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R. A. Humphreys, Technical Editor

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technical SECTION

NOISE IN TELEVISION RECEIVERS

By E. H. Boden, *Advanced Applications Engineer*

We have all wondered or have been asked what causes snow on the screen of a television receiver. You have undoubtedly thought or heard it said that if it were not for the snow the picture received would be a lot better.

The snow that we see is due to an unwanted signal which is present in the early stages of the receiver. For our discussion, we shall call this unwanted signal "noise". The effects of noise are observed in all sensitive receiving equipment. In television we see snow, in radio we hear a frying sound, on a radar screen it is grass and now with color television we have confetti. Regardless of the type of receiver, we have the effects of noise.

Shot Noise

As we know, electrons in a vacuum tube leave the hot cathode, travel through the grid and strike the plate. When the electrons strike the plate they produce a noise current. Just as a handful of pebbles produce a noise when thrown on a tin roof, electrons produce a noise when they strike the tube's plate. This noise is called "shot" noise. The magnitude of this noise current is given by the equation

$$\overline{i} = \sqrt{2e\ I\ \ B\ A^2} \quad \text{(Equation No. 1)}$$

Where $\overline{i}$ = the average noise current in amperes

e = the electric charge of an electron (1.59×10^{-19}) coulombs

I = the dc plate current in amperes

B = the bandwidth of the tuned circuits in c.p.s.

A^2 is a constant which is dependent on the randomness of the electrons.

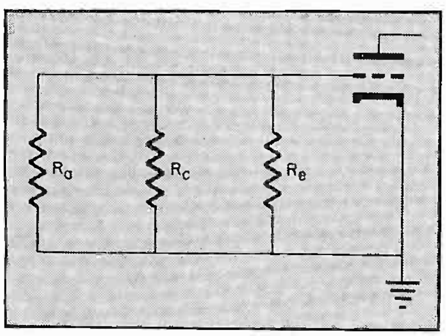

Figure 1

Equivalent input circuit of first amplifier stage of any receiver.

Ra Transformed antenna resistance

Rc Resistance due to circuit losses

Re Transit time resistance

The term A^2 will need some explanation. If the plate attracts every electron emitted by the cathode, the arrival of the electrons at the plate will be completely random (in no order whatsoever). In this case $A^2 = 1$.

If the plate takes only some of the electrons emitted by the cathode and there is an electron cloud formed around the cathode, then the electron arrival is not random and A^2 is approximately 0.05.

Noise in Resistive Elements

In addition to shot noise there is also "Johnson" noise. "Johnson" noise is present in all resistive elements; i.e., an ordinary carbon resistor, the resistance in a wire or the resistance of the antenna all produce a noise power when at some temperature other than absolute zero. Therefore, if we were to connect a theoretical, ultra-sensitive voltmeter across any of the above mentioned resistances, we would find a voltage. In fact, the average voltage read ($\overline{e}$) would be

$$\overline{e} = \sqrt{4k\ \ T\ \ B\ \ R} \quad \text{(Equation No. 2)}$$

In this equation k is a constant equal to 1.38×10^{-23}, T is the temperature (absolute scale) of the resistance, B is the frequency bandwidth of the voltmeter and R is the ohmic value of the resistance. This will mean more if we have some numbers. Therefore, let us say that the voltmeter bandwidth is about that of a television set, say 5

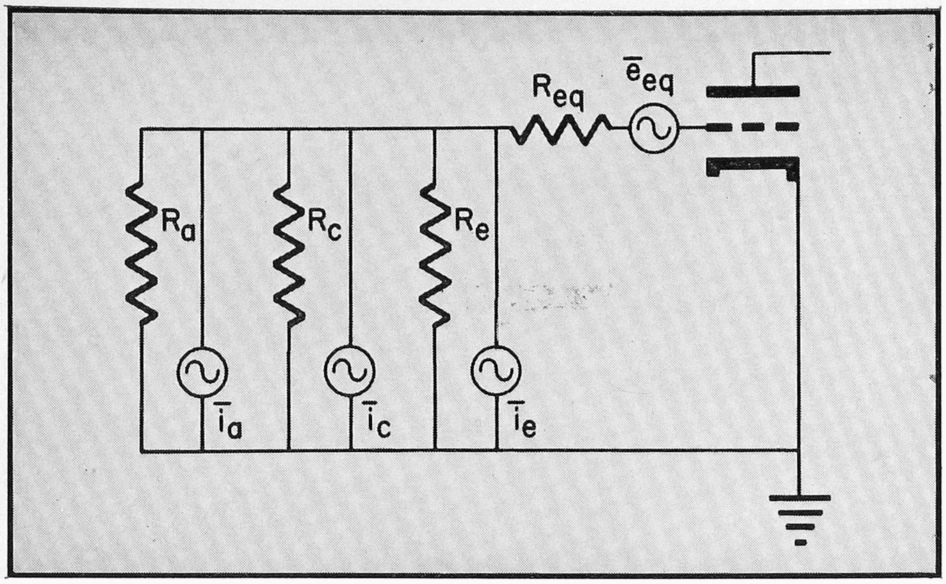

Figure 2 Complete input circuit showing "shot noise" expressed as an equivalent series resistance, Req.

mc. Also, let us say that the voltmeter is connected across the 300 ohm terminals of an antenna and that the temperature is 290° K (just below room temperature). Under these conditions, an average voltage of 4.9 microvolts is measured across the antenna terminals. In the same way, a 300 ohm ¼ watt or 100 watt resistor at the same temperature measured with the same voltmeter would have 4.9 microvolts across its terminals. These then are the two kinds of noise found in a receiver.

Before going further, let us look at the input circuit of the first amplifier stage of any receiver. As we see by the circuit shown in Figure 1, there are three resistances between grid and cathode. Ra is the transformed antenna resistance and Rc is a resistance due to circuit losses. Re is transit time resistance. Because the electrons require a definite length of time to travel from the cathode to the grid plane and because as the frequency of operation is increased the electron travel time becomes a larger portion of the time for one cycle, a resistive loading is produced between the grid and cathode of the tube. This resistance can be measured with suitable equipment. As the frequency of measurement is increased, the value of Re becomes lower and lower. Briefly the formula for Re is:

(Equation No. 3)

$$Re = k \frac{1}{f^2}$$

In this equation f is the frequency of operation. The constant k is dependent on the tubes transconductance, time required for electrons to travel from the cathode to the grid plane and/or element voltages. So we see that Re reduces quite rapidly as frequency increases. For most tuner types, Re is approximately 1000 ohms at 200 mc. The Type 6AN4 at 1000 mc has an Re of about 50 ohms.

Now, returning to equation No. 2, T is room temperature (290° K) for Ra and Rc. However, because Re is within the tube where the temperature is approximately five times room temperature, due to the heated cathode, the "Johnson" noise output voltage is equal to the $\sqrt{5}$ or 2.4 approx. times that of a resistor at room temperature having the same ohmic value as Re.

At very high frequencies, the transit time resistance (Re) is the most important term. Its value will change with tube construction. Good circuit design can keep circuit losses at a minimum.

Since we have found there to be three noise-producing resistances in the input, Ra, Rc and Re, it would be most convenient if we could speak of "shot" noise in terms of some resistance in the tube input. Measurements have shown that the equivalent resistance of "shot" noise reflected at the input is equal to 2.5 divided by the tube's transconductance. Actually, this is a fictitious resistance called Req and is used to more easily add in "shot" noise. Figure 2 shows the complete input circuit.

Measuring Noise

We now need some convenient method of comparing tubes and circuits and this we do in this way. If we could eliminate Rc, Re and Req we would have a perfect receiver. Therefore, for convenience, circuits and tubes are compared with a theoretical tube and circuit. If an amplifier is found to have ten times the noise of a perfect amplifier, it is said to have a "noise factor" of 10 or 10DB. If it is four times noisier than a perfect amplifier, its noise factor is then four, or 6DB.

To measure the noise figure of a receiver one makes use of a circuit similar to that shown in Figure 3. With this circuit and an AC voltmeter connected to the receiver's detector output, one may measure the noise figure of a television receiver (VHF). The 300 ohm resistor (in the circuit) has replaced the antenna impedance. The Sylvania type 5722 is a temperature limited noise diode and, therefore, has an $A^2 = 1$ (equation No. 1). To find the noise figure of a receiver, the noise power measured by the AC voltmeter connected to the detector output is first recorded. The noise diode is then turned on and R_1 is increased until the noise power measured by the AC voltmeter is doubled; i.e., twice the power output. Since we now observe twice the noise output, we know that the noise diode is just as "noisy" as the receiver. Therefore, knowing the noise diode current, we may compute the noise figure of the receiver by

(Equation No. 4)

$$NF = 20\ I_d\ R_a$$

Where Id = the diode plate current in amperes

Ra = antenna resistance which is 300 ohms in a tv receiver

Wa have measured the noise figure of the entire receiver. Let us now see what the noise figure of a receiver is with a booster.

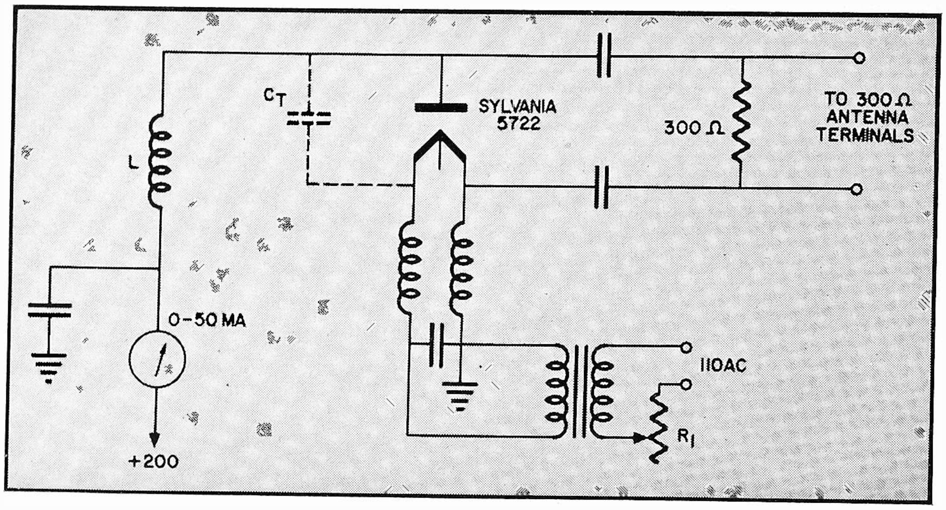

Figure 3 Noise generator for measuring receiver noise figure.

The Effects of Boosters

If we know the noise figure of the receiver itself, the noise figure of the booster and the power gain of the booster the overall noise figure N_{12} will be

(Equation No. 5)

$$N_{12} = N_1 + \frac{N_2 - 1}{G_1}$$

Where N_{12} = the noise figure of the booster and receiver

N_1 = the noise figure of the booster

G_1 = the power gain of the booster

N_2 = the noise figure of the receiver

Equation No. 5 will tell us if we can improve the picture by adding a booster, providing we know N_1 and G_1. G_1 can be measured with a signal generator. We can determine the noise figure of the booster (N_1) if we perform an algebraic manipulation on equation No. 5. The new equation becomes

(Equation No. 6)

$$N_1 = N_{12} - \frac{N_2 - 1}{G_1}$$

Now, by connecting the booster in question to the input of a receiver whose N_2 we know, N_1 may be determined by equation No. 6.

It is important to take heed to what equation No. 5 is telling us. If a receiver has a tuner with a high noise figure, say 10 or 20 on Channel 4, and we add a booster whose $N_1 = 4$ and $G_1 = 5$ the overall noise figure would then be about 6 (7.8DB). The noise figure is one half and the sensitivity has been doubled. (Noise figure has been reduced 3DB or sensitivity has been increased by 3DB.) Suppose G_1 of the booster were 100, then N_{12} would be 4, in which case the improvement would be 3 times (4.8DB). Let us now take another example. This time $N_1 = 4$, $N_2 = 4$ and $G_1 = 100$. In other words, we have a good set and a good booster. Substituting these numbers in equation No. 5, we see we have not improved the sensitivity of the receiver one bit. The booster is of no use.

Visible Improvement

This brings us to a very interesting question. How much does the noise figure have to be improved to produce a visible improvement on the screen? Experiment has shown that the minimum visible improvement in noise figure which can be observed on a tv screen is from 2 to 2½ DB, providing the change is made while watching the screen. If, however, the eyes are removed from the screen while the noise figure is degraded then 3 DB is about the minimum. This means if you have a snowy picture and equation No. 5 says the improvement in noise figure is less than 3 DB, there may not be visible improvement in the picture.

Long Transmission Lines

We may make further use of equation No. 5. This time we have a tv set of noise figure N_2. For one reason or another, the antenna is several hundred feet from the tv set. The loss (total) in the transmission line between the set and the antenna[1] is L_1. The noise figure as seen by the antenna is

(Equation No. 7)

$$N_{12} = N_1 + (N_2 - 1) L_1$$
$$N_{12} = 1 + (N_2 - 1) L_1$$

Where:

$N_1 = 1$

N_2 = noise figure of the television receiver

L_1 = transmission line loss

Here we see that if L_1 is large because of line length and/or the frequency involved, the noise figure of the system will be greatly increased. The addition of a booster at the receiver, having a noise figure equal to that of the receiver, will not improve the system's noise figure. If, however, we place a booster at the antenna which has a noise figure equal to the receiver's and a power gain equal to the transmission line losses, the damaging effects of the transmission line will be removed.

1. "An Antenna for UHF TV Reception", by J. S. Allen–SYLVANIA NEWS, March, 1952.

To summarize, the limit of a receiver's sensitivity is its noise figure. A booster can only improve the sensitivity if its noise figure is better than the receiver's and has sufficient gain to remove the effect of the receiver's noise figure. And finally, if transmission line losses increase the noise figure, then a booster should be used at the antenna.

SYLVANIA OSCILLOSCOPE HINTS—MODEL 400

A change can be made in the earlier model 400 oscilloscopes using the neon lamp in the sweep oscillator circuit which will improve the sync stability especially at the lower sweep speeds.

The procedure for making this change is as follows:

a. Unsolder the red and black wires from the neon lamp and remove the black wire from the circuit completely. Note which terminal strip lug that this wire was removed from. Remove the neon lamp.
b. Remove resistor R-44 which is 56,000 ohms and replace with 47,000 ohms, 1 watt.
c. Install a single lug terminal strip to the inside screw of the 5V4 tube socket mounting bracket.
d. Add a 2700 ohm ½ watt resistor from the terminal strip installed in step c to the terminal strip lug from which the black wire was removed in step a.
e. Connect the red wire removed from the neon lamp to the open end of the resistor installed in step d.
f. Check sweep speed for the proper overlap on each position of the course frequency control and adjust if necessary.

These changes have been made on all 400 models with serial numbers from 2700 up.

To obtain flat square wave response on the model 400, a special compensating adjustment, R-99, is provided. This control is located on the chassis between the first and second vertical amplifier tubes. In making this adjustment, be sure that you have available a perfect 60 cycle square wave from a reliable square wave generator. With this square wave connected into the vertical input terminals of the oscilloscope, set the sweep speed to obtain three stationary square waves on the screen with about 4" of total deflection. Set the step attenuator to the 10:1 position. If the figures observed on the screen are not absolutely flat-topped, carefully adjust R-99 until this condition is obtained.

Many of the earlier 400 model 'scopes used a dual 4 mfd capacitor, C-9a and C-9b, one section located in the plate circuit of the first vertical amplifier and the other section in plate circuit of the first horizontal amplifier. Any leakage between sections of this capacitor causes a "vertical bounce" condition, that is, a continuous vertical jumping of the pattern. To correct the condition, remove the dual capacitor and substitute two single 4 mfd capacitors.

Slight leakage in C-29, located between plate and grid of V-8a, will also cause vertical bounce. More than .1 volt drop across the associated resistor, R-55, will indicate excessive leakage in C-29. After replacing C-29, adjust R-100 so that exactly 1.6 volts appears at the grid of V-8A. (Measurments should be made with a VTVM.)

Test Equipment Service Dept.
Williamsport, Penna.

CORRECTION

Figure 2 appearing on Page 6 of the November issue should have shown the following electrode potentials:
Plate Voltage ....40 Volts
Grids Number 2 and 4, 30 Volts

SERVICE HINTS

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USE FOR BATTERY SNAP FASTENERS

Remove the snap fasteners before discarding small 45 and 67½ volt batteries. They make excellent connectors, especially for speakers. Because of their sturdy construction and large contact surface, they can safely carry large currents.

Hyman Herman
Flushing, New York

CONTROL REPAIR

With the wide variety of television receiver panel controls employed in modern sets, the serviceman is often forced to hold a set until an exact replacement control can be obtained. Sometimes, however, a temporary repair can be made to restore service. Rough operation is often caused by fatigue of the area directly under the sliding contact. The contact should be bent slightly so that it rides on the unworn surface. Such a repair, *although temporary,* has proven very satisfactory.

J. F. Koller
New York, New York

SYLVANIA NEWS

MARCH 1956 VOL. 23 NO. 3

R. A. Humphreys, Technical Editor

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technical SECTION

TRIODE SYNC SEPARATOR-AMPLIFIER CIRCUITS

By C. A. PETERSON and R. A. HUMPHREYS

A previous issue of the Sylvania News (November 1955 Vol. 22 No. 9) described the operation of the Sylvania Types 6CS6 and 3CS6 in a typical sync separator-clipper-amplifier stage of a modern TV receiver. This article will describe another popular circuit utilizing two triodes to accomplish the functions of sync separation and amplification. Variations of the circuitry described can be made to include noise immunity and other special features. The basic circuit, however, enjoys widespread popularity and can be found in a great many TV receivers, both old and new.

Basic Circuit Requirements

Figure 1 shows a typical circuit which uses a Type 12AU7 dual triode tube and functions as a sync separator and amplifier. The circuit consists basically of two cascaded resistance coupled amplifier stages; however, these two stages are so designed as to be able to select the desired portion of the input signal, separate it from the remainder and amplify the selected portion for use in following stages. The input signal is in the form of composite video, which includes picture information, blanking pulses and the vertical and horizontal synchronizing pulses.

The polarity of the input, i.e., sync positive or sync negative, must be taken into account. If the vertical output pulses from the sync amplifier are to be used to trigger a conventional blocking oscillator, they must be positive. Since we have two basic amplifier stages in series, Figure 1, each of which inverts the signal, it follows that to obtain positive sync output we must have a video signal input which has positive going sync. In order to have the circuit operate effectively we also require a signal of appreciable amplitude, approximately 60 volts peak to peak.

These two requirements of the input signal are easily met in almost all present day receivers. Since the video signal to the picture tube is generally applied to the cathode, it must have positive going sync and must also have an amplitude of approximately 60 volts. Hence, we take the signal voltage for the sync separator from the plate circuit of the video amplifier, or looking at it another way, from the cathode circuit of the picture tube. This signal should resemble that shown in Figure 2.

Sync Separation

The only part of the video signal that is useful in synchronizing the sweep oscillators is that portion contained in the blacker-than-black region represented between the two horizontal lines in the top portion of Figure 2. Furthermore, it can be said that we must have nothing but this

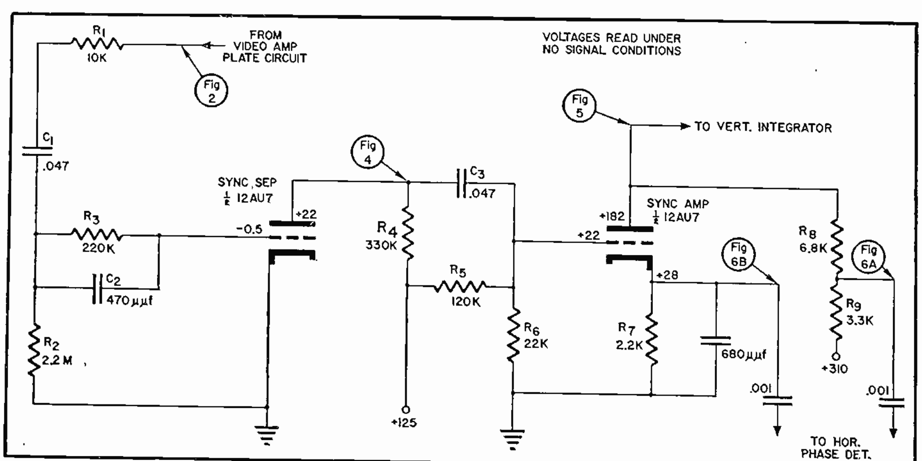

Figure 1 Circuit diagram of a typical Double triode type sync separator-amplifier.

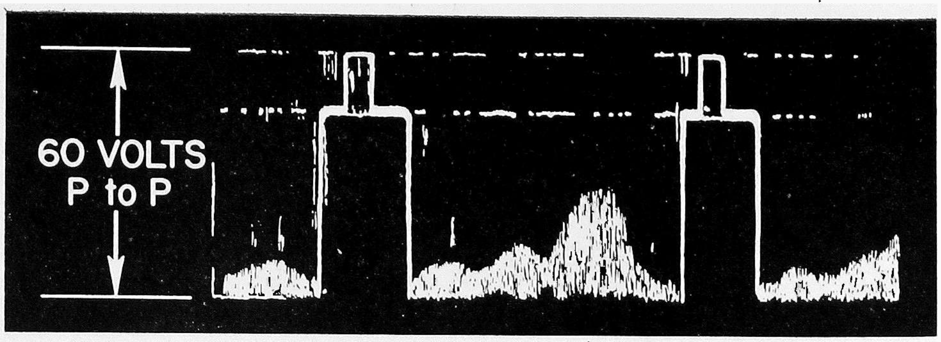

Figure 2. Composite video signal applied to sync separator.

portion for proper operation. The function of the sync separator section of the circuit in Figure 1 is to remove the video from the signal and pass the remaining portion through the tube to the sync amplifier section.

The signal is taken from the video amplifier plate circuit through a series circuit consisting of R_1 and C_1. Capacitor C_1 is used to AC couple the signal to the sync separator grid circuit and also stores the developed bias voltage when the circuit is in operation. Resistance R_1 is used primarily to prevent excessive loading on the video amplifier plate and subsequent deterioration of the picture.

The grid circuit consists of the high value grid resistor R_2 and the parallel combination of R_3 and C_2. The time constant of R_3 and C_2 maintains the proper clipping level and also accentuates and preserves the steep wavefronts of the sync pulses, so necessary in maintaining perfect triggering and good interlace.

It will be noted that the sync separator plate voltage is extremely low and that the input signal of approximately 60 volts peak to peak is much too large for the tube to pass completely. The large input signal causes the grid to be driven into conduction and the resulting grid current flow through the grid resistance R_2 results in a DC bias being developed. This becomes the operating bias upon which the signal rides, with only the tips of the sync pulses driving the grid to conduction. Only enough grid current is drawn to maintain this bias, consequently, only minor clipping occurs on the positive peaks in the grid circuit.

With the low plate voltage present, the negative grid voltage required to stop plate current flow is very small. Consequently, as the signal swings in a negative direction, plate current ceases and the portion of the signal below this cut-off point is not passed through the tube to the plate circuit. The plate voltage, signal amplitude, and grid circuit resistance and capacitances are so chosen that only a portion of the available sync is passed through the tube. This assures a safety factor to compensate for incoming signal strength and a shift in components or tubes. Figure 3 will serve to demonstrate the action of the grid circuit in removing the sync from the video signal.

As stated previously, the sync separator is basically an amplifier and, although its primary purpose is to remove the video from the signal, it also amplifies the sync. In the process of amplification, however, the positive tips of the sync pulses are also clipped somewhat. Because of a peculiarity of triodes operated at low plate supply voltages, the lowest plate voltage swing can be achieved before the maximum grid voltage is reached. Consequently, a point is reached where increasing the grid voltage will give no change in plate voltage. The result is plate circuit clipping. This clipping action takes place when the grid signal approaches the grid current point. Additional clipping is usually required, however, and is accomplished in the grid circuit of the sync amplifier. The waveform of the separated sync appearing at the plate of the sync separator is shown in Figure 4.

Sync Amplification

The separated sync signal is applied to the grid of the sync amplifier through coupling capacitor C_3, Figure 1. The sync amplifier grid is returned to a source of positive voltage via R_5. The purpose of this is to make the grid conduct harder on the positive portion of the applied signal, thus causing the positive going signal to be clipped. This is necessary to remove any irregularities which may have been passed by the sync separator. Because the grid draws current, a negative voltage is developed at the grid. As with the sync separator stage, the signal (approximately 60 volts p/p) is too large to be amplified completely by the tube. The negative portion once again drives the grid into the plate current cut-off region, thereby clipping off that portion of

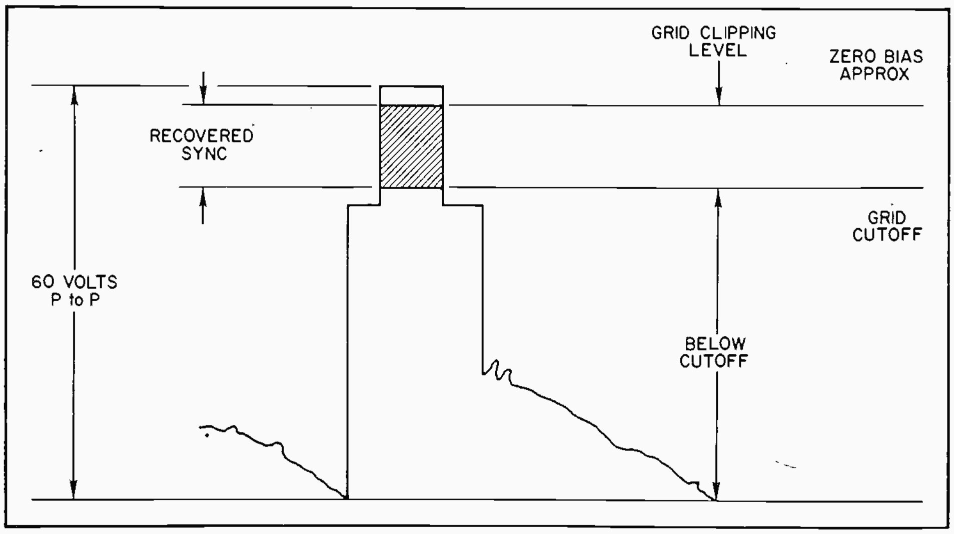

Figure 3. Line presentation illustrating separation and clipping action of sync separator stage.

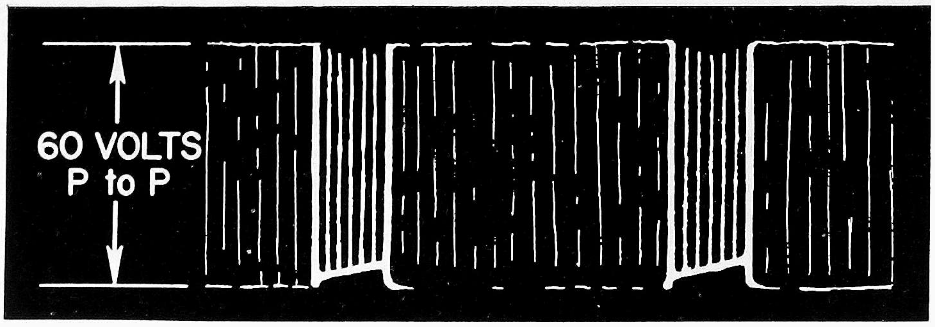

Figure 4. Sync signals at plate of sync separator. Note that the sync has been separated, clipped and amplified. (Vertical)

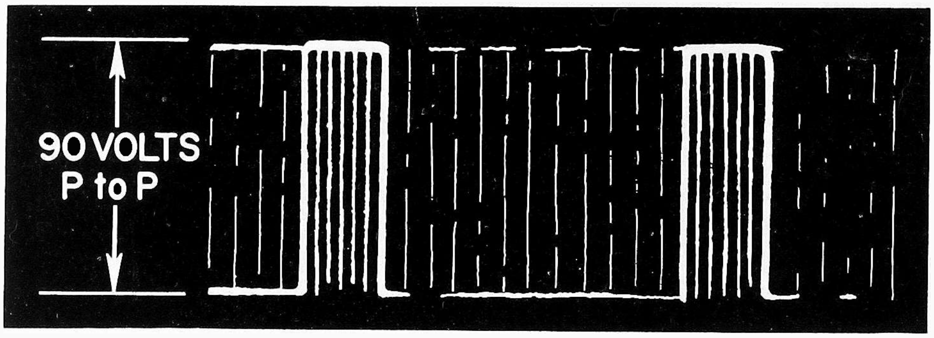

Figure 5. Sync signal appearing at plate of sync amplifier. The sync signals have again been clipped in both the positive and negative direction and amplified. (Vertical)

the signal below the cut-off point. This action tends to clip off noise spikes which may be present on the incoming video signal, especially when the signals are of lower than normal value.

Thus it can be seen that the sync amplifier effectively clips both the positive and negative extremes of the sync signals fed to it from the sync separator. This amplifier section operates at considerably higher plate voltage and the output is consequently higher than that of the separator section alone. An output of approximately 90 volts peak to peak is readily available at the plate. This is somewhat lowered by the fact that the tube is also used as a phase inverter where an appreciable cathode resistance is used, R_7. The output at the plate of the sync amplifier takes the form shown in Figure 5.

The sync pulses at the plate of the sync amplifier are in the positive direction and are coupled directly to the vertical integrator network where the wider vertical pulses are integrated to form the synchronizing pulse for triggering the vertical oscillator.

The phase inverter characteristics of the circuit are used to provide the two out-of-phase signals required for the typical double-diode horizontal phase detector. Positive pulses are obtained from the plate circuit and negative pulses from the cathode. To obtain pulses of equal amplitudes, a voltage divider is used in the plate circuit, R_8 and R_9. Figure 6 shows these pulses.

Circuit Variations and Features

The simplicity of the circuitry involved in the double triode type of sync separator amplifier system has made it one of the more popular in use today. Although it has some measure of "built in" noise suppression, additional immunity can be gained by refinements to the circuitry. Some manufacturers add a noise gate, which is usually a biased diode set to clip signals above a predetermined level. Others reduce the influence of noise by adding another stage of clipping, which operates in the same manner as that portion of the circuit described herein.

Servicing

The problems involved in servicing this type of circuit can best be solved by knowing how the circuit operates and using this knowledge in isolating the trouble. An oscilloscope, along with a good vacuum tube voltmeter are indispensable aids. In TV receivers using a phase detector type of horizontal control, troubles in the sync circuits resulting from low output alone will usually be detected in the vertical system first, since the amplitude of the vertical sync pulse determines directly the vertical oscillator sync stability. The horizontal phase detector, on the other hand, is more prone to act up when irregularities are present. Hence, if the horizontal appears stable while the vertical is touchy, it is a good bet that the output has dropped off somewhere along the line from the video input to the sync amplifier output.

If the horizontal is touchy and the vertical appears stable, look for something getting through the sync separator or amplifier that shouldn't, i.e., hum, noise or video. A good example of this is the horizontal pulling so often experienced when video gets through along with the sync. Another example of pulling occurs when 60 or 120 cycle hum gets into the sync. These troubles are not always generated in the sync circuits, however. Whenever they do occur, you can usually isolate them with the aid of your oscilloscope.

Although these circuits are not generally considered to be critical, they do require that the voltages applied to them are reasonably close to those stated by the manufacturer on his circuit diagram. If they are too far out of line, the circuit may not operate well under all conditions.

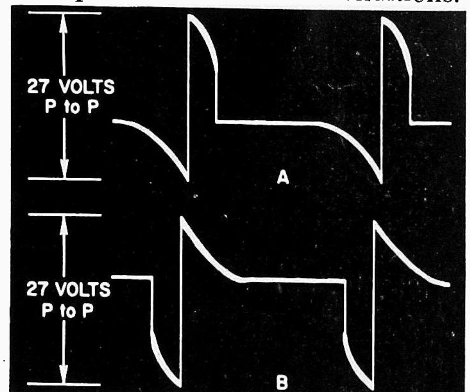

Figure 6. Horizontal sync pulses A. Junction of R_8 and R_9 B. Cathode of sync amplifier

SERVICE HINTS

TIE POINT ON DAMPER TUBE SOCKET

I was called in to service a set with a burned out fuse. Thumping the damper tube produced internal arcing, so after replacing the fuse and damper, I went on my way. Next day, I was called back for the same trouble. Therefore, I decided the chassis should go to the shop for a check.

In the shop, I noticed internal arcing in the new damper tube. Checking the damper tube socket with an ohmmeter, I found only 100 ohms between pins 2 and 3, which were gone on removal of the tube.

This particular model used pin 2 as a grounded tie point. Apparently the internal arcing between the cathode (pin 3) and the ground formed a carbon path of 100 ohms. Removing the tie point soldering cured the trouble.

John D. Hand, Jr.
Shreveport, La.

EDITOR'S NOTE:

Tube manufacturers caution that unused pins on damper tubes should not be used as tie points. For example, data on Sylvania Type 6AU4GT states: Caution: Note: Precautions should be taken on terminals 1, 2, 4 and 6 when used as tie points, due to high voltage breakdown.

MOTOROLA TV MODEL 21T8A AND SIMILAR SERIES

The symptoms were intermittent picture brightness, narrow raster and sound always present.

This set would work fine most of the time. The only indication of faulty operation was an occasional reduction in width. When it finally did this on the service bench all voltages were ok, except the filament voltage which was only 4.5 volts. It was discovered that the filament ground through a rivet to the chassis measured approximately 400 ohms. The rivet is a lug on a stand-off insulator which holds the filament fuse (a piece of #28 wire). To cure the trouble, solder a heavy wire to a spare soldering lug and also, for double protection, solder the rivet to the chassis.

J. Nolter
Mahanoy City, Pennsylvania

CONTROL REPAIR

With the wide variety of television receiver panel controls employed in modern sets, the serviceman is often forced to hold a set until an exact replacement control can be obtained. Sometimes, however, a temporary repair can be made to restore service. Rough operation is often caused by fatigue of the area directly under the sliding contact. The contact should be bent slightly so that it rides on the unworn surface. Such a repair, *although temporary,* has proven very satisfactory.

J. F. Koller
New York, New York

TV PICTURE WITH PULLING ON LEFT

An Airline Model 15 WG 3046C had vertical pulses getting into the horizontal. The symptoms picture wise: a curved pix (not an S curve but one that looked more like a C) and very poor horizontal sync. Vertical sync not too bad. The trouble was traced to C77, a filter condenser which is more or less common to the B supplies to the two sections (vertical and horizontal).

George's Radio Service
Santa Ana, California

SCREW ALIGNMENT POINTER

Adjustment of trimmers and controls of tv sets can result in quite a bit of additional work if the trouble is found elsewhere and it is necessary to return the adjustments to the original positions. It is easy to lose track of where they had been before, especially in the case of recessed adjustments.

To simplify this I use common bobby pins and solder the open end by wrapping around some fine tinned wire and soldering. This makes a pointer with good tension that can be slipped on the shaft of an alignment tool and can be moved up or down the shaft for best position.

During trimmer adjustment I insert tuning tool into adjustment screw and then move pin down shaft of alignment tool close to chassis and mark chassis to coincide with end of pin which is the reference point.

By observing movement of pointer it is easy to see whether your adjustment is ¼ turn etc. and right or left.

Adams Radio Service
Williamsport, Pennsylvania

COVER SWITCHES ON BATTERY PORTABLES

The switches which open and close the A and B circuits of personal type portables are usually operated by opening and closing the cover. Many times the switch is not pushed down far enough to cut off the circuit, thereby running down the battery. I add a bead of solder to the exposed part of the switch on sets which have this trouble. The longer lever will insure that the switch opens every time.

Hyman Herman
Flushing, New York

SYLVANIA NEWS

technical SECTION

MAY-JUNE 1956 VOL. 23 NOS. 5 & 6

R. A. Humphreys, Technical Editor

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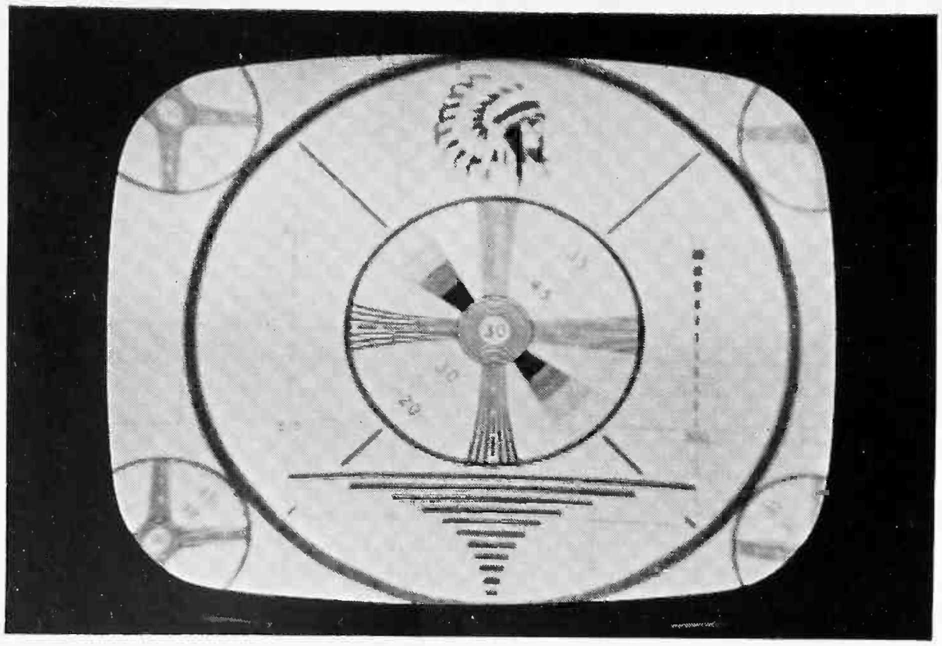
SYLVANIA'S NEW 8-INCH CHECK TUBE, TYPE 8XP4

by Thomas A. Lesh

EDITOR'S NOTE: Sylvania's new type 8XP4 rectangular glass check tube joins Sylvania's popular 5AXP4 round glass check tube in the Sylvania line of picture tubes for testing purposes. The type 8XP4 is packaged in a long-lasting easy-to-carry white protective carton with top handles—permitting safe and easy carrying for home service calls. Complete application instructions are enclosed with each unit.

A new TV-receiver check tube with an 8-inch rectangular screen has been designed by Sylvania Electric Products Inc. This tube, the 8XP4, can be used with nearly any receiver as a temporary substitute for the picture tube. It has great value as a servicing aid because of its compactness and adaptability. Although the 8XP4 is small, it is capable of displaying almost the entire raster produced by a 90-degree deflection system. See Fig. 1A. This feature is very desirable because it permits the technician to detect troubles that affect the edges of the pictures and to make adjustments of size and linearity while the check tube is being used. Until now, checks and adjustments like these could not be adequately performed on a receiver having 90-degree deflection unless a full-sized picture tube of the proper type were connected to the chassis.

When the 8XP4 tube is used in a 70- or 53-degree deflection system, it will usually be found that the picture does not completely fill the screen. In addition, some pincushion effect may be visible at the edges of the picture. These effects will detract only slightly from the usefulness of the tube in normal testing applica-



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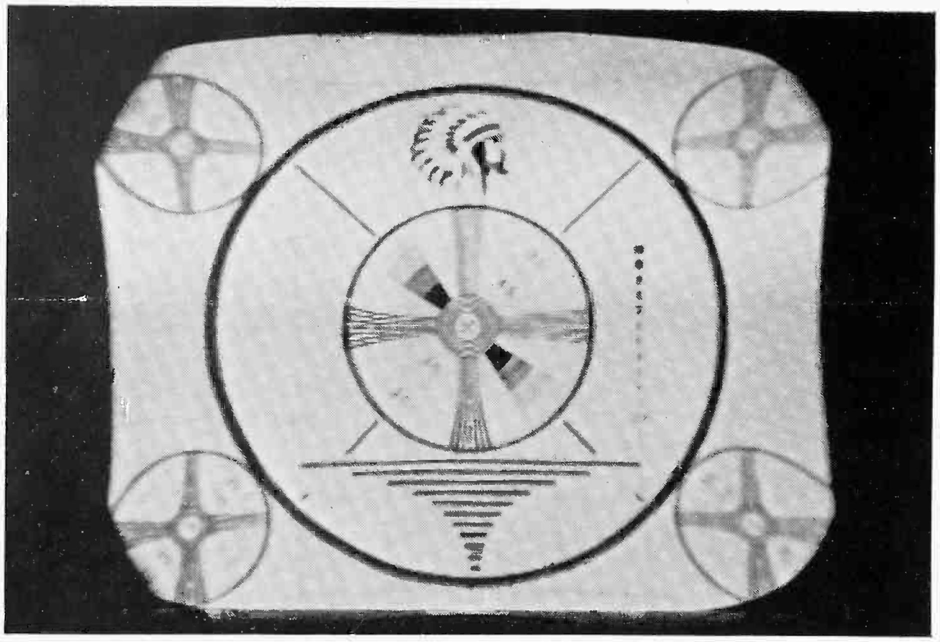


B

(Fig. 1.) Test Patterns Produced on the Screen of the 8XP4 Check Tube.
(A) By a 90-Degree Deflection System.
(B) By a 70-Degree Deflection System.

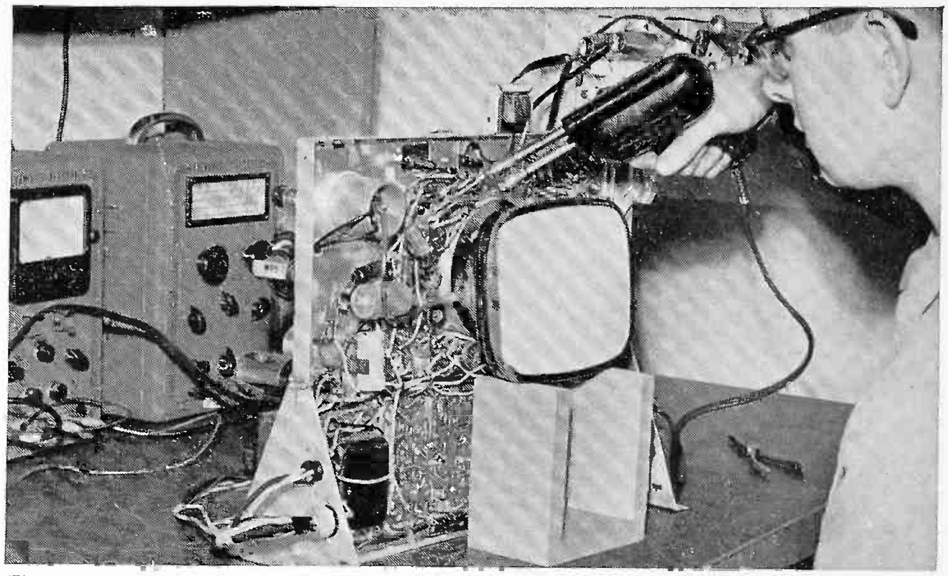
tions. A test pattern that was produced on the 8XP4 tube by a receiver having 70-degree deflection is shown in Fig. 1B.

The check tube has many features which simplify the handling of the tube on the service bench. The 8XP4 is able to reproduce a good picture under a wide variety of operating conditions, and connections between the check tube and a receiver can be made rapidly and easily. All the technician has to do when hooking up the 8XP4 tube is to slip the yoke around the neck of the tube and to attach the tube socket and the anode lead. Since electrostatic self-focusing is employed, no external focusing device is required. In addition, the electron gun is constructed to operate without an ion trap magnet. It may develop an ion spot during use, but the spot will not impair the tube's usefulness. Centering magnets will, in general, be unnecessary. The 8XP4 voltage ratings are high enough to permit its use in any conventional receiver. Potentials as high as those encountered in any conventional receiver may be applied to the anode.

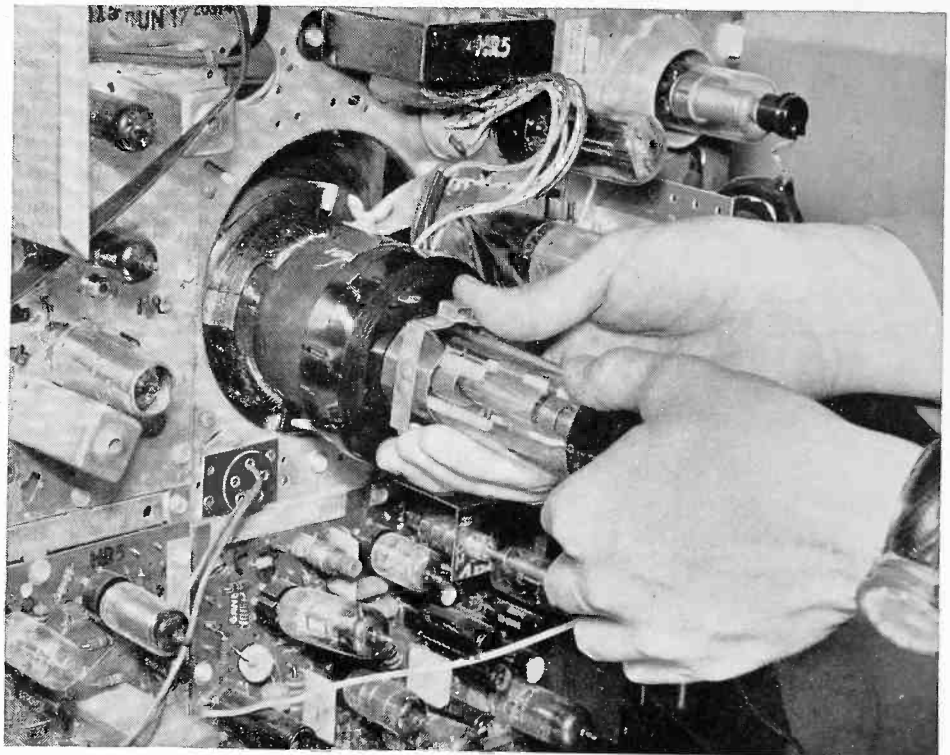
The results of using the 8XP4 in testing picture tubes by substitution are conclusive. If a picture tube is suspected of being defective, the check tube should be tried in its place. A normal picture will be developed on the check tube if the receiver circuits are operating properly, and any suspicion that the picture tube might have been causing trouble will then be confirmed. In some cases, the picture on the check tube may be better than that on the old picture tube but still not satisfactory. This indicates that there may be defects in the circuits as well as in the picture tube. The use of the check tube allows the technician to isolate defects to the chassis or to the picture tube so that trouble shooting can be done more efficiently.

Even if the picture tube of a receiver might appear to be in good condition, the technician may wish to replace it with an 8XP4 during servicing for the simple reason that the check tube is much less bulky than the picture tube. This use of the check tube for the sake of convenience in handling is especially important in view of the current trend toward the cabinet mounting of picture tubes. Many of the new receivers having vertical chassis are featuring this style of tube mounting, and an increasing percentage of the receivers with horizontal chassis are also using cabinet mounting.

When a receiver must be taken to the shop for servicing, the chances are that the chassis will have to be removed from the cabinet sooner or later. In the case of a receiver that has a cabinet-mounted picture tube, it is a sensible practice to remove the chassis in the customer's home. The chassis should then be taken to the shop where it can be serviced with the aid of the check tube, and the



(Fig. 2.) Technician Repairing a Cold-Solder Joint on a Vertical Chassis in Which the 8XP4 Is Installed.



(Fig. 3.) Technician Using an Ion-Trap Bracket as a Mounting Clamp for the 8XP4.

cabinet and picture tube should be left behind. This practice saves the technician the effort of hauling the entire receiver to the shop, and it minimizes the risk that the picture tube might be broken or that the cabinet might be scratched. The picture tube should be taken to the shop only if it is suspected of being defective.

The yoke assembly does not ordinarily have to be removed from the picture tube if a satisfactory substitute yoke is available at the shop, but there are certain cases in which the yoke will be taken along with the chassis. The yoke leads of some receivers are soldered directly to various terminals on the chassis, and the technician has the choice of unsoldering these leads or of removing the yoke from the picture tube. He should follow whichever course he considers to be the easier.

One practical way in which the 8XP4 can be connected to a vertical chassis is demonstrated in Fig. 2. The yoke is placed in its normal operating position, and the neck of the tube is inserted into it. All connections to the 8XP4 can then be made without the use of extension cables in spite of the fact that the yoke and second-anode leads of most vertical chassis are very short.

Notice that the check tube does not interfere with the accessibility of parts on the wiring side of the vertical chassis. Nearly all servicing operations can be carried on while the tube is installed in the position shown in Fig. 2.

More often than not, a yoke is attached to a vertical chassis only by its leads. Even if the yoke is held in place on the chassis by a mounting device, this device will seldom be rigid enough to provide a firm support for the 8XP4. Some kind of prop should therefore be placed under the check tube. The U-shaped support which is shown in Fig. 2 is very handy for this purpose. This should be placed under the front of the tube because the weight of the tube is concentrated near its face. Since the tube is supported at two points, it is held steady and does not tend to rock from side to side as it might if it were set upon a flat surface.

A better picture will be obtained and the tube will be held in place more firmly if the yoke is pressed tightly against the bell of the tube. A clamp which will accomplish this can be made out of a discarded ion trap (with magnet removed) or a centering-magnet assembly. Remove the magnets from whichever is used, and slide the clamp forward on the neck of the tube until it rests against the yoke. The positioning of this clamp is shown in Fig. 3. Once in place, the clamp grips the neck and prevents the tube from sliding out of position.

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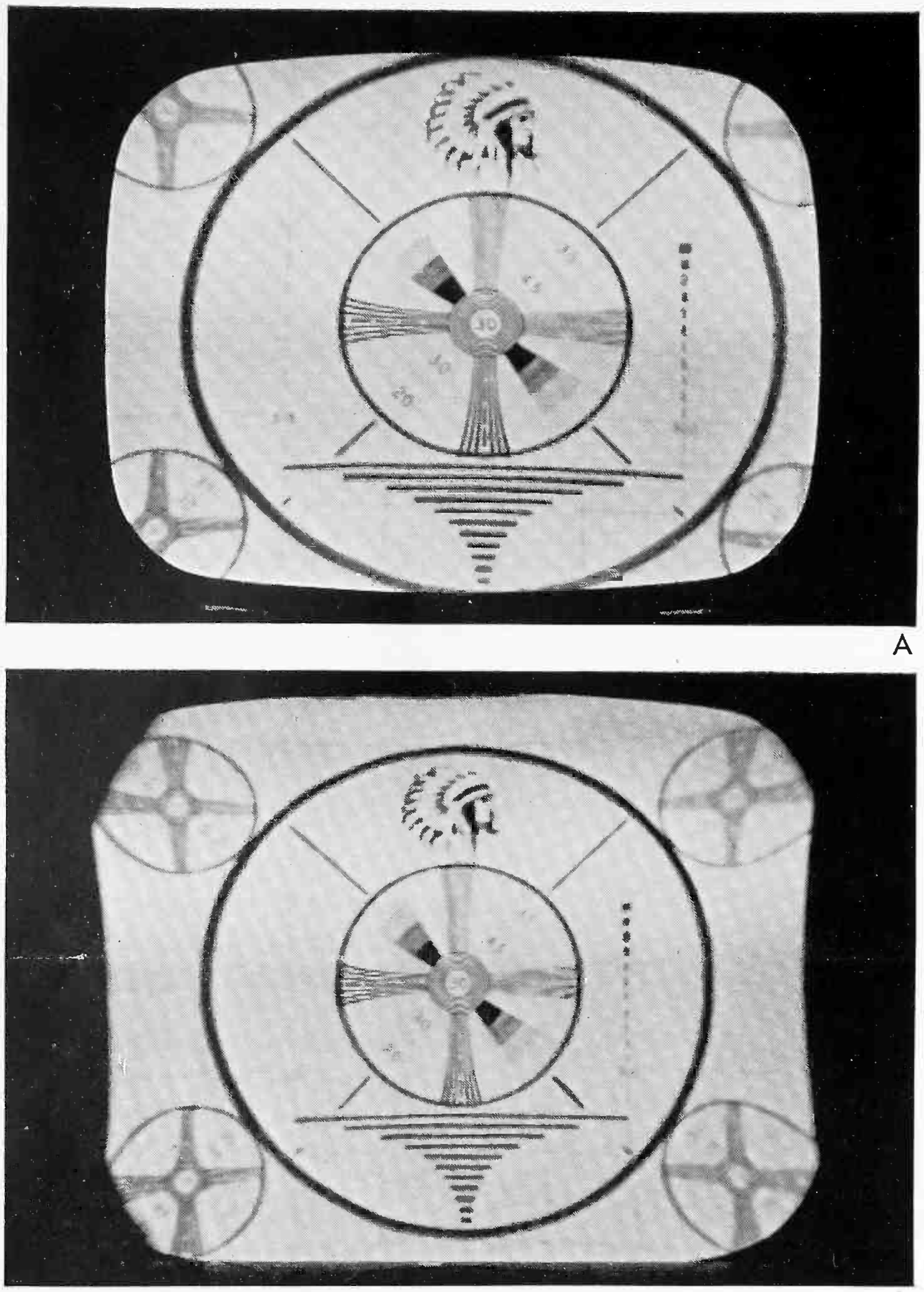

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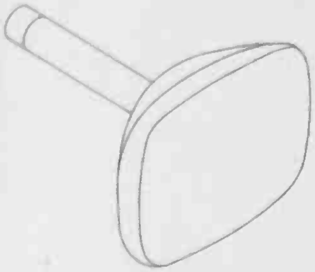
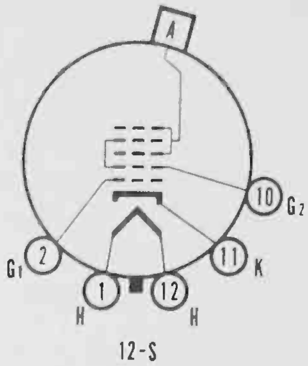
SYLVANIA TYPE 8XP4

TELEVISION RECEIVER CHECK TUBE

8" Direct Viewed	Magnetic Deflection
Rectangular Glass Type	Self Focusing (Electrostatic)
Gray Filter Glass	No Ion Trap Required





CHARACTERISTICS

GENERAL DATA

Focusing Method	Self Focusing (Electrostatic)
Deflecting Method	Magnetic
Deflecting Angle (approx.)	
Vertical	68 Degrees
Horizontal	85 Degrees
Diagonal	90 Degrees
Phosphor	P4
Fluorescence	White
Persistence	Short to Medium
Faceplate	Gray Filter Glass
Light Transmittance (approx.)	80 Percent

ELECTRICAL DATA

Heater Voltage	6.3 Volts
Heater Current	0.6 Ampere
Direct Interelectrode Capacitances	
Cathode to All Other Electrodes	5 $\mu\mu f$
Grid No. 1 to All Other Electrodes	6 $\mu\mu f$

MECHANICAL DATA

Overall Length	$11\frac{7}{16} \pm \frac{5}{16}$ Inches
Minimum Useful Screen Dimensions	$7\frac{3}{16} \times 5\frac{3}{8}$ Inches
Bulb Contact (Recessed Small Cavity Cap.)	J1-21
Base (Small Shell Duodecal 5-Pin)	B5-57
Basing	12S

RATINGS

MAXIMUM RATINGS (Absolute Maximum Values)

Anode Voltage	22,000 Volts d c
Grid No. 2 (and Grid No. 4) Voltage	550 Volts d c
Grid No. 1 Voltage	
Negative Bias Value	155 Volts d c
Negative Peak Value	220 Volts
Positive Bias Value	0 Volts d c
Positive Peak Value	2 Volts
Peak Heater-Cathode Voltage	
Heater Negative with Respect to Cathode	
During Warm-up Not to Exceed 15 Seconds	450 Volts
After Equipment Warm-up	200 Volts
Heater Positive with Respect to Cathode	200 Volts

TYPICAL OPERATING CONDITIONS

Anode Voltage	16,000 Volts d c
Grid No. 2 (and Grid No. 4) Voltage	300 Volts d c
Grid No. 1 Voltage Required for Cutoff[1]	−28 to −72 Volts d c

CIRCUIT VALUES

Grid No. 1 Circuit Resistance	1.5 Megohms Max.

SYLVANIA PICTURE TUBES

Issued as a supplement to the manual in Sylvania News for May-June 1956

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Notice that the check tube does not interfere with the accessibility of parts on the wiring side of the vertical chassis. Nearly all servicing operations can be carried on while the tube is installed in the position shown in Fig. 2.

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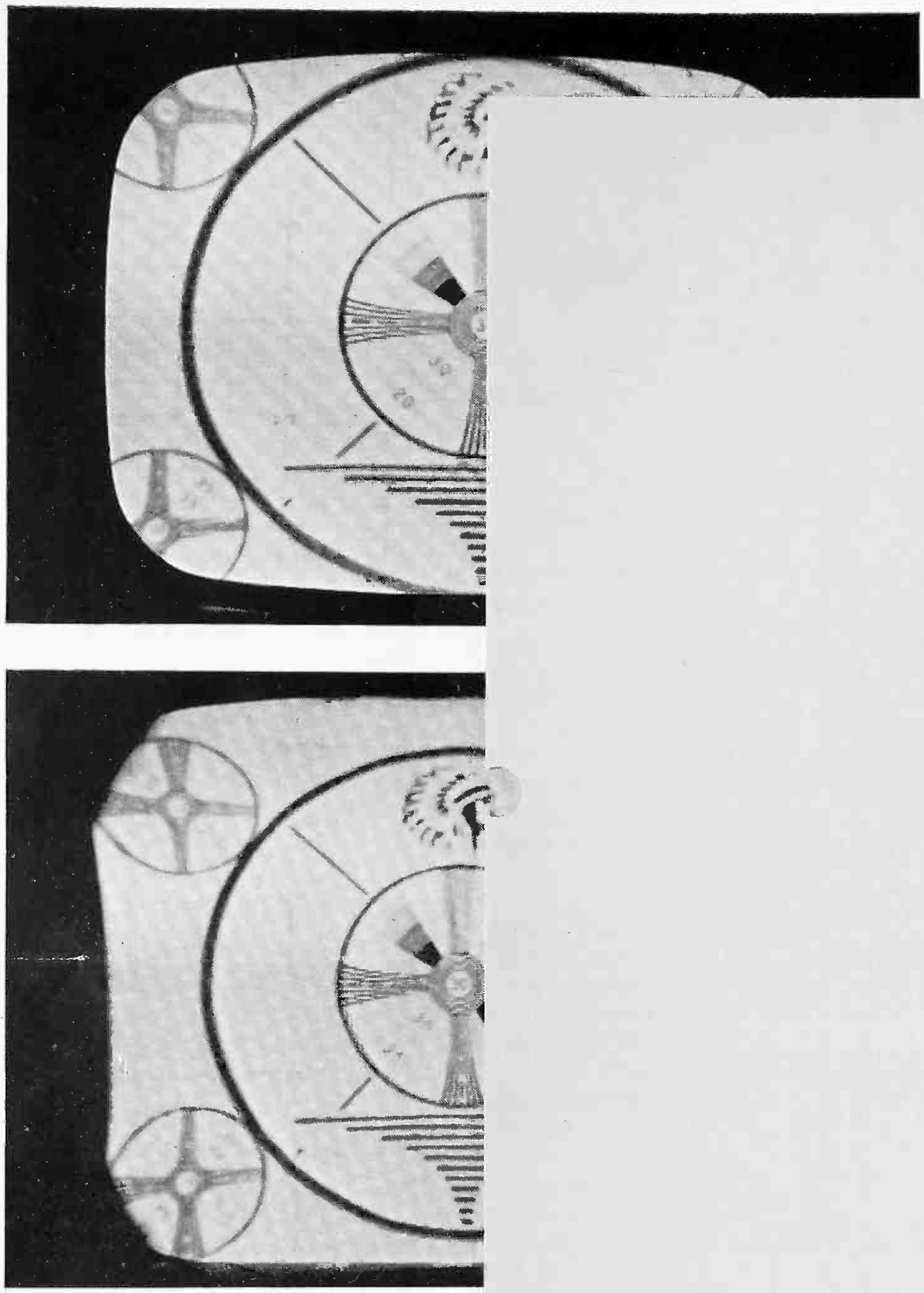

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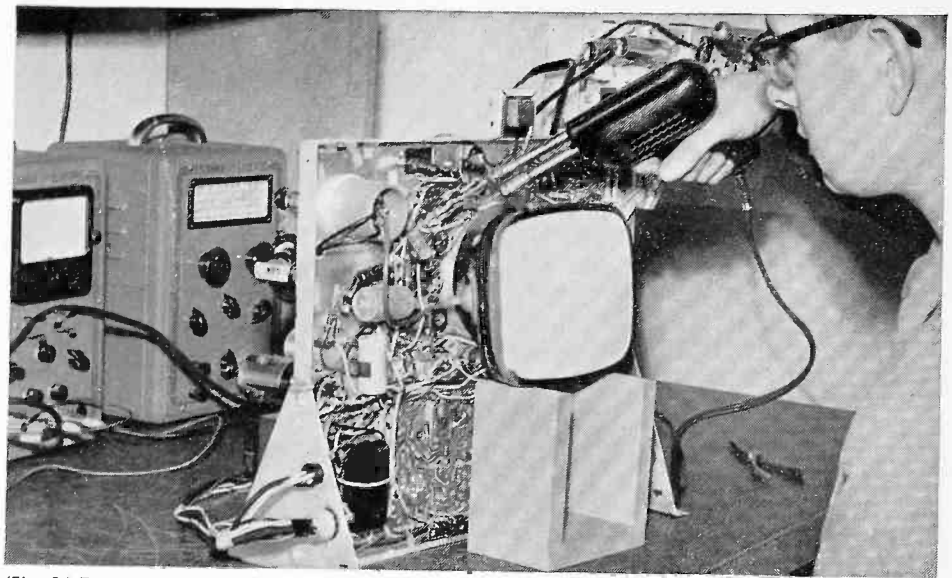
SYLVANIA ELECTRONIC TUBES



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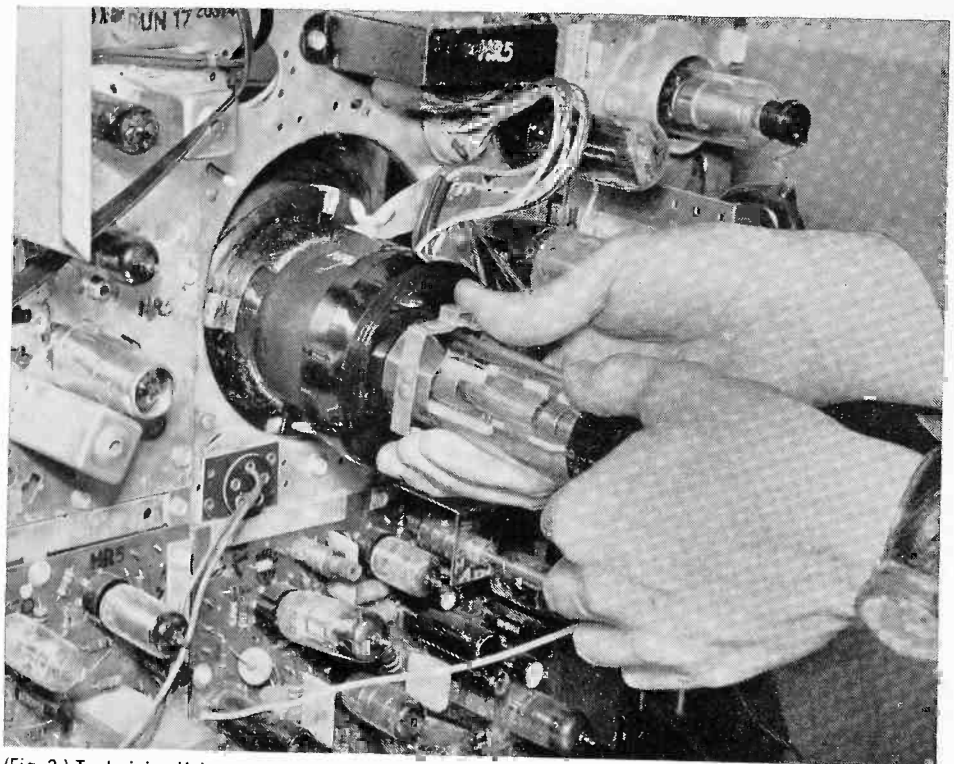

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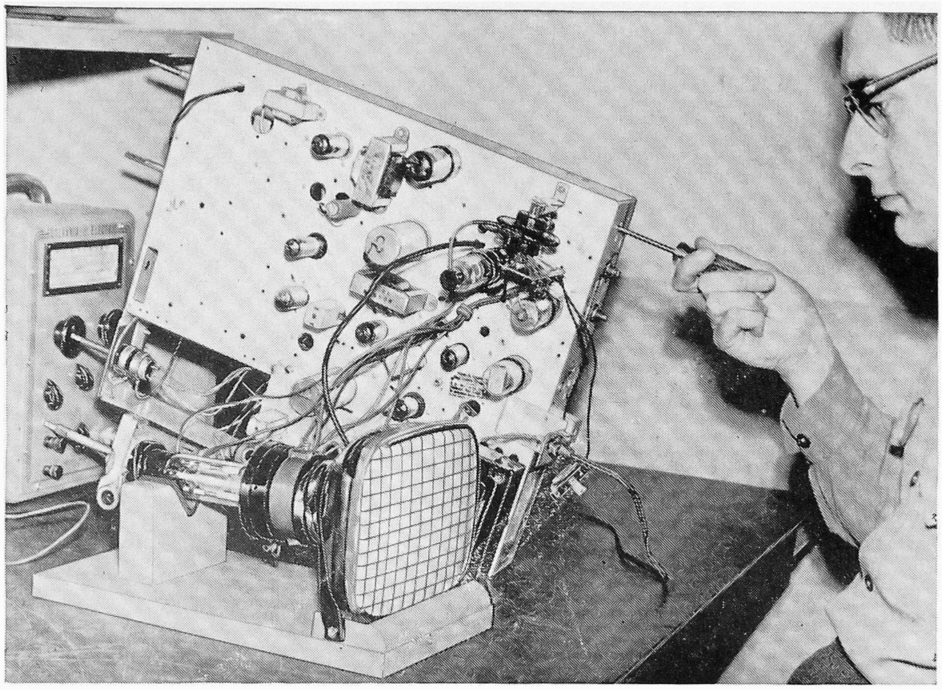

(Fig. 4.) Technician Using the 8XP4 in a Rack.

in Fig. 4, are already equipped with connecting leads that are long enough to reach the check tube without difficulty. The picture-tube leads of some other receivers are so short that a direct connection is awkward or impossible to make. In the latter case, extension cables must be employed. The rack can be used with both horizontal and vertical chassis. The check tube is protected against rough handling when it is mounted in this manner, and it can be easily moved around on the bench. The rack is also useful as a storage place for the tube.

Construction of such a mounting rack is a simple task. The one in Fig. 4 was made from several small pieces of wood, a strip of sponge rubber salvaged from the rim of an old picture tube, and an elastic band obtained at a dime store. A strip of wood and two small triangular blocks are fastened to one end of a wood base. These serve to hold the bell of the tube. A large block of wood with a notch cut in its top is attached by screws to the other end of the base, and this block supports the neck of the tube. Strips of rubber are used as cushions for the neck of the tube and for the rim of the faceplate. The elastic band is fastened to the sides of the triangular blocks; and when it is slipped over the bell of the tube, it exerts a forward pressure and seats the tube firmly in its mounting. The tension of the elastic is only moderate, and the base of the tube can easily be lifted so that a yoke can be placed around the neck.

More elaborate mountings could also be devised for the 8XP4. For example, the tube might be permanently enclosed in a box which could be used in the shop or carried in the service truck. Why would a technician wish to carry an 8XP4 in the service truck? The answer is that a suitably mounted check tube would be useful on home calls for the testing of picture tubes by substitution. If the technician specializes in servicing receivers which all have approximately the same yoke inductance, he may build a self-contained unit that includes a yoke and a set of extension cables as well as a check tube. He should keep in mind the fact that no single yoke will work properly with all receivers. For general use, such a box should be designed so that various yokes can be temporarily slipped over the neck of the tube. The mounting brackets should be kept clear of the neck. This could be done if the bell of the tube were held in place by straps fastened to the front of the box.

This discussion of mounting methods for the 8XP4 has dealt mostly with receivers that have cabinet-mounted picture tubes. Receivers in which the picture tube is mounted on the chassis can usually be serviced conveniently with the picture tube in place. There would be some advantage in using a check tube in place of the picture tube if a chassis were undergoing extensive repairs. The implosion hazard would be greatly reduced, and the chassis would be much lighter. The chassis could therefore be moved around on the bench with considerable freedom during a long series of servicing operations.

The 8XP4 was designed so that versatility would be its most outstanding feature. It is adaptable to nearly any situation in which a convenient substitute for a picture tube is needed.

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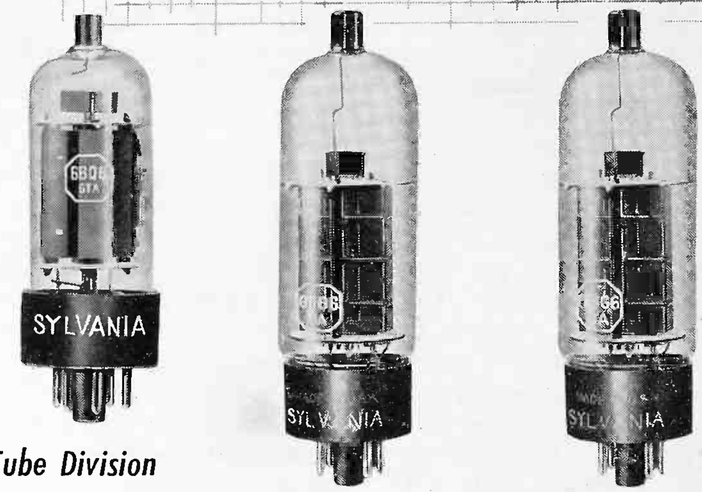
SYLVANIA NEWS

SEPTEMBER 1956 VOL. 23 NO. 8

R. A. Humphreys, Technical Editor

technical
SECTION

FACTORS AFFECTING THE LIFE OF HORIZONTAL OUTPUT TUBES



By G. L. Quint — Field Engineer, Radio Tube Division

The continual advancement in TV receiver circuits has produced a need for many new tube types. Notable among these are horizontal deflection tubes. The TV service technician has demanded that the tube industry supply more reliable and rugged replacement tubes. These factors have caused the electron tube manufacturers to upgrade their early and sometimes overworked types. The information and know-how gained through making these improvements is applied in the design and manufacture of new tube types.

Most Frequently Serviced Circuit

The horizontal deflection tube is one of the hardest working tubes in a television receiver. The energy it delivers to the horizontal deflection system must perform many functions, such as providing horizontal scan, high voltage to the picture tube second anode, focusing voltage for some types of picture tubes, filament voltage for the high voltage and focus voltage rectifiers, keying pulses for keyed and amplified a g c systems, a keying pulse for the burst amplifier in color receivers, a feedback timing pulse for some types of horizontal oscillator control systems, and other functions which may be germinating in the minds of TV receiver design engineers.

It can be seen that the horizontal deflection system is being monitored not only by its ability to provide sufficient scan and high voltage but also by other circuits whose operation depend upon signals derived from the horizontal deflection system. The ability of these other circuits to function properly as the horizontal deflection tube characteristics decline on life will determine how soon and how much the picture will be affected. Since the eye is much more critical than the ear, small amounts of picture distortion or degradation are more irritating to the viewer than a comparable distortion of the sound. Thus, the TV service technician is called upon to service the horizontal deflection system more often than the other circuits in the receiver.

Design and Environmental Factors

Some other factors which must be considered since they affect the failure rate of the tubes are the operating conditions imposed upon the tube. These factors may be broken down into two groups—design and environment.

The design factors are those which determine the plate and screen dissipations, peak and average plate, screen and cathode currents, the high amplitude pulse (or peak positive plate voltage) across the tube during horizontal retrace time, and the d c plate supply voltage (d c plus boosted B+). Normally, the adjustment of the drive, linearity, and width controls are also design considerations. Depending on the amount of "knob twisting" done by the layman, they may be "environmental factors."

Some of the environmental factors are the line voltage and ambient temperature at which the tubes operate.

Some of the operating conditions described above also affect the initial performance of the tube and the TV service technician should make the proper width, linearity and drive adjustments when replacing the horizontal output tube.

Design Improvements and Features

The new Sylvania Types 6BG6GA, 6BQ6GTA and 6CD6GA are a few examples of the changes that have been made to improve the reliability and performance of the horizontal

(Continued on page 6)

(*Continued from page 5*)
deflection tubes. We shall discuss three types since they reflect the improvements made over their prototypes 6BG6G, 6CD6G and the 6BQ6GT. Bear in mind that the newer deflection tubes such as the Sylvania Types 6DN6, 6CU6, 6DQ6 and 6DQ6A, incorporate parallel improvements plus other features as dictated by the particular requirements that these newer types must satisfy.

One of the first steps taken during the redesign of the deflection tubes was to alleviate the destructive effects caused by the high temperature and voltages encountered in horizontal deflection tube operation. Heat speeds up the liberation of gas from glass, metal, and mica parts. The heat and high voltages combine to cause chemical decomposition of the glass, known as glass electrolysis. The part of the tube most susceptible to glass electrolysis is the stem, or that part which holds the leads that provide the electrical (and mechanical) connection between the tube elements and the base pins.

Wafer Construction— Stem Electrolysis Minimized

Figure 1, right, shows the old-style, flat-press stem construction. Note that the leads are small in diameter and closely spaced. Figure 1, left, shows the new wafer stem construction utilized extensively by Sylvania not only on deflection tubes but on upgraded versions of practically all old GT type tubes. The circular pin arrangement of the wafer stem allows the use of larger diameter lead wires with greater spacing between the wires. These features are also clearly shown in Figure 2. The larger lead wires provide for greater heat conduction away from the tube elements while the wider lead spacing reduces the voltage gradient between leads. These two advantages of the wafer stem have eliminated the problem of stem electrolysis.

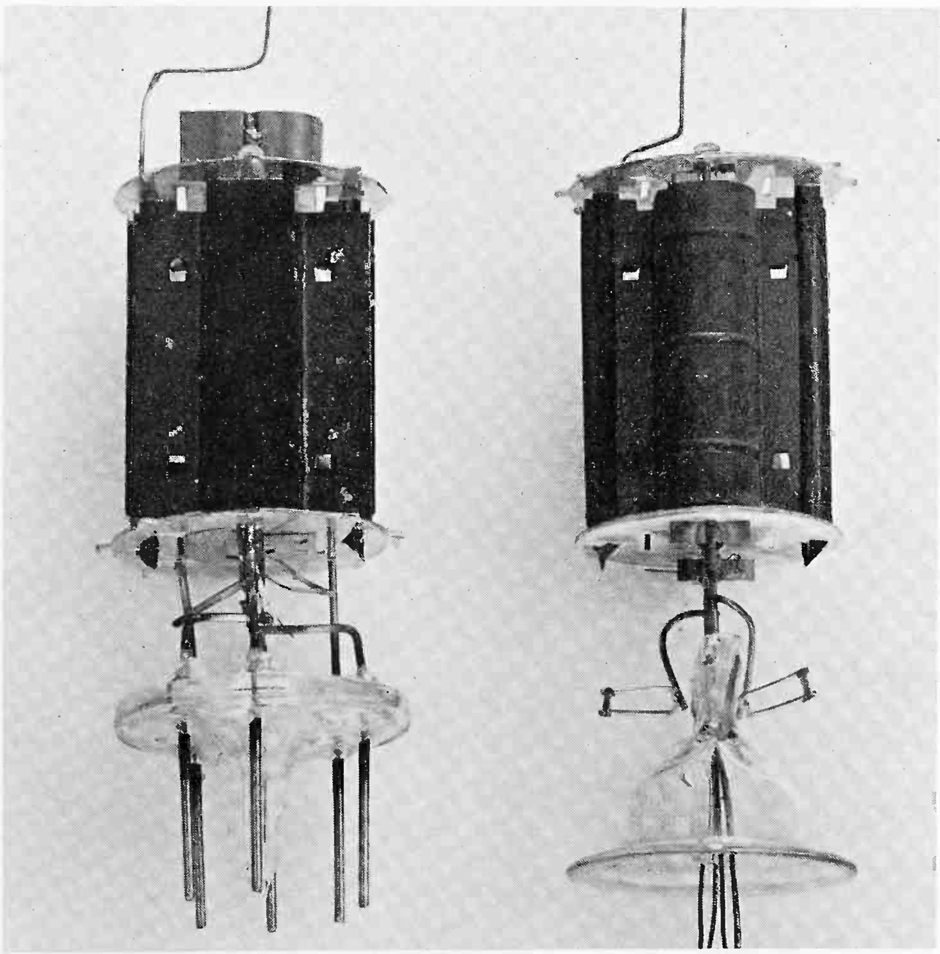


FIGURE 1—SHORTER, MORE RUGGED MOUNT. Added support, shorter construction, and larger diameter leads are clearly visible in the mount employing a wafer stem, left, as compared to the press stem mount shown on the right.

Less Susceptible to Vibration

The wafer stem construction also provides a rugged three-point support for the tube mount which makes it less susceptible to vibration, as compared to the weaker two point support of the flat press construction. Thus, the wafer stem construction provides much needed electrical and mechanical tube improvements.

Reduced Internal Arcing

With the wafer stem construction the mount may be placed lower in the bulb. This provides for greater spacing between the plate pigtail lead, going to the top of the bulb, and the rest of the mount. This allows a greater safety factor for peak plate voltages and has substantially reduced internal arcing in the tube.

New Screen Grid Construction

One of the greatest sources of trouble with the deflection tubes has been screen grid dissipation. Recent changes in screen grid structure, coating materials and advanced processing techniques have eliminated "wild" tube characteristics which occur when the screen grid becomes so hot that its mechanical dimensions become distorted.

It must be appreciated that the performance requirements for the various horizontal deflection tubes sometimes change as new receiver designs come on the market. This can temporarily cause some difficulty in the replacement field. There will be a time delay until the tube manufacturer can ascertain what improvements are needed; the given tube's design is upgraded; and the upgraded product is placed in the field. Sylvania keeps a watchful eye on the replacement market to detect any such potential difficulties so that the time lag in getting the upgraded version of the tube type on the serviceman's shelf will be minimized.

Thorough Testing

To support and insure continuation of the improvements which have been built into the deflection tubes, Sylvania has imposed more stringent specifications and developed new test procedures to pick out as many latent defects as possible in the tubes which might show up in the field as short life.

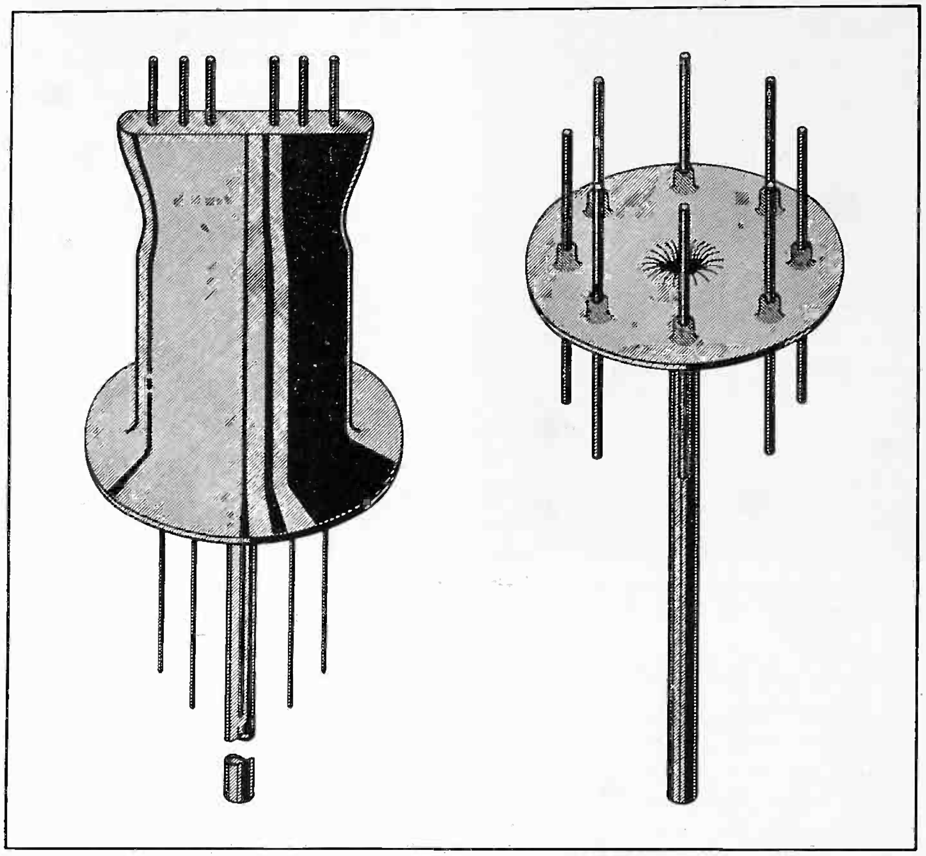


FIGURE 2—REDUCED GLASS ELECTROLYSIS AND ARCING. Wafer stem construction is shown on the right, the old press stem construction on the left. It is readily seen that the wafer stem leads are farther apart which (coupled with cooler operation resulting from heavier, shorter leads) reduces glass electrolysis and arcing.

Also, in order to further study and improve the performance capabilities of these deflection tubes, as well as many other types in the line, Sylvania has established an Application Quality Laboratory which continually evaluates tube production for performance, Figure 3. Samples of all production lots of tubes are tested in receivers. Sylvania feels that the Application Quality tests are very important since mere reliance on the data from static test conditions, Figure 4, is no assurance of satisfactory tube performance in actual applications. Once the initial operating capabilities of the tubes have been ascertained, information as to how they will perform during months and months of set operation is also very necessary.

TV Life Test

Sometime ago, Sylvania instituted the life testing of tubes in TV receivers representing many different makes and models, Figure 5. The life test is performed with the receivers operating at high a c line voltage. The receivers are cycled on and off each hour for approximately 1500 hours (approximately one year of set operation). The tests are run at high line voltage to accelerate any tendency for the tubes to fail. The performance of the receiver is continually monitored during the life test period and any failure, whether tube or component, is carefully noted. These tests have shown that operating a TV receiver at 130 volt line will cause the failure rate of the entire receiver to increase by a factor of 2.37 times as compared to the failure rate at 117 volt line*. What is the line voltage in your area?

Static Life Test

A static life test is performed in addition to the TV life test. The static life test operates the tube under d c circuit conditions, at or near maximum plate and screen dissipations and d c cathode current. The tubes are read periodically for electrical characteristics. When the characteristics which must be controlled on life to insure satisfactory tube operation read above or below specified values, the tube is considered to have

(*Continued on page 8*)

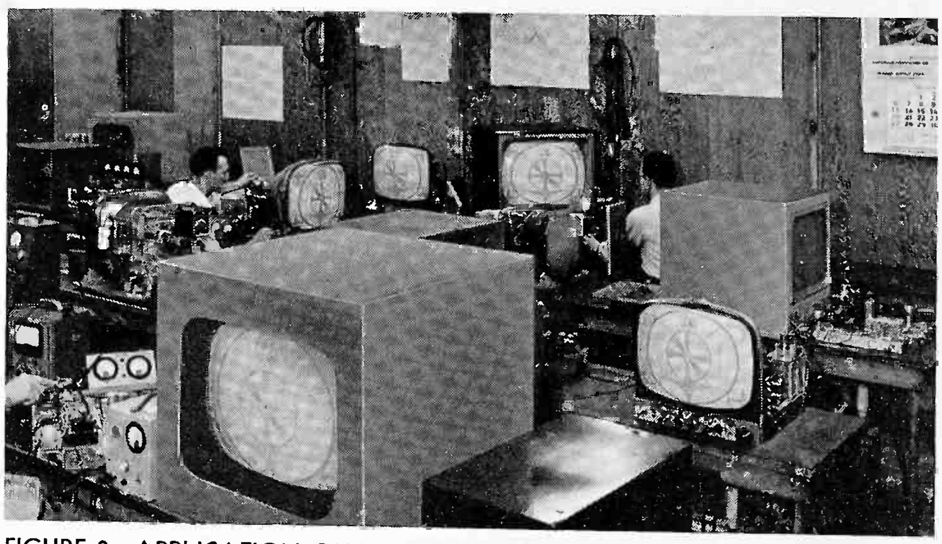


FIGURE 3—APPLICATION QUALITY LAB. Corner of the Application Quality Lab. Samples of all production lots of tubes are evaluated for performance in TV receivers.

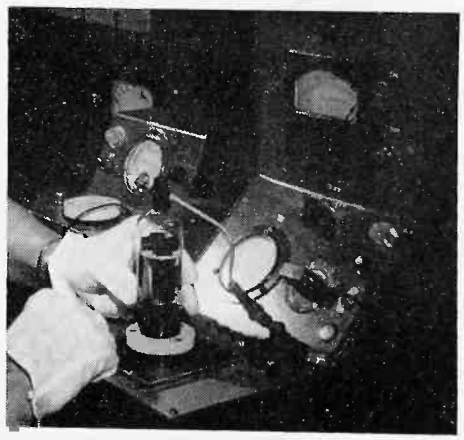


FIGURE 4—PORTION OF TEST set up for checking major electrical characteristics of horizontal deflection tubes. Although very necessary in determining quality level, Sylvania feels that this test alone does not assure satisfactory performance in actual application.

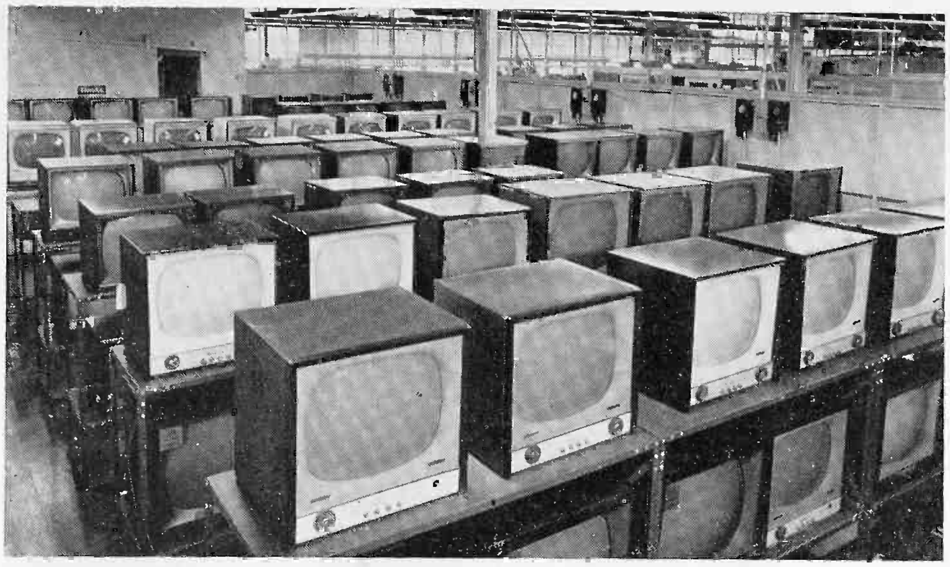


FIGURE 5—TV LIFE TEST. Tubes are life tested in TV receivers representing many different makes and models, for a period approximately equivalent to one year of set operation.

(*Continued from page 7*)

reached the end of its life as far as this test is concerned. It must be remembered that the specified life test end points cannot possibly include values for all of the different circuit conditions which the many receiver manufacturers may impose upon the tubes in their various receivers. These limits must be chosen with certain compromises and with the idea that the tubes will give satisfactory performance in the great majority of receivers.

Dynamic Life Test

In the dynamic life test, Figure 6, tubes are operated in horizontal sweep systems which are adjusted so that each tube type is operated under conditions more severe than those encountered in a properly designed horizontal deflection system in a TV receiver. The operating conditions of the dynamic life test can be closely controlled. Thus, this test provides standardized information as to tube performance, whereas the TV receiver life test provides information about tube performance under the different conditions found in various makes and models of TV receivers.

The Final Product and Field Problems

The product is released for use in the field only when all efforts of the tube manufacturer have been expended to the point where reliable performance has been ascertained by the various characteristic and life tests. It is at this point, especially in the replacement tube business, that the manufacturer usually loses all control on how his product will be used. True, the tubes are intended to replace a defective tube of the same type in some equipment, the design of which was, or should have been, such that the tubes are operating in a reliable environment to give satisfactory life and performance. However, the gradual deterioration of all the components in a TV receiver may change the operating conditions of the tubes to the point where certain maximum ratings are approached or exceeded. Adjustment by the layman may change operating conditions to the point where tube failures are accelerated. The receiver may be in a locality where the line voltage is high, or fluctuates during the day as various industries increase or decrease their demands, thus affecting the set failure rate as discussed previously.

Since no manufacturer of equipment, especially home entertainment devices, can possibly know or control the local conditions under which his product must operate, he is in the same position as the component manufacturer in that he must determine under what average or perhaps extreme conditions his product must operate satisfactorily.

After due consideration of all the factors, technical and economic, the resulting decisions are of necessity a compromise of all the important factors. Sometimes an accumulation of compromises produces a high percentage of field headaches, but the fact that there are millions of tubes operating in millions of receivers proves that the electronics industry has been very successful in providing home entertainment devices of reliable and satisfactory performance, even in these highly competitive days.

*Effect of Environment on Tube Life—Electron Tube Life and Reliability—Chapter IV by M. A. Acheson.

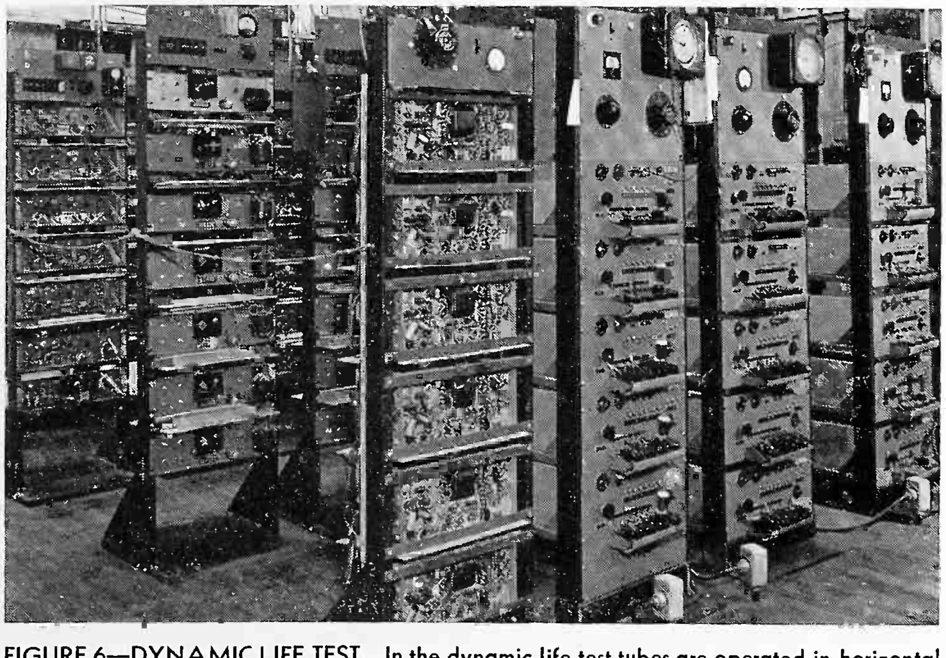


FIGURE 6—DYNAMIC LIFE TEST. In the dynamic life test tubes are operated in horizontal sweep systems which are adjusted so that each tube type is operated under conditions more severe than those encountered in properly designed receiver deflection systems.

SYLVANIA NEWS

technical
SECTION

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R. A. Humphreys, Technical Editor
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UNDERSTANDING FLYBACK CIRCUITS

By R. F. Bergdahl

Modern television receivers have shown vast improvements in circuits, components and tubes, giving us performance unthought of a few years back. This article is intended to give a better understanding of a frequently encountered modification of the usual flyback circuit. The knowledge of both types is necessary for effective and efficient troubleshooting.

BASIC CIRCUIT DIFFERENCES

The two types of flyback circuits, which are most often encountered, may be classified by the type of flyback transformer employed. The first is the conventional flyback transformer which is easily identified by the separate windings for the damper and deflection yoke, Figure 1. The second is the direct drive or auto type flyback transformer, Figure 2. The principle of operation is very similar for both types. A few special notes, however, will clarify the basic circuit differences. (1) The conventional flyback transformer applies a negative pulse to the plate of the damper and the boosted B+ voltage is taken from the cathode. (2) The direct drive type of flyback transformer (auto) applies a positive pulse to the cathode of the damper while the plate goes to B+ and the boosted B+ voltage is taken from the low side of the flyback transformer winding.

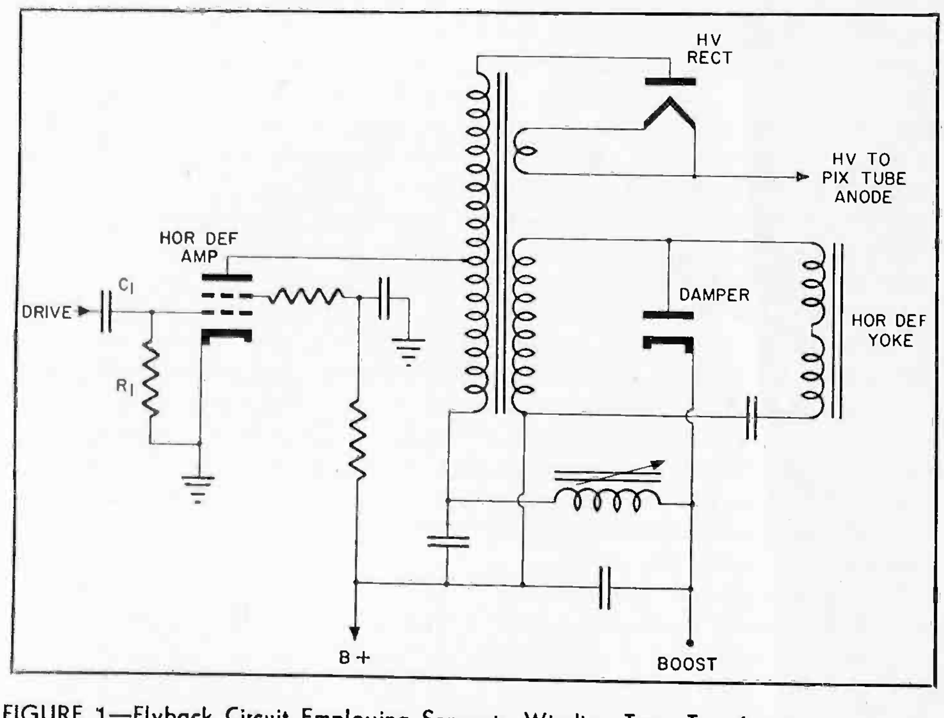

FIGURE 1—Flyback Circuit Employing Separate Winding Type Transformer.

CIRCUIT OPERATION

Now let us consider the operation of a typical horizontal deflection circuit employing an auto type flyback transformer, Figure 2. The waveshape of the driving voltage is the familiar sawtooth, common to the application, Figure 3A. Operating bias is developed by the tube; that is, the input signal drives the grid slightly positive, thus causing current to flow from the cathode to the grid and through the grid resistor, R_1. The resulting voltage drop across R_1 charges the coupling capacitor, C_1, in a manner such that the d c operating level of the grid is negative with respect to the cathode.

It should be noted that the cathode of the horizontal deflection amplifier shown is grounded directly, Figure 2. In the absence of drive, in such a case, the tube would be operating without bias, resulting in excessive plate and screen current. In many circuits a protective bias voltage is provided by the incorporation of a cathode resistor. This arrangement limits the current flow to a safe value should grid excitation not be present.

Now that we have established the method used to obtain bias, let's see what basically happens in the rest of the circuit for the period of one drive

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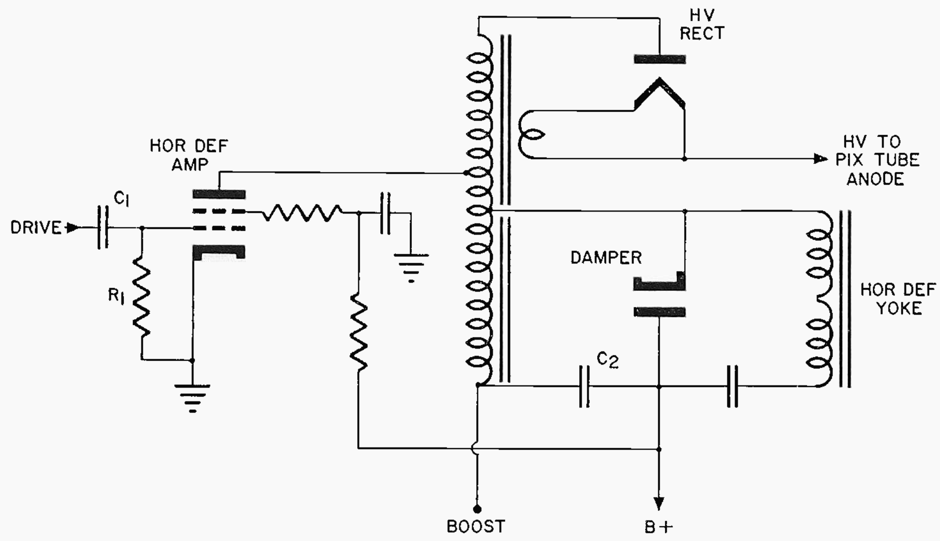

FIGURE 2—Flyback Circuit Employing an Auto Transformer.

(*Continued from page 5*)

cycle. Referring to Figure 3A, time T_1, we find that the tube is cutoff. At time T_2 the drive voltage has increased to a value which is equal to the cutoff voltage of the tube. At this point the tube begins to draw current and continues to do so, increasing steadily, until time T_3. At this point the tube is drawing its maximum cathode current. Figure 3B shows the waveshape of the cathode current through the tube, and therefore through the flyback transformer. This increasing current through the circuit, between times T_2 and T_3, produces a corresponding and proportionate increase in the magnetic lines of force in the flyback transformer and deflection yoke, thus providing the energy required for one-half the scanning cycle (to be discussed later).

Returning to Figure 3A, it will be noted that the driving voltage, upon reaching time T_3, suddenly drops to its most negative value, T_4. This naturally causes the tube to be cutoff sharply and stops the current flow in the flyback transformer. Since there is no longer any current flow through the flyback transformer the developed flux rapidly decays and in so doing produces a large positive voltage pulse, Figure 3C (1), of short time duration. Now, as this positive pulse decays it induces a magnetic field in the flyback transformer which is of the opposite polarity. Collapse of this newly created flux produces a negative pulse voltage in the flyback transformer windings, but of a lower magnitude than the positive pulse, Figure 3C (2). These pulse voltages have somewhat of a sinewave appearance and will continue "ringing" or "flying back and forth" until the energy required to continue the action is expended in transformer losses. This ringing effect can be compared to a musical instrument in which the plucking of a string will cause the string to vibrate back and forth until it gradually comes to rest.

DAMPING ACTION

Since a smooth, linear scan is required on the picture tube, and the magnetic flux required to bend the electrons in the picture tube is directly proportional to the current in the yoke, the yoke must not have the current fluctuations that result from the ringing action just described. To eliminate this difficulty a damping diode is placed in the ringing circuit so that every time the ringing voltage swings negative the tube will conduct and absorb the energy required to continue the ringing. Nothing need be done to the positive pulse voltage, Figure 3D, (first swing of the flyback transformer) since it occurs at a time when the picture tube is cutoff, i.e., during the horizontal retrace time.

To understand how the damping diode absorbs power from the negative pulse voltage, let us look at the simulated circuit shown in Figure 4 and operate a rectifier tube with the cathode a c fed. Under these conditions the tube will conduct when the a c voltage on the cathode swings negative with respect to the plate. When conduction occurs, capacitor C_3 becomes charged and the positive rectified voltage then appears at the cathode. Since the plate of the rectifier tube is already at B+ potential, effectively there are two supplies connected in series. Thus, the sum of both the rectified a c voltage and the battery B+ voltage will be present across the load resistor, R_L. In the actual flyback circuit, Figure 2, the negative portion of the ringing sinewave voltage is rectified by the damping diode and appears as a d c voltage across the boost capacitor (C_2). This voltage is called the boost voltage and the sum of the boost voltage and B+ (boosted B+) is used in many makes of television receivers to (1) supply the first accelerating anode voltage to the picture tube, (2) supply the vertical and/or horizontal oscillator plate voltages, (3) supply the vertical deflection amplifier plate voltage, as well as supply a higher voltage to the plate of the horizontal deflection tube.

HORIZONTAL SCAN

To continue with the basic functions of the horizontal flyback circuit, let us examine the deflection yoke. The horizontal deflection yoke consists of two separate windings. (These coils are usually connected in series but depending on the impedance required may be connected in parallel.) With a normal operating receiver, let us assume no current flow in the horizontal coils of the yoke. This would leave a vertical white line at the approximate center of the picture tube screen. Therefore, to produce scan on the left side of the picture tube screen, current must flow in one direction, which we will call the negative direction, and to produce scan on the right side of the picture tube screen, current must flow through the yoke in the opposite direction, which we will call the positive direction.

To scan the left side of the picture tube, the negative current required is produced when the damper draws current during the negative portion of the flyback ringing. To understand

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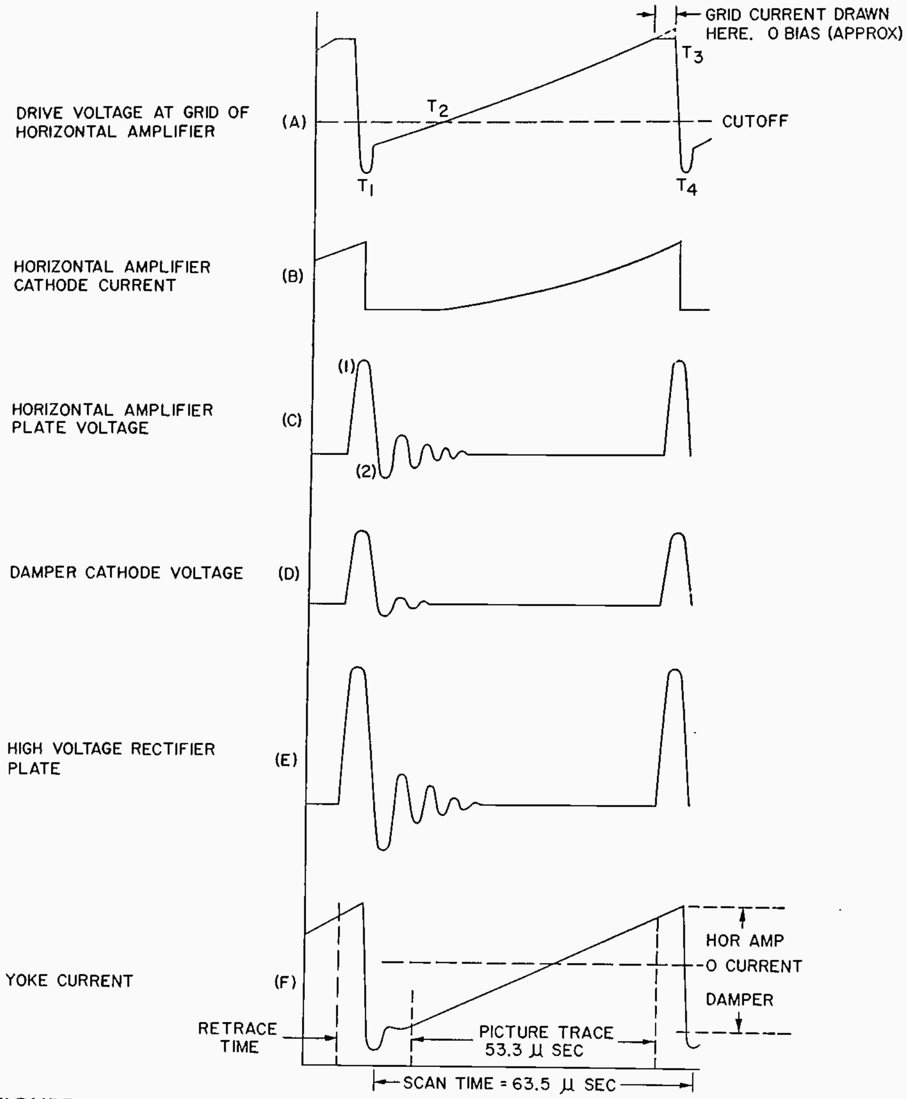

FIGURE 3—Waveforms Encountered in Typical Flyback Circuits.

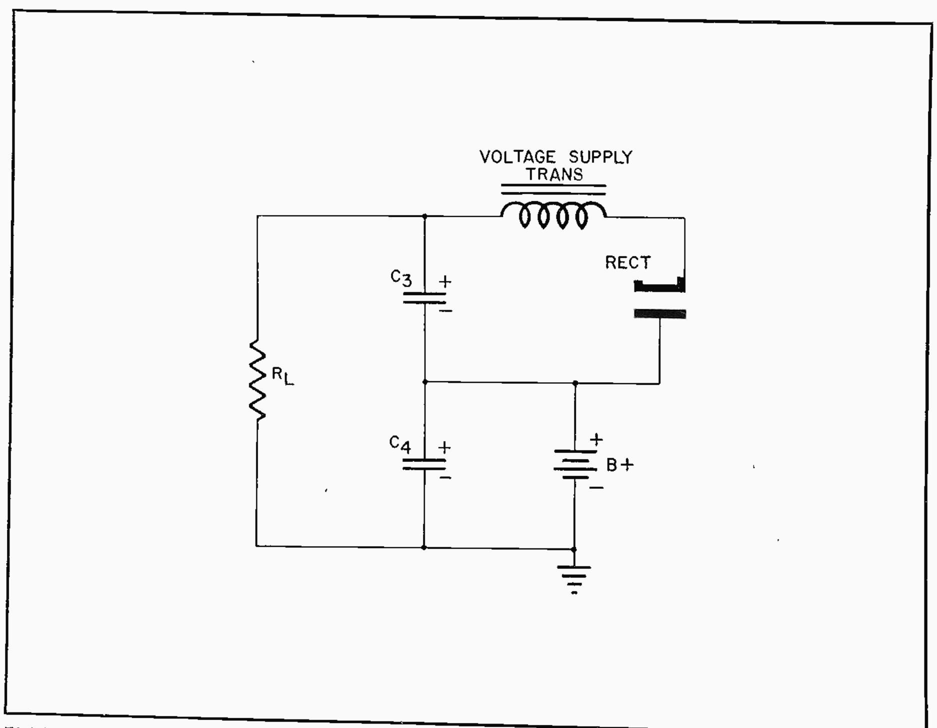

FIGURE 4—Simulated Boost Circuit.

(*Continued from page 6*)
how the damper draws current through the yoke in a negative direction it must be understood that the yoke and flyback transformer are tied in parallel and together represent a tuned circuit. Therefore, at the time of the negative pulse (Figure 3C-2) power from both the flyback transformer and yoke supply the negative pulse which is rectified by the damper. This resulting "negative" current is represented by I_1, Figure 5.

I_2, Figure 5, represents the "positive" current required to scan the right half of the picture tube and is produced during the conduction period of the horizontal deflection amplifier tube.

Currents I_1 and I_2 are plotted against time in Figure 6. When current I_1, from the damper-yoke circuit dies, the trace returns to the center of the screen. By this time, however, the driving waveform has reached the point where the horizontal deflection amplifier starts to conduct (Figure 3A, T_2) thus beginning the right hand portion of the sweep cycle. The dotted line in Figure 6 shows the resulting yoke current waveform when the I_1 and I_2 currents are combined and, being linear, produce a linear flux in the yoke and a resulting linear trace on the picture tube.

DEVELOPMENT OF HIGH VOLTAGE

The flyback transformer has still another important requirement in the television receiver. It supplies the high voltage to the picture tube anode. We previously mentioned that a high voltage pulse (Figure 3E) is generated by the flyback transformer during the retrace time. This pulse, when stepped up and rectified, is the source of high voltage for the picture tube. Step up of the pulse is accomplished by an additional auto transformer winding which is placed on the flyback transformer in series with the horizontal amplifier plate winding, Figure 2. The filament supply for the high voltage rectifier is ordinarily obtained by a single turn of wire wrapped around the core of the flyback transformer. Since the power requirements of the filament are usually low, this arrangement does not affect the operation of the flyback transformer.

UNDERSTANDING FLYBACK CIRCUITS

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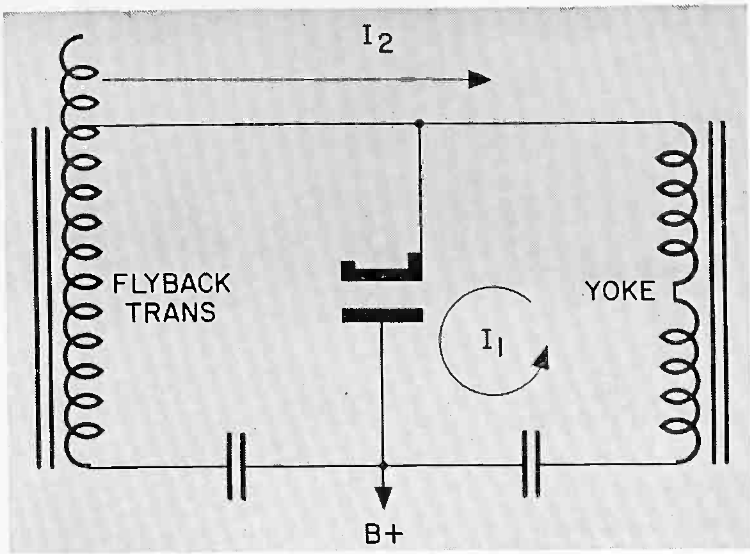


FIGURE 5—Deflection Current Paths.

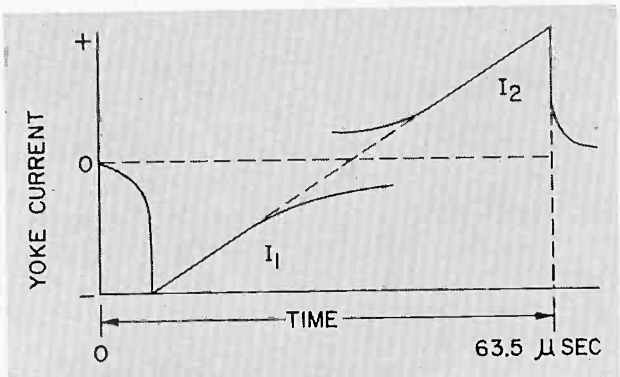
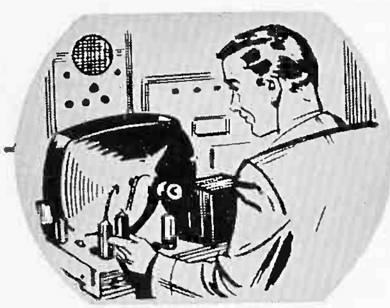


FIGURE 6—Yoke Current For One Scan Line.

SERVICE HINTS



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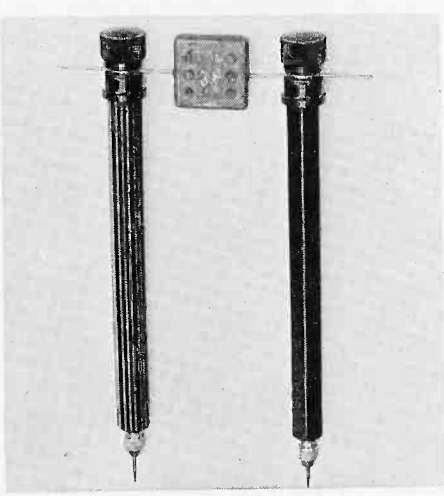

HOLDER FOR SUBSTITUTE PARTS

The photo shows two test prods equipped with binding posts (small size) which are utilized for substituting capacitors and resistors in defective circuits. Parallel connections can be made to obtain desired values and a wire connected between the terminals enables the prods to be used for shorting purposes.

Fred W. Brown
Los Angeles, California

5AXP4 MOUNTING

The 5AXP4 TV test tube can be firmly held in place by putting a hand type vacuum cleaner belt around the neck of the tube. By clipping the belt close up to the deflection coil, you will find that it will hold the tube firmly enough even when chassis is lying on its side.

Alex Radio & Television Service
Woodhaven, New York

PICKUP HEAD PROTECTIVE SHIELD

The sponge rubber liners from defective vibrators have proven useful to the serviceman in a multitude of ways. We would like to add to this list its use as a pickup-head protective sleeve when transporting phono units.

Stein's Shop
Los Angeles, California

REMOVING TV CABINET FACEPLATES

Two small suction cups, equipped with handles made from large washers, can be a big help in removing glass faceplates from TV sets for cleaning.

The Radio Shop
Rockland, Maine

SYLVANIA NEWS

technical SECTION

NOVEMBER • DECEMBER 1956 VOL. 23 NO. 10

R. A. Humphreys, Technical Editor

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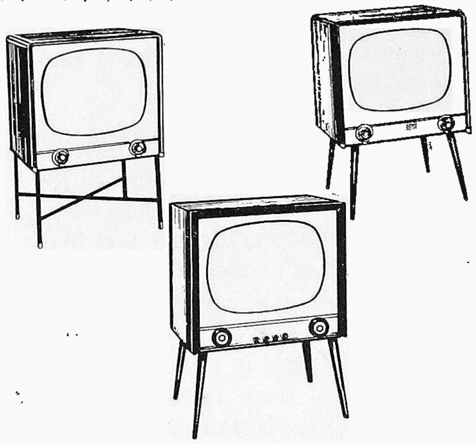
ELECTRON TUBE OPERATING CONDITIONS IN HORIZONTAL DEFLECTION SYSTEMS



By G. L. Quint — Field Engineer — Radio Tube Division

The automobile has been with us for about a half century. We are all quite familiar with this mechanical marvel. In the early days there was great difficulty in keeping the "Horseless Carriage" running, but, through the years, design improvements, improved testing techniques, improved equipment, and improved understanding of the operation of the automobile now permits the technicians who service these machines to analyze difficulties and correct them on very short notice. Indeed, we are very much put out if a garage mechanic cannot promptly analyze and lastingly correct an operating difficulty.

The engine in your automobile is an interesting device indeed. It is a central source of power which drives the wheels, but it does other jobs too. It drives the electrical generator which provides the lights, runs the radio and operates the heater. It requires protective devices such as the radiator, the fan, the water pump, air cleaner, etc., and has adjustments to permit it to be tuned up for optimum performance and efficiency. It has a gas pedal which regulates how hard it will operate.

What happens when something goes wrong with this complex system? Suppose the radiator clogged up, it could conceivably cause the motor to burn up. True, we will have to replace the engine, but will it work any better if we don't correct the radiator trouble? This same holds true for any of the other protective equipment as briefly discussed above.

What happens when the controls get out of adjustment? The engine must work harder to do the same job and it does not have its customary "zip". It also tends to wear out faster. The owner becomes very unhappy. Would we now change the motor and leave the adjustments as they were before? Indeed not. We would attempt to have it readjusted for optimum performance.

The things which we discussed above seem quite obvious. We have come to know this from over fifty years of experience in this field. Some of the situations discussed can be directly related to television servicing.

For example, the horizontal deflection tube is a power source. It is coupled via a transmission (transformer) to its load (the horizontal deflection yoke.) It renders auxiliary services such as providing high voltage and boost voltage to other parts of the receiver. It has protective devices surrounding it in the form of a screen resistor, cathode resistor and other passive circuit elements. It has a drive control and, in most cases, has other adjustments to permit optimum performance. Included would be width and linearity controls.

If a component associated with a horizontal deflection tube becomes defective and causes it to fail, simply replacing the tube may make the system work for a short time, but, we will very soon have a call-back. If we replace the tube in a circuit which has many hours of operation and has components which have substantially deteriorated, we will again have a call-back on our hands. If the horizontal deflection circuit is not adjusted for optimum operation, the set will lack zip and the auxiliary services will suffer.

Now, let us actually explore the effects of improper circuit adjustment, deteriorated auxiliary components and/or "old age" and excessive line voltage on the operating conditions of tubes in the horizontal circuit. In other words, just how hard does our engine have to work when operating under adverse conditions and what can we expect from it in terms of life.

We now come to the point of selecting a receiver for our investigation. Because there are so many variations in circuit designs and components, it is difficult, if not impossible, to choose

(Continued on page 6)

(*Continued from page 5*)

a receiver and say that it is typical. Consequently, the data and measurements taken on a given receiver are not necessarily typical. Therefore, receivers were selected at random and measurements taken on the circuits with the tubes in the sets which were supplied by the manufacturer. We must also have a reference condition and this was logically chosen to be at a line voltage of 117 volts with the set adjusted for normal viewing. The operating conditions were limited to the worst probable to provide a realistic evaluation.

EFFECTS OF HIGH LINE VOLTAGE

Now, let's see what happens to the operating conditions of the horizontal deflection amplifier, damper and high voltage rectifier as the line voltage is increased. At a line voltage of 130, increases in operation conditions for the three tubes in the deflection system ranged from 7.4% to 34.6%, Table I, O.C. 2. Note that the 34.6% increase is for the screen dissipation of the horizontal deflection amplifier. Plate currents of the horizontal deflection amplifier and damper also show an appreciable increase, as does the heater voltage of the high voltage rectifier, 12.2%.

Let's now readjust our test receiver for a normal picture and see how the operating conditions of the tubes in question are affected, still maintaining a line voltage of 130 volts. The results are shown in Table I, O.C. 3. At first glance, some decrease will be noted for the majority of measured characteristics; but, note that the peak positive plate voltage of the horizontal deflection amplifier has further increased, 23.7%, as has the heater voltage of the high voltage rectifier, 20.4%, and the peak plate current of the damper, 15.5%. The screen dissipation of the horizontal deflection amplifier is still 34.5% above the value recorded when the set is operating at 117 volts line.

IMPROPER ADJUSTMENT OF DRIVE

Next, let's return to the 117 volt line condition and see what happens when the drive is at maximum. It is interesting to note that no drive lines were evident at the maximum setting of the drive control with this particular receiver. The effects of operation under this condition are shown in Table I, O.C. 4. With reference to the horizontal deflection amplifier, the d c plate current and d c cathode current have increased by 31.5% and 28.7%, respectively.

This increase in d c cathode current exceeds the rating for the tube by approximately 26%. The d c cathode current of the damper also shows a sizable increase (33.4%) under conditions of maximum drive. It should be remembered that the picture being viewed appeared to be normal and did not indicate excessive abnormal drive by the presence of drive bars.

LINEARITY AND WIDTH ADJUSTMENTS

With some receivers, improper linearity and width adjustment may also radically affect tube operating conditions, as to adversely affect tube life.

For example, some receivers have been encountered in which adjustment of the linearity control at the 130 volt line condition caused the heater-cathode voltage of the damper to increase to such an extent that rapid failures resulted from heater to cathode arcs.

WHY CALL-BACKS

How does all this relate to call-backs? First of all, our experiment has shown that there are many voltages and currents contributing to the operation of the horizontal deflection system. Many of these characteristics are not ordinarily measured in normal servicing techniques but may be contributing to poor tube life or performance. Secondly, we have seen that although the picture may appear normal, operating conditions of the tubes in the horizontal system may be far from normal.

A light foot on the gas pedal of an automobile will normally result in long engine life. On the other hand, abnormally hard driving may drastically shorten engine life. The same holds true in the case of the horizontal deflection system. Increases in electrode dissipations, resulting from improper set adjustment, component deterioration, or high line voltage, accelerates the liberation of gas and increases bulb and stem temperatures, thus decreasing tube life. Excessive cathode current may cause loss of emission early in life. Abnormal heater voltage, as evidenced in the case of the high voltage rectifier, will seriously impair the life of this tube.

DIFFERENCES BETWEEN RECEIVERS

To illustrate the wide differences which may be encountered between various receiver designs, two other receivers were selected and compared from the standpoint of variations in tube operating conditions.

As would be expected, increases in measured characteristics are evident for both receivers at increased line voltage, Table III, O.C. 2. The interesting point, however, is that while receiver C shows an increase in deflection tube screen dissipation of 24.7%, receiver B shows an increase of over twice this value, 56.5%. Thus, the variations between makes and models of receivers are immediately evident. It is also interesting to note that when receiver B was readjusted to obtain a normal picture, still maintaining the 130 volt line condition, the plate dissipation of the horizontal deflection tube increased by 84% (almost twice normal value).

The effects of improper drive upon tube operating conditions also show wide variations between different receivers. For example, in a certain 21″ receiver, when operated at the 117 volt line condition with the drive control adjusted for minimum drive, the plate dissipation of the horizontal output tube exceeded the maximum rated value of plate dissipation by some 100 per cent. At the same line voltage but with the drive control at maximum, the plate dissipation was well within the rated value for the type.

In some cases, a slump in the horizontal oscillator output may make it impossible to obtain sufficient drive, thus causing the horizontal output tube to fail in a short time.

The wide differences in tube operating conditions between receivers, whether caused by improper set adjustment or high line voltage, may well be responsible for many call-backs.

"Rule of thumb" servicing techniques are not adequate if long tube life is to be insured. Each receiver

(*Continued on page 8*)

TABLE I
EFFECTS OF CIRCUIT ADJUSTMENT AND LINE VOLTAGE ON TUBE OPERATING CONDITIONS

Tube Type	Circuit Characteristic Measured		1 (Reference)	Operating Conditions (% Change) 2	3	4
6CD6GA	E_{bboost}	V DC	515	14.6	16.5	9.70
	Ec2	V DC	98	14.3	11.2	-4.09
	Ik	Ma DC	108	15.8	14.8	28.7
	ik	Ma Pk	360	20.8	11.1	—
	Ic2	Ma DC	11.2	18.2	21.4	6.25
	Ib	Ma DC	96.8	15.5	14.1	31.5
	Pc2	Watts	1.1	34.6	34.5	—
	eb_{pp}	Kv	4.45	16.9	23.7	5.61
1B3GT	Ef	V RF	0.98	12.2	20.4	—
	EH.V.	Kv DC	13.0	7.7	15.4	-2.3
	P.I.V.	Kv	14.08	7.4	15.4	-2.28
6AX4GT	Ib	Ma DC	96	16.7	14.6	33.4
	ib	Ma Pk	390	12.8	15.5	-5.3
	Ehk	Kv Pk	3.03	17.1	21.3	5.62
	P.I.V.	Kv	2.78	17.6	21.6	6.5

Operating Condition (O.C.)

1—E_{line} = 117 V. Width, drive and linearity adjusted for normal picture.

2—E_{line} = 130 V. No readjustments from O.C. 1.

3—E_{line} = 130 V. Set adjusted for normal picture.

4—E_{line} = 117 V. Normal picture, drive at maximum. Note: The maximum setting of the drive control was obtained with no drive line appearing in the picture.

TABLE II
DEFINITIONS OF SYMBOLS

Ik = DC Cathode Current

ik = Peak Cathode Current

Ic2 = DC Screen Grid Current

Ib = DC Plate Current

Pp = Plate Dissipation

Pc2 = Screen Grid Dissipation

P.I.V. = Peak Inverse Plate Voltage

ib = Peak Plate Current

Ehk = Heater-to-Cathode Voltage (DC + Peak)

Eb = DC Supply Voltage at Stage Measured

E_{bboost} = Boosted B+ Voltage

eb_{pp} = Peak Positive Plate Voltage

Ec2 = DC Screen Voltage

Ef (RF) = Filament Voltage for High Voltage Rectifier at 15,750 cps

$E_{H.V.}$ = Picture Tube Second Anode Voltage Measured at the Picture Tube Second Anode

Ec1 = DC Grid No. 1 Voltage

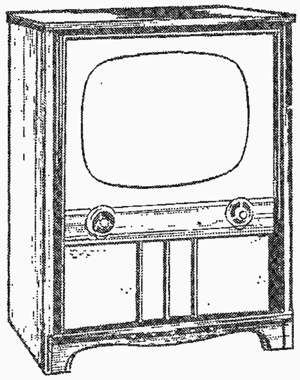
% Change = Percent by which measured characteristic varied from the reference condition.

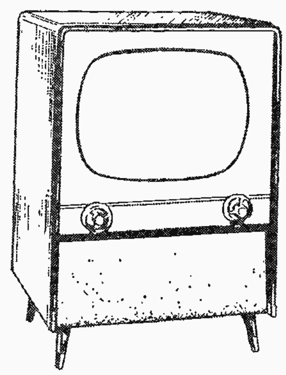
TABLE III
VARIATIONS IN TUBE OPERATING CONDITIONS BETWEEN RECEIVERS

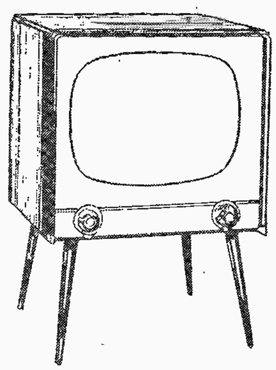
Circuit Characteristic Measured		OPERATING CONDITIONS (O.C.) Type 12DQ6 Rec. B: 1 (Reference)	Type 12DQ6 Rec. B: 2 % Change	Type 6CD6GA Rec. C: 1 (Reference)	Type 6CD6GA Rec. C: 2 % Change
E_{bboost}	V DC	540	10.6	580	12.1
Ec2	V DC	140	12.8	140	10.0
Ec1	V DC	− 36	5.55	− 37	16.2
Ik	Ma DC	105.8	6.1	118	12.7
ik	Ma Pk	340.0	0	335	19.4
Ic2	Ma DC	9.5	37	14.1	13.5
Ib	Ma DC	96.3	2.8	103.9	12.6
Pc2	Watts	1.33	56.5	1.98	24.7
eb_{pp}	Kv	4.0	5.0	4.5	13.4
ec1	V Pk	−125	16.0	−105	13.3
Pp	Watts	6.18	23.7	—	—

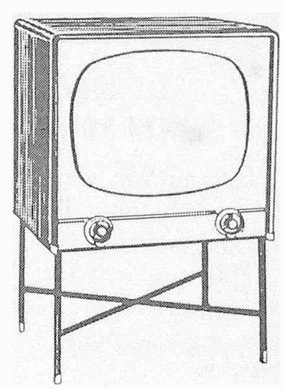
O.C. 1 = E_{line} = 117 V. AC. Picture and scan normal.

O.C. 2 = E_{line} = 130 V. AC. Picture and scan as adjusted at 117 volt line condition.









Electron Tube Operating Conditions In Horizontal Deflection System

(*Continued from page 6*)

presents a different problem and requires special attention.

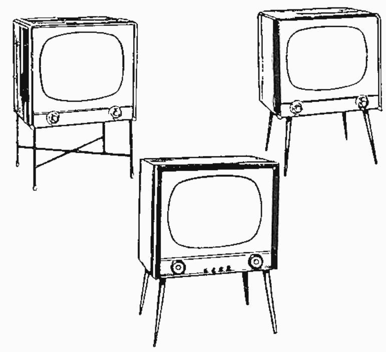
VARIATIONS DUE TO OTHER CIRCUIT COMPONENTS

Variations in circuit components also influence tube operating conditions and consequently tube life. For example, a decrease in the value of the screen grid dropping resistor of the horizontal deflection amplifier will tend to increase the screen grid voltage and dissipation. Depending upon exact conditions, the life of the tube may be radically affected. In such a case, replacing the tube without replacing the defective component only leads to a call-back.

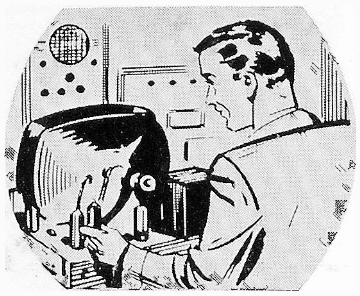
An increase in the value of the screen-grid resistor will cause the screen voltage to be lowered. With this lowered screen voltage, the original and replacement tubes may give short scan. Real circuit difficulty cannot be corrected by a new tube.

Defective components in the horizontal circuit, as well as improper circuit adjustment, may influence the life of tubes and components of other circuits. An increase in screen voltage of the horizontal deflection amplifier due to a defective screen grid resistor may increase the boost voltage, thus increasing the electrode voltage, current, and dissipations of other circuits, such as the vertical deflection system, which derive their B supply from this source.

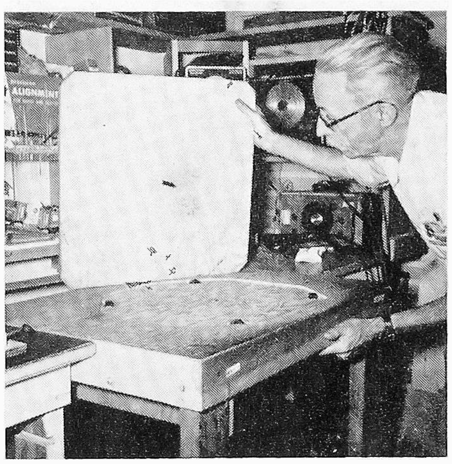
In conclusion, there are many factors affecting the life of tubes in the horizontal deflection system, as well as other associated tubes and/or circuits. From our investigations we can see the disastrous result of improper circuit adjustment, excessive line voltage and defective components on tube life. If normal tube life and a minimum of call-backs is expected, each of these items must be carefully considered by the service technician.



SERVICE HINTS



EDITOR'S NOTE: Sylvania offers $10.00 in Advertising Material Certificates for all technical hints that it believes useful to the service-dealer readers of SYLVANIA NEWS. Sylvania is not obligated to return any material submitted for publication, whether or not published.



SECTIONAL BENCH WITH ROTATING TOP

Intermittent sets often remain on the bench for a long time, thus reducing available bench space.

This problem can be avoided by making part of the bench into a moveable section supported by furniture casters.

In addition, the chassis rest rotates on casters, making it easy to revolve the set to any position without lifting or dragging it about, see photo.

Henry Mayo
Sarasota, Florida

MODIFIED INVERTER

For those radio shops that are repairing auto radios and don't have an inverter or at least whose inverter doesn't have an ammeter, the addition of an ammeter in series with the battery or inverter of the 20 or 50 ampere variety can greatly simplify the locatization of power supply troubles. The meter need not be very accurate, even an old car ammeter will suffice. Of course, the meter should be fused at or below its full scale value.

With a little experience one soon becomes aware of the current consumptions of the various types of car radios. If current is only half of the normal value chances are the B-plus supply is dead. Either the vibrator is inoperative or the rectifier is defective. (Open power transformers are not very common.) If the current consumption is half again to twice the normal value, the B-plus supply may be shorted. If the ammeter shows this abnormally high current immediately upon switching on the receiver, chances are the buffer condenser is shorted. (Shorted rectifiers and shorted transformers are not too common.) If, however, the ammeter reaches this abnormally high value after the rectifier has warmed up, the B-plus is probably shorted after the rectifier.

If the ammeter indicates a near-dead short, or at least several times normal value, chances are the vibrator contacts are sticking, indicating a defective vibrator.

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