias so that the AFC tube can conduct. Tube conduction generates a positive voltage in the cathode circuit (across R77 in Fig. 4-6). This voltage reduces the negative-grid bias at the oscillator, causing oscillations to speed up. The value of the positive voltage which is thus generated depends on the phase relation between the sawtooth voltage and the pulse. If the pulse moves slightly to the left on the sawtooth, a wider pulse appears on top, thus making the conduction interval longer. In turn, more positive bias is generated and the oscillator speeds up. The sawtooth then pulls to the right—part of the pulse is lost—and the pulse width decreases effectively. Equilibrium occurs at the width which keeps the sawtooth frequency exactly in step with the sync pulse.

Component defects in either the control or the oscillator stage can cause the oscillator to pull excessively. The pulse width becomes narrower or wider than normal, causing inability to obtain stable operation. Leaky capacitors are a common cause of this difficulty—the leakage changes the normal DC voltage distribution in the system and forces the control bias from its normal range. Off-value resistors are less likely to cause pulling, but they should be checked in case the capacitors are good. The transformer is checked last, because it is an infrequent cause of operating trouble.

All the *Synchroguide* circuits except the AFC cathode have comparatively high impedance, which limits the usefulness of peak-to-peak probe and VTVM tests. Instead, reliance should be placed on evaluation of circuit response, followed by DC-

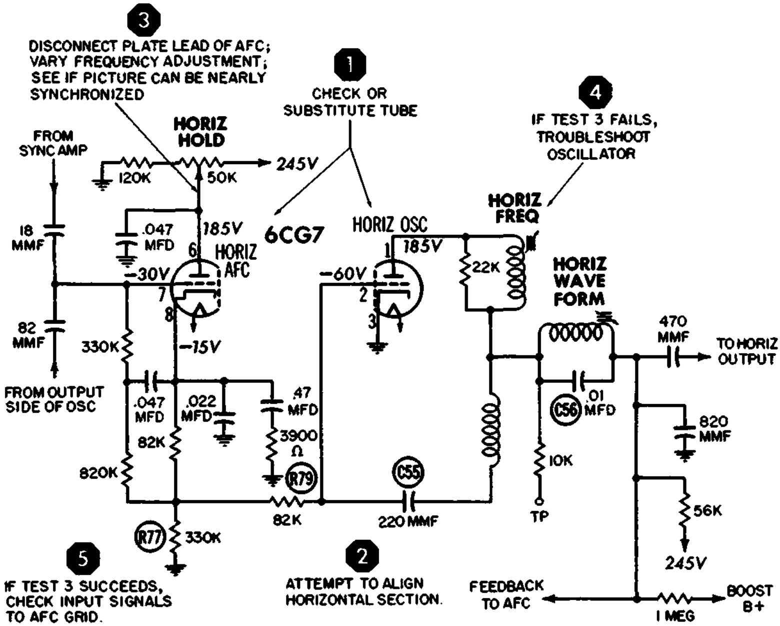


Fig. 4-6. The *Synchroguide* circuit.

voltage and resistance measurements. Defective capacitors are the most common cause of abnormal operation. Off-value capacitors cannot be localized by ordinary test methods, and substitution is the only practical procedure. However, leakage often shows up as an abnormal DC voltage in the associated circuit.

RINGING COIL AND MULTIVIBRATOR CIRCUIT

In older receivers, one will often find the AFC tube controlling a multivibrator-sawtooth generator which includes a ringing coil, as shown in Fig. 4-7. A comparison sawtooth from the sweep circuit is fed into the AFC diodes, where it is mixed with stripped sync from the phase inverter. If the sawtooth voltage is weak or absent, the multivibrator frequency is uncontrolled. Leakage or shorts in the .01-mfd capacitor are likely to be the cause. About 15 volts should be measured at *X* in Fig. 4-7, with a peak-to-peak probe and a VTVM.

Positive sync pulses are coupled to the plate of one AFC diode, and negative sync pulses to the cathode of the other diode, unless one of the 1000-mmf capacitors is open, or if trouble is present in the preceding inverter stage. Thus, both diodes are normally conducting simultaneously. At point *A* in Fig. 4-7, there is a mixed pulse and sawtooth wave. Practically no signal voltage is found at *C*, unless one of the capacitors in the circuit is open. It is practical to check DC voltage

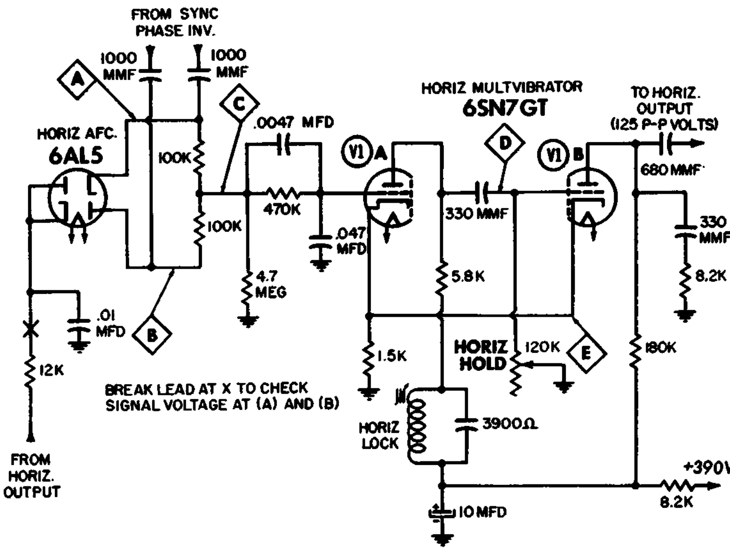


Fig. 4-7. Multivibrator with ringing-coil stabilization.

only at *D* because of the comparatively-high circuit impedance. However, the signal amplitude can be measured with a peak-to peak probe and a VTVM.

The RC network in the grid of V1 is a filtering and holding circuit. It provides a smooth DC-control voltage to the grid, and it also delays passage of sudden-input changes. As a result, noise pulses tend to average out and the oscillator is less likely to tear the picture when the noise level is high. Look for open capacitors if appreciable AC is found at the grid of V1. This is normally a comparatively low-impedance circuit, because of the low shunt reactance of the .047-mfd capacitor.

TYPICAL CIRCUIT-LOADING ERRORS

The nature of circuit-loading errors in signal-voltage measurements has been explained in previous chapters. Let us see how these principles apply to the horizontal-AFC and oscillator circuitry. Fig. 4-8 illustrates a common configuration comprising a semiconductor-AFC section and a vacuum-tube multivibrator. If we check the stripped-sync voltage entering the AFC-diode circuit, we find that a peak-to-peak probe and a VTVM loads this circuit considerably; in fact, the VTVM indicates approximately one-half of the actual signal voltage.

The circuitry to the left of the test point obviously has a high source impedance. Since the AFC diodes feed into com-

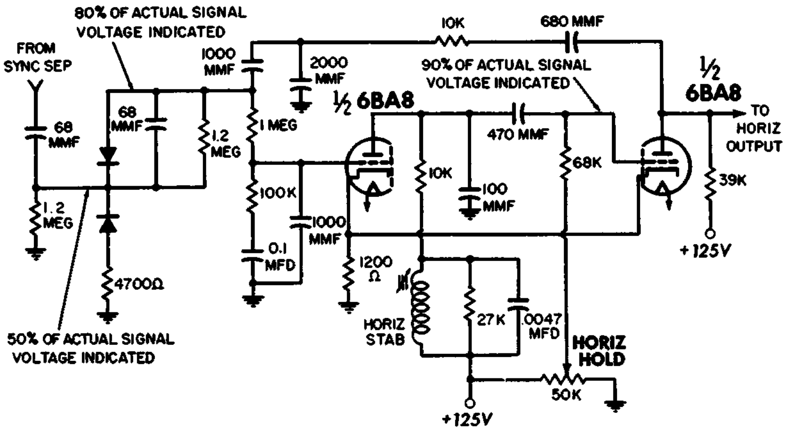


Fig. 4-8. Examples of circut-loading errors in signal-voltage readings.

paratively low-impedance circuits, it might be supposed that the circuitry to the right of the test point has a rather low impedance. However, the impedance is comparatively high at the common connection to the diodes; it is for this reason that we encounter considerable circuit loading at this test point. The upper diode feeds into a 1000-mmf and a 2000-mmf capacitor connected in series with ground. This constitutes a fairly low-impedance circuit, with the result that a peak-to-peak probe and a VTVM indicate about 80% of the actual signal voltage. The grid of the second multivibrator triode is also a fairly low-impedance circuit because of the shunt 68-K resistor and the effective resistance of the horizontal-hold control. Hence, a peak-to-peak probe and VTVM does not impose serious loading, and approximately 90% of the actual signal voltage is measured at this test point.

TESTING TRANSISTORIZED AFC-OSCILLATOR CIRCUITS

The typical transistorized circuit illustrated in Fig. 4-9 has considerable resemblance to its vacuum-tube counterpart. However, DC operating voltages are comparatively low, and the output-signal voltage is correspondingly less than in the circuits previously analyzed. The oscillator output is fed to a buffer stage, both to step up the signal power and to provide isolation from the horizontal-output stage.

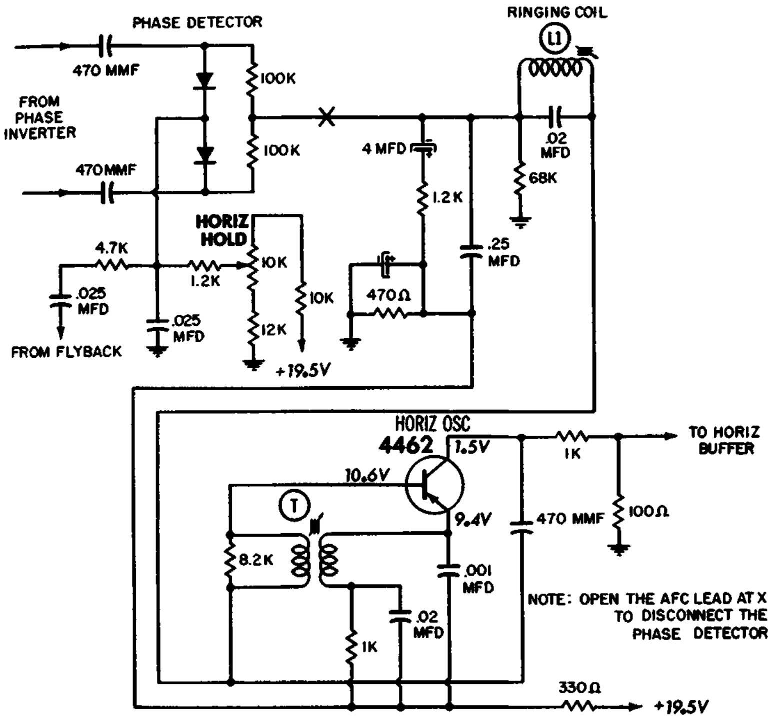


Fig. 4-9. Typical semiconductor AFC and horizontal-oscillator circuit.

In the phase-detector stage (Fig. 4-9) the horizontal-sync pulses are compared with a sawtooth waveform from the flyback section for coincidence. (To put it another way, the horizontal-oscillator frequency is compared against the sync-pulse frequency.) Oscillator pulling results in a correction voltage from the AFC diodes, as the rated 10.6 volts at the oscillator base swings up or down to keep the oscillator on frequency.

To adjust the AFC action, short-circuit ringing coil L1 and disconnect the phase detector. Adjust the slug in the oscillator transformer *T*, to frame the picture momentarily; then remove the short from the ringing coil, and adjust the coil slug to permanently frame the picture. Finally, reconnect the phase detector and turn the horizontal-hold control to the middle of its lock-in range. If the sync lock is not normal, there is a circuit defect present.

The diodes and R-C components in the AFC section are checked out in the same manner as previously discussed for vacuum-tube AFC circuitry. The transistor is usually checked last, unless a circuit fault or testing accident has occurred which would be expected to damage the transistor. For example, if the base is shorted to ground, the transistor would be expected to burn out.

CHAPTER 5

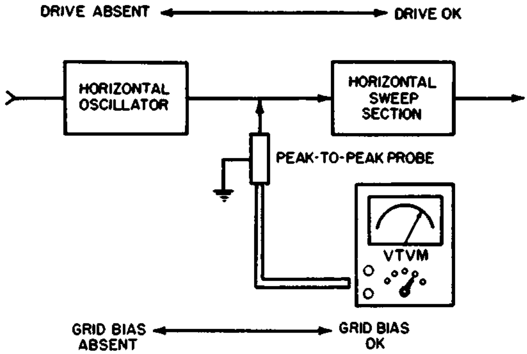
Tests in the TV Horizontal-Sweep Section

The horizontal-sweep section is often considered to be the toughest section in a TV receiver to troubleshoot. While it *is* somewhat more complex than some of the other sections, logical voltage and resistance measurements greatly simplify what can otherwise be a time-wasting trial-and-error procedure. Always check the drive-signal voltage first, as shown in Fig. 5-1. This immediately sectionalizes a horizontal-sweep symptom. If the drive is absent or weak, the trouble is in the horizontal oscillator. Normal drive, however, indicates trouble in the sweep section.

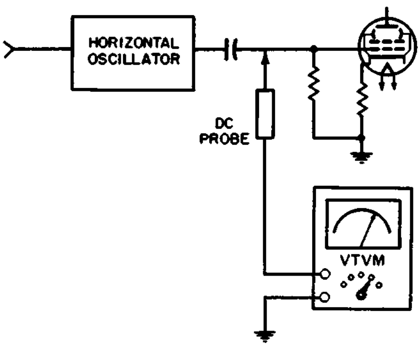
DRIVE VOLTAGE VERSUS SIGNAL-DEVELOPED BIAS

There is a basic distinction between peak-to-peak drive voltage and signal-developed bias, as shown in Fig. 5-2. In the absence of drive, the grid of the horizontal-output tube has practically zero-volts bias. When signal voltage is applied, however, the grid circuit operates as a half-wave rectifier, and charges the grid capacitor on the positive peaks of the drive voltage. (This develops negative-grid bias.) As seen in Fig. 5-2, the positive-peak voltage of the drive signal is only 1/5 of the peak-to-peak voltage in a typical situation. Hence, only 20% of the peak-to-peak drive voltage will be measured in terms of signal-developed bias.

It must not be supposed that this 20% ratio holds true for all TV receivers. Drive waveforms vary considerably, and in some chassis the drive waveform is essentially a sawtooth instead of a peaked sawtooth. The average value of a sawtooth divides the waveform into equal positive and negative excursions. In turn, the signal-developed bias becomes equal to half the peak-to-peak drive voltage in the circuit of Fig. 5-2. As a note of caution, suppose that the coupling capacitor has lost a substantial



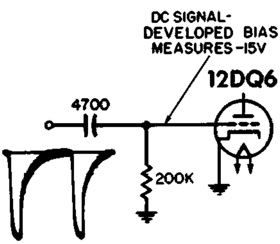
(A) Measurement of peak-to-peak voltage.



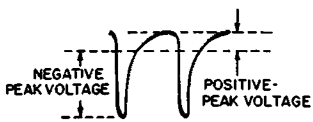
(B) Measurement of signal-developed bias.

Fig. 5-1. Two common methods of checking drive voltage.

portion of its capacitance; in this case, the time constant of the grid circuit is subnormal, and the signal-developed bias falls below the positive-peak voltage of the drive waveform.



(A) Drive voltage measures 75 volts peak-to-peak.



(B) Only the positive-peak voltage acts to produce signal-developed bias.

Fig. 5-2. Distinction between peak-to-peak drive voltage and signal-developed bias.

The horizontal-deflection system generates a sweep waveform for the yoke, DC voltage for the second anode of the picture tube, and (in many receivers) a sawtooth feedback wave for the AFC circuit. It also provides boost B+ voltage for its own and other receiver sections, and often a pulse or pulses for keying AGC and noise-gate circuits. In some sets, a horizontal-retrace blanking pulse is also fed to the picture tube. DC-grid bias from the horizontal-output tube may be fed to the AGC system and/or to the audio amplifier.

Before making extensive measurements, pay particular attention to the picture symptoms. (Even a completely dark screen is a definite starting point.) Forming logical conclusions from initial observations can often save you hours of effort in tracking down a defect. Diagnosis of picture symptoms may reveal no raster, a horizontally distorted (nonlinear) image

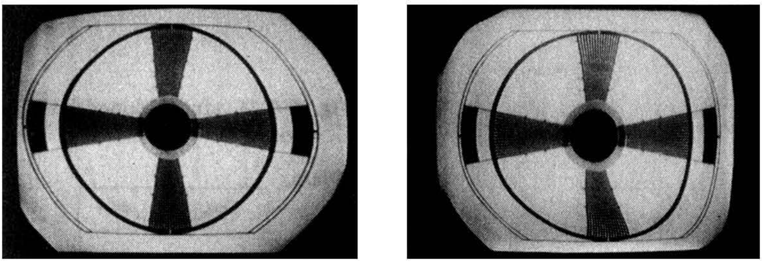


Fig. 5-3. Examples of horizontal nonlinearity.

(see Fig. 5-3), or unstable sync. Of course, there are others, but these three are encountered most frequently in bench servicing. Raster distortion and sync instability may both be present simultaneously—when the sync symptom is cleared up, the raster distortion may also disappear. If not, the trouble is horizontal nonlinearity. Do not confuse symptoms of pincushioning (Fig. 5-4) with circuit trouble. This is due to incorrectly adjusted pincushion magnets, or to a mismatch of the yoke to the picture tube.

Weak Drive Voltage

When drive voltage is zero, it is best to troubleshoot the horizontal oscillator. Not only can weak drive be caused by a defect in either the oscillator circuit or the sweep circuit; if the horizontal oscillator should obtain plate-supply voltage from the booster circuit, weak drive can result from sweep-circuit defects which reduce the booster-output voltage. In that case, confirm the possibility by measuring the boost voltage. If low, one can connect a bench power supply to the oscillator B+ line to restore normal drive.

Resistance Measurement in the Boost Circuit

Resistance measurements in the boost circuit can be misleading, due to dielectric absorption of charge by the electrolytic capacitor(s). Although the circuit might appear to be open to DC insofar as the circuit diagram is concerned, dielectric absorption causes the boost circuit to have a voltage source, even after the electrolytic capacitors have been short-circuited and supposedly fully discharged. In turn, a measurement of boost circuit resistance does not indicate the leakage resistance of the capacitor(s). Instead, the ohmmeter reads higher than infinity.

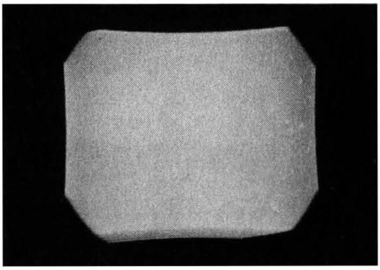


Fig. 5-4. A pincushioned raster.

However, it must not be concluded that this false resistance reading is useless. If you encounter this situation, it is usually safe to assume that the boost circuit is all right. In the event that substantial capacitor leakage were present, the dielectric-absorption voltage would be drained away as fast as it is generated. Of course, it is possible that the circuit can appear to be normal in an ohmmeter test, and still be defective because a capacitor has lost a substantial portion of its capacitance.

PROGRESSIVE TROUBLESHOOTING BY PICTURE SYMPTOMS

Having checked the horizontal sweep section drive, progressive troubleshooting can now be performed on the rest of the circuit. While troubleshooting, however, keep in mind that there may be a short circuit in the wiring which is killing a DC voltage or a signal flow. If this happens, an ordinary ohmmeter will indicate the presence of a short, but is not much help in running down the short-circuit point. The reason is that very low resistance values cannot be read satisfactorily with conventional ohmmeters. However, you can use a low-ohms adapter with a VOM, and measure low resistance values accurately.

To run down a short circuit with a low-ohms meter, proceed as in signal-tracing tests. In other words, follow along the circuit, noting the resistance reading at each point. If the reading is decreasing, you are proceeding toward the short-circuit point, and vice versa. When the point of zero (or minimum) resistance, is reached the short has been localized.

Blooming

Blooming occurs when the regulation of the high-voltage circuit is poor. This means the circuit cannot supply the normal beam-current demand of the picture tube without a substantial drop in second-anode voltage. As the brightness control is turned up, the picture blooms still larger because more beam

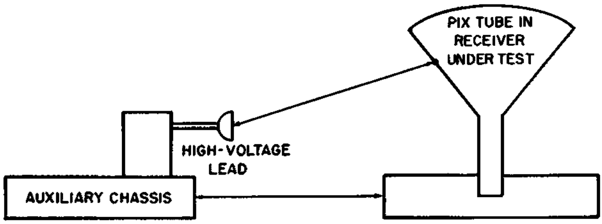


Fig. 5-5. High-voltage substitution test.

current is demanded. If the high-voltage rectifier tube is good, look for (1) a series resistor in the second-anode circuit (if used) that has increased in value, (2) a leaky high-voltage filter capacitor, (3) heavy corona which is bleeding current from the high-voltage circuit, (4) a defective high-voltage rectifier socket, or (5) partial breakdown in the high-voltage winding of the flyback transformer. The output from the high-voltage circuit is measured with a DC high-voltage probe and a VOM or VTVM. It is easy to make a high-voltage substitution test as shown in Fig. 5-5; just use the high voltage from another TV chassis.

Nonlinearity

Horizontal nonlinearity in the picture can be caused by weak tubes in the horizontal section, or, in some receivers, by misadjustment of the horizontal-linearity control (quite a few chassis have no linearity control). Defective capacitors or off-value resistors are also common offenders. While a linearity control can be added to a chassis which lacks the control, this leads to redesign measures which are generally considered to be outside the area of service work.

If a customer objects to unavoidable nonlinearity in a low-priced receiver, it is usually advisable to sell him another more elaborate one. Of course, if the customer is willing to pay for it, there is no reason why redesign jobs should be refused. A narrow and nonlinear picture almost always points to deficient power in the sweep system. In turn, a defect may be found in the boost section, or a low supply voltage.

Wavy Edges

Wavy raster edges (often with 120-cycle hum bars) point to trouble in the low-voltage power supply, which is discussed in a following chapter. A few receivers with half-wave power circuits will display a single bend in the raster and 60-cycle hum bars, instead of a double-wavy edge and 120-cycle hum bars.

Note that wavy raster edges are not caused by defects in the sync section. A sync-section fault can cause vertical lines in the picture to bend, but the raster edges remain straight. A wavy edge in the raster necessarily points to either poor filtering or poor decoupling in the sweep circuit. In rare instances, however, a raster edge bends because of a stray magnetic field in the vicinity of the picture tube such as caused by a speaker mounted near the tube. It is also possible for this symptom to appear in a series-string receiver which has been converted to transformer supply, if the power transformer has been mounted improperly.

Associated Sound Symptoms

In case the screen is dark and there is no sound, it is only natural to measure the B+ supply voltage first. On the other hand, if sound is present, the high-voltage output will be suspected first. Arcing in the sweep section often is associated with snapping and rushing in the sound. If the sound is normal or you fail to find any defects in the heater or B+ voltages, examine the horizontal-sweep and high-voltage circuits (Fig. 5-6). Do not overlook the fuse (usually 0.25 amp), employed in many chassis to protect the sweep circuit. Note that one can make a quick test for signal-voltage presence by simply placing a signal-tracing probe near the output tube, as shown in Fig. 5-7.

After checking or replacing the fuse, check whether there is high voltage. The simplest test (even quicker than substituting tubes) is to turn off the receiver and unplug the anode

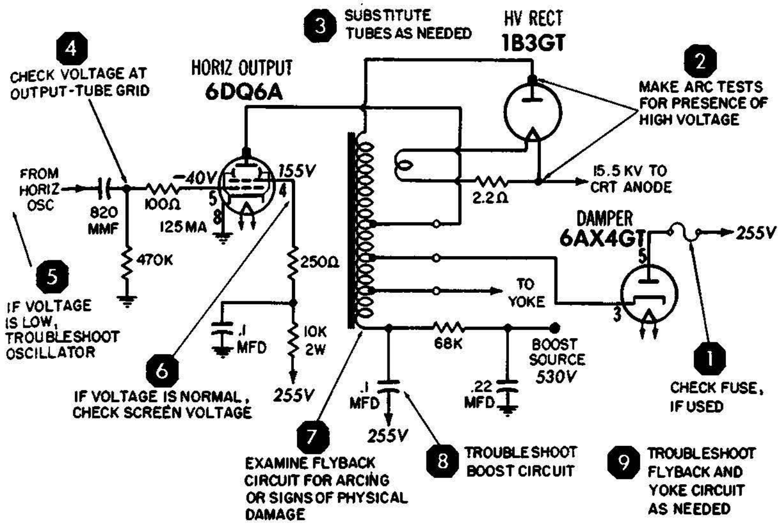


Fig. 5-6. Troubleshooting a condition of sound but no raster.

connector from the picture tube. Grasp it with a well-insulated tool, hold it about ¾ inch from the chassis, turn on the receiver, and see whether a spark jumps across the gap. As long as the connector is not short-circuited to the chassis, you will not burn out any high-voltage system components. If the spark is weak or absent and good tubes do not help, proceed with the following isolation tests.

Unplug the plate-cap lead of the high-voltage rectifier tube, and hold a screwdriver about ¾ inch from the lead. If there is an arc, suspect a breakdown in the rectifier circuit. A weak

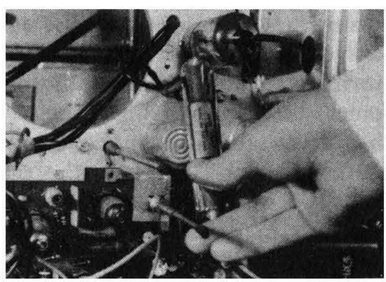


Fig. 5-7. Quick test to determine whether output-tube circuit is live.

arc or none at all means the horizontal-sweep system is probably defective. (It is assumed that good tubes have been plugged in.) Proceed to the grid circuit of the horizontal-output tube, and measure the negative DC-grid bias there—or better still, check the grid-drive waveform. If drive is normal, the

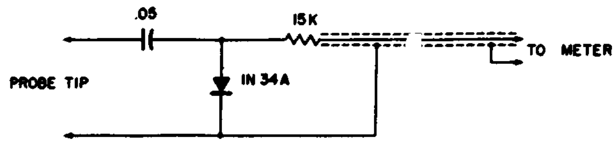


Fig. 5-8. Half-wave signal-tracing probe for VOM.

trouble is in the output stage or beyond. Otherwise, the trouble may be in the horizontal oscillator.

Measuring Drive Voltage with VOM

If one does not have a VTVM, a VOM can be used to some extent in measuring drive voltage. Use the signal-tracing probe shown in Fig. 5-8 on the DC-voltage function of the VOM. Circuit loading is quite appreciable, but it can be determined whether drive is present or absent, and traced back to the plate of the horizontal oscillator. In some receivers, there is more than one capacitor between the plate of the horizontal oscillator and the grid of the horizontal-output tube. Presence of drive voltage on one side of a series capacitor, and absence of drive on the other side indicates a defective capacitor.

Sweep and Oscillator Interaction

Remember that if the plate-supply voltage for the oscillator is below normal, the horizontal-drive waveform will have less than the normal amplitude. The oscillator often receives its plate voltage from the boost B+ line as previously noted. A defect in the horizontal-output or damper circuit can lower the boost voltage; this will affect oscillator operation and change the drive to the output tube. Horizontal-system analyzers which can be helpful in such situations, provide a drive waveform for the horizontal-output tube; or the drive waveform from an auxiliary chassis can be used. If another chassis is used, it is advisable to break the grid lead, as shown in Fig. 5-9, to avoid loading the drive circuit in the auxiliary chassis (and thereby defeating the purpose of the test).

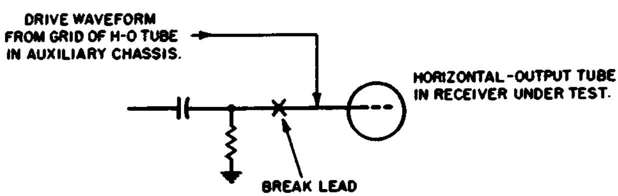


Fig. 5-9. Substitution of drive signal from auxiliary chassis.

If the raster appears normal and if adequate drive signal is being fed to the grid of the horizontal-output tube, the trouble is probably in the boost stage. In the event the boost voltage is adequate, notice the horizontal-oscillator section (covered in a preceding chapter). Boost B+ is readily measured at the point where voltage is supplied by the damper circuit. When the raster has disappeared because of a horizontal-sweep failure and not because of the picture tube being cut off, it is doubtful that the voltage on the boost line will be anywhere near normal. Nevertheless, it can be in exceptional situations, so exercise the usual care in measuring boost voltage. Check the voltage across the boost capacitor—but not at the cathode of the damper tube; since, in most modern sets, the pulse voltage at this point is high enough to damage the voltmeter.

Weak Signal Drive

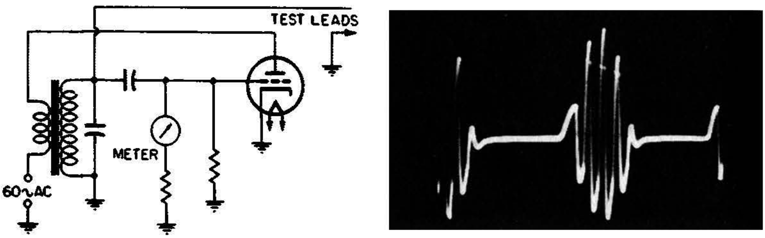
The picture-tube raster does not necessarily disappear when the horizontal-drive waveform is weaker than normal. Even if the amplitude is 25% below the value specified in the receiver service data, the receiver will still generate a fair amount of high voltage and usually some semblance of picture. Nevertheless, a defective waveform (or none at all) at the output-tube grid usually points to the circuits prior to the output stage. To repeat a vital point, the drive-waveform test quickly isolates a horizontal-sweep trouble to either the oscillator or output sections. In the former instance, a blank screen indicates that the oscillator or its discharge circuit has stopped functioning and that further waveform, voltage, and resistance tests are needed to find out why. In the latter instance, waveform and voltage tests are somewhat limited by the high pulse voltages in the output circuit. However, the DC voltages on the output-tube screen grid and the boost B+ line are safe to measure and do provide valuable information.

Inspection of the flyback and yoke circuits will unearth arcing or charring. Also sniff around for the odor of ozone. Other useful servicing techniques include replacement of suspected capacitors, ohmmeter checks to locate possible open circuits, and specialized instrument tests for shorted turns in the flyback and yoke.

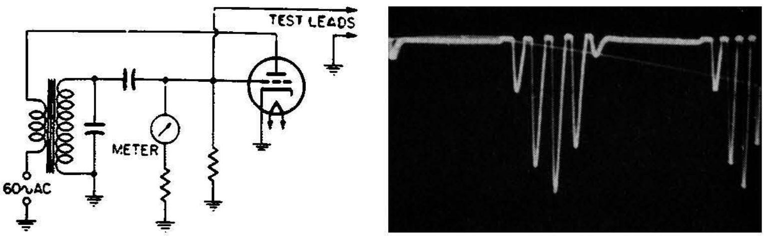
Flybacker Doubles as Capacitance Meter

If a capacitance meter is not available, but a flybacker is (Fig. 5-10), the latter can be utilized as a capacitance meter. Either the short or continuity function can be used to measure capacitance values, because both have a burst-type driving voltage. To operate in this mode, set the calibration control to bring the pointer to 100 (full scale). Connect the capacitor under test to the binding posts on the panel of the flybacker, and note the scale reading. Small capacitors produce a small deflection, while large capacitors produce a large deflection.

The flybacker operates as an AC ohmmeter in this application. The deflection is proportional to the reactance of the capacitor. Make a layover scale for indicating capacitance



(A) A short-circuit indicator configuration.



(B) A continuity indicator configuration.

Fig. 5-10. Using the flybacker as a capacitance checker.

values (up to about 0.1 mfd). Otherwise, a chart or graph can be drawn to relate the 0-100 scale calibrations to capacitance values. It is evident that the instrument finds useful application wherever an AC ohmmeter is required. For example, one can measure the impedance of inductors with an AC ohmmeter, check the input impedance of a transformer, etc.

Screen-Circuit Tests

If normal DC voltage is not measured at the screen in Fig. 5-6, the screen resistor may have increased in value. When the screen-dropping resistance is too high, the picture becomes narrow. Too high a screen resistance reduces the DC voltage to the screen grid, which limits the power from the tube. In case the screen bypass capacitor is open, the signal amplitude at the screen grid increases, although the DC voltage decreases. The screen-grid circuit operates as a triode plate-load circuit. When the load impedance is increased, the screen-signal voltage increases. In a beam-power tube, however, the useful power is not supplied by the screen grid, but by the plate. The screen-grid signal is 180° out of phase with the control-grid signal.

The screen grid has an amplification factor which is less than the control-grid factor. For this reason an increase in screen-signal amplitude reduces the output from the plate. Or, the unbypassed screen-grid has a degenerative action. A check of signal voltage at the screen terminal with a peak-to-peak probe will locate an open screen-bypass capacitor.

Check of Cathode Current

It is easy to measure the cathode current of a horizontal-output tube; if there is a cathode resistor in the circuit. Connect the DC-voltmeter-test leads across the cathode resistor and observe the reading on the DC scale of the instrument. Determine the value of the resistor, and calculate the current by Ohm's law. Align the drive and linearity controls as follows: adjust the horizontal-drive control for minimum current; maintain full sweep width without drive lines. Adjust the horizontal-linearity coil for a current dip or for minimum current without picture distortion. The meter indicates average cathode current. (Tube manuals give maximum ratings for both peak and average currents.) The 6BQ6 is rated for a maximum of 110-ma cathode current; 6CD6, 200 ma; and 6DQ6, 140 ma.

Screen Dissipation

Short tube life can also result from excessive screen dissipation. This too, is a simple measurement. Connect the DC-voltmeter-test leads across the screen resistor and connect the leads from the screen terminal to the cathode. Observe the reading on the DC scale of the voltmeter. Note the color-coded value of the screen resistor (or measure value of screen resistor by using an ohmmeter with the set turned off). The screen dissipation is calculated by the formula:

$$P_s = \frac{E_s \times E_{SR}}{R}$$

where,

P_s is the screen dissipation in watts,
E_s is the screen voltage,
E_{SR} is the voltage drop across the screen resistor,
R is the value of the screen resistor in ohms.

Check the value found for screen dissipation against ratings for the tube as specified in the tube manual. If the screen dissipation is excessive, increase the value of the screen resistance.

Output- and Damper-Tube Voltage Measurements

If a high-voltage DC probe with a VOM or a VTVM is used, one can safely measure DC voltages at the plate of the horizontal-output tube, or at the cathode of the damper tube. Connect the probe- and shielded-output cable into the meter jacks in place of the usual test leads. Apply the probe to the horizontal-output plate (cathode of damper tube or horizontal-deflection coils), and connect the shielded-cable braid to chassis ground. Observe the readings on the DC-volt scale of the VOM, and multiply that reading by two (for the probe described next) to obtain the DC-voltage value, or by the scale factor appropriate to the particular probe.

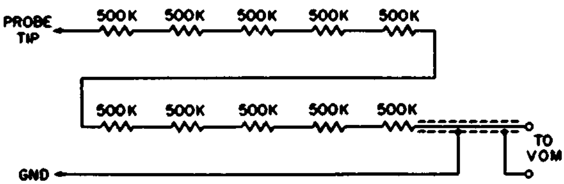


Fig. 5-11. A high-voltage DC probe for use with a VOM.

Construction of a typical home-made high-voltage DC probe is shown in Fig. 5-11. Ten 500-K, ½-watt resistors are connected in series. When this probe is used with a 20,000 ohms-per-volt VOM having a 250-volt DC range, the indication is one-half the value obtained with the usual test leads. The series resistance of 5 megohms, working into the shunt capacitance of the shielded-input cable, operates as a low-pass filter. This filter permits the VOM to measure the DC voltage at the point under test, but suppresses passage of high AC-voltage pulses into the meter. (A single 5-megohm resistor must not be used because it will arc over and break down).

Self-Oscillation in the Sweep System

There is at least one make of chassis designed with a horizontal-sweep system that breaks into oscillation in the event of drive failure. This is a fail-safe measure, and is done to prevent loss of signal-developed bias on the grid of the output tube. Since these oscillations are off-frequency, the screen remains dark. The beginner can be confused by this type of chassis, because signal voltage is measured throughout the sweep system, although there is no drive voltage from the horizontal oscillator.

Damper-Circuit Troubleshooting

The three principle types of damper circuitry are illustrated in Fig. 5-12. In the transformer configuration (Fig. 5-12A), the high-voltage pulse appears at the plate of the damper tube. The damper cathode is connected to the boost-B+ or low AC, side of the circuit. (The boost voltage (B++) is generally less than 600 volts DC.) The damper heater is connected to the cathode to eliminate the possibility of arcing between the two, but this makes the heater hot. For this reason, a separate winding on the power transformer is used for the damper heater. If this winding becomes grounded or arcs to ground, the transformer must be replaced.

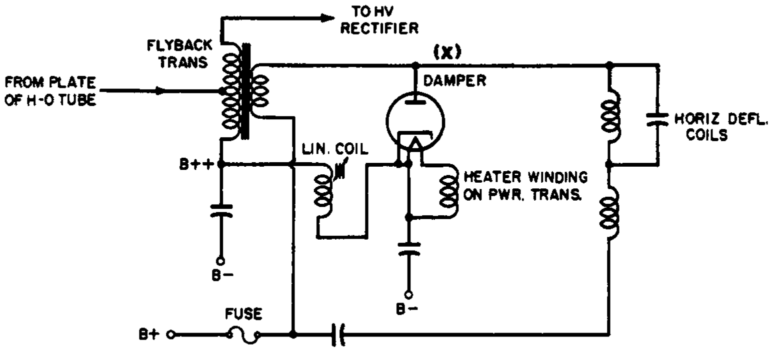
Fig. 5-12B shows a direct-drive configuration. Here the high-voltage pulse appears at the cathode of the damper tube. (The peak-cathode voltage may run several thousand volts above ground.) The heater winding is not only well insulated from the power-transformer core; but it also has comparatively low capacitance to ground to provide proper damper operation. Heater and cathode are connected together to prevent arcing. If the power transformer must be replaced, be sure to use the correct type. Haphazard replacement can result in arcing; and even if the winding can withstand the high peak voltage, the high capacitance to ground will result in a narrow picture or dark screen.

Flyback Fuses

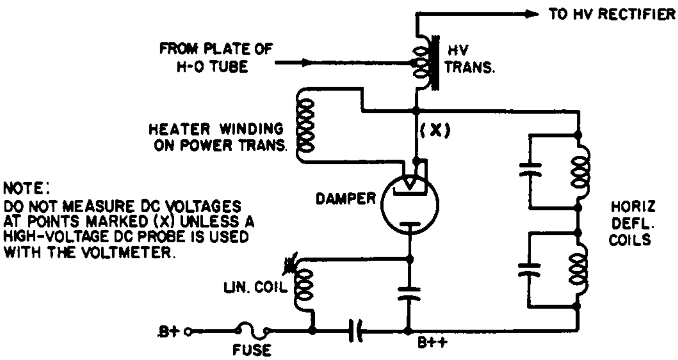
Figs. 5-12A and 5-12B have a fuse in B+ line. Sometimes a momentary arc-over in the damper or horizontal-output tube during the warmup will blow the fuse and black out the screen. In such case, it is advisable to use a special flyback fuse (commonly called a chemical fuse). Of course, if a special fuse does not hold, a definite circuit trouble is present and must be tracked down. Fig. 5-12C shows a basic autotransformer configuration. As before, the damper cathode is at a high pulse potential, and the same considerations of heater-winding insulation and capacitance-to-ground apply. (The heater is connected to the cathode to prevent arcing.)

TRANSISTORIZED SWEEP CIRCUITS

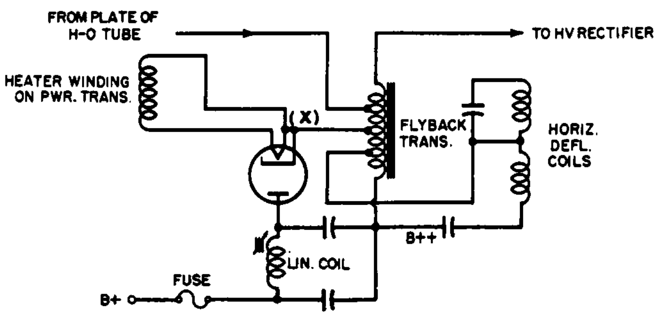
A typical transistorized horizontal-deflection system is shown in Fig. 5-13. A buffer and amplifier and an emitter-follower driver are used between the horizontal-oscillator and horizontal-output stages. These stages generate the power for driving the output transistors. Failure of the drive voltage cuts off the transistors in the output stage to protect them from damage. In



(A) Transformer coupled.



(B) Direct coupled.



(C) Autotransformer circuit.

Fig. 5-12. Three common types of damper circuitry.

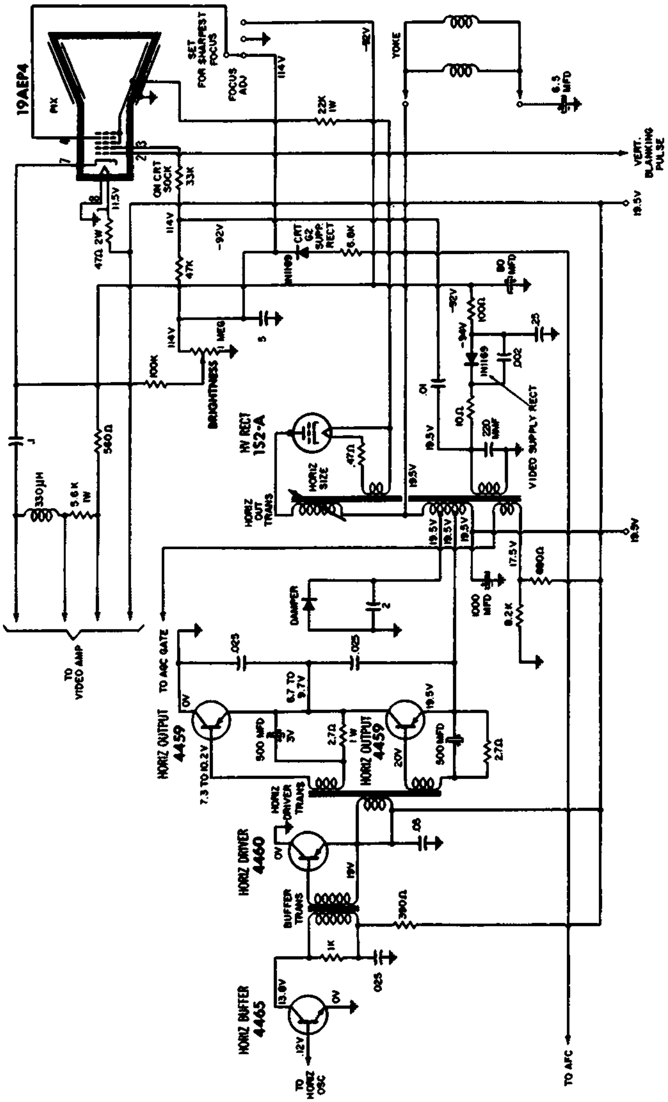


Fig. 5-13. A typical transistorized horizontal-sweep section.

case of horizontal-sweep symptoms, check the bias at the base of the output transistors first—it should measure between 7.3 and 10.2 volts. This bias is determined by the 2.7-ohm resistors between emitter and base; if they change in value, the bias will go up or down accordingly. Higher bias requires more drive voltage and causes a narrow picture; while lower bias prevents the transistors from saturating. Lower bias also increases internal resistance of the transistors and, in turn, their power dissipation. The latter condition can damage the transistors.

Off-frequency operation of the oscillator, or badly distorted drive waveforms, can also damage the output transistors by exceeding their rated dissipation. If a defective transistor is suspected, check the base-to-collector resistance with an ohmmeter—a short circuit confirms the suspicion. Do not try to draw an arc from the high-voltage circuit, or you may damage an output transistor (corona at the high-voltage rectifier can also damage a transistor). Silicon rectifiers are used in auxiliary flyback circuits to provide both a positive bias to the picture-tube cathode, and a negative supply voltage to the video amplifier tube.

Horizontal width is controlled by an adjustable air gap in the output-transformer core. This adjustment also affects the high voltage. The damper is a semiconductor diode which prevents ringing of the deflection waveform. No boost circuit is used. The horizontal-deflection coils are connected in parallel to minimize ringing and to provide a suitable impedance match to the output circuit.

To troubleshoot this circuit (Fig. 5-13), trace the drive waveform from the input of the buffer to the output of the driver stage with a peak-to-peak probe and VTVM. If the drive is weak or absent at some point, make DC voltage, resistance, and capacitor checks to close in on the faulty component.

Resistor or capacitor defects are the most likely cause of trouble in the output circuit; and may in turn, burn out the output transistors. A weak high-voltage rectifier tube will cause the picture to bloom. There may be a defect in the horizontal-output transformer, yoke, or semiconductor diodes; but these are less probable trouble areas than the others discussed above. Although the horizontal-deflection system is not simple, and it differs from its vacuum-tube counterpart in several ways, the systematic approach which has been described will help avoid waste of time in troubleshooting.

High-power transistors have the same basic construction as low-power ones, except for their increased size. They are often mounted on a metallic heat sink (such as an aluminum radiator or plate) to reduce their operating temperature and permit the handling of appreciable power. The basic difference between a power transistor and a conventional junction transistor is the higher current-handling capacity of the power type. Often, the DC operating voltages are the same for both types; however, power dissipation and heating are higher in the power type. Because the junctions in the power transistor are larger, the internal capacitances are higher, the maximum operating frequency is lower, and input and output impedances are lower than in conventional transistors. The flyback time is somewhat longer in a transistorized-sweep circuit, than in tube-type circuits.

CHAPTER 6

Vertical-Sweep Section Servicing

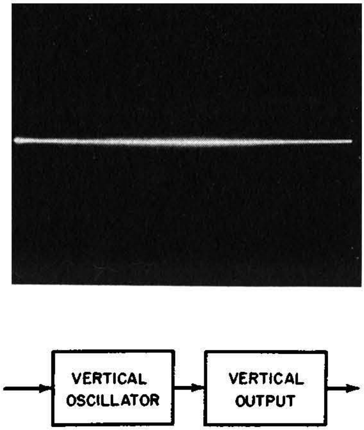
The function of the vertical-sweep circuit in a TV receiver is to generate and build up a 60-cycle signal that will produce a sawtooth current in the vertical-deflection coils. This waveshape, together with the properly shaped 15,750-cycle signal in the horizontal coils of the yoke, deflects the electron beam in the picture tube to produce a raster on the screen.

TESTS AND OBSERVATIONS

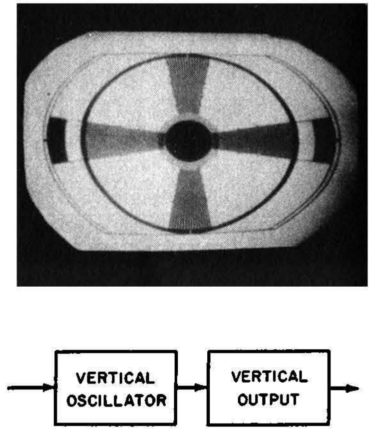
Several common trouble symptoms in the vertical-deflection system and associated circuit sections of a TV receiver are shown in Fig. 6-1. Lack of height that cannot be corrected by adjustment of the height control can be caused by several defects. The B+ supply voltage to the vertical section may be low, a fixed resistor in the height-control circuit may have increased in value, or a capacitor may be leaky.

Absence of vertical deflection can be caused by defects anywhere in the vertical system. The vertical oscillator may be dead, or there may be a short or open in the vertical-output circuitry—a defective capacitor, for example. Another possibility is a defective vertical-output transformer. A very practical test for checking the vertical sweep is to rapidly turn the vertical-linearity control and note whether the line jumps on the picture-tube screen—if it does, the output stage is working. Likewise, rapidly turning the height control will cause the line to bounce if the discharge, coupling, and output circuits are all right.

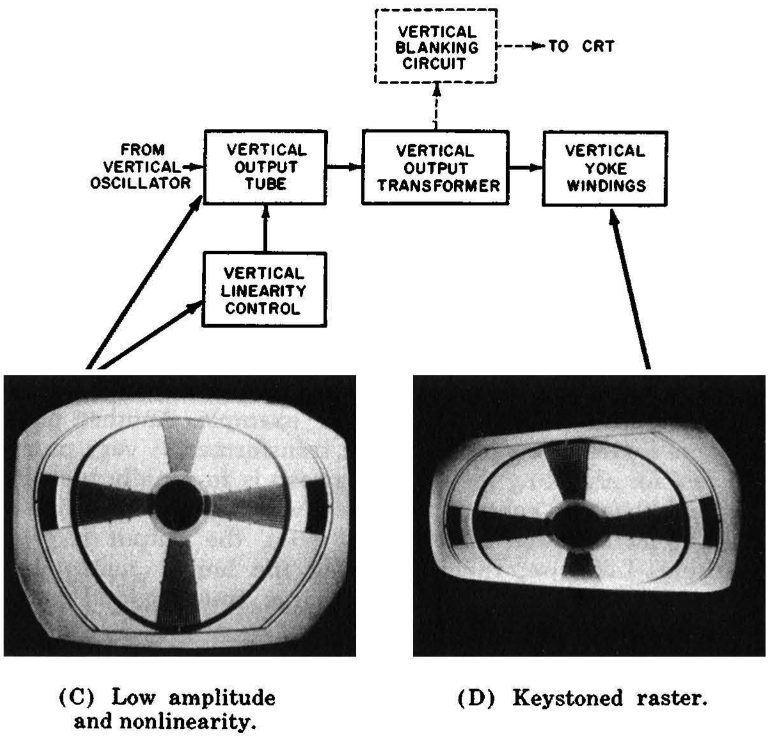
Sixty-cycle hum deflection is often caused by heater-to-cathode leakage in a tube but can result from less obvious circuit troubles such as an open grid that is picking up stray fields. The characteristic symptom is a picture which appears to be rolled up on a cylinder.



(A) Loss of vertical deflection.



(B) Low deflection amplitude.



(C) Low amplitude and nonlinearity.

(D) Keystoned raster.

Fig. 6-1. Some vertical-section trouble symptoms and the associated circuits.

Excessive height points to excessive plate or screen voltage on a tube in the vertical section. A shorted dropping resistor, defective height control, or similar defects can raise the plate screen voltage. The opposite symptom—insufficient height—is the more common symptom.

Foldover at the bottom is almost always caused by a defect in the output circuitry. Incorrect grid bias, which can bleed through a leaky coupling capacitor, is a common offender. Similarly, incorrect cathode bias (as might result from a leaky bypass capacitor or a change in the biasing resistor) can produce the same picture symptom.

Keystoned raster (vertical keystoning) usually points to a short in the vertical-deflection coils—one of the deflection coils breaks down and produces a short between layers. Infrequently, a damping resistor across one of the coils arcs through, and in effect, is shorted. In addition, in some chassis it is possible for an open decoupling capacitor to cause keystoning symptoms.

The vertical oscillator-and-output section is straightforward, particularly in older-model receivers which utilize separate oscillator and output stages. Modern receivers lean toward simplified circuitry in which the two functions are combined, as shown in Fig. 6-2. In this type of circuitry, interaction of oscillator and output functions results in some added complexities of trouble analysis.

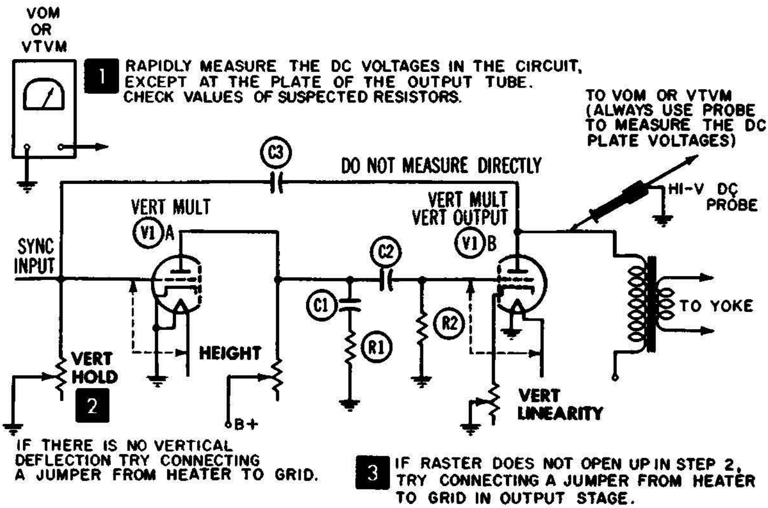
VOM Check of Deflection Voltage

As surprising as it might seem, a VOM can be used to check for the presence of sawtooth voltage across the vertical-deflection coils. With the VOM switched to its *output* function, connect the test leads to the terminals of the vertical-deflection coils. (If it is not operated on the output function, the VOM may be damaged by DC voltage at the vertical-deflection coils.) A reading of several volts normally is obtained; of course, the reading depends on the type of yoke, size of picture tube, and voltage range. For comparison, a test can be made against a receiver of the same type in good operating condition. The VOM is not damaged in this test because the circuit is heavily loaded. This loading, which reduces the peak-to-peak voltage amplitude, would normally overheat the DC probe of a VTVM. (In a VOM test, always using the highest output range first and then lower ones as required to get an appropriate reading protects the meter from damage.)

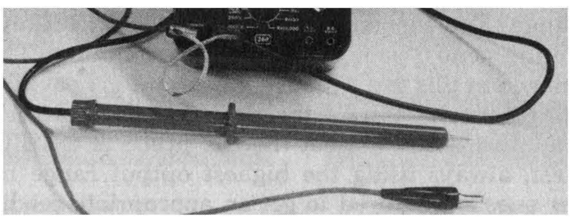
One can always check the deflection voltage with a peak-to-peak probe and a VTVM, provided the meter is rated for adequate voltage. Actually, this is the preferred test, because practically the true value of the deflection voltage will be read, and this can be compared with the value specified in the receiver service data.

Generation of Deflection Voltage

The two stages shown in Fig. 6-2 constitute a simple plate-coupled multivibrator that generates a peaked-sawtooth scanning voltage. This voltage produces a nonpeaked-sawtooth current flow through the deflection coils, because the coils have resistance as well as inductance. To generate this deflection voltage, one stage must conduct much longer than the other. (This prolonged conduction takes place in output stage V1B in Fig. 6-2.) Discharge section V1A remains cut off except



(A) Preliminary tests in the vertical circuitry.



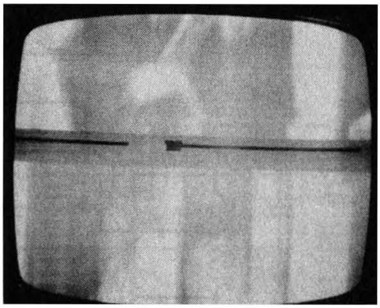
(B) High-voltage DC probe.

Fig. 6-2. Testing with the DC probe.

during the comparatively short vertical-retrace time (during passage of the vertical sync pulse). The "hammerhead", as seen in Fig. 6-3, is normally invisible on vertical retrace, but can be observed by adjusting the vertical-hold control to roll the picture down.

While V1A in Fig. 6-2 is cut off, C1 charges through R1 and the height control and develops a peaked-sawtooth drive waveform. The peaking pulse is developed by R1, which prevents the complete discharge of C1 through V1A during vertical retrace. C2 and R2 are used for coupling (DC isolation) only; and have no appreciable affect on the multivibrator frequency. This is an important difference between the combined-type vertical circuit and ordinary multivibrator. Grid bias on the output tube is determined to some extent by C2 and R2, as well as by the vertical-linearity control setting.

Fig. 6-3. The vertical-retrace interval seen here is normally invisible.



When a positive sync pulse arrives at its grid, V1A is triggered into conduction, in turn cutting off V1B. In the absence of a sync signal, V1A is free-running because of its grid-circuit time constant. The free-running frequency, however, is not as precise as when sync pulses trigger the conduction. When V1B is suddenly driven into cutoff, a positive-going pulse appears at its plate and is coupled back to the grid of V1A through C3. This feedback pulse drives the grid of V1A positive, and grid current flows. Immediately following passage of the pulse, C3 is charged negatively and V1A is therefore cut off. The output tube conducts, and the deflection waveform is coupled to the yoke coils via the output transformer. The sawtooth component is formed by the inductive opposition of the primary to current change.

The hold control provides for adjustment of the grid-circuit time constant. Thus, the discharge rate of C3 can be set so that successive sync pulses trigger the tube into conduction reliably. This means the oscillator will be set for a somewhat lower free-running frequency than the 60-cycle vertical-sync pulse rate. If the hold control must be reset often to keep the picture locked, replace it; worn controls can become unstable and drift in value. Of course, C3 can develop leakage, or an integrator fault can also cause the grid bias to drift. In either case, the hold control will have to be reset, but it is not necessarily defective.

Linearity and Size Troubles

Lack of vertical height can be caused by a defective output transformer, or low supply voltage to the vertical section. Electrolytic-decoupling capacitors may have lost a substantial portion of their capacitance, in which case, vertical nonlinearity will accompany lack of normal height. If nonlinearity consists of compression at the bottom of the picture, look for leakage in

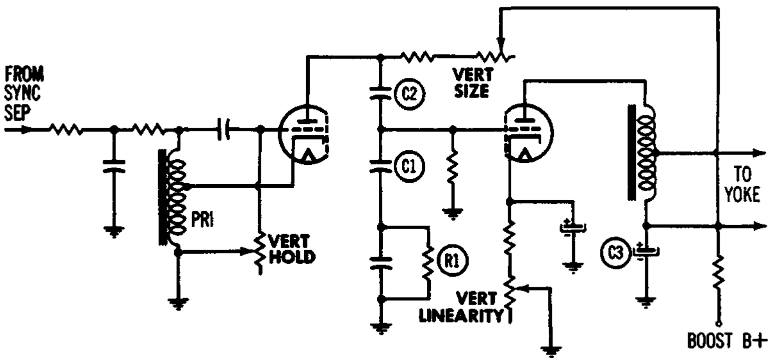


Fig. 6-4. Vertical oscillator and output configuration.

the sawtooth capacitor, such as C1 in Fig. 6-4. The same general symptom can also be caused by an increase in the value of R1 or leakage in C2. If the leakage in C2 is substantial, the bottom of the raster will be folded over.

When the top of the picture is compressed, look for a defect in the output circuit. The output tube may have too much bias, a defective cathode-bypass capacitor, or low plate voltage. Bunching of the lines at the top of the raster usually occurs in blocking-oscillator configurations, as shown in Fig. 6-4. It is often caused by residual magnetism in the autotransformer core. Transformer laminations sometimes change their metallic texture after long use, and become semipermanent magnetic iron. This condition is largely overcome by shunting a 15-K resistor across the primary section of the winding.

In case C3 is open, or nearly open, bunching occurs at both the top and bottom of the picture, and the central portion is expanded. This defect gives a test pattern with somewhat of a square appearance, instead of circular. Often, vertical lines in the picture will appear to be bent—an indirect symptom of linearity trouble, which is caused by the escape of the vertical-sweep voltage into the horizontal system. Keystoning, not caused by yoke trouble, may also be in evidence, in which case the raster appears narrower at the bottom than at the top. Bunching in the central region of the raster is a more

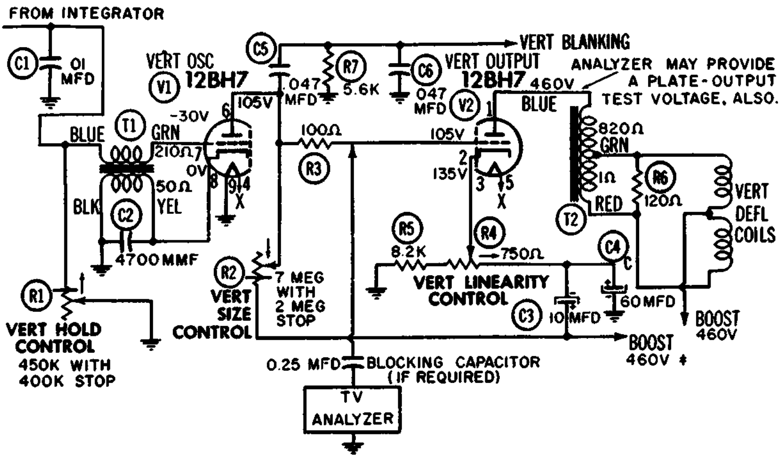


Fig. 6-5. Vertical-drive voltage can be applied from a TV analyzer.

difficult problem. Tube selection may help; otherwise, minor redesign measures may be in order, such as increasing the air gap in the transformer core. Another approach, in the class of expedients, consists of adding a 20-K resistor in series with a .05-mfd capacitor between the grid of the vertical-output tube and the high side of the yoke. This provides a negative-feedback branch which assists in reducing the scanning distortion.

Vertical Drive Substitution

Remember that in difficult situations, vertical-drive voltage from a TV analyzer can be applied, as shown in Fig. 6-5. If a normal raster appears, the trouble is definitely localized to the vertical-oscillator section. This test is more informative than if heater voltage is applied to the grid of the vertical-output tube. Some TV analyzers also provide for driving the vertical-output transformer. This is a useful test to distinguish between lack of height due to a defect in the vertical-output transformer, or to an RC fault in the output circuitry.

Intermittent Loss of Vertical Locking

Sometimes the vertical-hold control (Fig. 6-2) is thermally unstable. This causes the picture to break vertical sync at intervals, necessitating the resetting of the hold control. To check this possibility, touch a soldering gun to a terminal of the vertical-hold control. If the picture rolls vertically, replace the control.

Intermittent loss of vertical locking can also be caused by leakage in a coupling capacitor which changes value during operation. Suspected capacitors must be disconnected and checked on a capacitor tester, or a direct substitution test made.

Picture Rolling

Picture rolling points to faulty-incoming sync or to a defective component in the output stage. When thermal drift occurs, concentrate on the nature of the symptom, and then try monitoring the voltages in the suspected area, since any change in the operating voltage helps to pinpoint the trouble source. Rolling is a familiar vertical symptom—first determine whether the defect is in the sync section of multivibrator circuitry. This can usually be done by turning the hold control. If the picture can be framed momentarily, look for sync trouble. However, this conclusion will not apply in some cases of intermittent rolling. Hence, it is a good practice to make a peak-to-peak measurement of the sync signal at the point where the sync pulses enter the vertical circuit.

Signal Voltage Versus DC Voltage

Fig. 6-6 shows a multivibrator driving a vertical-output tube, with the normal peak-to-peak voltages indicated. Beginners are sometimes puzzled by the fact that a peak-to-peak voltage may either be less than, equal to, or greater than the DC voltage in the circuit. For example, at test point 1, the signal voltage is equal to the grid-cathode DC bias; but at test point 2, the signal voltage is 240% of the cathode DC bias. This condition exists because V1B drives an AC signal back into the cathode circuit of V1A. The signal voltage at test point 3 is 90% of the plate-cathode DC voltage; but at test point 4, the signal voltage is 350% of the grid-cathode DC bias. This occurs because V1 drives an AC signal through C2 into the grid of V1B.

Pulsating Sweep

A pulsating-sweep symptom occurs when the multivibrator is biased to a marginal oscillating threshold. In turn, small variations in line voltage and signal strength cause the vertical sweep to start and stop at irregular intervals. The most common fault of this trouble is a leaky coupling capacitor in the feedback circuit.

In the same category is a vertical-sweep system that works on active but not on inactive channels. This points almost definitely to an open feedback circuit. When the receiver is tuned to an active channel, the incoming positive-sync pulses key the discharge stage into conduction to produce a normal scan. Pulsating vertical sweep is occasionally caused by parasitic oscillation in the vertical-oscillator circuit. In such a case, 50-ohm resistors can be connected in series with the grid and plate leads (at the tube socket) to suppress the parasitic oscillations.

Vertical Blanking Circuit

Most receivers have vertical-blanking networks to cut off the picture tube during vertical-retrace time (Fig. 6-7). In theory, blanking should not be required; however, it is desirable in practice because viewers sometimes operate the picture tube at higher brilliance than normal, and this defeats the purpose of the blanking pedestals in the video signal. Also, not all receivers have DC-coupled video amplifiers. An AC-coupled amplifier intensifies the problems of retrace visibility. When an AC-coupled video amplifier is used, the operating point of the picture tube shifts with changing background brightness in the televised scene. As a result, retrace lines which do not appear in light backgrounds become evident in darker backgrounds.

As a picture tube weakens, the viewer automatically turns up the brightness control to compensate for lower screen illumination. This shifts the picture-tube operating point abnormally, and brings up the visibility of vertical-retrace lines. These considerations weigh in favor of vertical-blanking networks. If DC-voltage and resistance measurements do not indicate a circuit defect, check for the presence or absence of the blanking pulse with a peak-to-peak probe and a VTVM at points *A*, *B*, and *C* (Fig. 6-7). If coupling capacitor C1 is open or low in value, the blanking amplitude is subnormal at *A*.

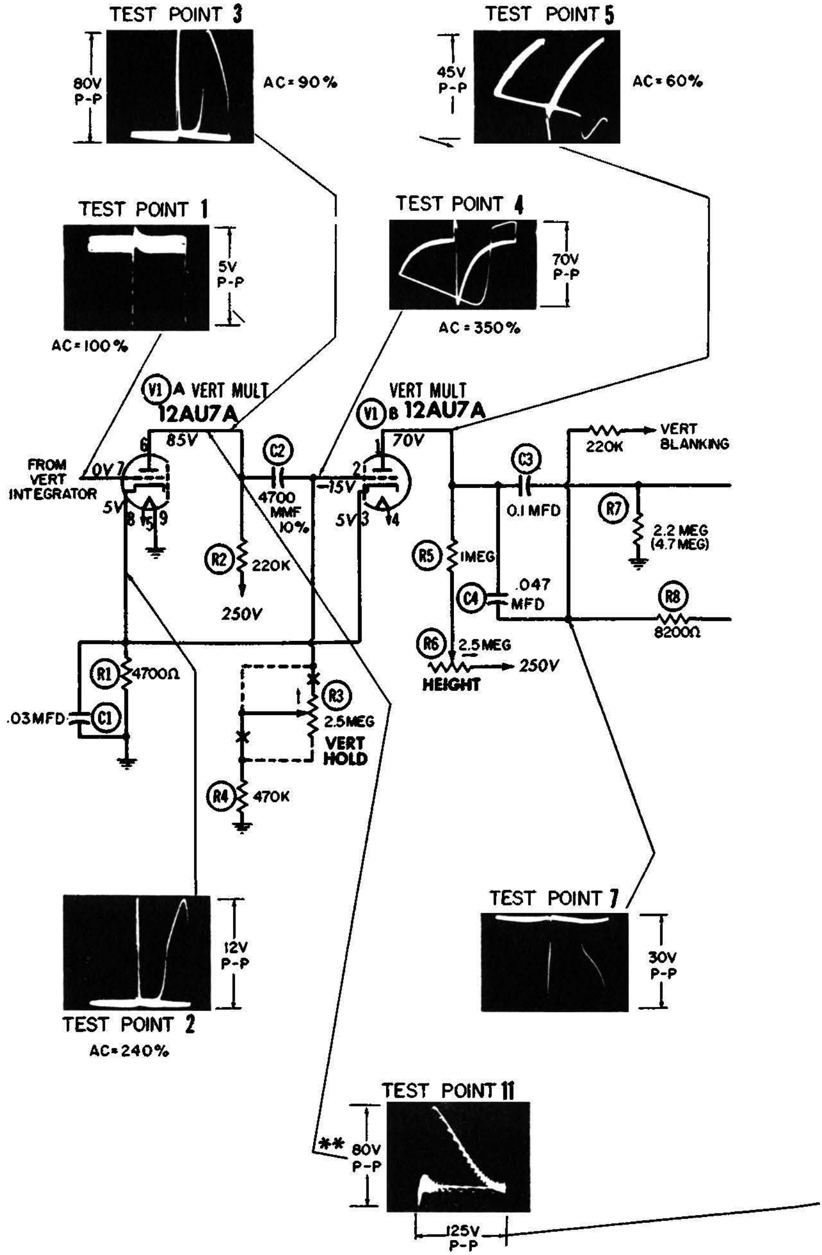
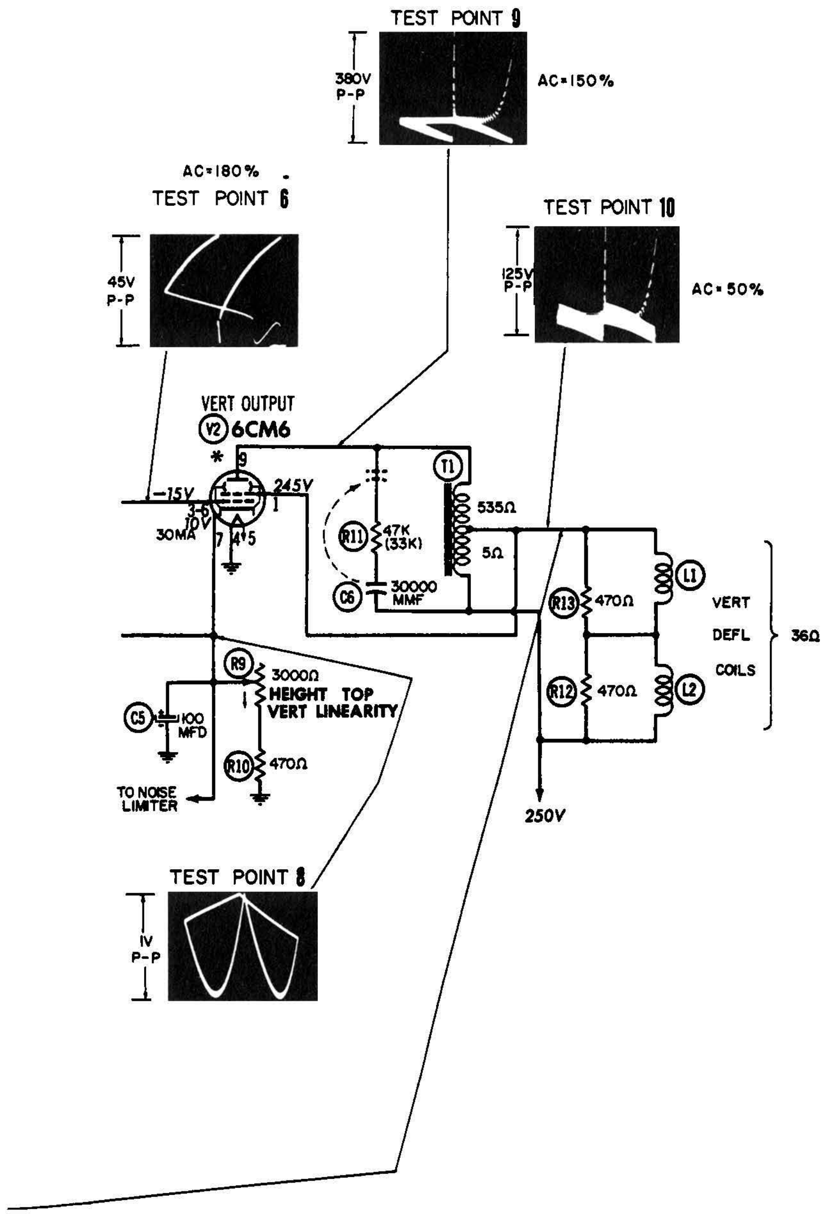


Fig. 6-6. Multivibrator driv



* DO NOT MEASURE UNLESS 100-TO-1 HIGH-VOLTAGE DC PROBE IS USED
** USE LOW-C PROBE TO CONNECT SCOPE TO TEST POINT 3

ing a vertical-output tube.

The VTVM will indicate zero volts, due to loading of the very high-impedance circuit. If C1 is open, the normal blanking voltage is found, of course, at the input end of C1 (point C). Note that leakage in C2 makes it impossible to lock the picture vertically.

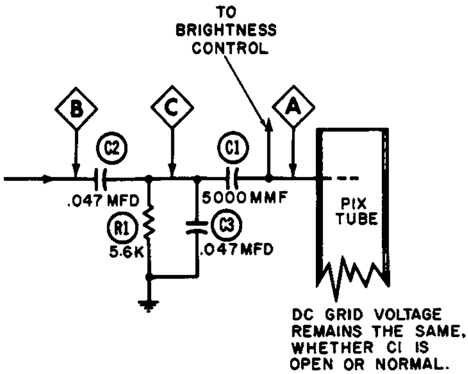


Fig. 6-7 Vertical-retrace blanking circuit.

R1 and C3 serve two functions: in combination with C2, this is a waveshaping network which changes the peaked-sawtooth input into a pulse output for proper blanking action. Thus, if C3 is open, a distorted peaked-sawtooth wave is applied to the grid of the picture tube, and proper blanking action does not occur. The blanking action is very uneven and part of the picture is dimmed or blanked out completely. The blanking network also has a voltage-divider action which prevents excessive peak voltage from being applied to the picture-tube grid. Although capacitor trouble is first to be suspected, be sure to check R1.

TRANSISTORIZED VERTICAL CIRCUITRY

Fig. 6-8 illustrates a typical transistorized vertical-oscillator and output-circuit. Stripped sync pulses from the phase inverter are passed through the integrator, which comprises a 5.6-K series resistor and .01-mfd shunt capacitor. Horizontal pulses are rejected by the low-pass filter action, and vertical pulses are integrated into trigger pulses which enter the vertical oscillator via the semiconductor-blocking diode and tertiary winding on the oscillator transformer. The blocking diode prevents interaction between the oscillator and sync-phase inverter.

When the oscillator transistor is triggered into conduction, vertical retrace takes place. Feedback from the collector to the base, through the transformer, causes a brief pulse of base-current flow and leaves the transistor cut off with a signal-developed bias of 16.5 volts at its base. The bias discharges to ground through the vertical-hold control circuit, and the transistor is almost out of cutoff when the next trigger arrives. At this time, the free-running frequency of the oscillator is slightly lower than 60 cycles.

The vertical-size control determines the emitter bias and, in turn, the amplitude of the collector output. The sawtooth component of the collector waveform is exponential (i.e., curved). To linearize the deflection waveform, an opposing curvature is produced by the vertical-output transistor via the feedback network, which includes the vertical-linearity control as a series resistance. Base bias on the output transistor can be set as required to compensate for tolerances on commercial transistors. Feedback also takes place through the output transformer, which is primarily a waveshaping component. The vertical-deflection coils are energized directly from the collector of the output transistor.

A conventional RC waveshaping network changes the peaked-sawtooth deflection wave into a pulsed waveform suitable for vertical-retrace blanking. A varistor shunted across the vertical-deflection coils, provides final linearization of the deflection voltage. Thus, the output transistor operates in Class-AB, while the oscillator transistor operates in Class-C (and the blocking mode). Varistors are semiconductors which change resistance value with temperature.

If there is no vertical deflection, use a peak-to-peak probe and a VTVM to find out whether there is drive to the base of the output transistor. If the drive voltage is missing, the oscillator is dead; next make voltage, resistance, and capacitor checks to localize the defective component in the oscillating network. On the other hand, if there is no vertical deflection, but drive is present at the base of the output transistor, check the output components. The 500-mfd capacitor between the deflection coils could be open, or the .025-mfd shunt capacitor could be shorted. Also, an open-yoke winding can cause the same symptoms. If the picture lacks height, has excessive height, or is nonlinear, check the varistor (preferably by substitution). If it is good, check the feedback capacitors for any

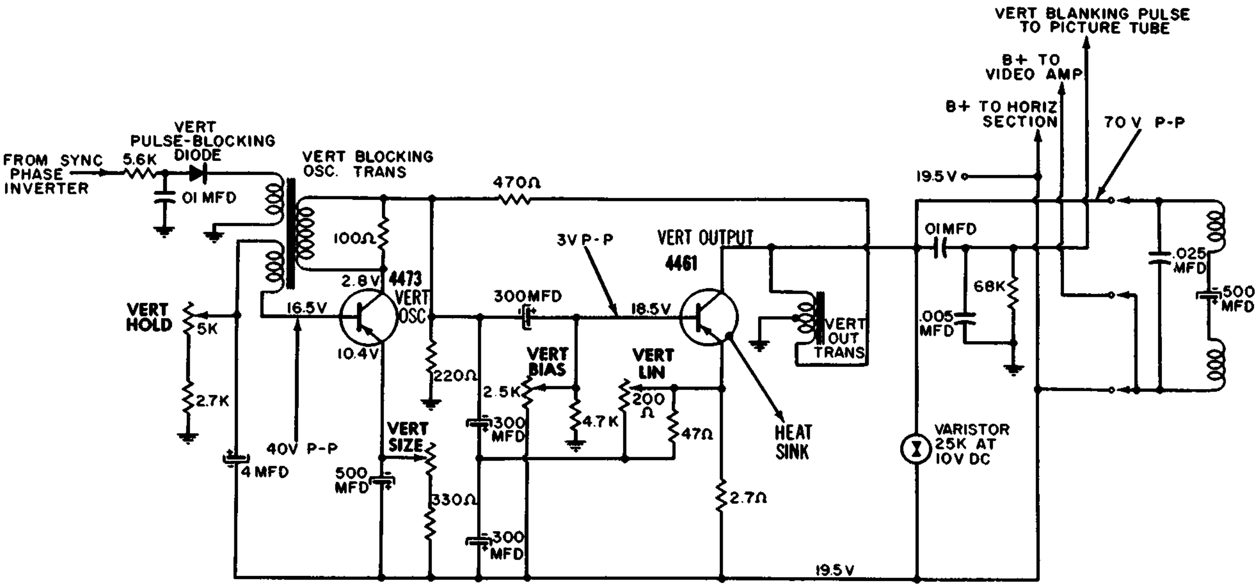


Fig. 6-8. The transistorized vertical-sweep section of a TV receiver.

change in value, leakage, or both. Vertical nonlinearity can also be caused by resistors that have changed in value.

In case deflection is satisfactory but vertical-sync lock is unstable or absent, check the vertical pulse-blocking diode and the integrator components. Unless recognized, leakage between transformer windings, or from winding to core, can cause obscure symptoms of scanning distortion and unstable operation. Like transistor failure, transformer defects are not usually expected but must be taken into consideration after the more likely defects have been eliminated from suspicion by the proper troubleshooting methods.

You will find that most of the signal voltages are higher than the DC voltages (Fig. 6-8). This is due to inductive kickback, and to high-level drive from the previous stage.

CHAPTER 7

Intercarrier Sound and Audio Section

The function of the sound or audio portion of the television receiver is to amplify the separated intermediate-frequency sound carrier, extract or detect the audio intelligence contained within this carrier, and then amplify the audio information to a power level sufficient to drive a speaker.

TESTS AND OBSERVATIONS

A typical intercarrier-sound and audio system is shown in Fig. 7-1. Some TV receivers have more stages than this, however. These include a 4.5-mc IF amplifier preceding the limiter, and an audio driver following the sound detector. A ratio detector, or sometimes a discriminator, is also used instead of a gated-beam detector. In all cases, basic signal processing occurs in this order: 4.5-mc amplification, partial or full limiting, FM detection, and audio amplification.

The sound take-off coil (or transformer) may be connected at the video-amplifier output, or the picture-detector output. Although the sound take-off transformer sometimes performs a double duty as a 4.5-mc trap in the video amplifier, occasionally a receiver in which the output from the last IF stage branches into a limiter may be found. In this type of system, the 4.5-mc signal is generated by heterodyning in the limiter instead of the picture detector. Another difference is that in a few receivers a slope detector follows the limiter; while in others, the audio-output stage also serves as a B+ voltage divider.

Circuit Loading

As indicated in Fig. 7-1, only an RF probe should be used to measure the signal voltage at test points *A, B, C,* and *D*. In checking narrow-band tuned circuitry, capacitive loading must be minimized, and a peak-to-peak signal-tracing probe will

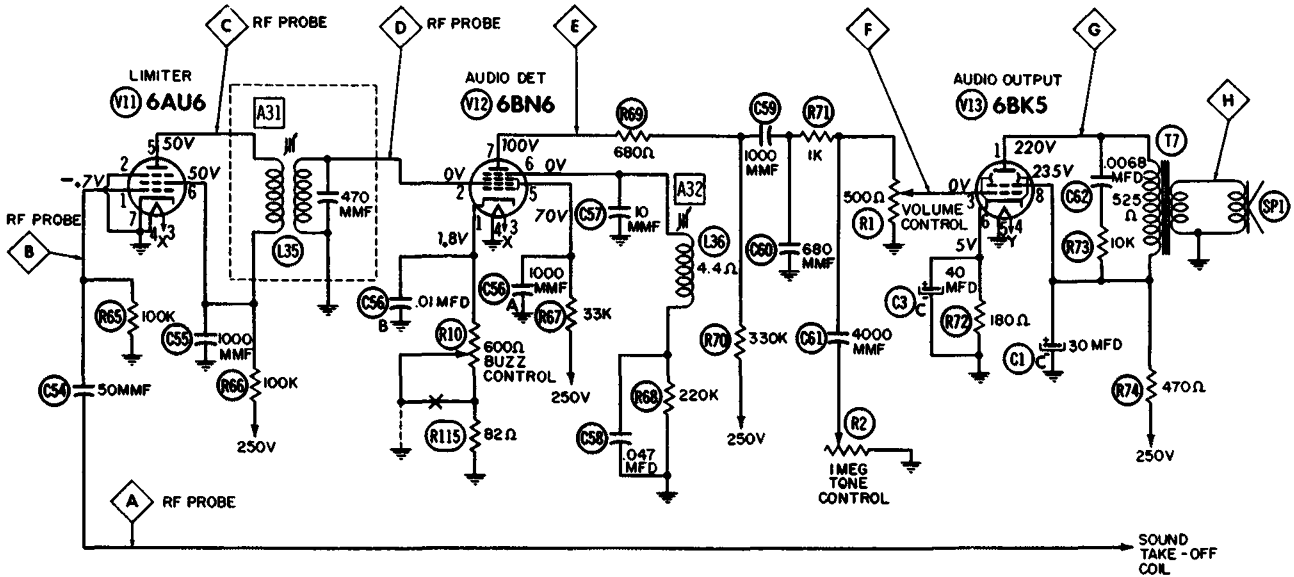


Fig. 7-1. Typical intercarrier-sound and -audio circuit.

kill the circuit response. If a peak-to-peak probe and a VTVM are used to trace the intercarrier sound signal, it is inevitable that false conclusions will be made regarding dead grid circuits. On the other hand, an RF probe does not load the grid circuits objectionably, and thus will give fairly accurate readings.

A TV-station signal, or a pattern generator with a 4.5-mc FM signal can be used to energize the intercarrier circuits. (The meter reading will jump up and down at some of the test points, if a TV-station signal is used.) If a modulated 4.5-mc sound signal from an ordinary AM generator is applied

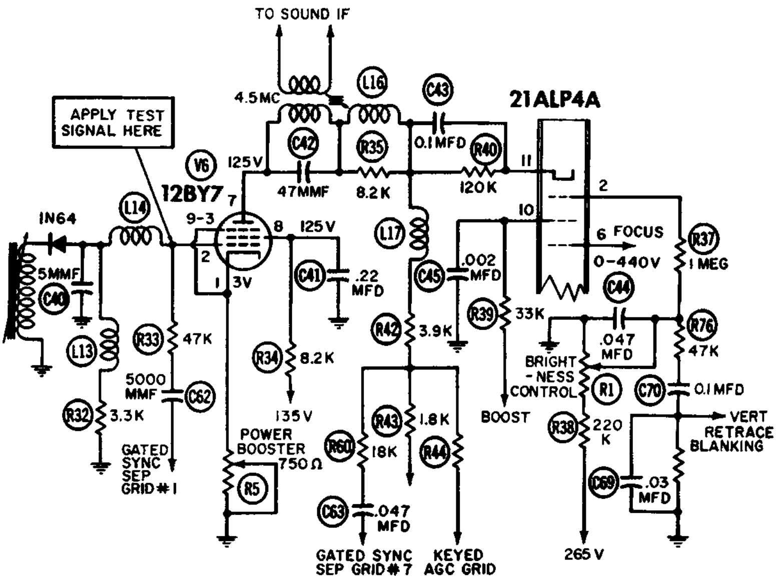


Fig. 7-2. Applying the intercarrier-test signal at the grid— not at the plate.

through a small blocking capacitor prior to the sound take-off point, it usually is possible to signal-trace the entire sound section. Offhand, this might seem to be impossible, because the limiter stage normally rejects amplitude modulation. On the other hand, most AM generators have appreciable incidental FM, particularly when set for high-percentage modulation. Incidental FM makes it possible for the generator to do double duty in testing the sound section.

If the limiter is saturated, amplitude modulation is reproduced at points *A* and *B*, but not at *C* (Fig. 7-1). As shown in Fig. 7-2, the generator output should be applied at the grid of the video-amplifier tube. If the signal is applied in the plate circuit at the actual take-off point, the 4.5-mc transformer will be detuned. Use a small blocking capacitor in series with the hot lead from the generator. This avoids possible drain-off of bias voltage in a grid circuit and possible damage to the generator and receiver in a plate circuit.

Limiter Action

A low-level output from the generator does not drive the limiter into saturation, and amplitude modulation accordingly is not rejected. This condition is analogous to weak-signal reception which may be noisy because the low-level intercarrier signal is below the limiter saturation point. As a rough rule of thumb, a 0.1-volt 4.5-mc signal injected at the output of the picture detector is normally expected to saturate the limiter.

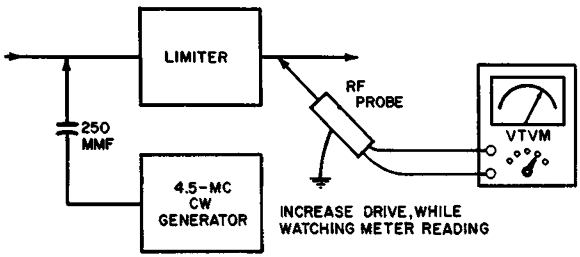


Fig. 7-3. Limiter saturation test.

Proper limiter action depends on correct DC supply voltages to the limiter tube and on good circuit components.

If the limiter is operating properly, the plate signal does not increase appreciably after a certain grid-drive voltage is passed, as depicted in Fig. 7-3. (Otherwise stated, the limiter is saturated.) In case the limiter does not saturate, there is a circuit fault present.

Approximately the same signal which is found at point *C* of Fig. 7-1 should also appear at point *D*. Otherwise the sound-IF transformer is defective or misaligned. An audio-frequency signal is normally present at points *E* through *H*. If not, check the DC voltages and resistances in the associated circuit. Also, if it is necessary to close in on the defective component, check the capacitors on a capacitor tester, or by substitution. Resistance checks can be made on coils, although this shows little beside continuity. If a coil does not tune satisfactorily, a substitution test is preferred. Electrolytic capacitors, if present, must be checked. Leakage or loss of capacitance can cause weak or distorted output, or both. Although numerous variations of sound-section circuitry are used in different chassis, the general principles are the same in all. It is necessary in each case to consult the receiver service data for specified voltages, resistances, and component values.

Inability of the limiter to eliminate amplitude modulation is one of the causes of sync buzz. Buzz modulation is generated in the IF amplifier, video amplifier, or both. It can also be intensified by misadjustment of the FM sound detector. If the modulation depth is excessive, audible buzz will be present, regardless of limiter efficiency. It is assumed here, however, that the IF and video amplifiers are operating properly, and that only a normal amount of buzz modulation is to be contended with by the limiter.

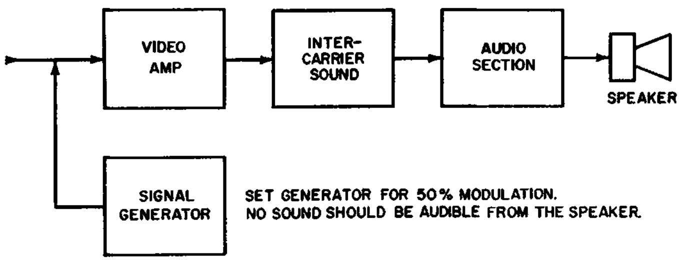


Fig. 7-4. AM rejection test.

The most severe demand is placed on the limiter stage when it is followed by a discriminator, because a discriminator has no inherent rejection of amplitude modulation. If you should be servicing a buzz complaint on a receiver of this type (they are in the minority, however), make a careful check of the limiter action. Up to 50% amplitude modulation should be completely wiped off both top and bottom of the test signal (Fig. 7-4). This does require an AM generator with very little incidental FM, because an adequate limiter stage will otherwise appear to be defective.

Less severe requirements are imposed on the limiter when followed by a ratio detector, because this configuration inherently can reject up to 30% amplitude modulation if operating normally. Ratio detectors should be preceded, however, with at least partial limiting, because misadjustment of the fine-tuning control, or too high setting of the contrast control, can otherwise lead to audible buzz and cause customer dissatisfaction. Again, if the ratio-detector alignment should drift slightly, partial limiting will assist in suppressing sync buzz.

A limiter becomes more effective as the plate and screen voltages are reduced (tube saturates earlier), but the peak-to-peak voltage output is reduced accordingly as shown in Fig. 7-5. A compromise between output level and limiting action is commonly made by the manufacturer.

Audio Distortion

The most common cause of distorted sound is clipping, which can result from low plate- or screen-supply voltages, or in-

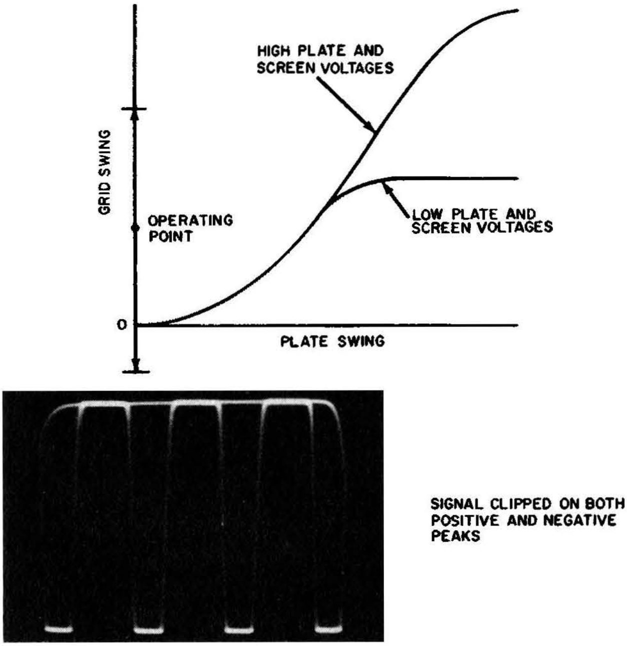


Fig. 7-5. Principle of limiter operation.

correct grid or cathode bias. This often results from a shorted cathode-bypass capacitor, or from a leaky grid-coupling capacitor. Leaky screen or decoupling capacitors can reduce the screen- or plate-supply voltage. Sometimes, resistors in the audio circuit increase in value and cause clipping distortion. These considerations are discussed in somewhat greater detail in a subsequent chapter.

TRANSISTORIZED SOUND SECTION

A typical transistorized sound section is shown in Fig. 7-6. As in many vacuum-tube counterparts of this configuration,

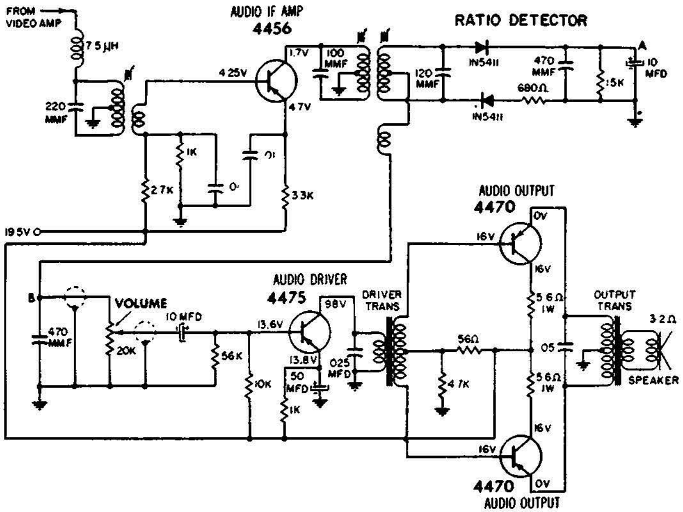
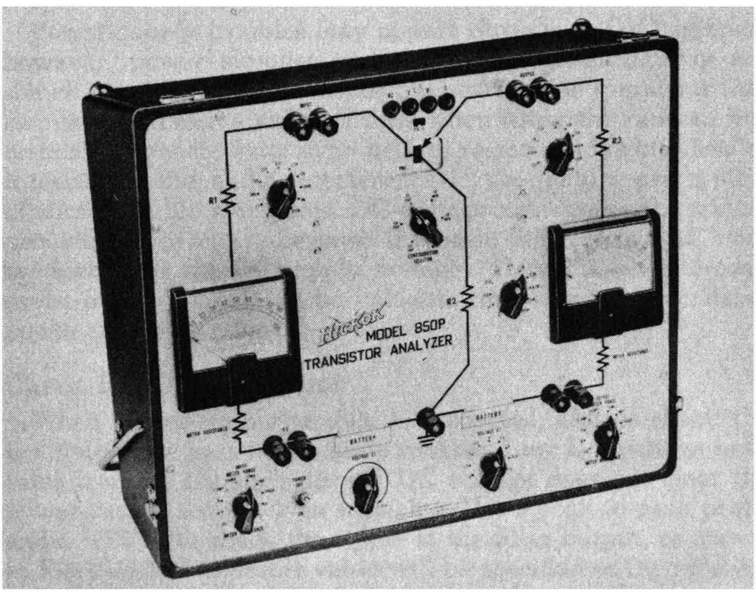


Fig. 7-6. Typical transistorized sound section of a TV receiver

the audio-FM amplifier has a limiting action, which takes place in the collector circuit. Subsequent limiting occurs in the ratio



Courtesy Hickock Electric Instrument Co.

Fig. 7-7. A transistor tester which provides a wide choice of test configurations.

detector, which utilizes a pair of matched 1N5411 semiconductor diodes. Output from the ratio detector is applied to a Class-A audio driver; and in turn drives a matched pair of 4470's operating in Class-B delivering 0.5 watt to the speaker.

Preliminary troubleshooting follows conventional signal-tracing techniques, as in the case of tube circuitry. After localizing a weak or dead stage, run down the defective component by making DC voltage and resistance measurements, supplemented by tests of suspected components.

A transistor tester such as illustrated in Fig. 7-7 is informative, because it gives the DC characteristics of the transistor in any configuration, and over any chosen range of operating current. However, even a simple ohmmeter test will spot a transistor which is definitely defective. The more elaborate tests serve to weed out marginal transistors which would be passed by an ohmmeter test.

CHAPTER 8

Power Supplies

Voltage for the filaments, and DC voltage for the plates and screen grids, are provided by the AC line voltage and low-voltage rectifier-power supply. The power supply changes the AC line voltage into the DC required for vacuum-tube operation. The filaments may be connected in series across the 117 volt AC line, or each filament may be connected in parallel across the 6- or 12-volt power transformer secondary.

TROUBLESHOOTING

Power-supply troubles may appear obvious to the beginner; however, power supplies and their associated circuitry are sometimes the source of various obscure trouble symptoms that can cause excessive waste of time when using the random hit-or-miss approach. Poor sync action, raster shadowing, loss of interlacing, and audio interference in the picture are typical of these trouble symptoms. DC-voltage measurements seldom provide useful clues, because the basic difficulty is AC contamination of the DC-supply voltages. Hence, a peak-to-peak probe and a VTVM can be valuable time-savers in localizing power-supply troubles.

Check B+ Voltage First

When power-supply trouble is suspected, always check the B+ voltage as part of the basic routine. Low B+ voltage indicates trouble, although normal DC voltage does not clear the power-supply section from suspicion. Use a peak-to-peak probe and a VTVM to check the ripple at the filter output, as shown in Fig. 8-1. The tolerable value will be specified in the receiver service data.

If the B+ voltage is low, whether semiconductor diodes or tubes are used first check the rectifiers. The rectifiers are worked hard, because considerable current must be supplied to the various circuits in the receiver; and thus one or more weak rectifiers will reduce the B+ output voltage. As a result, the picture will lack normal width and develop scanning nonlinearity.

Suppose you have measured the B+ voltage and find it low. Next, check the rectifier input voltage, and then the AC line voltage. If these two are normal, test the semiconductor rectifiers with an ohmmeter, power-rectifier tester, or by substitution. An ohmmeter will give a front-to-back ratio reading at low test voltage, but the reading is less reliable than the indica-

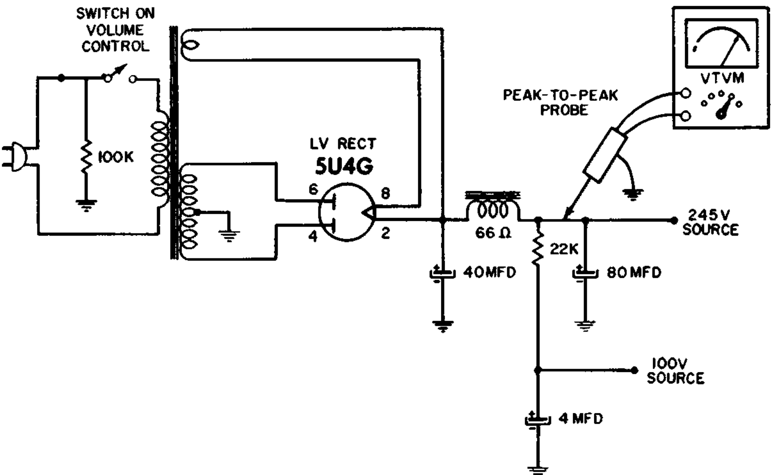


Fig. 8-1. Measurement of ripple voltage.

tion of a power-rectifier tester (or substitution). In tube-type rectifier configurations, the rectifier should be checked by substitution, because many tube testers do not pass enough current through the tube for a definitive test.

In case a filter capacitor is low in value, the picture will maintain its normal width but will show hum bars, a bent raster, or pulling. Check all filter capacitors at their normal working voltage and by substitution—not all capacitor checkers apply working voltage to the unit under test.

Dielectric Absorption

Due to slow release, dielectric-absorption ohmmeter tests of electrolytic capacitors are sometimes confusing. Fig. 8-2 illustrates the basis of the difficulty; if an electrolytic capacitor is charged and its terminals are then short-circuited, it might be supposed that there is no charge remaining. On the contrary, a DC voltage measurement will show that a charge

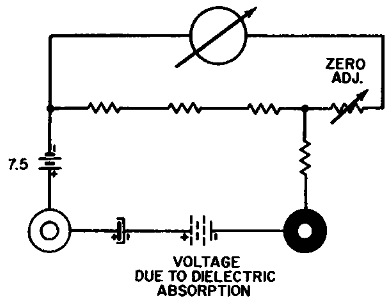


Fig. 8-2. Dielectric-absorption voltage adding to the ohmmeter battery voltage.

starts building up immediately after the short circuit has been removed.

In the event of an ohmmeter test, the dielectric-absorption charge adds to the voltage of the ohmmeter battery, and gives a false resistance reading. When switching ranges on the ohmmeter, the same difficulty is also encountered with an electrolytic capacitor that has stood idle for a long time. The applied voltage differs on adjacent ranges, so that dielectric absorption confuses the readings. Therefore, it is not good practice to check an electrolytic capacitor with an ohmmeter.

Power Factor

An electrolytic capacitor may lose a portion of its capacitance, develop effective series resistance, or become leaky. The latter defect appears in the form of a high-power factor, as illustrated in Fig. 8-3. Here, shunt resistance is located by a leakage test, but series resistance is found only on a power-factor test. The reactance of a capacitor is determined by its capacitance value; and in a half-wave power supply, the reactance at 60 cycles is most significant. However, in a full-wave power supply, the reactance at *120 cycles* is the more significant.

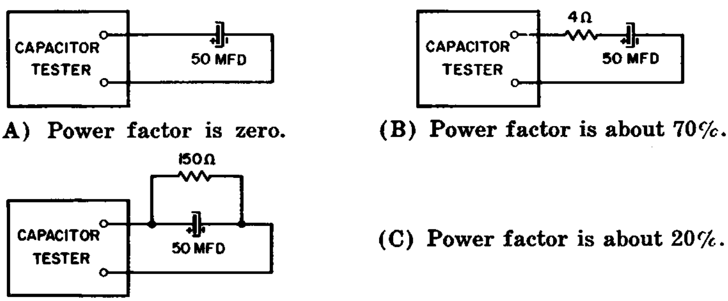


Fig. 8-3. Effect of series and shunt resistance on the power factor of a capacitor.

What is the meaning of the power factor which is indicated by a capacitor tester for an electrolytic capacitor? This is merely the phase relation between the voltage across the capacitor and the current into it. In an ideal capacitor, the current is 90° out-of-phase with the voltage (leads the voltage 90°), and the capacitor tester indicates a power factor of zero. On the other hand, if the capacitor has a very high series resistance, the current will be practically in-phase with the voltage, and the capacitor tester will read a power factor of almost 100%.

Even though an electrolytic capacitor has normal capacitance, its filtering action will be impaired if it has a high-power factor. This is due to the fact that series resistance tends to isolate the capacitor from its associated circuit. To put it another way, a high-power factor is the equivalent of a long time-constant. It prevents the capacitor from responding fast enough to the rise and fall in ripple voltage to effectively absorb the ripple.

In multiple-section electrolytic capacitors, leakage resistance sometimes develops between sections, as depicted in Fig. 8-3A. This resistance provides a sneak circuit which can cause baffling trouble symptoms. It can easily be missed in a routine test, if the capacitors are tested one-by-one. To check for a sneak circuit, connect an ohmmeter between a pair of open sections, as shown in Fig. 8-3A—normally, an infinite reading should be obtained. A more conclusive test can be made with a capacitor tester which provides working voltage.

Stacked B+ Circuitry

Many modern receivers use a stacked-B+ section for the power-supply system (Fig. 8-4) in which the audio-output tube doubles as a B+ voltage divider. Obscure trouble symptoms can arise if the 200-mfd capacitor becomes low in value. The DC-supply voltages remain about the same; but sound modulation appears in the picture, and sync action becomes unstable. A peak-to-peak voltage check at the output of the 240-volt power supply may show a ripple voltage below the maximum amplitude specified in the receiver service data. But, a check across the 200-mfd filter capacitor with a peak-to-peak probe immediately reveals the trouble.

When an audio-output tube is used as a voltage divider, the B+ voltage must be filtered once again in the circuit following the cathode of the tube. The reason is that the DC-supply voltage becomes contaminated with audio signal through the output tube.

DC Voltage Subnormal

In stubborn cases of low B+ voltage, disconnect all load lines from the power supply. If the B+ output voltage does not return to normal (or above), leaky filter capacitors may be draining excessive current and thus pulling down the voltage. On the other hand, normal output voltage means that the trou-

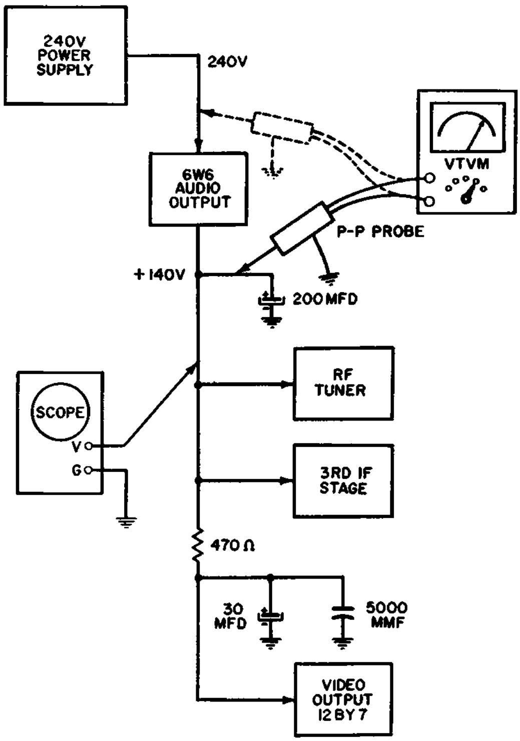


Fig. 8-4. Checking ripple voltage at both plate and cathode of the audio-output tube.

ble is due to excessive current-drain resulting from low resistance in one of the load circuits. Individual resistance measurements from each feedline to common ground may show which circuit is defective; or one line at a time can be reconnected and its effect noted on the B+ voltage. Each added line will cause the output to drop slightly; however, a marked decrease will occur when the defective branch is hooked in.

This procedure is slow, but there are no reliable short cuts for this type of trouble. (However, if the filter circuit is not leaky or short-circuited, some time can be saved by disconnecting the load lines, one by one, and checking the B+ voltage.) An interesting situation can occur in receivers using the audio-output tube as a voltage dropping resistor (Fig. 8-4). Here the voltage may be normal in the power supply itself, but low or absent on those stages which obtain B+ from the cathode of the audio-output tube.

In case tube replacement fails to restore normal voltage, one of the load circuits may be draining excessive current. Disconnect each load circuit individually and check the audio-output cathode voltage. Reconnect the circuit if the reading does not return to normal. Do not forget the filter capacitors connected to the cathode. Avoid disconnecting several load circuits at one time; as this will result in a misleadingly-high cathode-voltage reading. If the load circuits all check normal, but the low voltage still persists, make further tests of the components in the audio-output circuit. A low cathode voltage on this stage could be due to excessive bias, too high a plate resistance, or related troubles.

Wattmeter Monitor

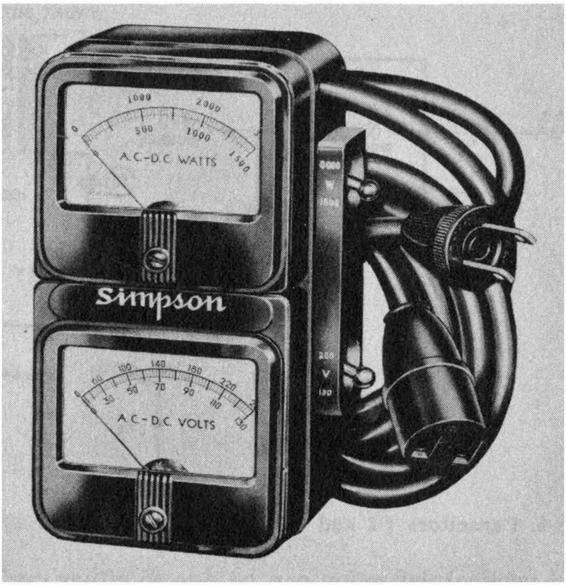
Some technicians prefer to monitor the power input to the receiver while making disconnection tests. A typical wattmeter, combined with an AC voltmeter, is shown in Fig. 8-5. This is a useful test instrument, because it shows if excessive power is being drawn by a defective power transformer.

If the power transformer runs too hot, it is being forced to supply too much current. The service data for the receiver will give the normal power consumption—which can be verified with a wattmeter. Exessive current consumption may mean a partial breakdown in the transformer, or a defect in the power supply. If any or all heaters are dark, look for a short circuit in the heater line(s).

As noted, one of the B+ supply lines could be drawing excessive current. It is often helpful to connect a wattmeter between the line and receiver while troubleshooting for an overheated transformer, low B+, etc. As supply leads are disconnected one-by-one, the wattmeter reading may drop to normal or below. If excessive power is being consumed when the power transformer is running idle, the trouble is certainly in the transformer.

With a series-string chassis under test, if the wattmeter pointer leaps, quivers, and falls back to zero when the receiver is first turned on, there is a burned-out tube. The momentary reading shows that the power supply charges up when the switch is thrown, but there is no heater drain and no current demand from the power supply.

The starting surge of power in a normally operating receiver is from 500 to 1500 watts. The wattmeter will then drop quickly to a reading of 70 to 100 watts, and creep up until the raster is about to appear. Then, as the horizontal system swings into operation, the wattmeter reading will rapidly climb to its normal value. There are a few exceptions, however. Trans-



Courtesy Simpson Electric Co.

Fig. 8-5. Typical wattmeter-voltmeter.

formerless chassis with silicon rectifiers have larger starting surges. On the other hand, a chassis which has temperature-compensating resistors for controlled-tube warm-up will show a much lower wattmeter reading at first plus a more gradual rise to normal power demand.

Receivers having a delayed B+ circuit will also show lower drop-back wattage readings; and when the delay device kicks in, a sudden rise in the wattmeter reading occurs. Open B+ protective-devices, rectifiers, and filters cause a lower initial reading; and after the power drain stabilizes, the reading will be about one-half normal value. This is a sure sign of power-supply trouble. On the other hand, a filter short-circuit causes the wattmeter reading to rise to an abnormally high value and stay there.

Suppose the horizontal-output tube is drawing excessive current (dark raster)—pulling the plate cap off the output tube will reduce the wattmeter reading to about 85% of its normal value. If the reading does not drop 15%, the power drain is elsewhere. Also, if the wattmeter reading is 15% below normal, look for a dead horizontal-output circuit (perhaps merely a blown screen fuse).

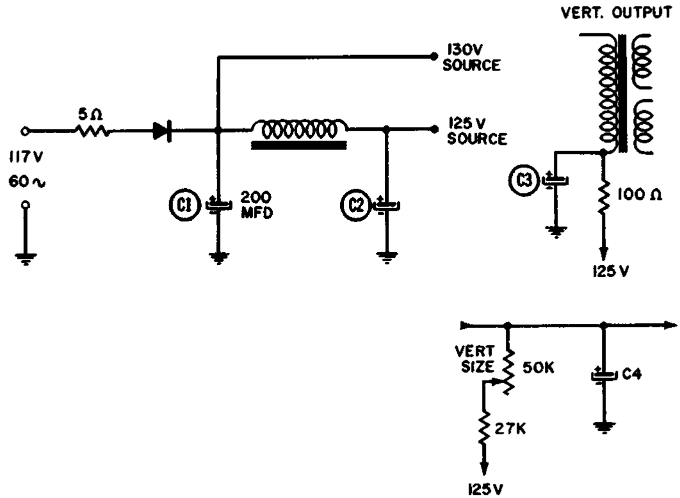


Fig. 8-6. Capacitors C2 and C4 are part of the filter system.

Loss of vertical deflection can be due to either oscillator or output-circuit trouble. If the oscillator is defective, the wattmeter will read nearly normal in most instances; but if the power reading is low, the trouble will probably be found in the vertical-output stage. The same analysis applies to no sound symptoms. In chassis with a power transformer, an inoperative stage can be localized by pulling the tubes, one at a time, while watching the wattmeter reading. If a tube does not change the meter reading when pulled from the socket, look for trouble in that stage.

Remote Filter Capacitors

In troubleshooting a power supply, do not make the mistake of overlooking remote filter capacitors (Fig. 8-6). Such capacitors are associated with other circuit sections, such as the vertical-output stage, vertical-oscillator stage, video amplifier, or audio-output circuit. Though they are called decoupling capacitors, they serve an effective filtering function. This is probably one of the beginner's chief oversights. It is necessary to analyze the circuit diagram for the particular receiver, since there are no general rules which can be laid down in this regard.

CHAPTER 9

Audio Amplifier Tests

Audio amplifiers are divided into two general classes: the first type is the utility amplifier found in most TV receivers, and the second is the high-fidelity amplifier found in others. Much less performance is demanded from a utility amplifier, and tests are less exacting.

CLASS OF OPERATION

Audio amplifiers are further divided into three general classes of operation. There are:

Class-A—an amplifier with grid bias and signal voltages such that the same average plate current in the tube flows at all times.

Class-AB—an amplifier in which the grid bias and signal voltages are such that plate current flows for appreciably more than half, but less than the entire electrical cycle. In this amplifier the average plate current increases as the signal level increases.

Class-B—an amplifier in which the grid bias is approximately equal to the cutoff voltage so that the plate current is practically zero when no signal voltage is applied, and so that plate current flows for approximately one-half of each cycle when signal voltage is applied. In this amplifier, the plate current increases, and the DC-plate voltage falls as the signal level increases.

NEGATIVE FEEDBACK

A negative-feedback circuit is sometimes called a degenerative circuit. A degenerative circuit is one in which a portion of the output signal is applied to the input of the same or a preceding tube in opposite phase to the input signal. (See R38, C29, and C31 in Fig. 9-1.) Two advantages of negative feed-

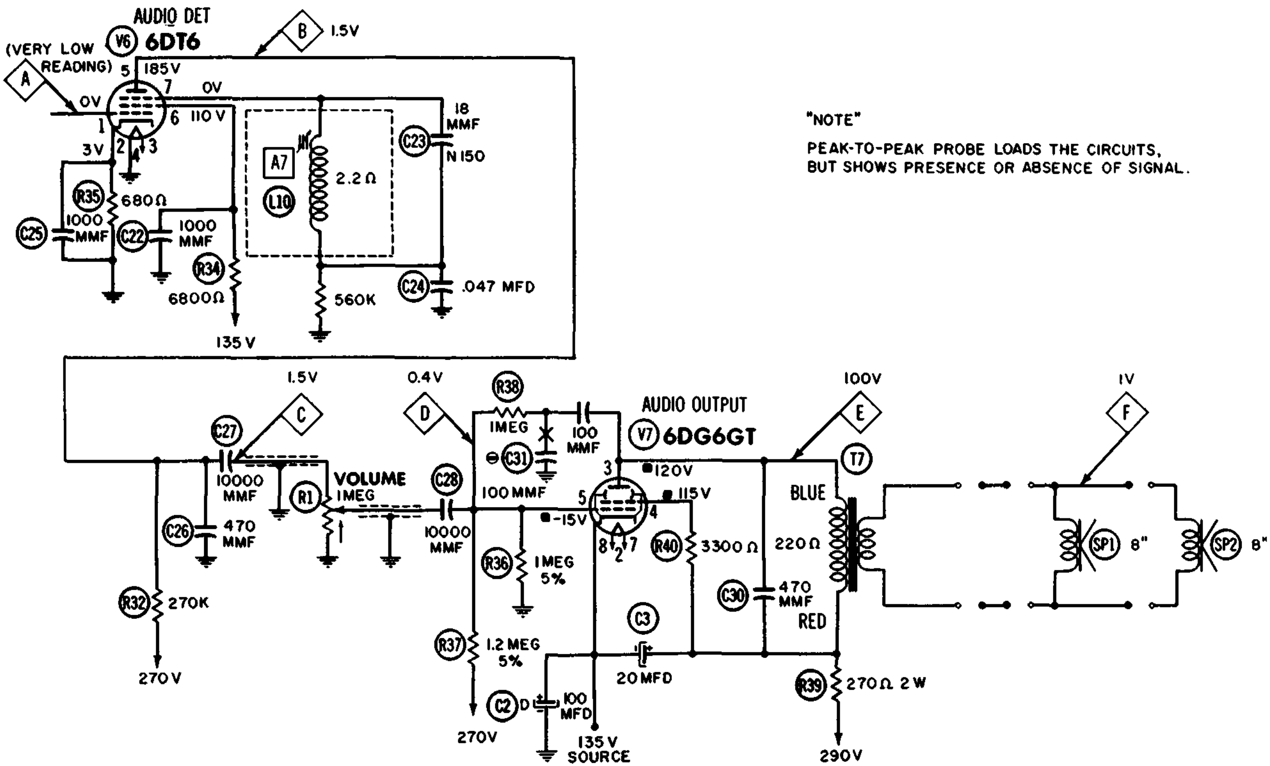


Fig. 9-1. Checking the audio signal from the audio detector to the speaker.

back are: (1) reduced distortion from each stage in the feedback circuit; and (2) reduction in the variations in gain due to fluctuation in line voltage, tolerances on tubes of the same type, or tolerances on values of circuit constants included in the feedback circuit. Negative feedback is used in audio amplifiers to reduce distortion in the output stage. Because the impedance of a speaker varies at different audio frequencies, the load impedance varies with the frequency variance. When the output tube is a pentode or beam-power tube, this variation in plate-load impedance can produce considerable frequency distortion unless negative feedback is used.

POWER AMPLIFIERS

A few power-amplifier circuits will employ power triodes; but, because a pentode or beam-power tube has a much greater power sensitivity, most will employ one or the other of these. Power sensitivity is the ratio of signal-power input to signal-power output. As an example, data from a tube manual shows that a 8.5-volt audio signal is required to drive a 6V6GT to its full output of 2 watts. From experience it is known that 470 K ohms is a standard grid load for a 6V6, and basic theory shows that power equals E^2/R. Therefore it can readily be determined that 0.154 milliwatts is sufficient to drive the tube to the limit.

Now look at a similar case with a 2A3 power triode. Again using data from a tube manual, it is seen that 45 volts of audio signal across a grid load of 500 K is needed to produce a maximum audio-signal output of 3.5 watts. Thus, by squaring 45 and dividing by 500 K, it is found that 4.05 milliwatts is required to drive this power triode to full output. Divide the output power by the input power in each case, and a comparison of the power sensitivities of these two tubes is the result; for the 6V6GT it is almost 13,000; while it is only 864 for the 2A3. The chief advantage of the power pentode or beam-power types over the power triode is, therefore, much greater power sensitivity. Power pentodes have only slightly less power sensitivity than their beam-power equivalents.

It was previously stated that voltage amplifiers employ plate-load impedances of fairly high values, (about 100 K ohms) and that plate current is normally on the order of a few milliamps. In power-amplifier circuits, just the opposite is true, i.e., low-impedance plate loads are employed and plate current is high (on the order of 35 to 50 ma for a single-ended stage and higher for push-pull stages). With the exception of the low plate-load impedance, high plate current, and large grid signal, the single-ended power amplifier operates much the same as a voltage amplifier.

TV AUDIO TESTS

In all television receivers, the audio system extends from the FM-detector output to the speaker. Trouble symptoms in this system include distorted or weak audio, or no sound at all. As shown in Fig. 9-1, use a peak-to-peak probe and a VTVM to trace the audio signal from the FM-detector output to the speaker. This will indicate immediately which circuits are working, and which are not. When the dead circuit is localized, make DC-voltage and resistance measurements in the preliminary steps for closing in on the defective component. Often, no further procedure is required.

A typical series of voltage readings are also noted in Fig. 9-1. The measurements made across high-impedance circuits are not the actual values but are nevertheless of obvious help in localizing a defective circuit. The same signal voltage will be measured at the plate of the audio-output stage, for example, no matter what peak-to-peak probe and meter is used. On the other hand, the signal voltage indicated at the audio-detector grid will vary from one probe to another, because of circuit loading.

Low Plate Voltage

In case the signal voltage is weak or absent at the plate of an audio tube, it is often found that either the plate or screen voltages, or both, are subnormal.

Low plate voltage can stem from the following causes:

1. Control grid less negative than it should be with respect to the cathode (Fig. 9-2).
2. Increased resistance in the plate circuit (Fig. 9-3).
3. Decreased cathode resistance.
4. Decreased screen-grid resistance.

Conditions 2, 3, and 4 can be checked out quickly. With the power switch turned off, simply measure the resistance in the plate, cathode, and screen-grid circuits with a VTVM or VOM. In order for the symptoms to be noticeable—such as weak volume—the resistance will generally have to change 50% or more; a 10 or 15% variation will hardly be noticeable. Note, too, that in conditions 3 and 4 the resistance decreases, whereas

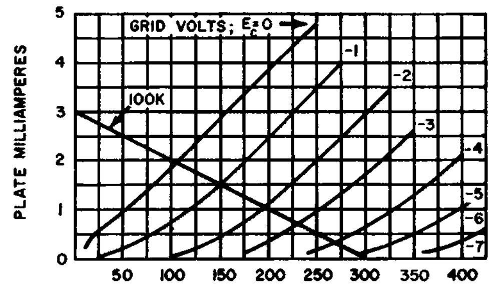


Fig. 9-2. Typical variation of plate voltage with grid bias.

in 2 it increases. In condition 3, the decrease will reduce the tube bias and cause more plate current to flow. In condition 4, a lower-valued dropping resistor will increase the screen-grid voltage—which will have a greater effect on plate-current flow than a comparable rise in plate voltage.

The screen grid makes plate current practically independent of plate voltage over a certain range. The screen grid is operated at a positive voltage and attracts electrons from the cathode. However, because of the comparatively large spacing between wires of the screen grid, most of the electrons attracted

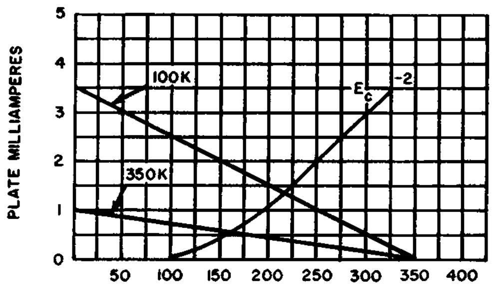


Fig. 9-3. Variation of plate-cathode voltage with load resistance.

to the grid pass through it. (The screen grid pulls electrons from the cathode to the plate.) The screen grid also shields the electrons between the cathode and screen grid from the plate, so that the plate exerts very little force on electrons near the cathode.

In condition 2, a decrease in resistance would raise the plate voltage. Next, consider condition 1; but from the standpoint that the lower bias is not being caused by a lower cathode resistance (as it is in condition 2). The trouble could stem from the tube itself, for example, if it is gassy. The preliminary tube check should reveal this condition, but only if you are alert to the possibility. However, if you are not, and the tube tester has no simple check for gas, this condition may easily pass unnoticed.

Another reason for condition 1 is a leaky coupling capacitor—when the grid resistor has a high value, not much leakage is required to upset the grid voltage. With a sensitive VTVM, check the voltage from grid to chassis (or to the low side of the resistor, if it is returned to a voltage source). The meter reading should be zero or slightly negative. Regard any positive voltage, no matter how slight, with suspicion—the grid is probably drawing current. Use the lowest DC-voltage range available—preferably 1 volt or less.

Caution in db Measurements

When measuring decibels with a VOM, always be sure to use the output function of the instrument, since the output circuit has a blocking capacitor which permits passage of AC, but blocks DC. This prevents damage to the meter from the DC-plate voltage. Since the blocking capacitor is often rather low in capacitance (0.1 mfd is typical), low audio frequencies will be attenuated by the capacitive reactance. Thus, the output function would not be used to check the frequency response of an audio amplifier. On the other hand, the output function is satisfactory to make db measurements, because the primary concern is with only a single frequency (400 cycles is typical). If one is not familiar with the effect of load (or source) impedance on db readings, he should refer back to the first chapter, which gives a brief summary of the considerations to be observed.

Regeneration

Positive feedback can occur when an audio decoupling capacitor is open, or has lost a substantial portion of its capacitance. In turn, the audio output becomes distorted—a tinny sound is characteristic of this defect. The same symptom is often noted when a negative-feedback capacitor is open. (C29 in Fig. 9-1.)

An open-decoupling capacitor, however, does not always produce positive feedback. This depends on the branch circuitry details. In some cases, an open decoupling capacitor will reduce the audio output, and make the sound boomy.

Grid Blocking

An open grid-leak resistance causes a wide range of sound distortions, from hissing, hum distortion, and popping, to rapid drift in output level. The particular symptom often changes when different tubes are plugged in. If the tube has a trace of grid emission, blocking will occur. This effect occurs when the floating grid becomes red-hot due to grid-current flow—often causing the sound output to stop, and the tube to overheat, generally to the point of destruction. Tube manuals specify the maximum grid-leak resistance which should be used with a given tube type.

Grid blocking is aggravated by a small amount of leakage in the coupling capacitor when the grid-leak resistance is open. B+ voltage bleeds through the leakage resistance and hastens the snowballing of grid emission. An open grid-leak resistance is also dangerous because all tubes contain traces of residual gas which cause a slight flow of current through the grid resistor. If the grid resistor is too large or open, the positive bias developed by the gas decreases the normal negative bias and produces an increase in the plate current. This increased current can overheat the tube and liberate more gas, which in turn, will cause further decrease in bias. The action snowballs and results in a runaway condition which can destroy the tube.

Overload Distortion

A 6AT6 voltage amplifier, with a plate-load resistance of 100 K ohms and a grid signal of 2 volts, can produce an output signal of 75 volts p-p, if the DC supply is 250 volts and bias is −2 volts. From tube manual data, it is seen that this exceeds the 8.5 to 12.5 volts p-p required to drive a single 6V6GT to full output. This explains why the sound on a TV receiver will distort when the volume control is turned to maximum.

Now you may ask, "Why is this excess gain built into an amplifier?" It is possible to hold the output signal down to the required level by simply adjusting the volume control; however, there is no control to make up for lack of signal. This high-gain factor is very useful in fringe areas where the signal at the grid of the audio amplifier is much less than 2 volts peak-to-peak.

Tracking Down Hum

To track down hum in a high-fidelity amplifier, an audio VTVM is needed. This type of instrument measures AC voltages on a range of 0 to 10 millivolts, for example. A typical tracing procedure is as follows: connect a resistive load across the output of the amplifier, to avoid excessive noise. Apply a test signal from an audio oscillator and adjust the volume control somewhat above the average listening level.

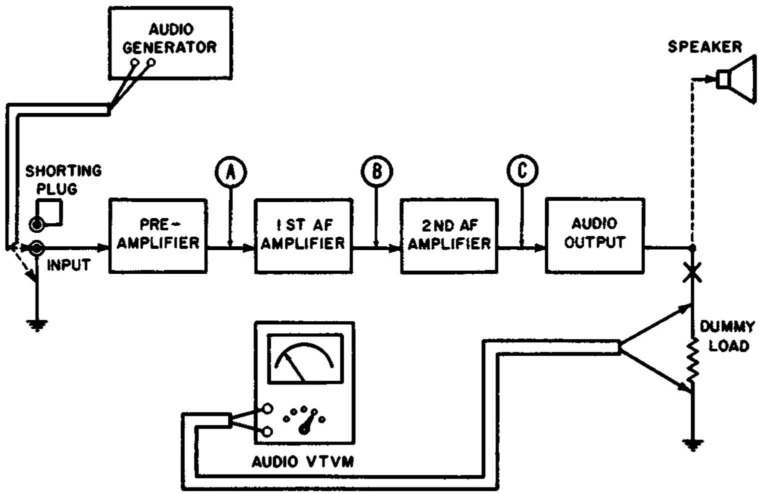


Fig. 9-4. Localizing a noisy amplifier stage.

Connect the audio VTVM across the dummy load. A voltage reading of 0.6 volt and −2 db is typical. Next, remove the audio oscillator and insert a shorting jack into the amplifier-input connector. Reduce the range setting of the VTVM to obtain a reading; this indicates the internal hum or noise level of the amplifier. A reading of .003 volt is typical, or −48 db. Or, the hum level in this example is −42 db down. However, in a high fidelity amplifier, the hum and noise level should be 50 to 60 db down. Try adjusting the hum-level control, to see if the level can be reduced to −60 db, or more.

When excessive hum or noise is encountered in an amplifier, one can often isolate the cause by monitoring the hum level as various points are grounded, such as *A, B,* and *C* in Fig. 9-4. If the meter reading drops substantially, the stage which is causing the trouble has to be isolated. The same procedure is useful for isolating power-supply ripple and turntable rumble.

CHAPTER 10

Servicing AGC Troubles

AGC defects are often mistaken for signal-channel trouble. However, there is a simple method of determining whether the AGC system is at fault. Because of its very high impedance, the AGC bus can be made inoperative by simply connecting the negative terminal of a small battery (or bias pack with low internal resistance) to it and the positive terminal to chassis ground (this is called clamping the bias) as shown in Fig. 10-1. A bias of −3 to −4.5 volts is regarded as normal, but the value will vary according to chassis and reception area. If a pattern generator, is used, the RF-output level can be adjusted to accommodate the bias voltage.

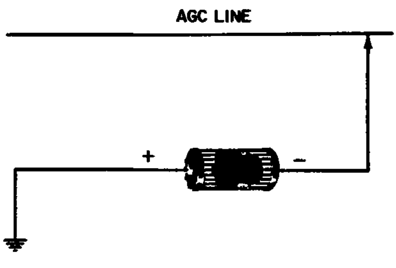


Fig. 10-1. Battery bias clamps the AGC line.

Should the picture and/or sound symptom clear up when the battery is connected, the trouble is in the AGC circuit. Otherwise check the signal circuits, as explained in the previous chapters. Many modern receivers have branched AGC lines to the RF and IF sections (Fig. 10-2). When the RF line is shunted by an AGC-clamp tube, it is good practice to connect two batteries, one to each line. Bias packs often have two

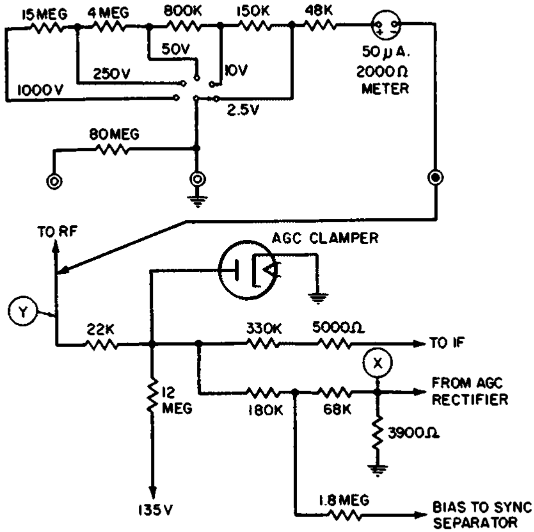
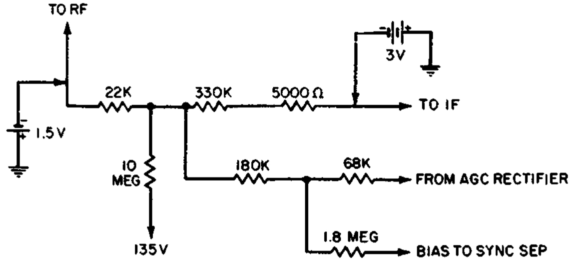


Fig. 10-2. Measuring AGC voltage.

or more outputs for this purpose. Although both lines can be clamped with one battery, as shown in Fig. 10-3, the RF line may operate at a somewhat lower bias than the IF.

CIRCUIT LOADING

In Fig. 10-2, the AGC voltage can be measured at various points—the value indicated will depend on the test point and on the VOM range used. For example, a higher voltage is measured at *X* than at *Y*, because the internal resistance of the circuit is much lower at *X* and the VOM therefore imposes less loading there. In general, different voltage readings will



(REFER TO RECEIVER SERVICE DATA FOR RECOMMENDED BIAS VOLTAGES).

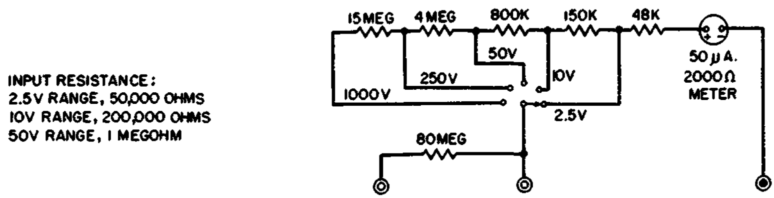
Fig. 10-3. Connection of two AGC-damp voltages.

be obtained on each range, because the VOM places a heavier or lighter load on the circuit as the ranges are switched. The input resistance of a VOM increases on the higher ranges, and circuit loading is therefore least on the highest range. (On the other hand, the scale becomes more difficult to read.) The tabulation in Fig. 10-4 illustrates this point. True AGC voltage is −7.8 volts.

The VTVM-input resistance at which AGC voltages should be measured (11 megohms is typical) is generally specified in the receiver service data. Although the actual AGC voltage may not be measured in very high-resistance circuits, the reading is a valuable guide to the presence or absence of circuit trouble.

TROUBLESHOOTING PROCEDURE

Suppose that sync buzz is present, but the main problem is severe video overloading. Since this is apparently a case of



Typical AGC voltage indications with a 20,000 ohms-per-volt VOM.

Range (Volts)	Indication (Volts)	Actual Error (%)
2.5	−1.7	78
10	−4.1	47
50	−6.6	15

Fig. 10-4. Examples of erroneous AGC voltages on a VOM.

AGC failure (Fig. 10-5), a new 6BU8 keying tube and two 6BZ6's should be tried in the first two IF stages. If this doesn't correct the trouble, check the plate voltage at pin 3 of the 6BU8 to find out if the keying stage is functioning. Suppose that the meter indicates +30 volts. As shown in Fig. 10-5, the cathode circuit of the first video IF stage includes a voltage divider (R22, R20, and R21) that produces +26 volts on the cathode. Therefore, the grid voltage supplied by the AGC system must be only a few volts less positive than the cathode voltage to set the proper bias.

Suppose the grid voltage of the first IF is checked, one expects to find about 25 volts at this point, but the VTVM reads 40 volts. The grid voltage is 10 volts higher than the AGC-tube plate voltage. This condition might possibly be due to a short in the first IF tube, but this possibility has already been eliminated by replacing the tube. The only other likely trouble is leakage to B+ through a defective C4 and the plate circuit of the mixer stage in the tuner. Current through this circuit could produce sufficient voltage drop across R12 and R14 to raise the grid voltage to the 40-volt level. When one dis-

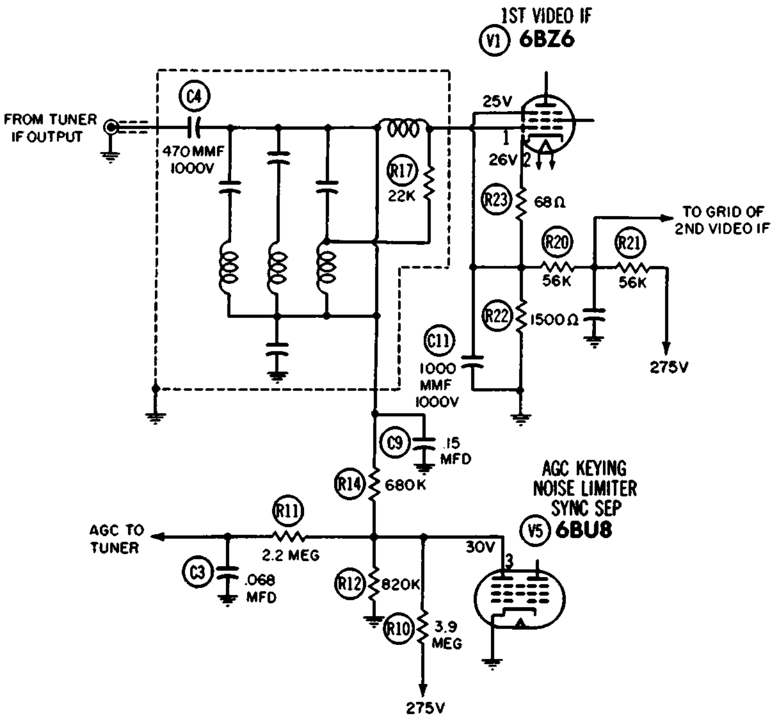


Fig. 10-5. AGC and 1st-IF amplifier circuitry.

connects the grid side of C4 and gives it a leakage test, his suspicion is proved correct. After replacement of C4 and adjustment of the AGC control, a normal picture is restored on the TV screen.

Open Cathode Circuits

Almost all of us tend to forget the danger of an open cathode circuit. As shown in Fig. 10-6, a broken cathode resistor or equivalent defect causes the plate-supply voltage to appear at the cathode terminal of the tube. In case a VOM is in use, damage to the instrument is almost a certainty. To put it another way, when troubleshooting, expect to find trouble; and the chief safety precaution is to proceed on the assumption that the maximum supply voltage in the receiver will be found where it is least expected.

Tube Sockets

After a receiver has seen much service, the tube pins sometimes make uncertain contact with the socket terminals. This can be a most baffling situation for the inexperienced technician, because although normal DC voltage is measured at the socket, the stage does not work. The moral is apparent: develop the habit of contacting projecting tube pins, instead of socket terminals. There is no percentage in making tough dogs out of pushovers, simply because of sloppy test techniques.

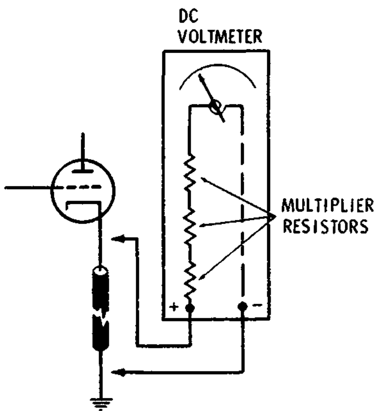


Fig. 10-6. Open cathode resistor causes B+ to appear on cathode.

Cold Heater—Crazy Readings

One seldom checks systematically to determine whether the tube heater is hot or cold. If most of the tubes are obviously hot, it is human nature to assume that all of them are. This assumption can occasionally cause needless waste of time. In most stages, plate and screen voltages are normally less than the supply voltage. But in case a heater pin is not making good contact to a socket terminal, for example, the plate and screen voltages rise to the supply-voltage value, the cathode voltage

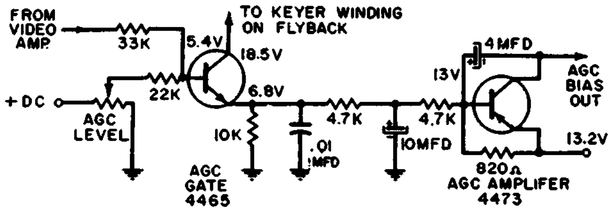


Fig. 10-7. Transistorized gated-AGC circuit.

falls to zero, and signal-developed bias voltage at the control grid drops to zero. In troubleshooting, the cause for the abnormal DC distribution is found eventually; however, good test techniques eliminate the eventuality in consequence of systematic and logical procedure.

TRANSISTORIZED AGC

A typical transistorized-AGC circuit is shown in Fig. 10-7. This is a gated forward-AGC system. Here, the stronger the incoming signal from the video amplifier, the more positive is the AGC-output voltage; i.e., the controlled transistors are shifted farther into saturation as the AGC bias increases (Fig. 10-8). This is a desirable mode of operation because the controlled transistors do not have remote-cutoff character-

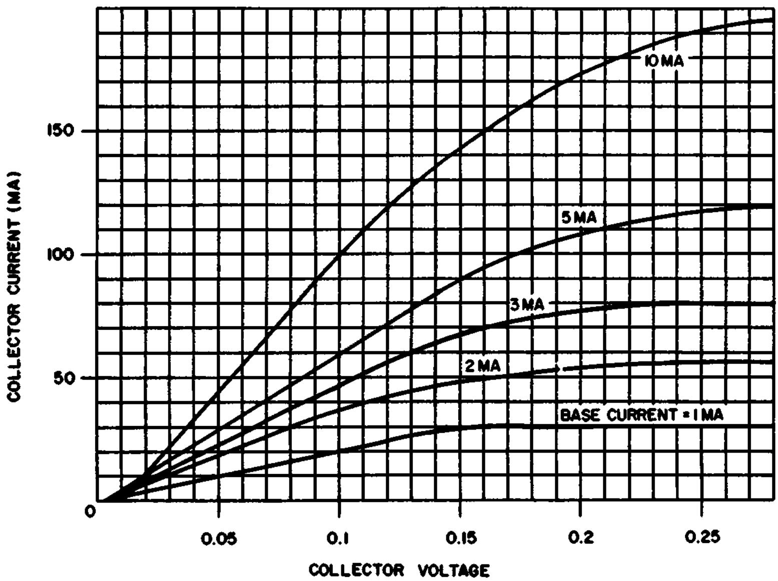


Fig. 10-8. Typical collector saturation characteristics.

istics—their cutoff is too sharp to be suitable for negative-AGC control. On the other hand, the controlled transistors shift into saturation more gradually and hence can be adapted to forward-AGC control.

The AGC-gate transistor is an emitter follower in which composite video is fed to the base electrode and horizontal flyback pulses to the collector electrode. DC-bias voltage (typically 5.4 volts) on the base is adjustable by setting the AGC-level control. Output from the emitter consists of 15,750-cps pulses, which are filtered to practically pure DC by an RC pi filter. This DC in turn controls the base bias of the AGC-amplifier transistor. (Amplified-DC output energizes the AGC line.) The AGC amplifier is a grounded-emitter transistor, and the configuration is DC-coupled throughout.

The AGC line can be clamped with battery bias when desirable, just as in a vacuum-tube configuration. (Remember to connect the negative side of the battery to ground, and the positive side to the AGC line.) Approximately 13 volts of battery bias is required to clamp this circuit. Troubleshooting the AGC system starts with DC-voltage measurements, followed by ohmmeter checks of resistors. Suspected capacitors can be checked on a tester or by substitution. It is possible that a transistor is defective—it can be tested on a checker or by substitution. When the AGC system is operating normally, an increase in RF input to the receiver will be accompanied by a rise in positive DC voltage on the AGC line. The picture must be in horizontal sync before the over-all AGC operation can be tested, because the keyer does not operate normally otherwise.

CHAPTER 11

VOM and VTVM Probes

The term *probe* is applied to a wide range of devices; e.g., direct-test leads (Fig. 11-1) are sometimes called probes; however, a somewhat more elaborate arrangement is shown in Fig. 11-2. Here, the probe comprises a switch with either direct feed-through, or with a series isolating resistor (Fig. 11-3). This arrangement is commonly used with a VTVM. The 1-meg isolating resistor is used for DC-voltage measurements only. It reduces the input capacitance of the cable to a very low value—typically 2 mmf. This minimizes circuit loading when DC voltages are measured across tuned circuits, as at the grid

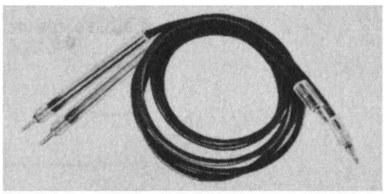


Fig. 11-1. Direct-reading-test probes.

or plate of an IF amplifier or local oscillator. The isolating resistor also serves an important purpose in preventing RF or IF voltages from entering the DC circuitry of the VTVM. Otherwise, the AC voltages would often overload the DC indicating circuit and cause a false reading.

The isolating probe holds back high-frequency AC voltages, and permits passage of DC voltage because it operates as a low-pass filter. Because AC voltages are filtered out through the isolating resistance, this probe cannot be used on AC functions of the VTVM. Hence a direct-through lead is used to measure AC voltages.

Suppose a mistake occurs, and an attempt is made to measure DC voltages using the straight-through lead. In such a case, the DC-voltage will be too high—usually by about 10%.

Also, if one tries to measure DC voltage at an oscillator grid, for example, the oscillator will be killed. Hence, it is necessary to throw the probe switch when going from AC to DC, or vice versa.

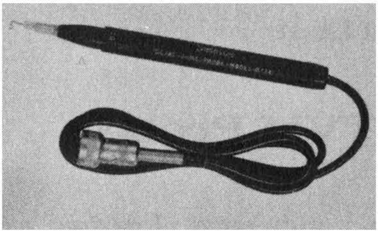


Fig. 11-2. Typical AC-DC probe for a VTVM.

It is apparent that the straight-through lead must be used on the ohmmeter function of a VTVM. Otherwise, the resistance reading will be 1 megohm plus the value of the resistance under test. When a straight-through lead is used, the multiplier resistors in the VTVM can be burned out by overloads.

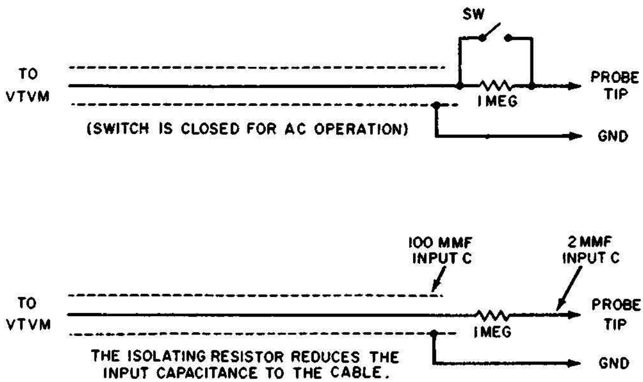


Fig. 11-3. Circuit of AC-DC probe for VTVM.

VTVM OPERATION ON AC-VOLTS FUNCTION

Some technicians who are not too familiar with meter circuitry, but realize that VTVMs use DC meters, ask how these instruments measure AC voltages. To clear up this point, examine the AC-input circuit of a typical VTVM (Fig. 11-4). Note that the isolation resistor in the probe is bypassed for AC operation, and that DC-blocking capacitors are placed in series with the applied voltage. The two diode sections of a 6AL5 rectify the input signal and produce a DC output proportional to the peak-to-peak value of the AC. This output is then applied to a voltage-divider network, where a certain portion—depending on the range selected—is tapped off and fed to the grid of a triode stage in the measuring circuit.

In a conventional circuit, employing a 12AU7, the meter movement is connected between the two cathodes (Fig. 11-5). The DC-bias change on one grid, which is produced by the rectified voltage being measured, causes unequal conduction in the two triode sections. This results in a difference of potential on the cathodes and also across the meter terminals.

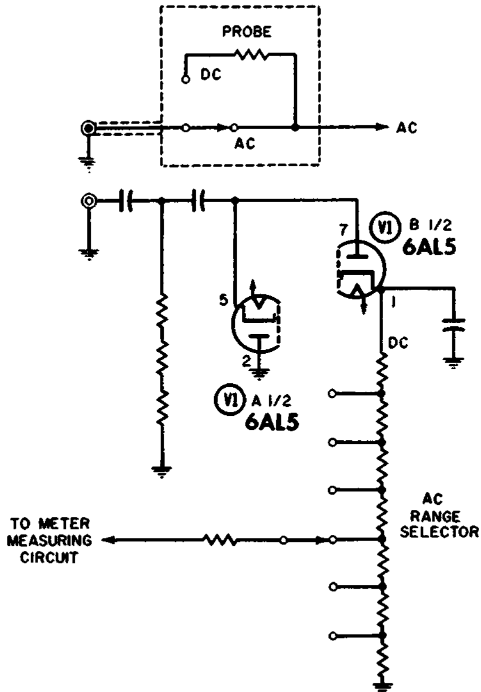


Fig. 11-4. Conversion circuit of AC-DC probe.

Deflection of the meter is calibrated so that indications of AC voltages are read directly on the appropriate scale.

Always keep in mind that an instrument of this type actually measures peak-to-peak values of AC inputs. The rms values on the meter scale are merely calculated from peak-to-peak results obtained with pure sine waves. Peak-to-peak measurements make a VTVM useful for checking the amplitude of nonsymmetrical waveforms such as video, sync, and sweep signals. Sometimes, the peak-to-peak readings on the

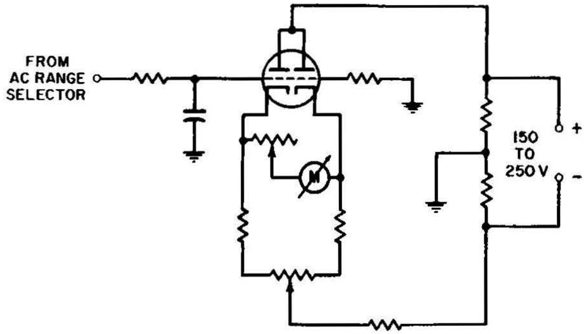
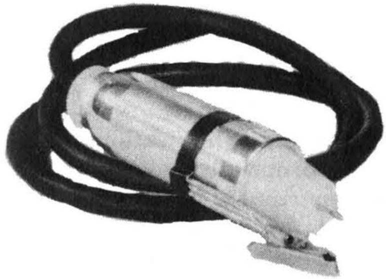


Fig. 11-5. Typical metering measuring circuit.

meter are even more accurate than those obtained by using a scope and separate calibrating voltage. The loading effect of the meter will, of course, vary with the signal frequency and the impedance of the circuit under investigation.

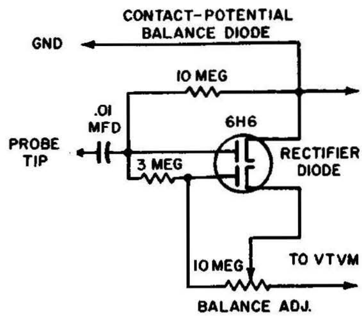
RF PROBES

An RF probe (Fig. 11-6A) differs from any other in that it contains a diode rectifier. This rectifier reduces the input capacitance on AC-voltage measurements (in a VTVM) from 100 mmf to a small fraction of this value. In turn, tuned circuits are not seriously disturbed when the RF probe is applied. Since no multipliers are used ahead of an RF probe, its input-voltage rating is limited by the permissible plate-cathode voltage of the diode. Hence, the peak-to-peak AC function of a VTVM accommodates a much higher input-voltage range. Next, observe the circuitry for a typical RF probe, shown in Fig. 11-6B—the probe is a half-wave rectifier.



Courtesy Hickock Electric Instrument Co.

(A) Picture.



(B) Schematic.

Fig. 11-6. RF probe.

Contact potential is balanced out by one of the diodes, and the balance adjustment is a maintenance control only. Some may be confused by the large blocking (charging) capacitor. The .01-mfd capacitor does not represent the input capacitance of the probe. It is merely a series coupling capacitor, and is analogous to the coupling capacitor in an IF stage, for example. The input capacitance to the probe is determined chiefly by the diode-plate capacitance, and the stray capacitance of the high-frequency leads (which are very short). A large charging capacitor is used merely to obtain correct voltage readings at low frequencies.

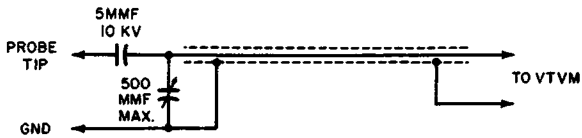


Fig. 11-7. An AC high-voltage capacitance-divider probe.

CAPACITANCE DIVIDER PROBE

Some VTVM manufacturers will supply high-voltage capacitance-divider probes, as shown in Fig. 11-7. This type of probe, used on the AC-voltage function of the VTVM, attenuates a high AC-voltage to 0.01 of its source value. Hence, the top range of the VTVM can be multiplied by a factor of 100 times in this example. Such probes are used more exclusively in labs than in service shops.

A capacitance-divider probe can be used satisfactorily at comparatively high frequencies only. The input resistance of the VTVM causes the AC-voltage readings to be erroneously low unless the frequency is high. Such probes are rated by the manufacturer for appropriate frequency ranges.

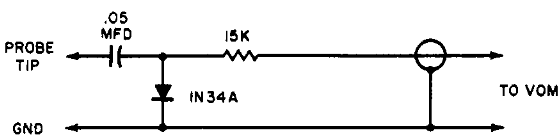


Fig. 11-8. Signal-tracing probe for a VOM.

VOM SIGNAL-TRACING PROBE

Signal-tracing probes, such as that shown in Fig. 11-8, can be used with a VOM (on its DC-voltage function) to check for the presence of RF or IF voltages. Its input-voltage capability is limited by the semiconductor diode to approximately

50 peak volts; however, this type of probe has utility when a VTVM is not available.

SEMICONDUCTOR VTVM PROBE

RF probes with semiconductors are sometimes used also with VTVMs. However, the series resistance (calibrating resistance) is higher than that used with a VOM, because the input resistance of a VTVM is comparatively high. The VTVM probe will not work with a VOM, just as the VOM probe will not work on the VTVM. (The VOM has too low an input resistance.)

Index

D

E

F

G

H

R

S

W