ELECTRONIC SERVICING

SEPTEMBER 1957 • 50¢

Phase Inverters in Hi-Fi Amplifiers

Introduction to Transistor Theory

Servicing the Microwave System

Check Your Oscilloscope Performance

Photo Electric Controls

The Home Intercom Market

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ELECTRONIC SERVICING (*formerly Radio-TV Service Dealer*) is published monthly by Cowan Publishing Corp., 300 West 43rd Street, New York 36, New York, JUdson 2-4460. Subscription Price: $3.00 one year, $5.00 two years in the United States, U. S. Possessions, Canada and Mexico. Elsewhere $1.00 per year additional. Single copies 50c. Second Class Mail privileges authorized at New York, N. Y.

POSTMASTER: SEND FORM 3579 TO ELECTRONIC SERVICING, 300 WEST 43rd STREET, NEW YORK 36, N. Y.

ELECTRONIC SERVICING

VOL. 18, NO. 9 — Member BPA, Audit Bureau of Circulations — SEPTEMBER, 1957

FEATURE ARTICLES

CIRCUIT AND SERVICE FORUM

DEPARTMENTS

THIS MONTH'S FRONT COVER

C. F. (Smokey) Hebard of Cushing Electronic Labs., Cushing, Oklahoma, at his Communications equipment test bench setup. Photo courtesy of Communications Company, Inc., Coral Gables, Florida.

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PROFESSIONAL RECOGNITION, INCREASED SERVICE VOLUME–
GENERAL ELECTRIC ALL-AMERICAN CAMPAIGN OFFERS YOU BOTH!

Full-page General Electric national advertising spotlights community service of independent TV-radio technicians such as yourself.

Your customers and prospects are being asked to help select an All-American award-winning team of 11 outstanding service dealers.

A complete package of promotion aids and display tie-ins is waiting for you. Your G-E tube distributor has this timely, colorful material. Ask him to help make your shop All-American service headquarters!

These advertising tie-ins can open your door wide to new fall business—

Easel-back display, "Football Time Is TV Tune-up Time"... Large football-theme window banner... Eye-catching window streamers... Special direct-mail folder and postcard...Newspaper mats... "Set-owners' TV Service Guide", a business-building booklet to give to service prospects.

FOOTBALL IS HERE. The star-studded entertainment programs are back. Millions of TV owners need to have their sets checked for top performance. Timed for this fall market, General Electric has kicked off its All-American campaign in support of the TV-service profession—the biggest ever—to 25,000,000 readers of LIFE. Full-page ads feature the all-around job service dealers like yourself are doing in and for the community...point to shops like yours as neighborhood TV-radio service headquarters.

To assist you further as an independent TV technician...to help identify your shop as first choice for tune-up work...General Electric has ready for you, through your G-E tube distributor, a new, timely kit of displays and advertising aids that will catch the eye of football fans and other set-owners who want tune-ups and repairs.

You also can make good use of the special football schedule shown below, carrying your name and address. It's a reminder item that prospects for TV-service work will value and keep with them for many months.

Phone your G-E tube distributor! Ask him how you can tie in *now* with this big General Electric fall campaign to strengthen your community standing, and underscore your reputation for service! *Distributor Sales, Electronic Components Division, General Electric Company, Owensboro, Ky.*

AVAILABLE IN QUANTITIES: 1957 college and professional football schedule, with space for your name and address. Everybody wants one. You can use this handy pocket guide to make friends for your shop and as All-American reminder advertising. Ask your G-E tube distributor how to obtain the copies you need!

Progress Is Our Most Important Product

GENERAL ELECTRIC

161-1A21

ASSOCIATION NEWS

Empire State Federation of Electronic Technicians Association (ESFETA)

The Empire State Federation of Electronic Technicians has elected Dan Hurley of Syracuse to head the association for the coming year. Former President Gordon Vroomen, also of Syracuse resigned after serving a short time and will soon be leaving for the West Coast. Dan Hurley was unanimously elected after Bob Larson, the present Guild treasurer, declined the nomination. Dan is well known for his work in State and National levels.

Radio Television Guild of Long Island (RTGLI)

Within the Mineola-New Hyde Park area of Long Island service centers and dealers are generally increasing their service charges to about $5.00. The average dealer in that region is now getting between $4.00 and $5.00 for his work.

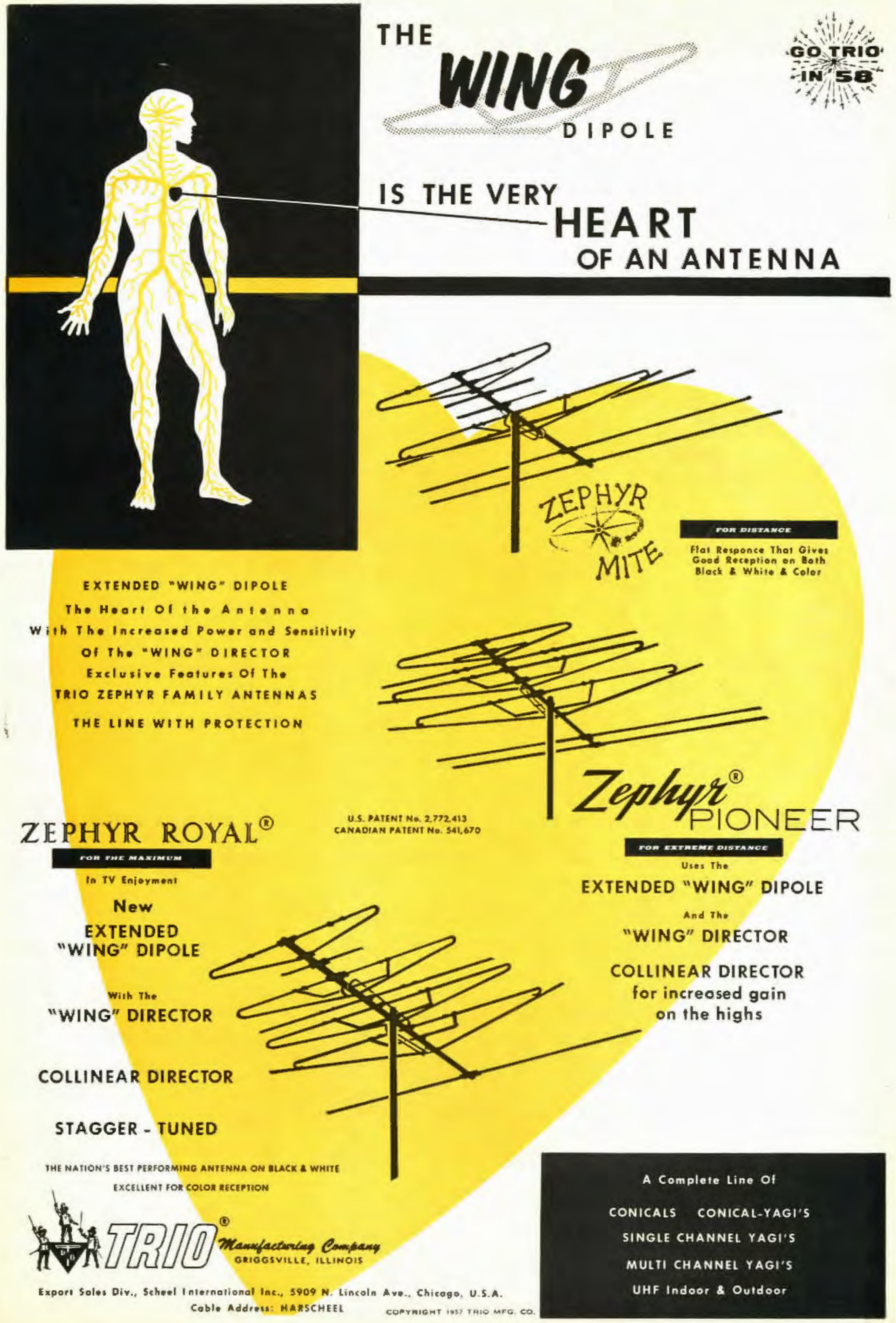
Most of the shops at the same time that house calls were increased also were able to increase their charges for bench work in the shop.

Of the dealers interviewed in preparation of this article, none reported any decrease in customers. It was interesting that some customers felt that the rate increase was overdue.

Increasing rates appears to be a matter of jostifying the increase first to the dealer himself. When service technicians believe that their work is good and competent, then they will have no cause for holding back on increasing their charge to a reasonable amount.

The board of television examiners of the City of Long Beach conducted written examinations to applicants for a television technician's license on Thursday, June 27, in the Community Hall of the City Hall of Long Beach, N. Y. All TV servicemen who work in Long Beach were urged to fill out application forms without delay. They are available in the city clerk's office. The application must be accompanied by a $10.00 fee.

[Continued on page 10]



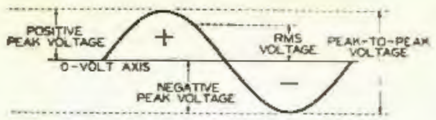


Fig. 1—Graphical representation of *rms* and peak-to-peak voltages

Fig. 2—Scope calibrator for sensitivity measurements

Check Your Oscilloscope Performance

by Robert G. Middleton
International Director
Radio Electronic Television Schools

The accuracy of a diagnosis and the speed of servicing depend in many cases on the condition of your test equipment. This article describes procedures by which you can keep your oscilloscope in top shape.

It must not be assumed that the performance of an oscilloscope is satisfactory, merely because it operated satisfactorily at some time in the past. Again, it should not always be assumed that its performance is satisfactory, simply because the instrument is brand new.

It is not difficult to check out a scope, in order to determine whether new tubes or possible circuit attention may be required. A regular check-up is advisable, to make sure that you are getting the most out of your scope. The performance tests which should be made are:

1. Measurement of sensitivity.
2. Check of frequency response.
3. Test of deflection linearity.
4. Determination of amplifier balance.
5. Measurement of attenuator decading.
6. Check of attenuator impedance uniformity.
7. Adjustment for minimum astigmatism.
8. Test for overload point.

It is the purpose of this series of articles to describe the more important tests of this type. In most cases, the tests can be made with conventional test equipment already available in the shop.

How to Measure Sensitivity

Sensitivity is measured in terms of millivolts per inch. A millivolt is 0.001 volt, and a scope which has a sensitivity of 20 mv/inch for example, will provide one inch of deflection when 0.02 volt *rms* is applied to the input terminals. Sensitivity is customarily measured in terms of *rms* voltage of a sine wave, as illustrated in *Fig. 1.*

The most convenient method of checking sensitivity is to use a scope calibrator, such as illustrated in *Fig. 2.* The output voltage from the calibrator is variable over a wide range, and the value of the output voltage is indicated directly on the meter. Use the *rms* scale of the meter when making such checks.

The output from the calibrator is applied to the input terminals of the scope, and the gain controls of the scope are advanced for maximum sensitivity. The calibrator is next adjusted to obtain one inch of deflection on the scope screen, and the meter indication is noted. If the meter should indicate 35 millivolts *rms*, we then know that the sensitivity of the scope is 35 mv/inch. Sensitivities of both the vertical and horizontal inputs of the scope can be checked in this manner. Low sensitivity is usually the result of weak tubes. Note that the horizontal amplifier is usually rated at a lower sensitivity than the vertical amplifier. The instruction book for the scope will specify the minimum sensitivities of vertical and horizontal sections. Most scopes will exceed the factory sensitivity rating somewhat.

A few service scopes are rated in terms of *rms* millivolts per centimeter, or in terms of peak-to-peak volts per inch. When such ratings are encountered, remember that there are 2.54 centimeters in an inch, and that peak-to-peak voltage of a sine wave is 2.83 times *rms* voltage.

This test indicates the scope sensitivity at 60 cycles, only. However, subsequent tests will show whether the sensitivity at higher frequencies is the same, greater, or less.

Check of Frequency Response

A test set-up most suitable for checking frequency response is shown in *Fig. 3.* Remember however, that the accuracy of test results can be no better than the accuracy of the sweep generator. The generator should have a flatness of swept output which is within 1 *db* or better over the swept band of 5 *mc.* The sweep generator must also have output down to a low frequency limit, such as 30 *kc* or less.

It is helpful to use this type of test signal, because you can see the frequency response of the scope at a glance. The scope should be swept horizontally with a phasable 60-cycle voltage, exactly as in visual-alignment procedures.

The display seen in *Fig. 4A* shows that the scope has a fairly flat frequency response to 4 *mc,* although a certain "hill and valley" contour is present, due to inaccuracies in the peaking circuits or incorrect load impedances in the vertical amplifier. *Fig. 4B* shows the type of pattern which is

[*continued on page* 60]

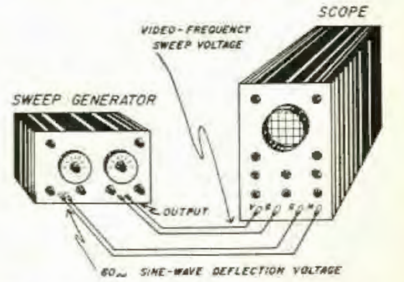


Fig. 3—Block diagram for checking scope's frequency response

ASSOCIATION NEWS

[from page 6]

National Association of Television and Electronic Service Associations (NATESA)

One of the most important actions at the coming NATESA Convention will be the elections of officers for the coming year. Much has been accomplished by NATESA thus far and the officers become more important each day. Voting for officers is not only your privilege but your duty as well. With the tremendous growth of NATESA we have potential presidential, secretary general, treasurer, regional vice-president and secretary material all over the nation. To eliminate the slightest possibility of charges of dictatorship, no president may succeed himself.

Radio Television Guild, Rochester (RTG)

The annual meeting of TESA of Rochester, called to order for the election of officers and directors was held on Tuesday, May 28th at 8 P.M. at the Powers Hotel.

Elected for the coming year were Norbert H. DeMay, president; Peter M. Ferrari, vice-president; Oswald Eggleston, recording sec.; Paul Rood, corresponding sec.; Harold Eskin, treas.; and Directors Bert Lewis, Louis Brener, Ralph Sahm, Carl Bellanca, Marvin Gleiner, Joe Ranaletta and Sam Profetta.

Electronics Technicians Association of Northern Illinois

The Electronics Technicians Association of Northern Illinois, a non-profit organization, has been formed here to represent both the Television Service Technician and the Television Service Shop Owners. Frank J Moch, NATESA Executive Director, addressed the group. He outlined the problems facing the independent service industry and means of solving these problems. He stressed the need for associations on a local and the national levels.

This group, currently 69 members, has elected its board of directors and will install its officers at the 1957 meeting. ■ ■

Phase Inverters in Hi Fi Amplifiers

Phase inverters found in present day hi fi equipment are treated with emphasis on circuit operation and service procedures

by Lawrence Fielding

ONE of the most important contributions to the art and science of high fidelity reproduction was the development of push-pull power amplifier output stages as a means of reducing harmonic distortion. Exactly how this type of output circuit operates will be discussed in the next installment. For the moment, however, we are still part way back in the power amplifier and must provide two out-of-phase signals to drive the subsequent output stages. That is, voltage amplifying circuits must be arranged to provide two audio signals, equal to each other in amplitude, but opposite to each other in instantaneous polarity. The circuits which perform this service vary in configuration and mode of operation, but they all produce signals which meet the two requirements stated. All such circuits are lumped under one heading: phase inverters.

Phase Inversion by Brute Force

The most direct approach to phase inversion is illustrated schematically in *Fig. 1.* While seldom used in hi fi applications, this circuit is probably the easiest to understand and is worthy of review before a thorough examination of more popular circuits is attempted. After initial voltage amplification of the audio signal has been accomplished, the signal is applied to the grid of V-1A. Let us assume that the voltages and components are arranged to affect a gain of 10 in this stage. Thus, if 1 volt of audio voltage is applied to the grid, 10 volts will appear across the plate load consisting of *R3* and *R4* in series. In addition, the phase or polarity of the output voltage will be opposite to that appearing at the grid of V-1A, as is true of all grid-fed vacuum tube amplifying circuits. This first output voltage is now available for, let us say, the "push" side of the succeeding push-pull output circuit. At the same time, 1/10 of this output voltage is fed to the grid of V-1B which is also arranged to produce a gain of 10. The application of 1/10th of the voltage to this grid is accomplished by the voltage divider action of *R3* and *R4* (*R4* is just 1/10 the total resistance of *R3* and *R4*). Since phase inversion of this signal occurs by virtue of its amplification by V-1B, the resultant output is equal in amplitude to the first or "push" signal (10 volts) but is opposite in phase and is now available for the "pull" side of the circuit. The disadvantages inherent in this type of circuit are many. Even a slight difference in amplification between V-1A and V-1B causes severe unbalance in amplitude between the two resulting signals. The values of *R3* and *R4* are so critical, that tolerances much better than 5% would have to be employed to get balanced results. While a theoretically balanced circuit might be produced, there is no guarantee that aging of one or both triodes will not upset the balance in time. Finally, a great many components are being used to accomplish the job where fewer parts would suffice.

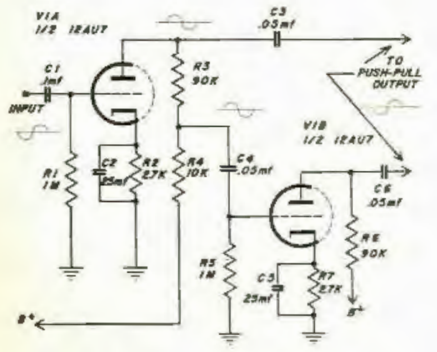


Fig. 1—One of the earlier but now seldom used phase inverters.

The Phase Splitter

By far the most popular type of phase inverter is the so called phase-splitter. This basic circuit is illustrated in *Fig. 2.* As can be seen from the partial schematic, the job of phase inversion is now accomplished by means of a single triode. The audio voltage is fed to the grid, but the cathode impedance is made equal to the plate load impedance. Since signal current flows through the series combination of the cathode impedance, the tube, and the plate load impedance, the signal voltages developed across the plate and cathode loads must be equal in amplitude, providing these two impedances are, themselves, equal. The cathode signal does not undergo phase inversion, but the plate signal is inverted 180 degrees in the usual manner. As a result, the two available signals are opposite in phase and therefore meet the second requirement for subsequent application to the output stages. Most of the disadvantages of the circuit of *Fig. 1* are overcome in the phase splitter circuit. Should the gain of the stage change with aging, both the cathode and plate audio signals change, but they always remain equal to each other. Only two resistors need be precision matched to each other. A total of only four resistors and three capacitors are associated with the circuit as opposed to seven resistors and five capacitors required for the circuit of *Fig. 1.* While it is true that this circuit

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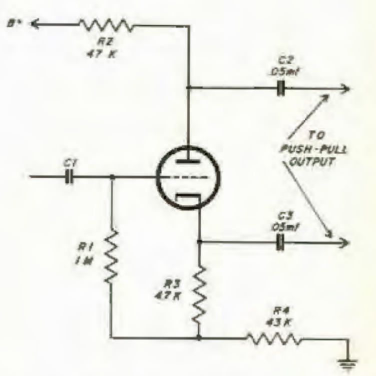

Fig. 2—Signal inversion is obtained here by phase splitting.

Introduction to Transistor Theory

Part 3

by George Browne

The principles developed in the two previous installments of this series are applied in explaining basic transistor action.

IN THE previous two installments of this series we discussed, in their order, the nature of holes and electrons in semiconductors, and the construction and operation of *NP* junctions with germanium as the semiconductor material.

The concept of holes, it was pointed out, was evolved in order to explain the apparent positive charge acquired by an electron pair bond when it loses one of its valence electrons. This loss occurs as a result of one or more of the following: heat, light, the application of an external electric or magnetic field, or the introduction of certain types of impurities.

An *NP* junction, it was brought out, consists of a zone of *N* and a zone of *P* type germanium joined intimately along one of their surfaces. In an *N* type semiconductor the majority carriers are electrons, and the minority carriers, holes. In a *P* type semiconductor the majority carriers are holes, and the minority carriers, electrons.

One of the important properties of an *NP* junction, as it applies to rectifying action (and more significantly, as it applies to transistor action) is its greater majority carrier flow for forward bias compared to reverse bias. This is shown in *Fig. 1*. In (A) where the junction is connected for forward bias, I_f, the forward current, consists of electron flow from the *N* to the *P* type junction and hole flow from the *P* to the *N* type junction. Recalling that hole flow in one direction is equivalent to a flow of electrons in the opposite direction, both types of carriers contribute to the total current flow I_f. The current I_g, which is the reverse minority current component, consists of minority electrons flowing from *P* to *N* and minority holes flowing from *N* to *P*. The net current flow around the circuit is equal to $I_f - I_g$.

Equivalent Resistance of N-P Junction For Forward and Reverse Bias.

The difference in net current for forward and reverse bias connection indicates that the equivalent resistance of the junction for reverse bias is very much higher than for forward bias. This ratio varies very widely with applied voltages and currents. In fact the forward current, in particular, varies as a parabolic function with voltage.

Junction Transistors

If a *P*-type semiconductor is sliced comparatively thin and is sandwiched between two *N*-type semiconductors, as shown in *Fig. 2A*, an *NPN* transistor is obtained. Similarly, a thin-sliced *N*-type semiconductor sandwiched between two *P*-type semiconductors results in a *PNP* transistor. *(Fig. 2B)*. Such devices may be made to duplicate practically all of the circuit functions of a vacuum tube, such as voltage, current, and power amplification. The term "junction transistor" is applied to transistors having the sandwich-type construction.

In attempting to explain transistor action we will assume an imaginary division in an *NPN* transistor along the *P* section as shown in *Fig. 3*. We now have an N_1P junction at the left and a PN_2 junction at the right.

At the outset we must point out two important characteristics that are included in transistor design. The first is that the center section is made to have a much lower conductivity than the two outer sections. The second characteristic is that the center section is very much thinner than the two outer sections. Thus, if a large number of electrons can be made to enter the center section from either *N1* or *N2*, under the influence of an external battery, they will have very little chance of losing their identities by recombining with holes in the center section. In addition, because of these two characteristics, electrons from *N1* find it easier to diffuse across the center section into *N2* and back to *N1* through the external circuit rather than through *P*, the external circuit, and back to *N1*. This also applies to electrons travelling from *N1* to *N2*. In other words, most of the electron carriers flowing from either end section will proceed across the two junctions into the other end section, very few being lost by recombination, or diversion into other paths of which the center section may be a part.

Let us now connect the *N1-P* junction at the left of the transistor for forward bias and the P-N2 junction at the right for reverse bias as shown in *Fig. 4*. In this case I_{f1} and I_{g1} represent the forward and reverse currents in the *N1-P* junction, and I_{f2} and I_{g2} represent the forward and reverse currents in the *P-N2* junction. It will be observed in this figure that the currents I_{f1} and I_{g2} are in the same direction, but are opposed by the currents I_{g1} and I_{f2}. Since I_{f1} and I_{g2} are much greater than I_{g1} and I_{f2} the net current will be a flow of electrons clockwise around the circuit. In accordance with accepted practice the center section is called the base. In the junction connected for forward bias the outer section is called the emitter, and in the junction connected for reverse bias the outer section is called the collector. Referring now to the principles set forth in the previous paragraphs, the electrons entering *P* from the emitter prefer to diffuse across the base rather than take the high resistance path through the base and back to battery No. 1. Thus, most of the carriers flowing across junction *N1-P* proceed into junction *P-N2*. The remainder of these carriers, which are comparatively small, flow down the *P* section into ground, and are partly responsible for I_b, the base current. Another component of I_b is the majority hole flow from the base to the emitter. However this component of the current is very small due to the low conductivity of the base material. The flow of carriers from the emitter through the base and on to the collector is augmented by a small number of minority electrons flowing from the base to the collector. Because of the positively charged ions lining the junction at the *N2* side, practically no opposition is offered to this larger of forward carriers. From the collector these electron carriers complete the circuit to the emitter terminal through both batteries.

It should be emphasized again that the *P-N* junction at the right is connected for reverse bias, therefore little forward current I_{f2} flows in this junction to oppose the forward current I_{f1} originating in the *N1-P* junction. Also opposing I_{f1} is the reverse current in the *N1-P* junction. However, this component of current is also very small so that combining opposition currents with the diversion of electrons through *P* to ground, about 95 to 98 per cent of the emitter current appears at the collector terminal.

Alpha

If the forward bias at the emitter is varied slightly, the net current appearing at the collector will also vary. The ratio of collector current change to emitter current change is referred to as "alpha," and varies in approximately the same ratio as the original ratio of total collector current to total emitter current.

Typical values of alpha (which is symbolized by the greek letter "α") for junction type transistors vary between .91 to .995.

Transistor Amplification

Up to this point we have established that the resistance ratio of an *N-P* junction varies between 1,000/1 and 2,000/1, and that the collector to emitter current ratio, alpha, varies between 95 and 98%. From the discussion presented immediately previous, if we assume an alpha of .95 then a small current signal source, i_1 inserted in series with battery No. 1 between its negative terminal and the emitter would result in a collector current change of i_1 x .95 or .95 i_1. Assuming also a collector junction to emitter junction resistance ratio of 1,000, the voltage amplification of this signal at the output would be .95 x 1,000, or 950. Thus, a junction transistor, connected as shown in *Fig. 4* is an amplifier primarily because of its resistance step-up characteristics.

Symbols

Conventional symbols for transistors are shown in *Fig. 5*. In both symbols the base is shown as a solid black bar. (Sometimes a line is used). The emitter is always shown with an arrow, the arrow indicating the direction of conventional current flow. (Opposite to electron flow). Thus, in an *NPN* transistor the electron flow is into the emitter and conventional current flow out of the emitter as shown.

In a *PNP transistor*, (*B*), hole flow is into the emitter. Electron flow being in the opposite direction, conven-

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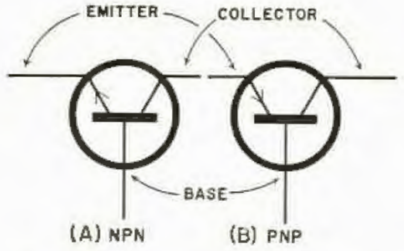

Fig. 5—Conventional schematic symbols for NPN and PNP transistors.

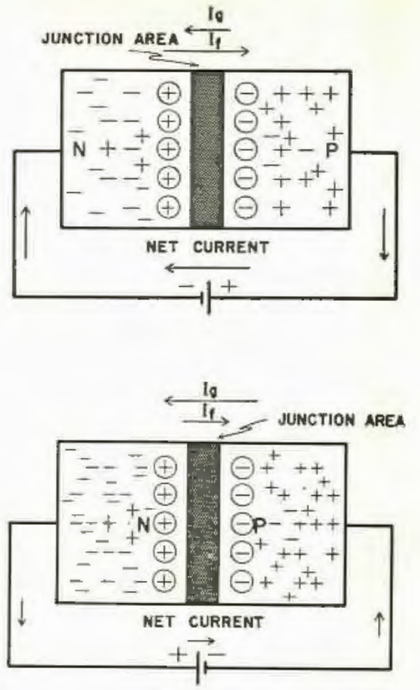

Fig. 1—Upper diagram shows forward bias; lower diagram shows reverse.

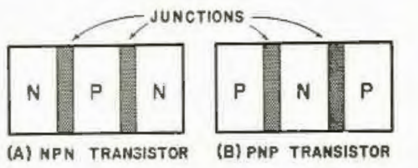

Fig. 2—Basic structure of NPN and PNP junction type transistors.

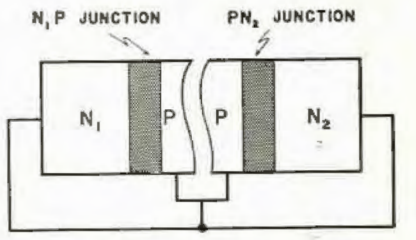

Fig. 3—Imaginary division of the transistor to help explain action.

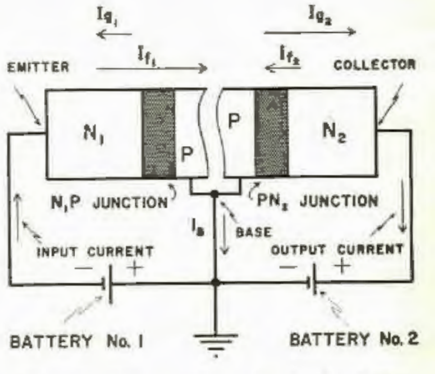

Fig. 4—Current flow in basic NPN transistor amplifier circuit.

SERVICING MICROWAVE SYSTEMS

by W. A. Peifer
Communication Products Department
General Electric Company

A MICROWAVE SYSTEM is a private communication network designed to fit the needs and demands of a particular business. Microwave today is in use in such diverse industries as Electric and Gas Utilities, or furnishing Toll Road Communications where it is used to extend the horizons of both police and operational VHF channels for companies requiring many channels of communications—whether phone, teletype, telemetering, etc. the versatile Microwave serves them all.

Today there are several hundred Microwave Systems in use in the United States each uniquely the product of the demands of the user. It would seem from the versatility of the Microwave that servicing the equipment of such a system would require specialized training on a particular system. This is not the case, for personnel trained in general communications servicing require only a few days training at the most to maintain a Microwave System.

These many microwave system users are vitally interested in the successful servicing of their equipment by companies such as the Meade Electric Company of Hammond, Illinois, which is presently engaged in maintaining the microwave system of the Indiana Toll Road. The packaged services offered by such independent electronics service companies, has already shown that such servicing is profitable to the service company and presents the system user with dependable maintenance.

Design Features

The design engineer has spent considerable time on the problems of microwave system servicing, for higher maintenance cost means higher operating expenses for the customer. One of the more recently designed microwave systems on the market today which incorporates the concept of low maintenance costs, has been devloped by the General Electric Company. This system utilizes the principal of time division multiplexing patented under the name of "Quadriphase." Time division multiplexing, in contrast with other types of multiplexing, permits a visual monitoring of all circuits and, in addition, requires a minimum of test equipment. In Quadriphase, pulse position time division has simplified the *rf* sections, which is another maintenance feature.

Basically all microwave equipment consists of two major components, the *rf* system and the multiplexing system.

The *rf* section of Quadriphase has been designed to eliminate emergency maintenance by the use of stand-by equipment. Options are available for stand-by multiplexing racks that are switched automatically when a fault occurs in the regular multiplex. The automatic switching also connects the stand-by transmitter to the transmission line and disconnects the faulty unit. In addition, a "fault sending" circuit alerts the maintenance personnel that the normal equipment is inoperative.

The multiplex equipment of Quadriphase is designed to prevent a loss of all channels, should a fault occur in one. With exception of the power supply and a receiving sync generator, a failure in a unit establishing a pulse for any one channel, would not affect the other channels in the multiplex video train. This feature permits the servicing of channel units on an individual basis. The synchronizing circuits are designed so that tube aging can be detected before a fault occurs when normal maintenance is performed. This almost eliminates, "Off the air time," for these units.

To service the individual components, the units are slide mounted on hinges which permits swinging or

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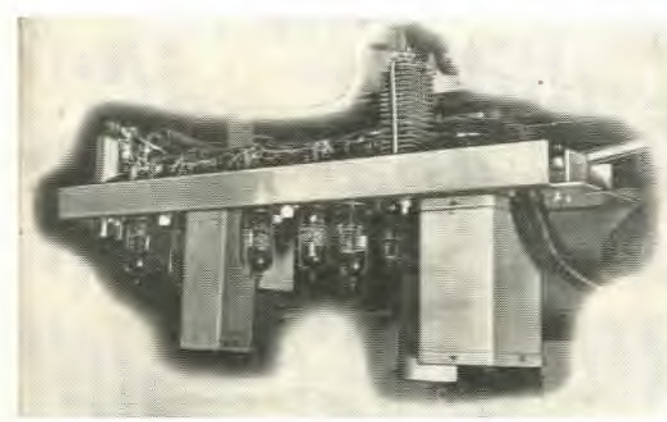


Fig. 1—A channel unit on slides pivots to expose the under chassis for easy maintenance.

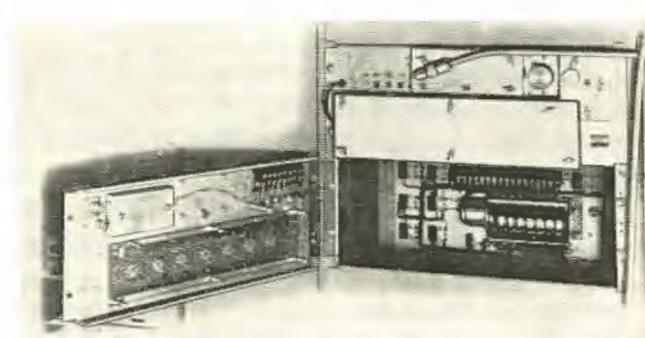


Fig. 2—Heavier units are mounted on hinges for rapid checks without having to be disconnected from the line.

1957 Philco TV-part 3.

by H. S. King
Supervisor, Electronic Training Dept.
Philco Corporation

This third installment deals with the Philco chassis 7L70 series which uses "Decatron Video System" video amplifier for high contrast reception.

7L70 Chassis Series

Models employing the delux 7L70 series chassis contain either 21-inch or 24-inch picture tubes. Some models feature Philco Automatic Tuning with remote control and contain provisions for *uhf*. The addition of these features determines the particular chassis of the series. The chassis appears physically similar to that of the 7L40 series.

Tuners employed are either 12-position or 13-position incremental types, the latter containing change-over switching arrangements for *uhf*.

The chassis contains four printed-wire panels. The vertical oscillator, sync separator, phase comparer and horizontal oscillator are contained on the oscillator printed-wire panel. The *if* panel contains three stagger-tuned *if* amplifiers and the video detector. Circuitwise it is similar to that employed in the 7L40 series, with intercarrier sound. The 4.5 *mc* sound *if* amplifier, dynamic limiter, ratio detector, 1st audio and audio output stages are contained on the sound panel. The 1st video amplifier, video output and noise inverter stages are located on the video panel.

Sync Noise Suppression

A noise inverter stage is featured in the 7L70 chassis, this function being performed by the triode section of a 6U8 tube. The circuits of the video amplifiers and the noise inverter circuit are illustrated in *Fig. 9*. Composite video from the output of the 1st video amplifier is applied to the sync separator and to the noise inverter. The noise inverter is biased to conduct only on noise pulses greater than sync tip level, such noise pulses being detrimental to the proper operation of the sync circuits. The output of the noise inverter, which consists of the noise pulses inverted in phases 180 degrees, is then combined with the composite video signal being applied to the sync separator. The noise pulses in the composite video signal and those from the inverter are the same noise pulses but 180 degrees out of phase and therefore cancel. Thus the signal being applied to the sync separator is relatively free of noise pulses that might be harmful to the sync circuits.

Decatron Video System

"Decatron Video System" is the name given to the video amplifier circuits of the 7L70 chassis. The name is derived from the use of two pentode amplifier tubes. Characteristics of the system are such that, from high quality studio transmissions, a high contrast picture with excellent resolution and detail can be obtained. The video gain is increased several times over that of the average video amplifier system, an important feature when coupled with the low noise figure of the tuner used in this chassis so that even at low signal levels improved picture reproduction can be obtained.

With respect to design considerations of this system, increasing the first anode voltage of the CRT provides a gain in high-light brightness and at the same time an improved focus quality is achieved. The obtainable high-light brightness is also determined by the available beam current at zero grid bias. Further, this beam current is also a function of the screen or first anode voltage. An increase in first anode voltage results in an increase in the cut-off voltage of the CRT control grid. A proportional increase in video drive is thus required so that the signal modulation for black level will be of sufficient

[*Continued on page* 53]

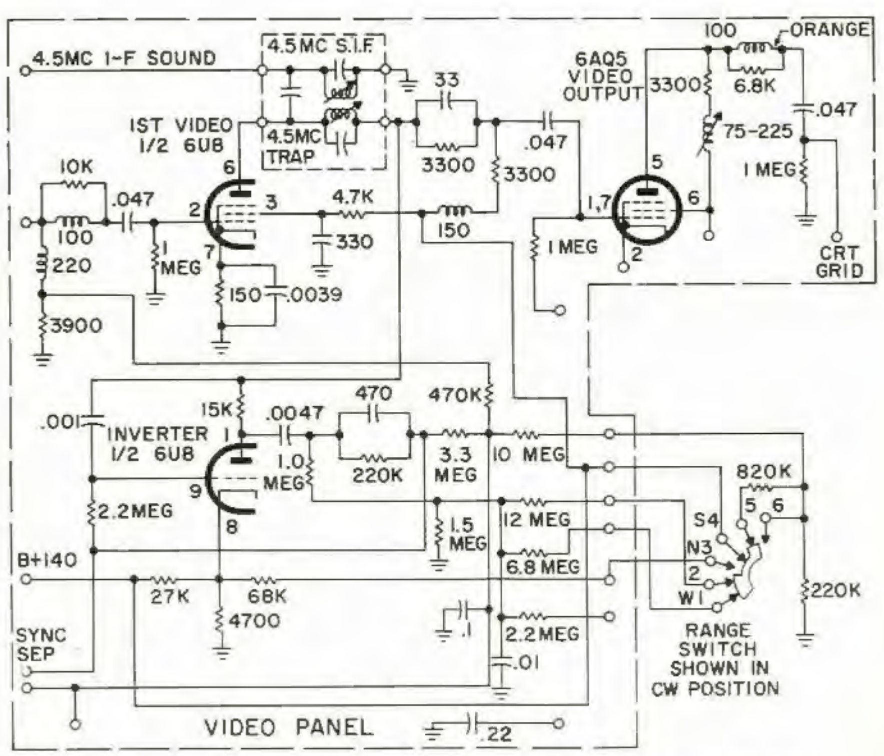


Fig. 9—Video printed wire panel schematic which includes the noise inverter circuit.

PHOTOELECTRIC CONTROLS

BY ALLAN M. FERRES

The ever expanding use of photo-electric controls in both commerce and industry mean additional profits for the electronic technician.

THE increasing use of photoelectric controls in homes, stores, factories and offices can mean additional sales and service profits for the radio and television service dealer entering the field. The equipment can be serviced by a radio and television technician and no additional test gear is needed.

Potential Customers

An idea of the sales and service possibilities for photoelectric control equipment can be gathered from the following list. In these applications, only the simplest type of equipment is used. The list is by no means complete, but it will serve to illustrate the widespread use of photoelectric devices.

Intruder Alarms for stores, factories, warehouses, homes, suburban driveways, offices

Automatic Door Control in restaurants, stores, factories

Smoke Alarms in housing projects, large apartment houses

Traffic Control on garage ramps, parking lots, drive-in theatres

Garage Door Openers for suburban homes, warehouses

Automatic Light Controls in stores, electric advertising signs on highways, tower lights

Animated Display Controls for theatres, store show windows

Automatic Car Washing Controls in garages

Film Exposure Controls for photographers' labs

Flash-operated Camera Light Controls to operate slave units for photographers

RCA phototube, 1P39, designed to withstand conditions of high humidity.

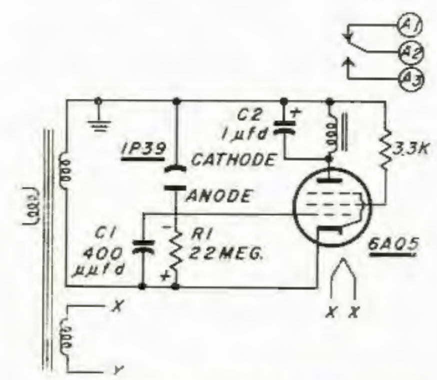


Fig. 1—Autotron photo-electric unit for conveyor belt control.

How They Work

Basically, a photoelectric device is one which is sensitive to changes in light intensity. This sensitivity to light is used to operate a meter, relay or counter, depending upon its application. The light-sensitive element may be either a photocell or phototube. An amplifier is usually used between the sensitive element and the load. Most commercial photoelectric controls use the vacuum or gas-filled phototube, a light-sensitive diode whose cathode current varies with light intensity.

Typical Control Unit

Figure 1 is the schematic of a photoelectric unit manufactured by Autotron, Inc. for conveyor belt control, automatic car washing or other applications where the beam of light is completely interrupted and moderate sensitivity is required.

The light-sensitive element is an RCA 1P39, a vacuum phototube designed to withstand conditions of high humidity. The tube and its load resistor, *R1*, are connected in series across the high-voltage secondary of the power supply transformer. When the tube is exposed to light, current will flow from the cathode to the anode, developing a voltage across *R1* of the polarity shown in the diagram. As current flows only when the cathode is negative, a pulsating *dc* appears across *R1*, and these pulsations are smoothed out by a filter condenser, *C1*. The capacity of *C1* is very small (400 μμf) so that it will discharge rapidly when the light on the phototube is interrupted. A 6AQ5, with a relay connected in series with its plate circuit, is used as a *dc* amplifier.

When light reaches the phototube, the voltage developed across *R1* is sufficient to cut off the plate current of the 6AQ5 and the relay is not energized. When the light on the phototube is interrupted, the negative bias on the 6AQ5 is removed, and the plate current flows through the relay, closing contacts A2 and A3. These contacts, which will handle a 1700-watt non-inductive load, are connected to the device that the photoelectric control is to operate. As the plate voltage on the 6AQ5 is *ac*, *C2* is required to prevent the relay from chattering.

The control unit is mounted in a splash-proof cast aluminum case, about 7" x 5" x 4". The case is tapped to accommodate ½" conduit for wiring and is furnished with adjustable mounting brackets.

Light Sources

Several types of lamps and lamp housings are used as light sources with photoelectric controls. The correct type to use depends chiefly upon the distance between the light and the phototube, the light intensity required, and the size

[*Continued on page 52*]

TRADE FLASHES

Transistor sales in June and the first half of this year established an all-time high for this fast-growing segment of the electronics industry, pointing up the increased utilization of the semiconductor device, the Electronic Industries Association (formerly RETMA) announced. Factory sales of transistors in June totaled 2,245,000 units with a dollar value of $6,121,000 compared with 2,055,000 transistors sold in May valued at $5,636,000 and 1,130,000 valued at $3,645,293 sold in June 1956. Cumulative sales of these devices during the first half of this year totaled 11,199,300 units valued at $31,249,000 compared with the 4,758,000 units worth $13,727,000 sold during the corresponding period of last year.

• • •

The newest wrinkle in entertainment for motorists is the remote-controlled radio receiver with a memory. Ford Motor Company engineers have developed a radio receiver that can be installed conveniently under the back seat or in the rear trunk. The receiver is operated by a tiny push-button box on the instrument panel, freeing panel space needed for other purposes. "Our device is an all-electronic unit having no moving parts and therefore requires less servicing," according to Charles W. Thomas, manager of the electronic and acoustical department, Ford Engineering Staff. "It has an improved automatic search-tuning mechanism that is practically instantaneous. If the station being listened-to leaves the air, the tuner will find another station automatically," Mr. Thomas said. "But to guard against losing a station whose signal is broken only momentarily by an underpass or viaduct, a memory circuit will delay the retuning for 10 seconds and retain the station setting."

• • •

In recent testimony before the Federal Communications Commission in Washington, Raytheon officials urged continuance of the principle of assigning frequency bands in which ISM (industrial, scientific and medical) equipment is permitted unlimited radiation.

• • •

A nationwide closed-circuit color telecast gave RCA Victor dealers a preview of a new series of deluxe color television receivers, it was announced by Charles P. Baxter, Vice President and General Manager, RCA Victor Television Division.

• • •

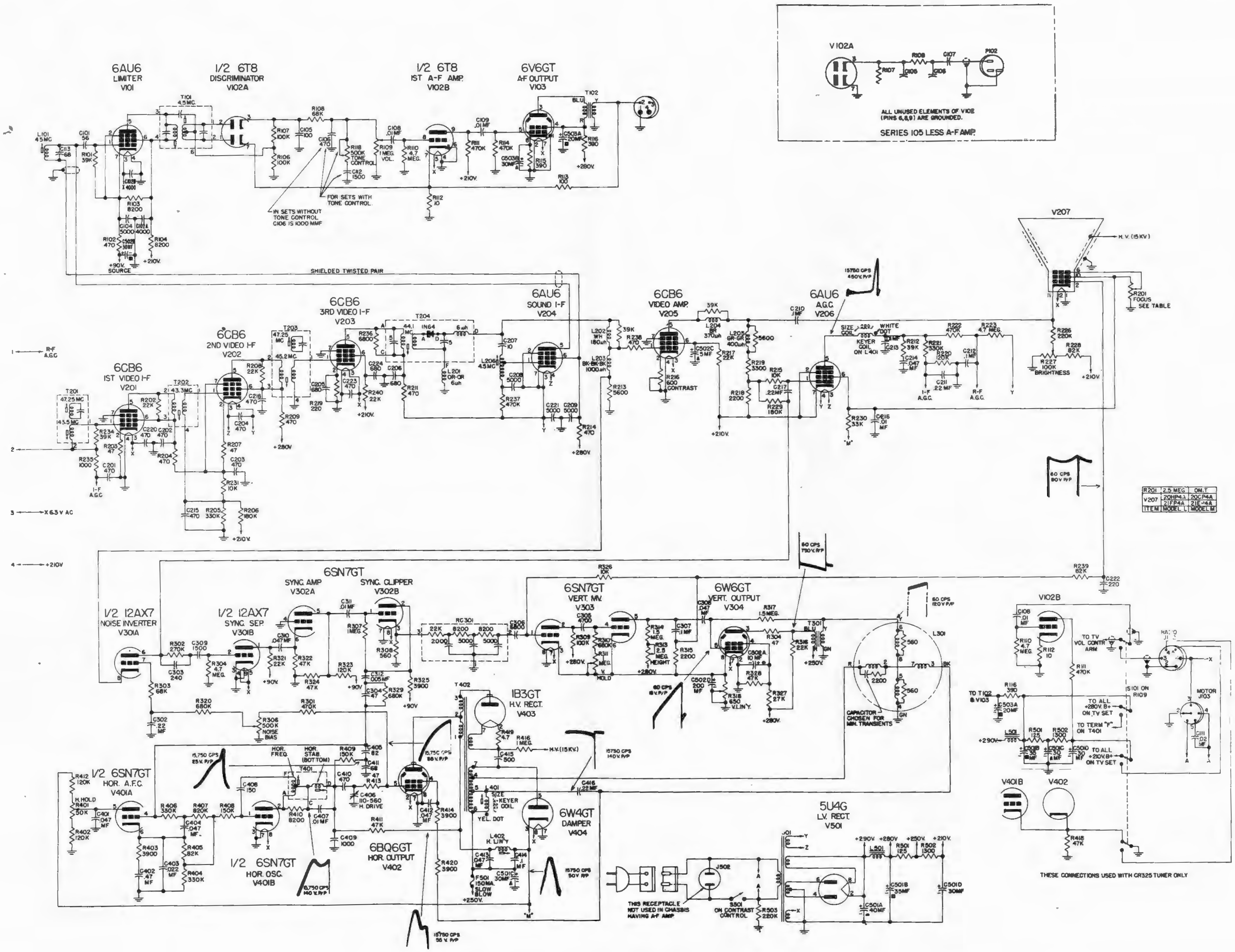
Groundwork has been laid for all-industry High Fidelity Shows to be held in New York and Los Angeles next year, with participation open to both components and packaged goods manufacturers, it was announced. The Los Angeles Show is planned for February and the New York Show for October, the latter to follow the Chicago Show which is scheduled for September. All three shows are expected to have the endorsement and support of the newly formed High Fidelity Council, a not-for-profit group of hi-fi makers dedicated to a broad public relations policy in behalf of "Hi-Fi For Everybody" and "open" hi-fi Shows in every major trade area.

• • •

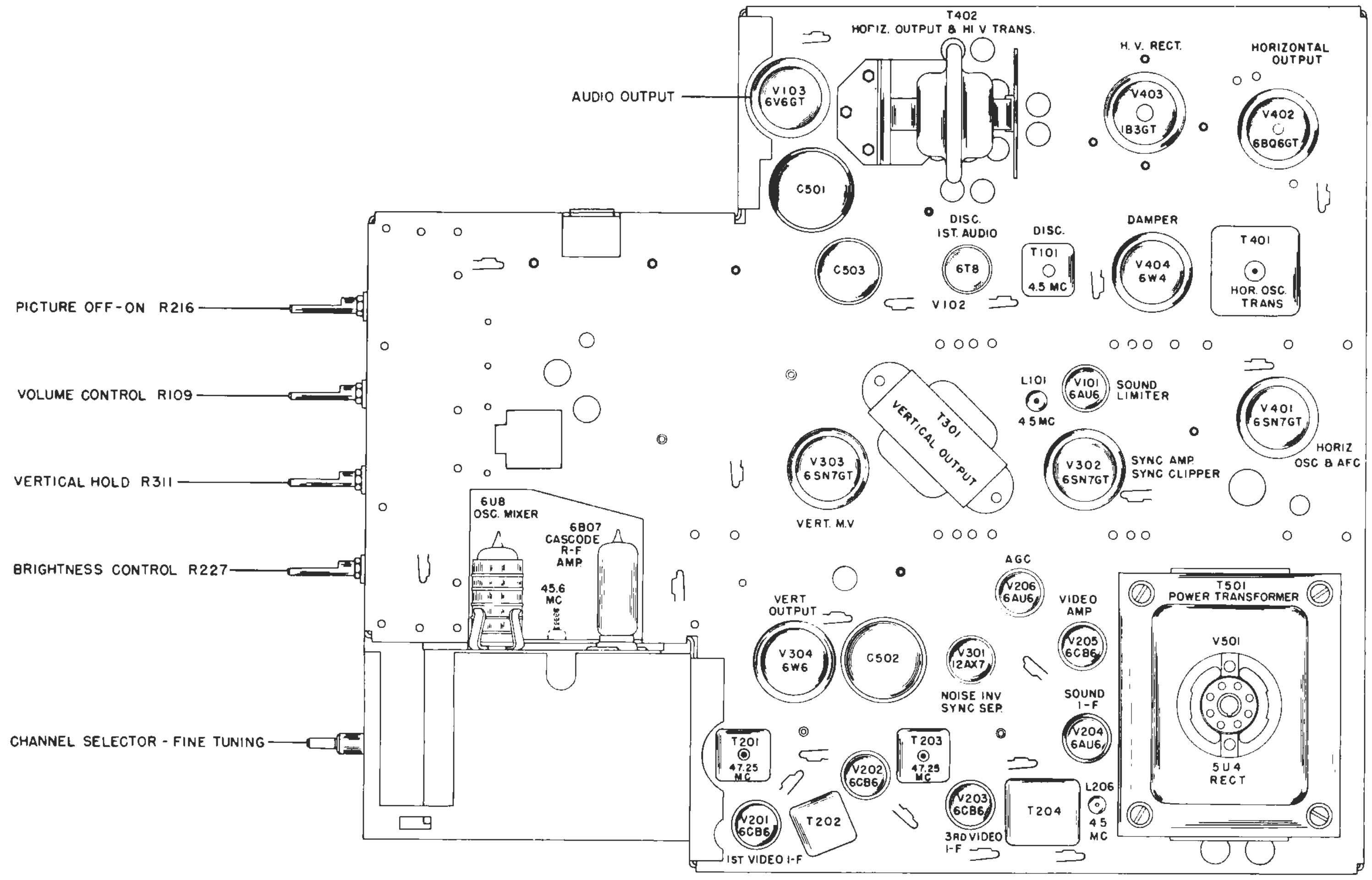
General Electric has announced the establishment of a new nation-wide program of public service awards for television service technicians. Entitled the "1957 All-American Awards", the program will bring national recognition to eleven television service technicians who have performed outstanding community service. Each winner will receive a trophy and a $500 check for use in a public service activity or charity of his preference. The series of awards will provide what the company feels is "much deserved recognition for an important segment of American public life", said Irvine D. Daniels in announcing the program. Mr. Daniels, general manager of the G-E Receiving Tube Department, is serving as chairman of the company committee administering the award program.

• • •

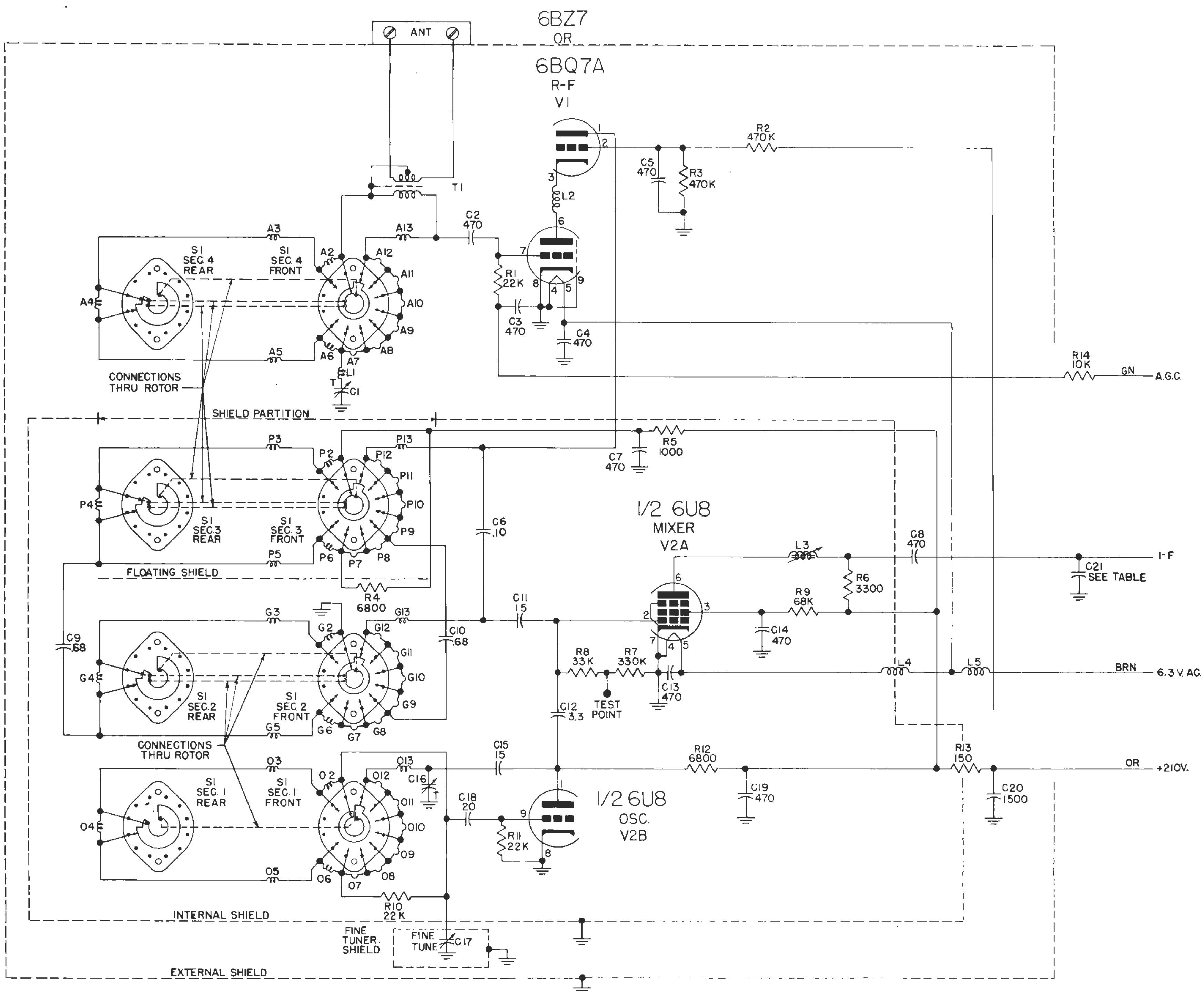
Introduction of a special television receiver for built-in enthusiasts was announced by Admiral Corporation. Ross D. Siragusa, Jr., television sales manager, said that use of the new 110-degree wide angle picture tube makes it possible to install the complete slimline TV chassis in walls or shelves only 16 inches deep. ■ ■



SCHEMATIC DIAGRAM, 105 SERIES L AND M



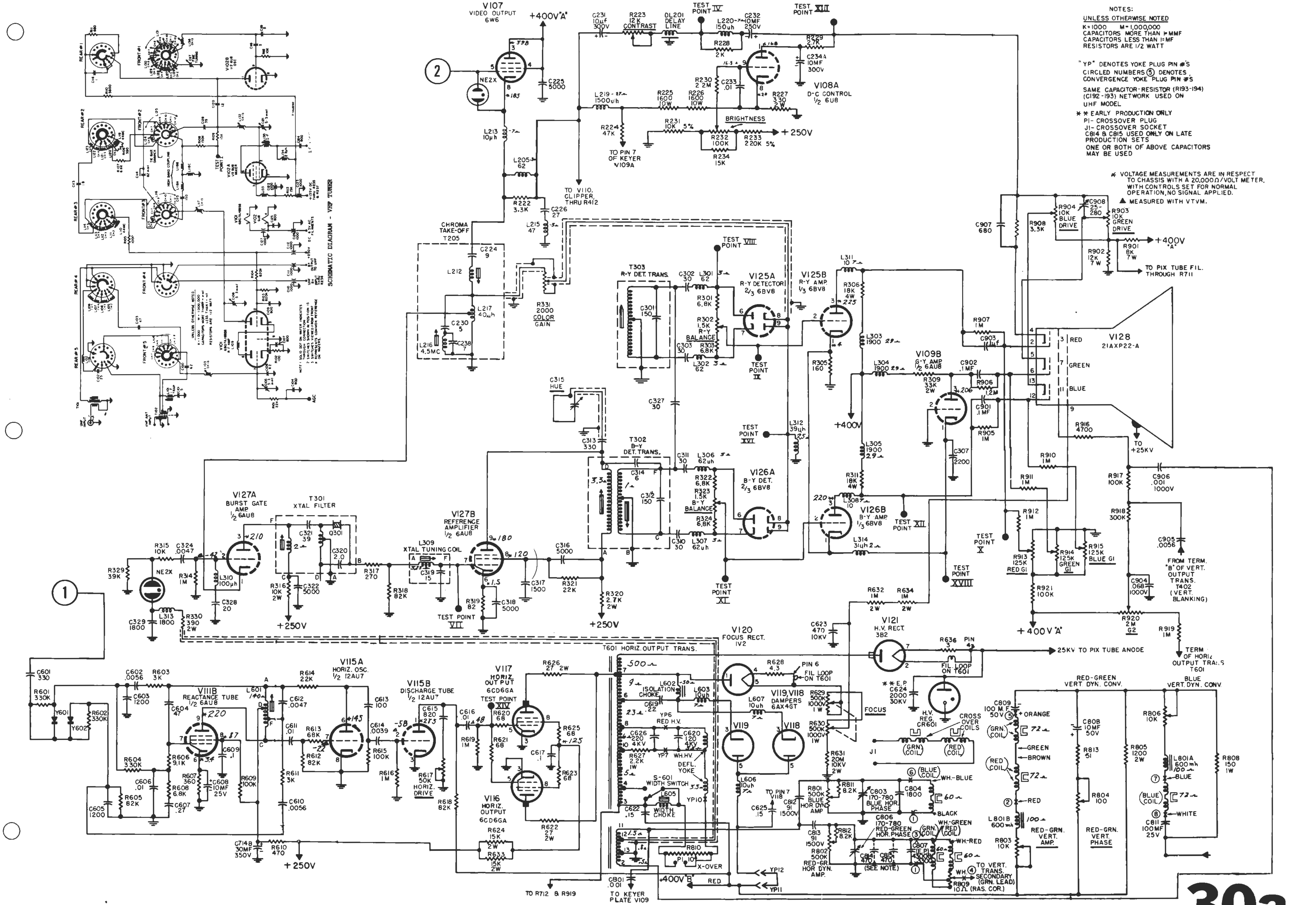
TOP VIEW OF CHASSIS



SCHEMATIC DIAGRAM, 700379 TUNER

MODELS 21T500, 21C700, 21C701,

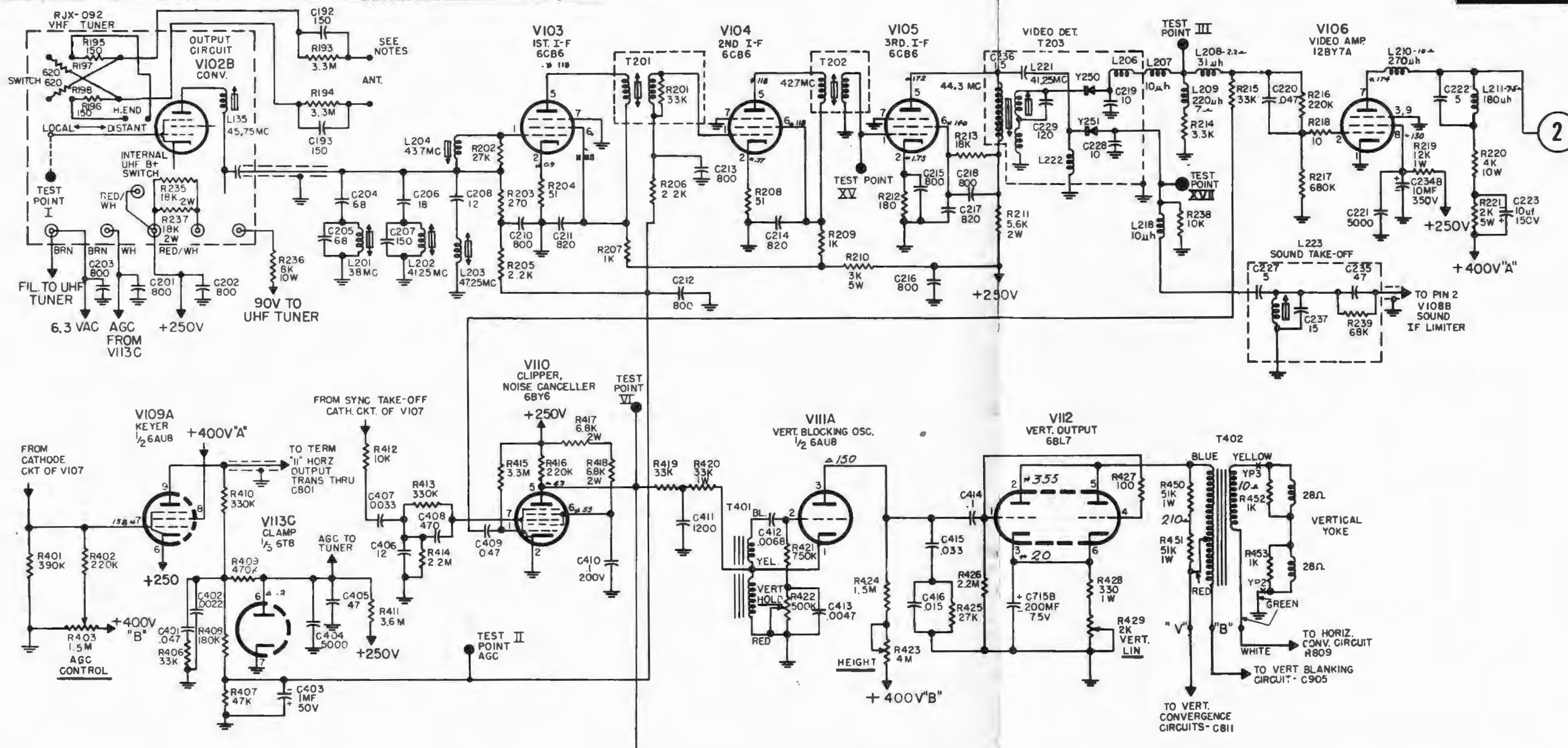
GENERAL ELECTRIC

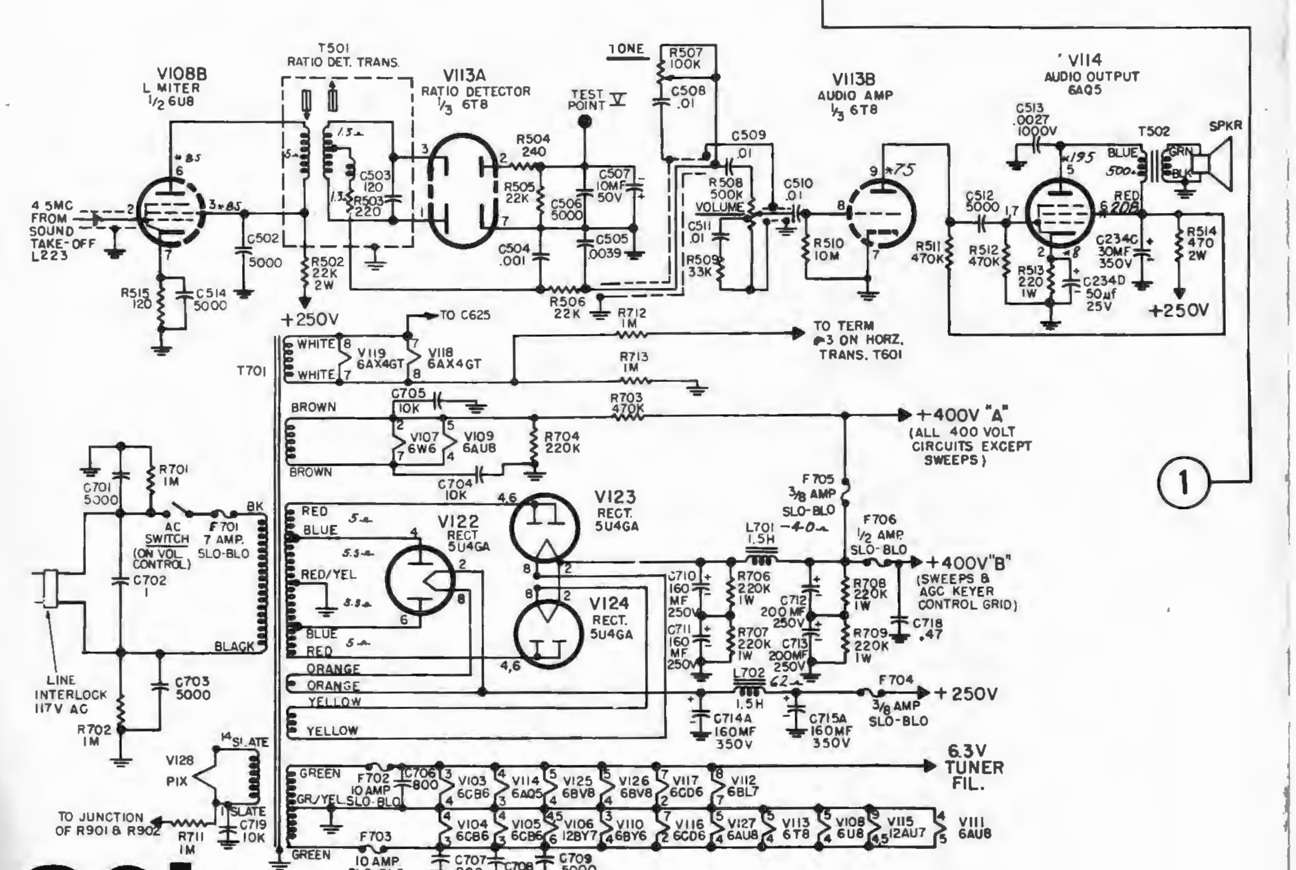


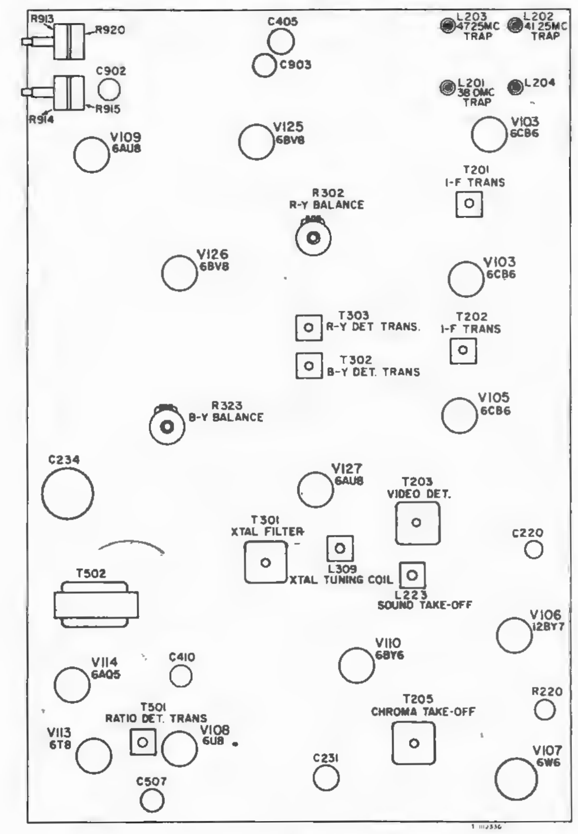
NOTES:
UNLESS OTHERWISE NOTED
K=1000 M=1,000,000
CAPACITORS MORE THAN 1=MMF
CAPACITORS LESS THAN 1=MF
RESISTORS ARE 1/2 WATT

"YP" DENOTES YOKE PLUG PIN #'S
CIRCLED NUMBERS (5) DENOTES CONVERGENCE YOKE PLUG PIN #S
SAME CAPACITOR-RESISTOR (R193-194) (C192-193) NETWORK USED ON UHF MODEL
** EARLY PRODUCTION ONLY
P1- CROSSOVER PLUG
J1- CROSSOVER SOCKET
C814 & C815 USED ONLY ON LATE PRODUCTION SETS
ONE OR BOTH OF ABOVE CAPACITORS MAY BE USED

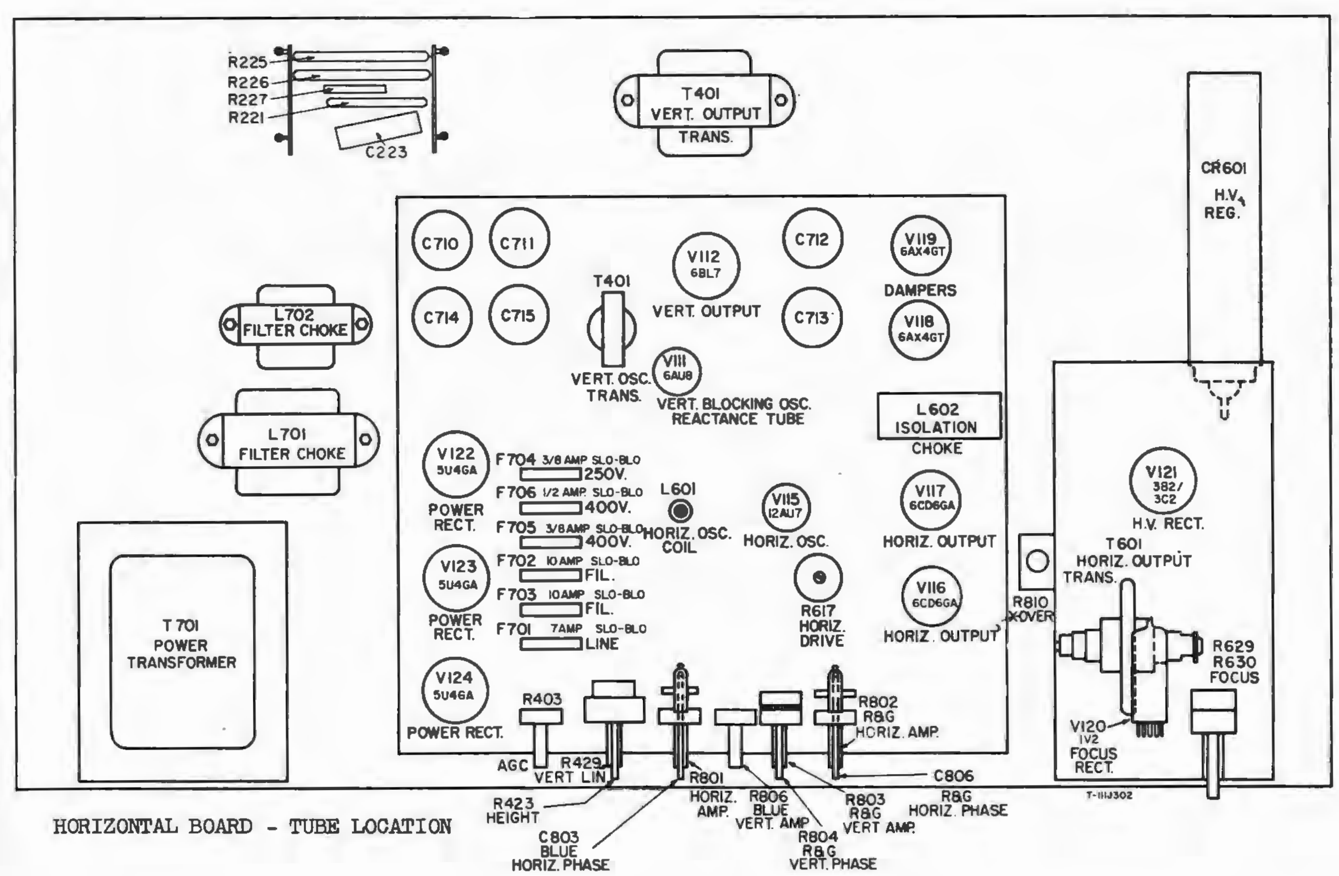
* VOLTAGE MEASUREMENTS ARE IN RESPECT TO CHASSIS WITH A 20,000Ω/VOLT METER, WITH CONTROLS SET FOR NORMAL OPERATION, NO SIGNAL APPLIED.
▲ MEASURED WITH VTVM.





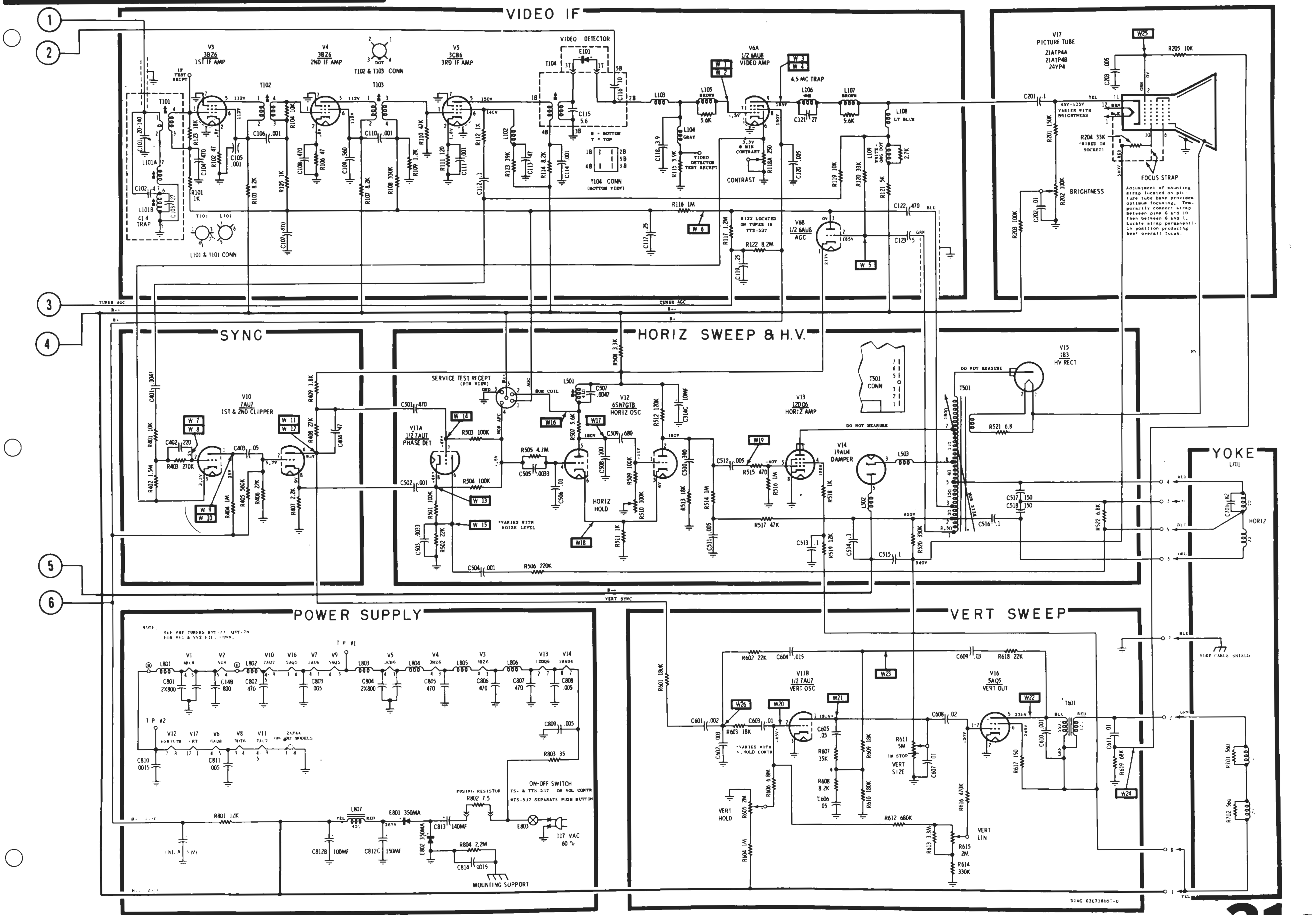


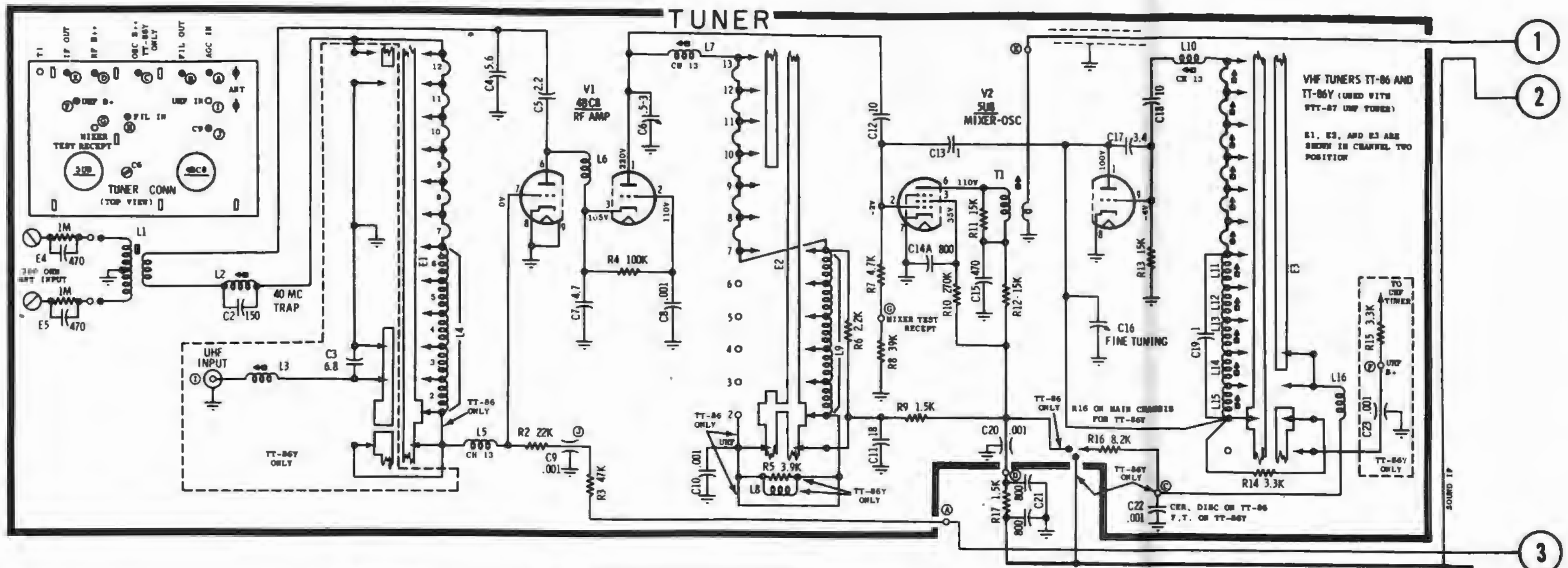
VERTICAL BOARD - TUBE LOCATION

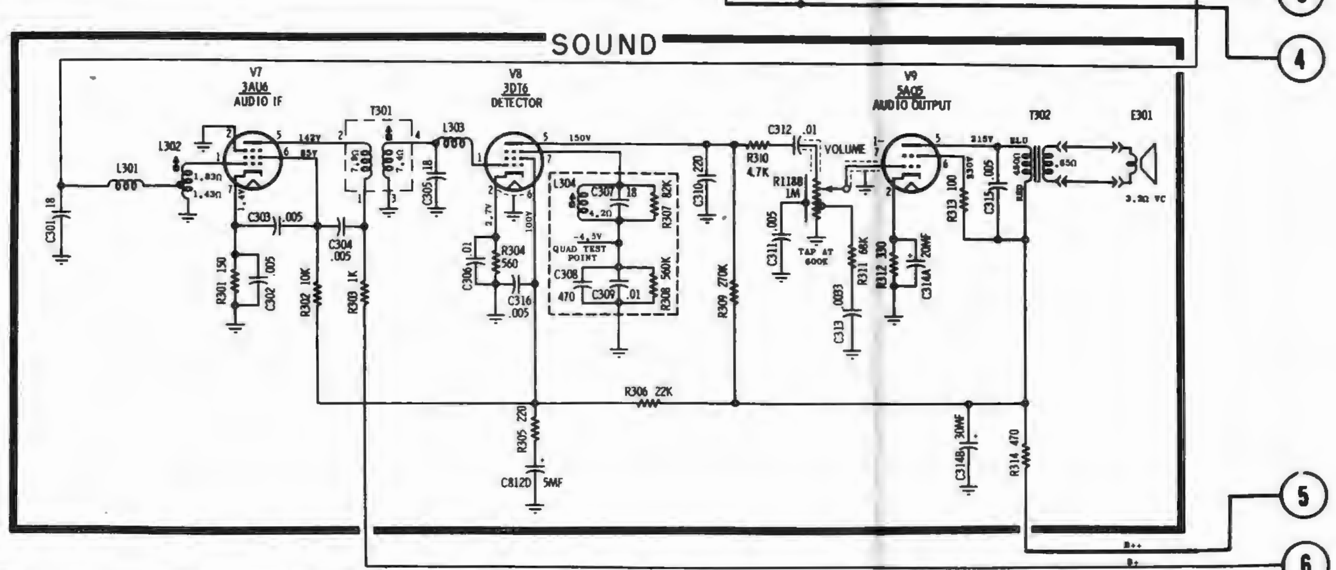


HORIZONTAL BOARD - TUBE LOCATION

ELECTRONIC SERVICING COMPLETE MANUFACTURERS SCHEMATICS. An exclusive service of Cowan Publishing Corp. by special arrangement with John F. Rider, Publisher.


VIDEO IF
V3 3BZ6 1ST IF AMP
V4 3BZ6 2ND IF AMP
V5 3CB6 3RD IF AMP
VIDEO DETECTOR
V6A 1/2 6AU8 VIDEO AMP
4.5 MC TRAP
V6B 1/2 6AU8 AGC
V17 PICTURE TUBE 21ATP4A 21ATP4B 24YP4
BRIGHTNESS
CONTRAST
FOCUS STRAP
SYNC
V10 7AU7 1ST & 2ND CLIPPER
HORIZ SWEEP & H.V.
V11A 1/2 7AU7 PHASE DET
V12 6SN7GTB HORIZ OSC
HORIZ HOLD
V13 12DQ6 HORIZ AMP
V14 19AU4 DAMPER
V15 1B3 HV RECT
SERVICE TEST RECEPT
T501
YOKE
HORIZ
POWER SUPPLY
ON-OFF SWITCH
117 VAC 60 ~
MOUNTING SUPPORT
VERT SWEEP
V11B 1/2 7AU7 VERT OSC
V16 5AQ5 VERT OUT
VERT HOLD
VERT SIZE
VERT LIN
T601
YOKE CABLE SHIELD





NOTES:

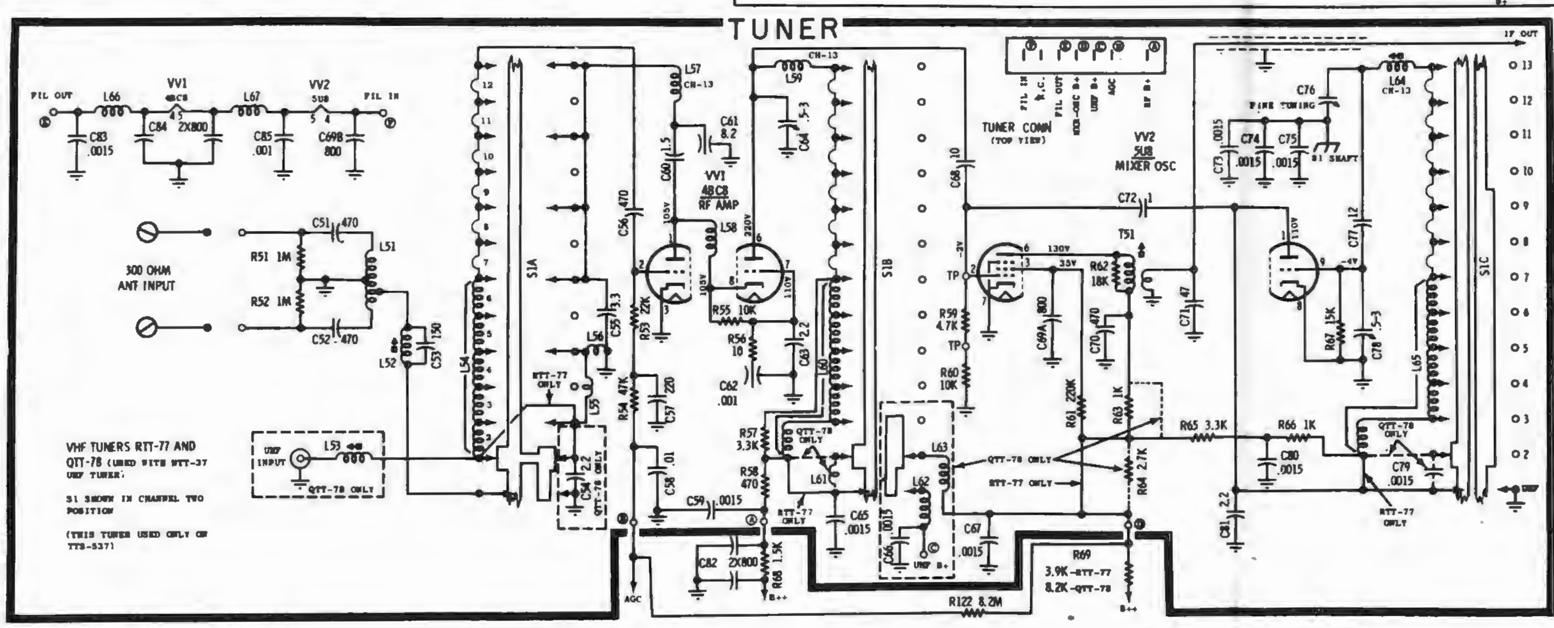
CAPACITORS - Decimal values in MF all others in MMF unless otherwise specified.

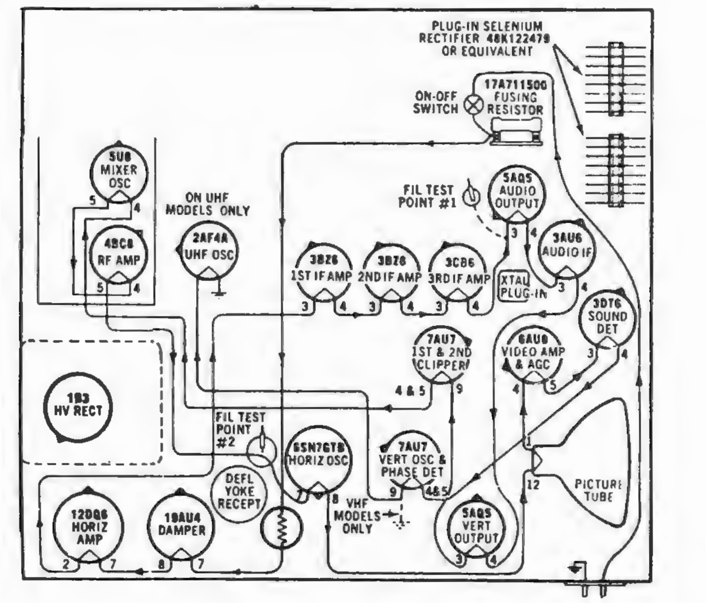
VOLTAGE MEASUREMENTS

1. Made with a VTVM from point indicated to chassis.
2. Line voltage - 117 volts (use Isolation Transformer).
3. Antenna disconnected and input shorted across.
4. Channel selector switch on channel which develops least noise at detector test receptacle.
5. Contrast control at maximum counterclockwise position.
6. All other controls in normal operating position.
7. Voltages associated with variable-control circuitry will vary with control setting.

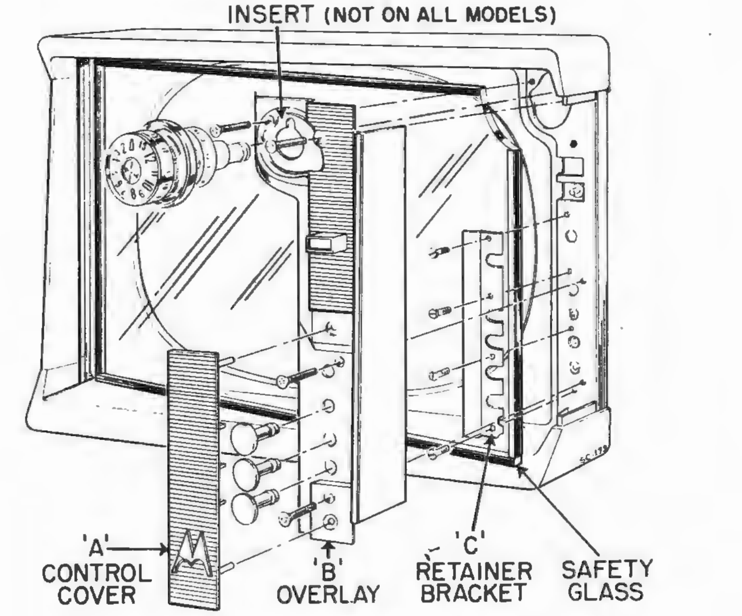
WAVEFORMS

1. Designated by "W" prefix and numerical reference.
2. Photographs of waveforms are on pages preceding the schem tic.
3. Required circuit conditions are given with each waveform.
4. Waveforms observed on wide-band oscilloscope.





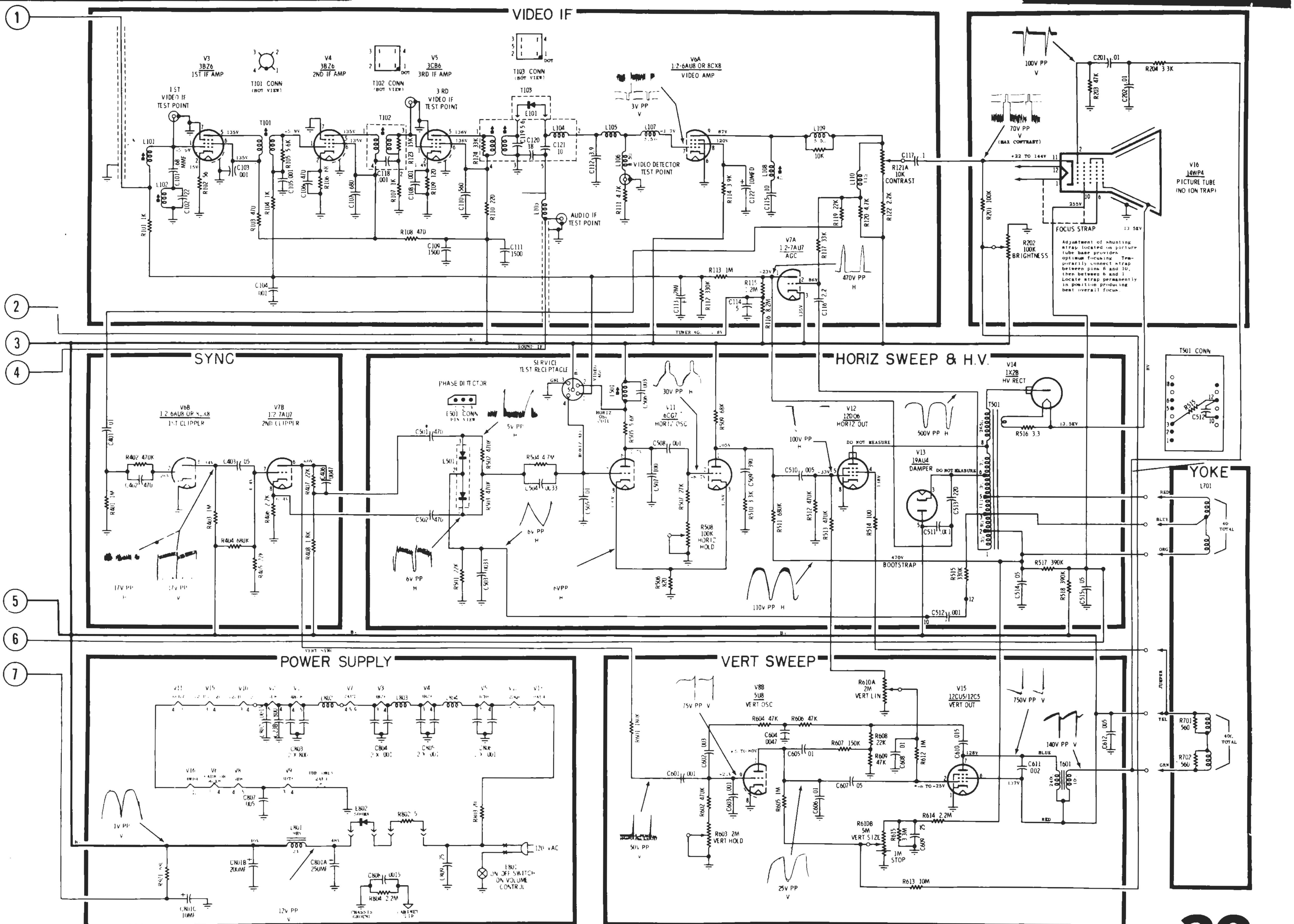
TS, WTS-537 SERIES TUBE LOCATION DETAIL

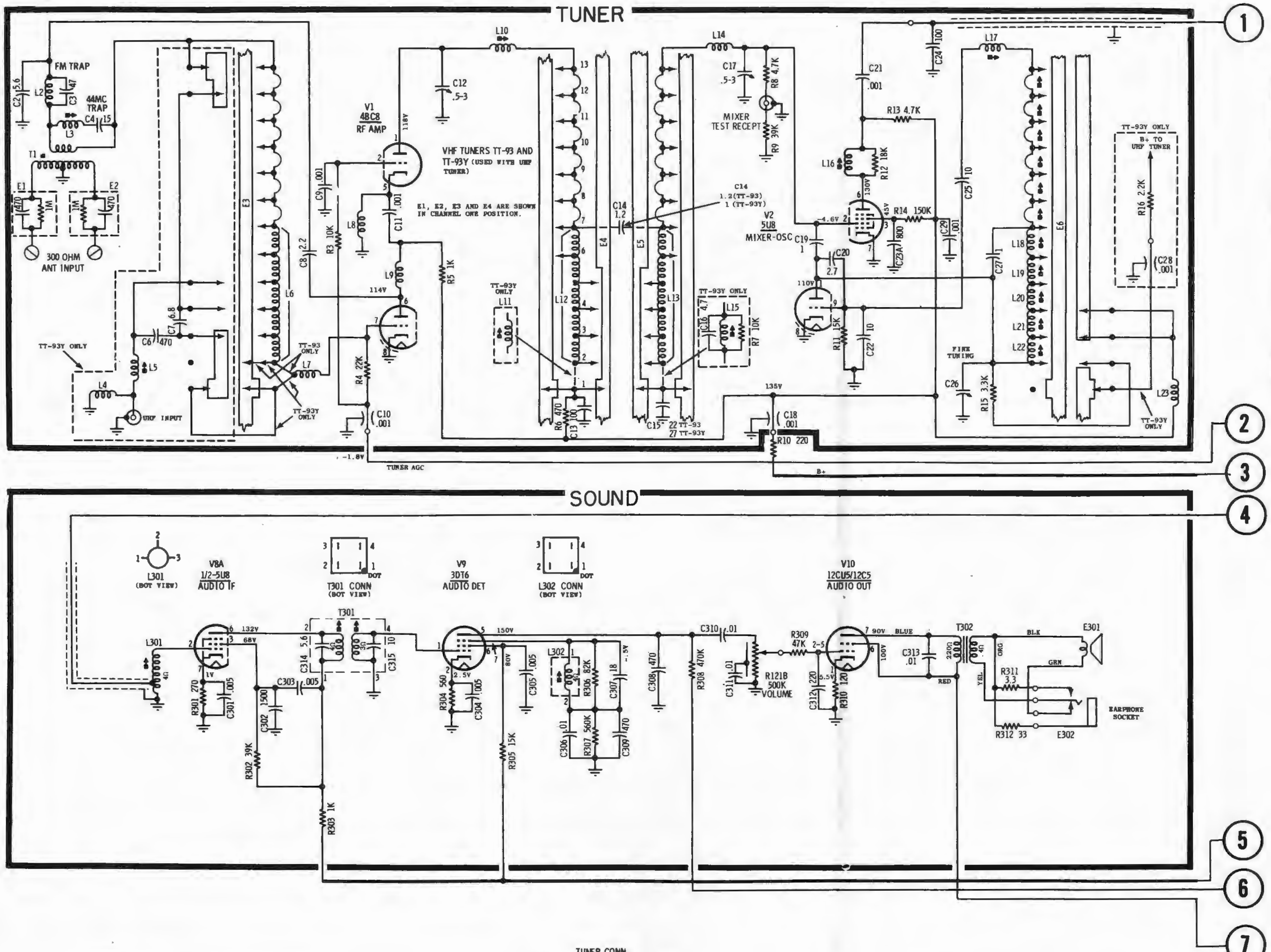


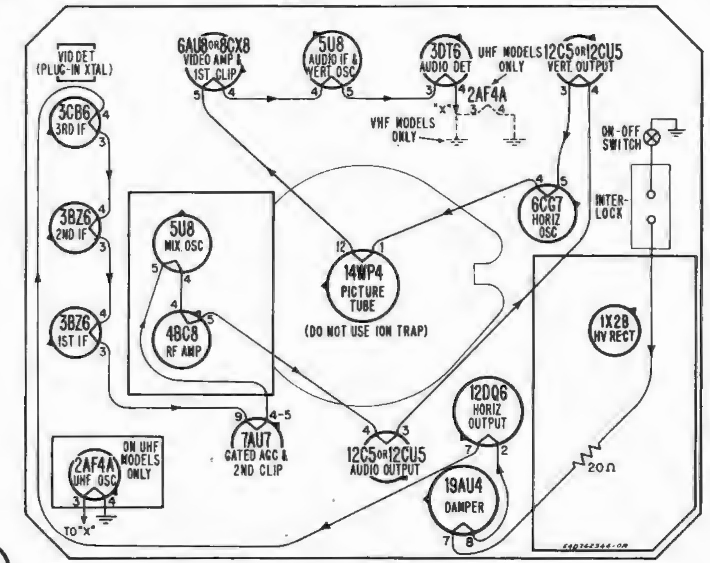
RECTANGULAR GLASS REMOVAL

CHASSIS TS-425A-00

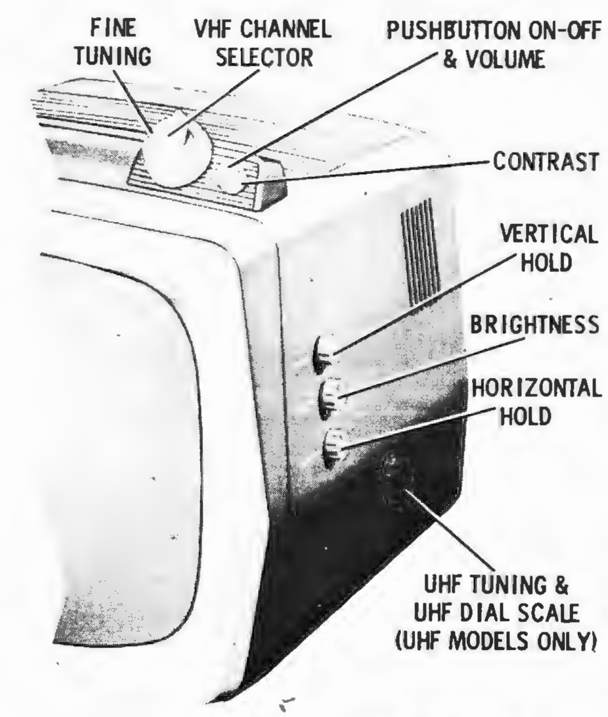
MOTOROLA







TUBE LOCATIONS & FILAMENT WIRING



MAIN OPERATING CONTROLS

NOTES:

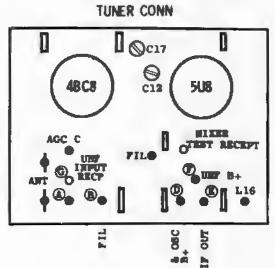
CAPACITORS - Decimal values in MF, all others in MMF unless otherwise specified.

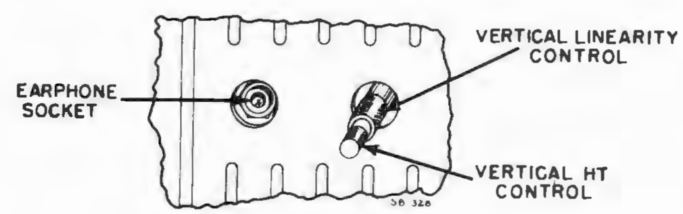
VOLTAGE MEASUREMENTS
1. Made with a VTVM from point indicated to common ground.
2. Line Voltage - 122 VAC (Use Isolation Transformer).
3. Voltages indicated by an asterisk (*) will vary with associated control setting.

WAVEFORMS
1. Taken with wide-band oscilloscope.
2. Receiver in operating condition and showing a normal picture.

V = VERTICAL
H = HORIZONTAL

TUNER CONN





REAR CONTROLS

Mfr: Crosley **Chassis No.** 472-473

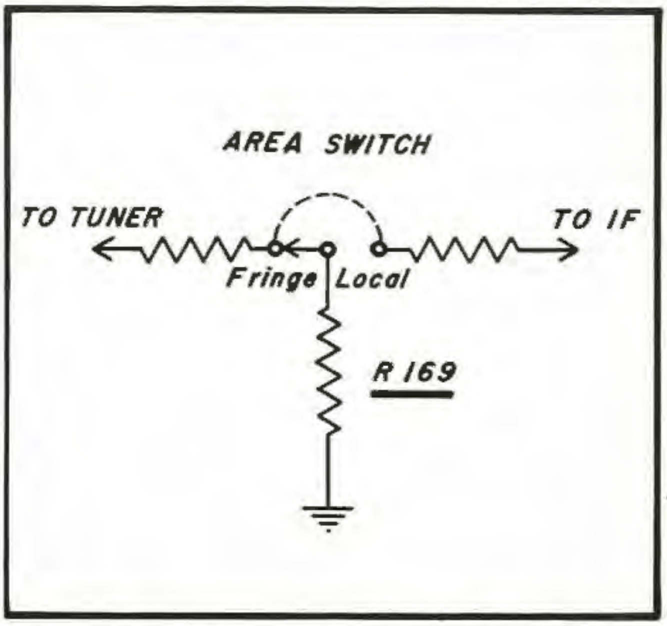
Card No: CR-472-473-1

Section Affected: Pix.

Symptoms: Poor *if* sensitivity.

Reason For Change: To improve picture quality. (Prod. change—code B)

What To Do:
Add *R169* between switch arm and ground (100K).



Mfr: Crosley **Chassis No.** 472-473

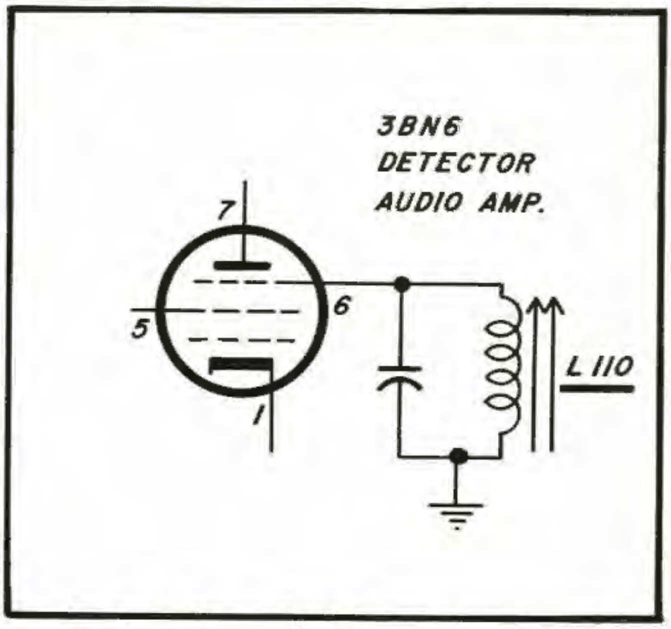
Card No: CR-472-473-2

Section Affected: Sound.

Symptoms: Poor impulse noise rejection.

Cause: Quadrature coil mis-adjusted.

What To Do:
Realign coil *L110*.



Mfr: Crosley **Chassis No.** 472-473

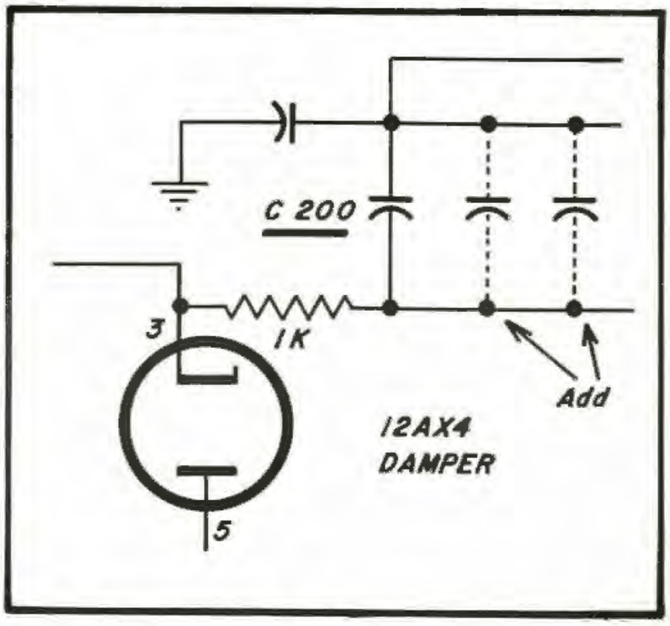
Card No: CR-472-473-3

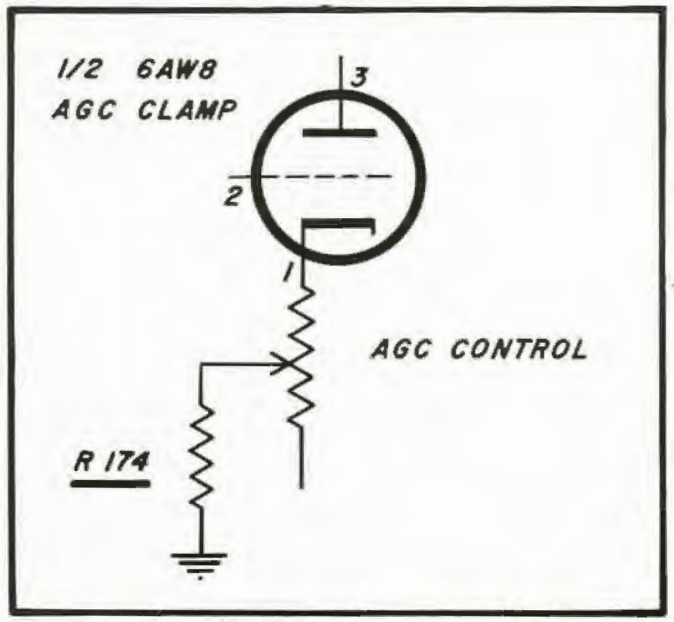
Section Affected: Horizontal sweep circuit.

Symptoms: Insufficient width.

Reason For Change: Capacity in cathode circuit of damper is too small. (Prod. change—code B)

What To Do:
Replace *C200 (100 mmf)* with a *47 mmf* and *82 mmf*.





Mfr: Crosley **Chassis No.** 472-473

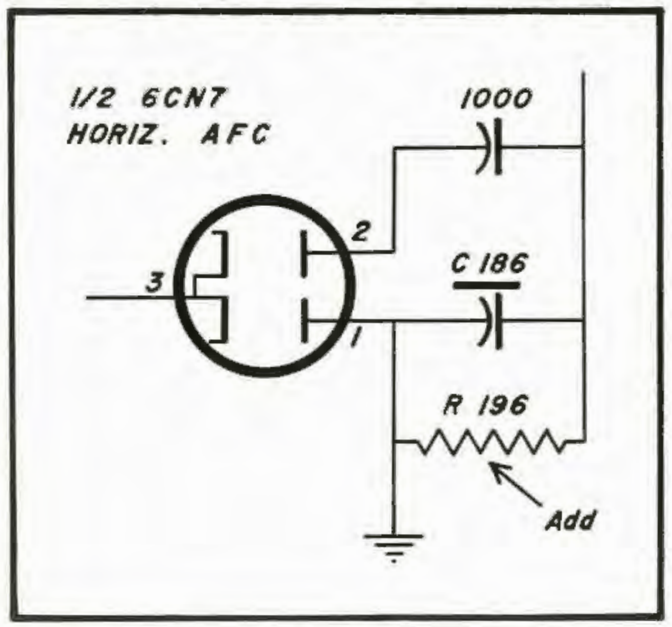
Card No: CR-472-473-4

Section Affected: Picture.

Symptoms: Improper *agc* control level.

Reason For Change: Range of *agc* control insufficient to reduce signal at video detecter to 3 volts peak to peak. (Prod. change—code B)

What To Do:
Change *R174* from 12K to 10K.



Mfr: Crosley **Chassis No.** 472-473

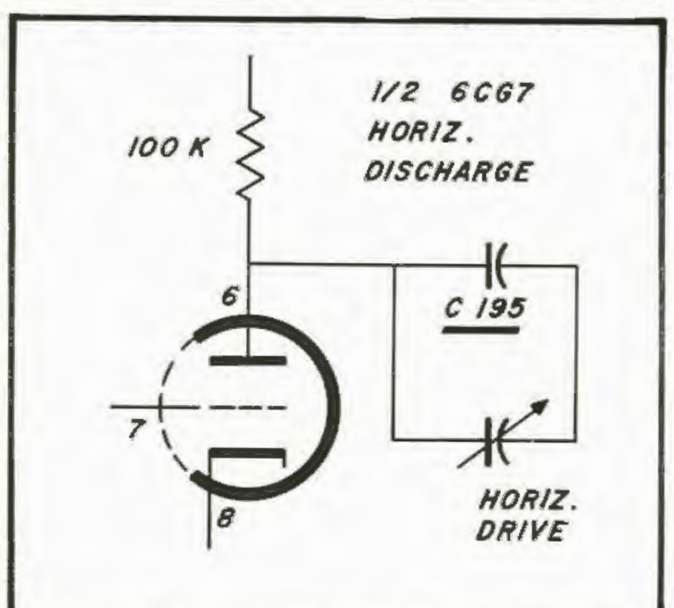
Card No: CR-472-473-5

Section Affected: Horizontal sweep circuit.

Symptoms: Horizontal foldover.

Reason For Change: *afc* condenser too large. (Prod. change—code E)

What To Do:
Change *C186* from *4000 mmf* to *3000 mmf.* Also add *R196* (8.2K)



Mfr: Crosley **Chassis No.** 472-473

Card No: CR-472-473-6

Section Affected: Horizontal sweep circuit.

Symptoms: Insufficient horizontal drive range.

Reason For Change: To increase horizontal drive range. (Prod. change—code D)

What To Do:
Change *C195* from *68 mmf.* to *330 mmf.*

Mfr: Philco **Chassis No.** TV-396

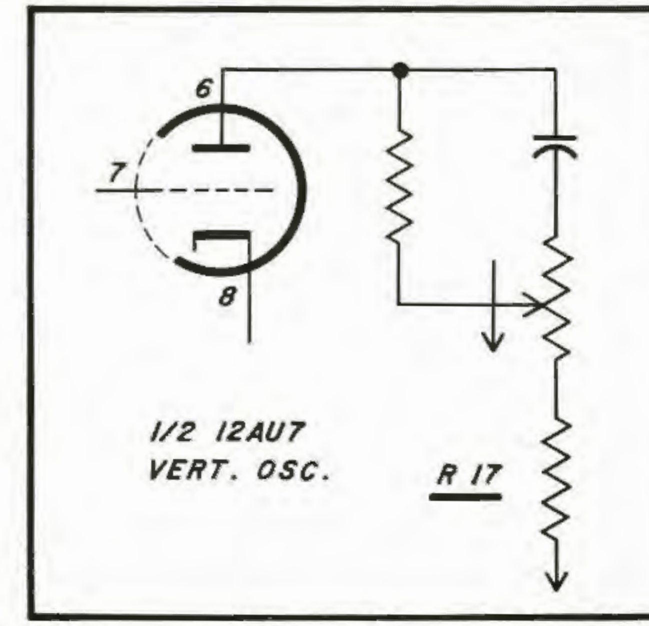
Card No: PH-TV-396-1

Section Affected: Raster.

Symptoms: Pix height adjustment inadequate.

Reason For Change: Circuit improvement. (Prod. change—run-3)

What To Do:
Change *R17* from *070K* to *820K.*



Mfr: Philco **Chassis No.** TV-396

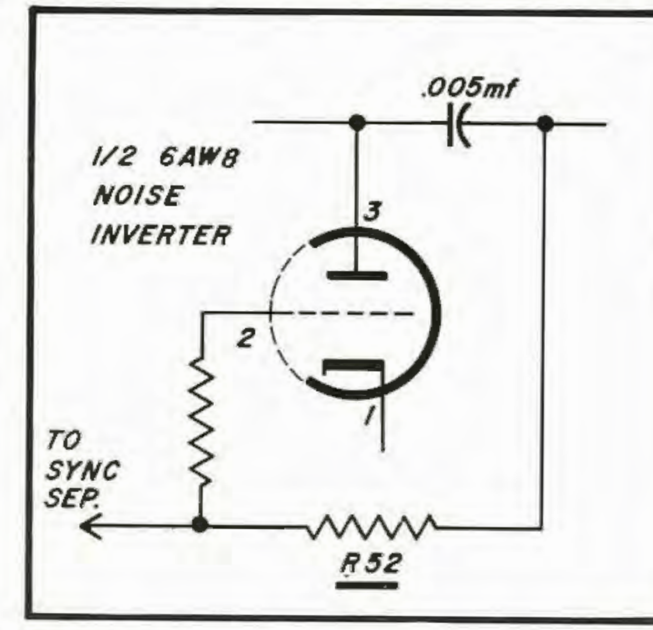
Card No: PH-TV-396-2

Section Affected: Sync.

Symptoms: Vertical sync and *agc* not performing at optimum.

Reason For Change: Circuit improvement. (Prod. change—run 2)

What To Do:
Change *R52* from *220K* to *390K.* See cards PH 396-3,4,5



Mfr: Philco **Chassis No.** TV-396

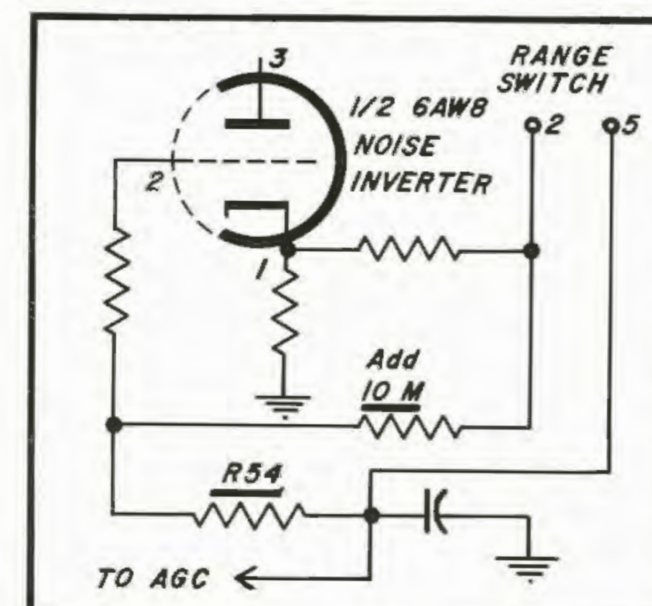
Card No: PH-TV-396-3

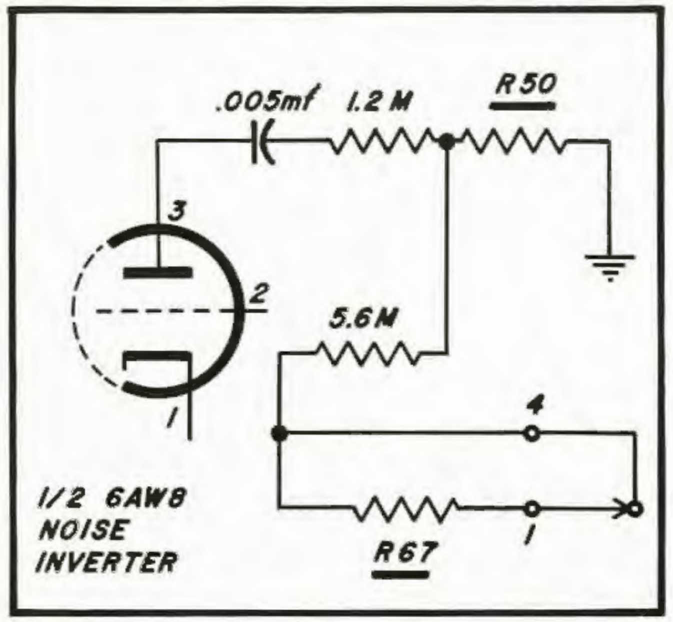
Section Affected: Sync.

Symptoms: Vertical sync and *agc* not performing at optimum.

Reason For Change: Circuit improvement. (Prod. change—run 2)

What To Do:
Add: *10 megohm* resistor between position 2 of range switch and the junction of *R48* and *R54.*
Change: *R54* from *6.8 meg.* to *5.6 meg.* See cards PH 396-2,4,5





Mfr: Philco **Chassis No.** TV-396

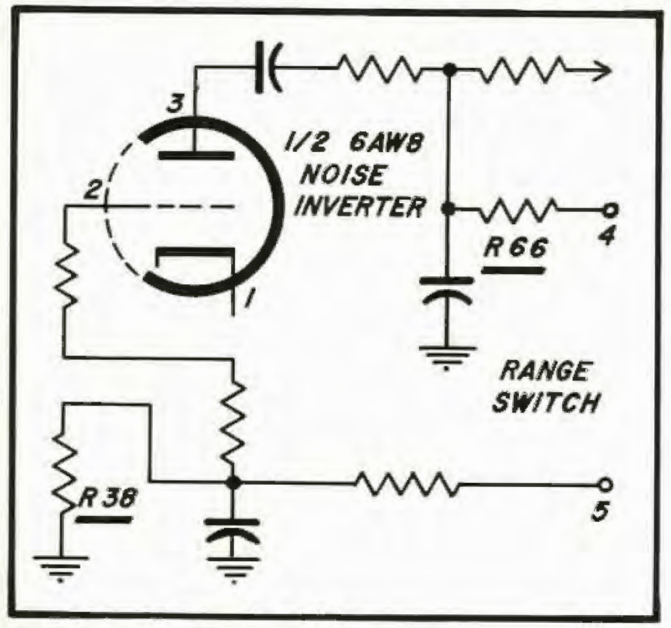
Card No: PH-TV-396-4

Section Affected: Sync.

Symptoms: Vertical sync and *agc* not performing at optimum.

Reason For Change: Circuit improvement. (Prod. change—run 2)

What To Do:
Change *R50* from *1 meg.* to *1.5 meg.* Remove *R67* (15 meg.). See cards PH 396-2,3,5



Mfr: Philco **Chassis No.** TV-396

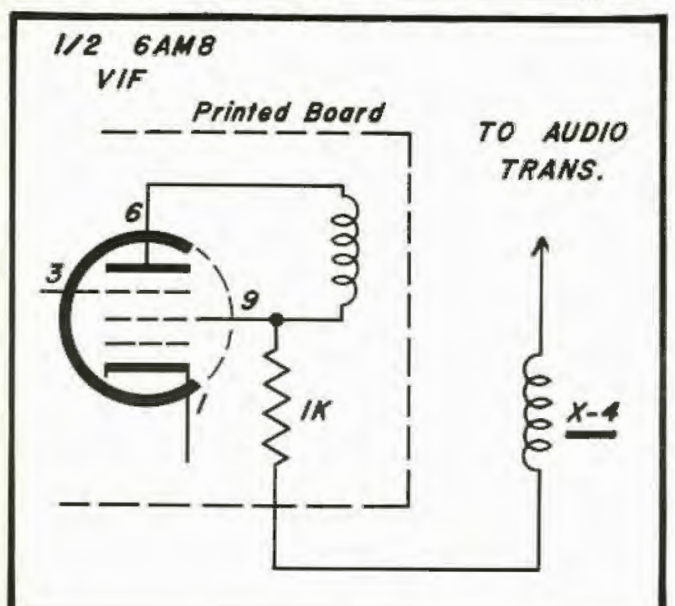
Card No: TV-396-5

Section Affected: Sync.

Symptoms: Vertical sync and *agc* not performing at optimum.

Reason For Change: Circuit improvement. (Prod. change—run 2)

What To Do:
Change *R66* from *5.6 meg.* to *6.2 meg.* Change *R38* from *2.2 meg.* to *4.7 meg.* See cards PH 396-2,3,4



Mfr: Philco **Chassis No.** TV-396

Card No.: TV-396-6

Section Affected: Picture.

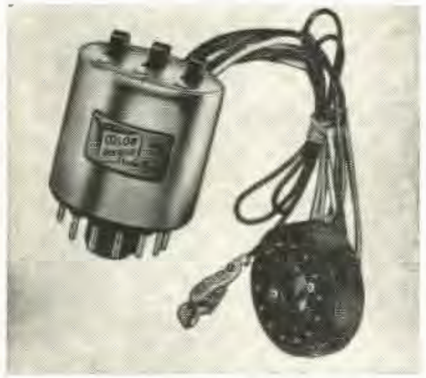
Symptoms: Poor adjacent channel beat attenuation.

Reason For Change: Better circuit operation. (Prod. change—run 3)

What To Do:
Move choke *X-4* from chassis onto the printed circuit board.

PERMA-POWER COLOR GUN KILLER

"Color Gun Killer" is the latest product released by the Perma-Power Company, Chicago. This unit, Model T-101, enables each gun of three gun color Kinescope to be operated singly or in combination. It avoids cutting or disconnecting leads to make color purity adjustments. List price is $4.95.



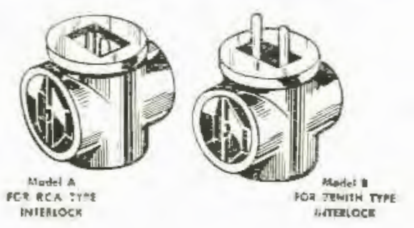
COUNTER DISPLAY BOX

Vaco Products Company, Chicago, Illinois, has just introduced their new, interchangeable, tool kit components counter display box, No. AZ614. In use, the lid is lifted, opening out into a back display panel 21″ wide and 10″ high. The display box is divided into 16 separate sections. Each section contains 6 each of 16 individual components. These components include: Heavy Duty Handles with clutch, Medium Duty Handles with clutch, 3 sizes of Straight Slot Blades, 2 sizes of Phillips Blades, 7 sizes of Hex Wrenches, and Vaco's patented extension piece which doubles the length of each and every blade. Also included

are empty plastic tool Bags with 14 compartments for making up Vaco Vari-Blade Tool Kits. Attention is called to the fool-proof interchangeability of all blades and handles. This has been made possible through the development of a special patented locking principle that holds handle and blade together as rigidly as in a one-piece tool.

CHEATER CUBES

Servicemen who want to save time on TV service calls, will be interested in the new Cheater Cubes developed by R-Columbia Products Co., Inc. of Highwood, Illinois. Instead of moving furniture to locate the nearest electrical outlet, the serviceman has only to remove the back of the TV set, plug in the proper Cheater Cube and he has a three-way source of electric power immediately. Available in two models, Model A for RCA Type Interlock and Model B for Zenith Type Interlock, these Cheater Cubes sell for 79c each, dealer net.



TRANSISTOR POWER SUPPLY

Perma-Power's Transistor Power Supply is especially designed to service and test transistor portable radios, amplifiers, phonos and similar equipment. Features of the new Model A-400 include extremely low ripple and constant internal impedance comparable to a battery. This one unit eliminates battery stocking and the need for additional low current metering necessary for quick diagnoses. Ranges of 0-15 *ma* and 0-60 *ma* and 0-15*v* and 0-30*v* cover all transistor and hybrid equipment with 2% accuracy.

HEATHKIT RIPPLE FILTER KIT

The model BF-1 is an L-type filter circuit exactly the same as the one incorporated in the new Heathkit model BE-5 Battery Eliminator. It is designed primarily for use with the Heathkit model BE-4 Battery Eliminator or other comparable units. It adds extra filtering to the *dc* output for powering transistors and "hybrid" automobile radios. Functions at 6 or 12 volts, up to 5 amperes maximum current.

THE WORK BENCH

Service Problems And Their Solutions

by PAUL GOLDBERG
Service Manager

THIS month's installment is devoted to pulse problems. A thorough knowledge of the receiver circuitry is very helpful in solving them.

Dumont RA-162B

The receiver was turned on and the picture was observed to have a video overload. A video overload usually means an *agc* problem. All the tubes effecting the *agc* system were replaced individually but had no effect. As shown in *Fig. 1* these were V209A and B, 12AX7; V204B, 6AL5; 1st and and 2nd video *if* amp., 6CB6's, and the *rf* amp., 6BK7. A voltage reading at the *agc* test point, *J227*, was made and the voltage measured around zero volts. Thus there was no negative *agc* bias being sent back to the *if* and *rf* stages. The diagram was then consulted. The composite, positive going, signal appearing in the plate circuit of V205, the video output tube, is directly coupled to the grid of V209A, the *agc* amplifier through *R256*. The sync signal is separated from the video signal by biasing this tube near cutoff. This is accomplished by the cathode resistor *R255* bypassed by *C255*. The sync signals which are of a higher amplitude than the video signal drive the tube above cutoff. Consequently only the sync signals appear in the output. The video signal is eliminated so that only the sync signal will determine the *agc* bias. Changes in brightness will effect the average amplitude of video information and thus effect the *agc* voltage. To avoid this the video signal is eliminated entirely. The varying cathode voltage across *R255*, which is a function of the signal strength at the antenna, is applied to the grid of V209B through a low pass filter network *R253*, *C238*, *R254* and *C219*. This low pass filter passes the sync pulse component of the cathode signal of V209A. As a result the signal applied to the grid of V209B consists of a positive *dc* voltage whose ampli-

[*Continued on page* 52]

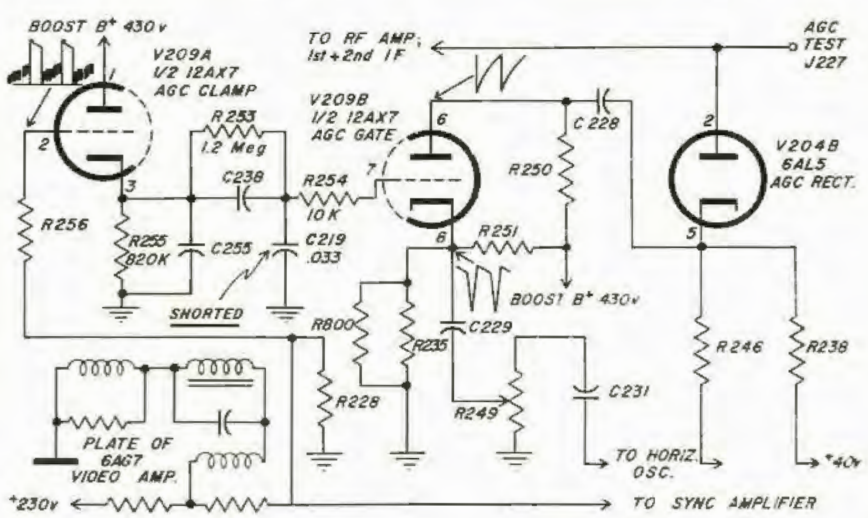


Fig. 1—Partial schematic of the Dumont chassis RA-162B showing the agc circuit.

THE ANSWERMAN

BY ELECTRONIC SERVICING TECHNICAL STAFF

Dear Sir:

I have an intercom system in which the owner complains of hearing strange voices. I listened to it and heard some audio that was probably a ham broadcasting. Somehow, he's getting into this intercom system. What would you suggest to correct this condition?

C. H.
San Francisco, Cal.

Interference of this type is common in intercom units and the easiest method of removing the rectified *rf* signals is to add a filter network in the grid of the first audio tube where it is probably being induced. The *rf* filter consists of a resistor and a condenser connected as shown in *Fig. 1.* These added components should be installed as close to the tube socket as possible. By inserting the components at this point in the system the interference is usually filtered. This type of filtering is also useful in correcting similar conditions in phonographs and P.A. systems as well as radios and hearing aids.

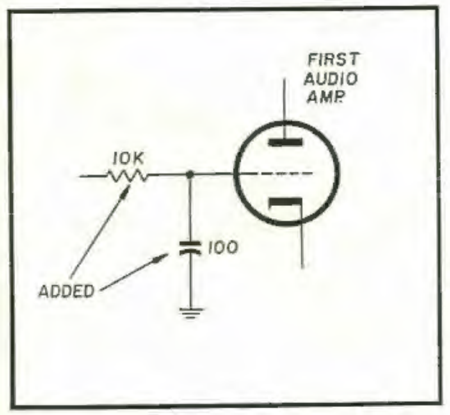


Fig. 1—A filter network can be added to suppress external interference.

Dear Mr. Answerman:

I have had trouble with a number of RCA chassis in which the horizontal output transformers, linearity coils and other components in the deflection systems have burned out. I am presently working on a KCS81 chassis in which I am unable to obtain sufficient width after replacing a burned linearity coil. I have substituted the high voltage transformer and other components and haven't been able to spread the picture to the edges of the tube. All usual checks have been made such as the output and damper tubes, B plus voltages, condensers, etc.

H. L.
Miami. Fla.

In these receivers using the air core transformer, it is important that the circuit adjustments be correctly made. This is particularly true with respect to the horizontal linearity and drive adjustments, where improper adjustment can possibly cause overheating and damage to the high voltage transformer and other components.

In making the necessary adjustments in the deflection circuit the width link is positioned in the minimum width position and the width coil adjusted to the maximum counter-clockwise position. The drive control is then backed off about two turns from tight clockwise. This position should be just about where the drive line disappears.

In these receivers the horizontal linearity is adjusted with a 0-500 *ma* meter in series with the horizontal output tube cathode resistor and ground. The linearity coil is adjusted for minimum tube current which is about 115 to 125 milliamperes. The width control is then placed in the position that will provide sufficient width to properly fill the screen.

Under low line voltage conditions it is possible that with the width link in the upper position as shown in *Fig. 2* insufficient width will be obtained. The width link can be moved to the lower position which removes the width coil from the horizontal output circuit and provides additional width to the picture. It is possible that if the circuit component tolerances add up in the wrong direction the width may be too narrow and overheating of the high voltage transformer and other components may occur. In this event a condenser can be shunted across the circuit as shown in *Fig. 2.* The value of this condenser can be from 18 to 33 mmf, 6000 volts. ■ ■

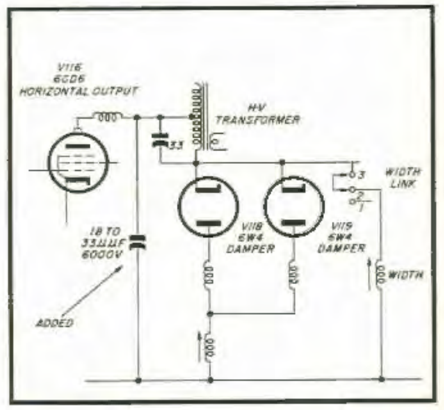


Fig. 2—Partial schematic showing horizontal output section of KCS81.

INTRODUCTION TO TRANSISTOR THEORY

[*from page* 15]

tional current flow is in the same direction as hole flow as shown.

The remaining element symbol refers to the collector in both (*A*) and (*B*). It consists merely of a straight line as shown.

Actual Gain

In a previous paragraph we discussed the theoretical gain of a transistor amplifier without taking into consideration the externally connected output load resistance. From vacuum tube theory we know that the output load is effectively in series with the internal output resistance of the tube. The same principle holds true for transistors, so that the total output resistance of the circuit consists of the internal output resistance of the transistor in series with the output load resistance. The output signal in the collector circuit is developed across these two series circuit elements. Therefore, only a portion of the theoretical voltage output will appear across the load resistor, R_L. In typical emplifiers such as shown in *Fig. 6*, the output resistance of the transistor may be 2 meg and the load resistor .1 meg. The theoretical voltage gain is approximately 1,500, and the voltage gain across the load resistor approximately 150.

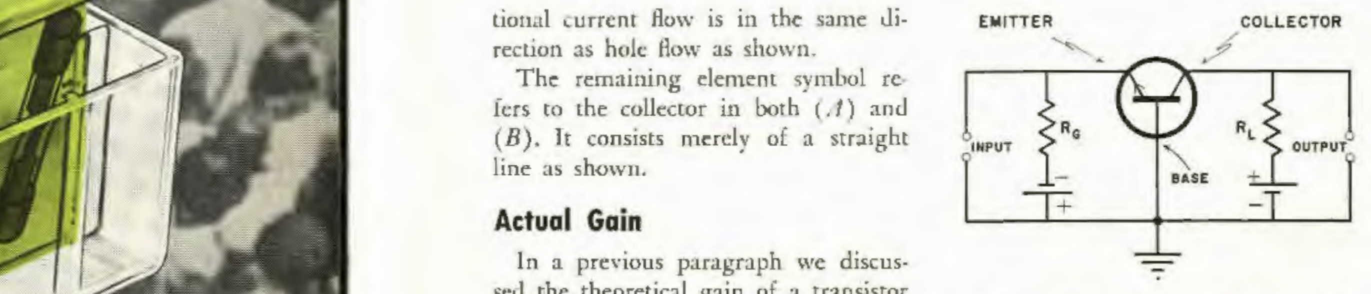


Fig. 6—Typical transistor circuit. Actual gain depends on size of R_L.

PNP Transistor

A *PNP* junction transistor with the base common to both input and output circuits is shown in *Fig. 7*. As in the case of an *NPN* transistor the emitter to base bias is in a forward direction and the base to collector bias in a reverse direction.

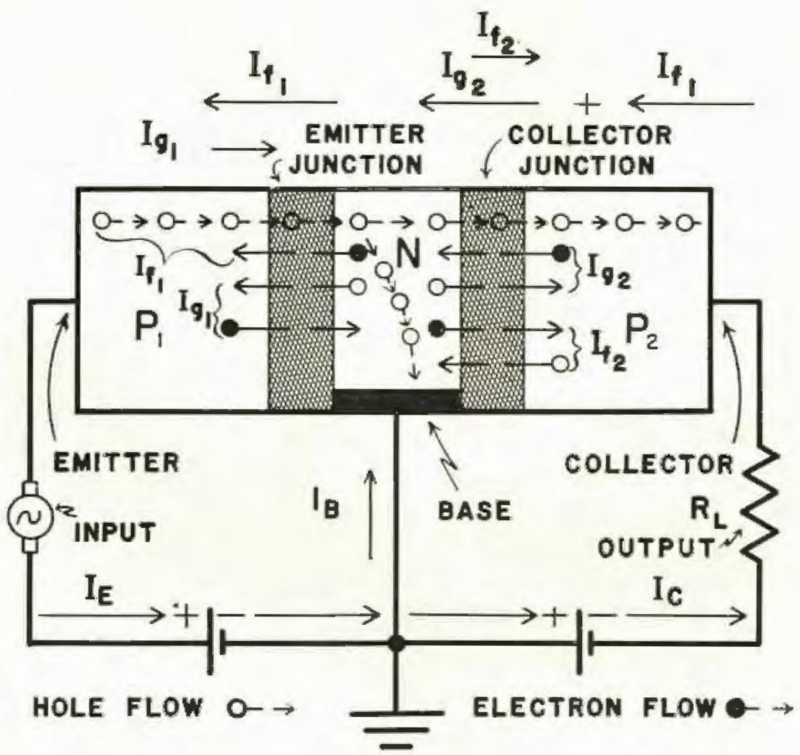


Fig. 7—Electron and hole flow for forward and reverse currents in a typical common base circuit using a PNP transistor.

The forward carriers from the *P1* to the *N* region consist mainly of holes. Because of the high resistance of the base region only a small number of forward carrier electrons make their way from the base region to the emitter. These two groups of carriers constitute the forward current I_f, which is shown as an electron flow in the direction opposite to the forward flow of holes. This is in accordance with the principle of hole flow being equivalent to an electron flow in the opposite direction.

The minority carriers in the *P1-N* section consist of electrons from *P1* to *N* and holes from *N* to *P1*. They set u pa reverse current I_g opposing the net forward current I_f. However, this effect is negligible.

A portion of the forward hole flow proceeds through the base region to ground, and gives rise to the base current I_b. The remainder of the forward hole flow proceeds across the collector junction into *P2*. This flow finds little opposition inasmuch as the *N-P2* unit is connected for reverse bias thereby permitting easy flow of holes from *N* to *P2*. Aiding this hole flow is the normal small reverse current in the *N-P2* junction consisting of minority holes flowing from *N* to *P2* and electrons flowing from *P2* to *N*. The net equivalent reverse current across the collector junction is the negligible effect of I_{g2} plus the large number of holes from *N* to *P2*. Opposing this net current is the small and negligible forward current (due to reverse bias) across the collector junction.

The net flow of holes across the collector section gives rise to an output collector current I_c. The ratio of collector current change to emitter current change is alpha. As in an *NPN* common base circuit, alpha varies between .91 and .99, and the impedance step-up is high. Therefore the voltage gain in a circuit using a *PNP* transistor is of the same order as that using an *NPN* transistor.

From the foregoing, we see that *NPN* and *PNP* transistors have comparable characteristics. However, because of their greater relative ease of manufacture, *PNP* transistors are in much greater use than the *NPN* types.

(To be continued)

WORKBENCH

[*from page* 46]

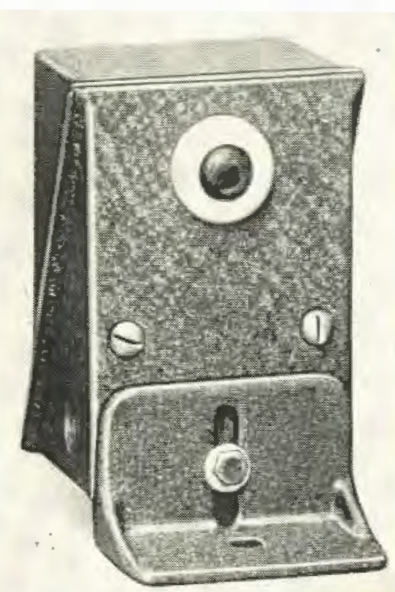
tude varies with the strength of the incoming signal. Since the amplitude of the cathode pulse is set at a constant value, the amplitude of the plate signal is directly related to the strength of the incoming signal. Thus the output of V209B, the *agc* gate, is directly related to the strength of the incoming signal. This signal at V209B's plate is applied to the cathode of V204B, ½ 6AL5, and rectified. The negative *agc* voltage produced at its plate is applied to the grids of the first and second video *if* amplifiers and to the *rf* amplifiers in the tuner. For delay purposes a positive voltage is applied to the cathode of V204B, the *agc* rectifier. Here the waveform was correct. A waveform check was next made at pin 3 of V209A. Here the waveform was also correct. Next a waveform check was made at pin 6 of V209B. Here no waveform appeared on the scope at all. This, therefore, was a stage with trouble. A waveform check was next made at pin 8 of V209B. This waveform was correct. The voltmeter was next set up and a voltage measurement was taken at the plate of V209B, pin 6. Here the voltage was a bit high. Apparently there was plate voltage and there was a cathode pulse yet no output appeared at the plate of V209B. A voltage reading was next taken at the grid of V209B, pin 7. The meter read zero volts instead of about plus 70 volts. A resistance measurement was then taken from pin 7 of V209B to ground. A study of the schematic shows that this resistance should be about 2 megs. The meter read only 10,000 ohms. After glancing at the diagram capacitor *C219* was clipped off at the ground side and was found to be completely shorted. (Zero ohms). *C219* was then replaced with a new .033 *mf* condenser. The receiver was turned on, and now functioned properly. With C219 shorted to ground, V209B was always cutoff and thus no negative *agc* voltage appeared at the plate of V204B, 6AL5. ■■

PHOTOELECTRIC CONTROLS

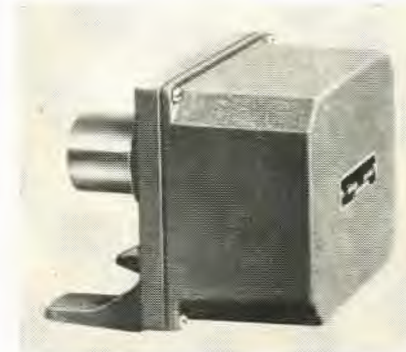
[*from page* 21]

of the object which activates the control. They may be equipped with either a fixed or adjustable lens. For use with intruder alarms, an infra-red or "black light" source is used so that the beam will be invisible to the naked eye. Too great a light intensity will shorten the life of the phototube and too little will cause improper operation. In all cases, the recommendations of the manufacturer should be followed when selecting a unit for a particular application.

A typical unit, the Autotron type L1AR, is equipped with a relay which can be used to sound an alarm or to stop a machine when the lamp burns out.



Typical photoelectric control unit with the "electric eye" visible.



Autotron photoelectric control unit, L1AR is pictured above.

Servicing Considerations

Servicing photoelectric control equipment will present no unusual technical problems. Lamp and tube failures will account for most of the trouble. Other components may break down, but good commercial equipment is designed for continuous operation and a wide margin of safety is provided for in the selection of parts. It is important to keep relay contacts and tube pins and sockets clean. Lenses on light sources and control units should be cleaned often enough to prevent an accumulation of dust from causing erratic operation. The focus adjustment of lenses should be checked periodically. When replacing the light source lamps, use the type specified by the manufacturer as the intensity and the color of the light from the wrong type of lamp may cause improper operation of the control unit. Lamps and tubes must be firmly seated in their sockets and all screw terminal connections kept tight against failure caused by vibration.

The most important point of any industrial electronic servicing is getting the equipment back in working order as quickly as possible. A supply of lamps, tubes and other components should be kept in stock so that any breakdown can be taken care of promptly. If you sell the equipment of only one manufacturer, it will not be difficult to keep an adequate supply of parts on hand. ■■

PHILCO 1957

[*from page* 18]

magnitude on the CRT grid to produce zero beam current.

The first anode voltage of the picture tube employed in the 7L70 chassis series has been increased by approximately 50% over that of the average television receiver. Thus, the available video drive has been raised by a corresponding percentage thus establishing one of the requirements for the video amplifier.

Range Switch

A three-position range switch is featured in the 7L70 chassis series, for strong, normal or weak signal levels. The switch, in various positions, alters the *agc* and *agc* delay circuits by changing the resistor divider network. Thus *agc* range can be extended for weak or strong signal levels (or adjusted to normal signal levels) beyond the range of the average *agc* system.

A second function of the range switch is to adjust the bias level of the noise inverter to compensate for signal level changes. Weak signals may not permit the inverter to pass and invert enough of the noise pulses above sync tip level for effective cancellation. On strong signals there is danger that a portion of the sync tips might be passed and inverted. The range switch adjusts the noise inverter bias to the proper operating level for the signal strength available.

Sweep Circuits

The oscillator panel contains, in addition to the sync separator, the vertical and horizontal oscillators and the phase comparer stage. Both oscillators are cathode-coupled multivibrator types. The frequency of the horizontal oscillator is controlled by a conventional duo-diode phase comparer stage. Both the vertical and horizontal output stages are mounted on the main chassis feeding their respective deflection circuits. A vertical retrace suppression circuit is connected from one side of the vertical output transformer to the cathode of the CRT.

Power Supply—7L70 Series

The low-voltage power supply is a transformer type, with full-wave rectification. A 12 volt center tapped winding is provided on the transformer, supplying 6 volts for tube filaments and 12 volts for the stepper motor of the automatic tuning system. The center tap of the transformer secondary winding contains a .7 ampere slo-blo fuse which is physically mounted on the rear of the chassis for easy access.

General Servicing Procedures

The use of printed-wire panels in all chassis series greatly improves the serviceability. Around the outer edges of the panels are located a number of tie lugs used for B-plus connections, filament connections, *agc*, bias, coupling between stages, etc. Thus a considerable number of test points are readily available, making it unnecessary, in a number of cases, for the service technician to remove the chassis. This also applies to the replacement of many of the components. The tie lugs are ideal test points for ohmmeter, voltmeter and oscilloscope checks of the various circuits. Further, because of the manner in which components are

mounted on printed-wire panels and the fact that the component side of the panels are, in many instances, accessible from the cabinet rear, a host of individual component test points are available to the service technician.

With the exception of width and focus, two of the least needed controls, all of the remaining service controls are accessible from the front of the receiver. Adjustments can easily be performed while viewing the face of the picture tube and the need for service mirrors and stands is eliminated. The controls on the front of the receivers are the volume-off-on, vertical linearity and brightness (tandem control), height and vertical hold (tandem control), auxiliary horizontal hold and horizontal hold (tandem control), contrast, channel selector and fine tuning and (7L70 series only) the range switch. The center shaft on some of the tandem controls is recessed and slotted for screw driver adjustment. Controls requiring screw driver adjustment are the vertical linearity, height and aoxiliary horizontal hold.

Serviceability of the 1957 Philco chassis is further facilitated by the use of connecting pins or plugs for the leads from the CRT and the speaker to the chassis. Removal of the chassis, CRT and speaker does not require the use of a soldering iron. On the 7L40 and 7L70 series chassis, the front escutcheon plate must be removed for chassis removal. Removal of the picture tube assembly requires removal of the four mounting nuts which secure the picture tube frame to the cabinet front. ■ ■

MICROWAVES

[*from page* 17]

sliding the unit out for easy accessibility to parts. See *Figs 1* and *2*.

Repairs made after a system fails constitutes emergency maintenance. These repairs must be made promptly to reduce outage time. For the service man this means an interruption of his routine maintenance and a possible interruption of his home and social life. To help in such repairs, a well kept station log is an invaluable asset. Results of emergency tests can be quickly compared with tests made previously. The service man can thus trace the trouble quickly to the faulty unit.

The reduction of tubes in Quadriphase is one of its most attractive features. For one voice channel there are less than 8 tubes in G.E.'s Quadriphase. This cuts inventory costs for stocking these items to a minimum. Another attractive feature involving considerable savings to the service company is that of setting levels. The testing, adjusting, and repair of an entire station can usually be done by one technician.

Path Margin Check

As the service man acquires experience in servicing the microwave system, he will rely on certain checks and tests to inform him rapidly where a fault is developing. One of these checks to ascertain the condition of an *rf* path between two adjacent stations is a path margin check. In the past, this was done by opening the coaxial cable to the receiver and inserting a lossy line calibrated for a certain number of *db* loss. At the point where the signal in the receiver was lost in the noise, the number of *db* loss inserted into the input of the receiver was the path margin (or, if you prefer, fade margin). This check tests the condition of the equipment at the two stations. The lossy line required to degrade the signal to the receiver threshold is an indication of the performance of the transmitter at the opposite end and the receiver where the measurements are made and the path condition. These readings, however, demand good propagation conditions, and the service personnel making such measurements must be sure that several other conditions are met before the lack of adequate margins are attributed to equipment degradation. Clipping levels must be correct and average propagation conditions must exist before the equipment is suspect. As the service personnel becomes more experienced in ascertaining these conditions, the path margin becomes a valuable tool.

The method summarily described above has one disadvantage, namely that the system service is interrupted to insert and remove the attenuator. On the new receiver sold with Quadriphase, a variable attenuator is built into this unit. This attenuator is on a hinge and has a calibrated scale. The point at which the signal (pulse) disappears is then readily read from the calibrated scale and a long interruption is avoided. Such measurements do not pinpoint a faulty piece of equipment, but they do show the need for further checks of the transmitter, the transmission lines and antennae at both ends, and the receiver. They indicate the relative condition of a path and, as such, are an invaluable aid to servicing. The data should be recorded along with the other tests and measurements for ready references.

Keeping Records

Since today's equipment is designed for long unattended operation, routine servicing requires the use of accurately kept records. The service supervisor can utilize these records to predict the ordering of spare stocks. In addition, they point the way for possible increase in payment for service as the system ages and demands more parts and service time. Accounting for spare parts can be done by word of mouth or by records, but some system for ordering spare parts should be incorporated into the maintenance procedures.

Preventive Maintenance

Servicing the microwave system requires rapid maintenance during complete station failure. Such a failure is almost invariably caused by a failure of the 60 cycle power mains. To increase the reliability of microwave during adverse weather conditions, microwave stations are usually supplied with emergency power units. These units are standing by during the periods that commercial power is available. When the commercial power fails, a relay disconnects the regular power mains, turns on the emergency power and connects the emergency power to the microwave racks. This additional feature has made microwave communications one of the most reliable means of transmitting intelligence in use today.

Maintenance procedures should be designed to keep circuit interruptions to a minimum. If stand-by equipment is available, the filaments of the stand-by equipment can be warmed up so that switching won't interrupt the services of the system.

The reliability of the system then hinges on an important item, namely the maintenance of the system, or more specifically, the maintenance personnel and their approach to routine or preventive maintenance. To the serviceman who in the past has serviced any of the many types of electronic equipment, the concept of preventive maintenance may be new. In contrast to servicing a unit after a failure has occurred, he must now rely on his routine maintenance to alert him to a possible failure and take the necessary steps to prevent it. Time is valuable when a service contract has penalty clauses for system or partial system failure. Such preventive maintenance then becomes a matter of having the available man power and the necessary test equipment along with a supply of spare parts.

As an example, one company is presently engaged in servicing a seven station microwave system, 168 miles in length. Five of the seven stations have *vhf* and mobile service. At this time, there are over 68 mobiles to service and the addition of 40 more are planned in the near future. Two of the microwave sites are multiplexed repeaters with audio drops for the two channels of the *vhf* and one service channel. The services available on this system are:

1. Extended coverage of the two *vhf* signals utilizing the microwave channels to pipe the audio portion of the *vhf* signal to the mobile receivers beyond the range of any one transmitter.
2. A microwave teletype channel
3. A maintenance service channel
4. Four private phone channels utilizing switchboard completed with an inter-building dialing system between the main buildings.
5. A fault channel to alert maintenance personnel of a station using the stand-by equipment.

This system has been maintained for approximately a year with all maintenance being furnished by an outside service company. The many problems of servicing and maintaining this complex microwave system has shown that alert and enterprising service personnel can handle the many demands of such a system profitably and with a minimum training period.

The three men engaged in maintenance have had no previous training in microwave systems servicing. The installation period was utilized for training on the equipment, cutting the casts and length of training to a minimum.

As in any enterprise, the initiative and hard work required in adjusting to a new challenge has paid off in service to the customer and profits to the service company. ■ ■

PHASE INVERTERS

[from page 12]

provides no actual gain (the heavy degeneration in the cathode circuit results in gain figures of up to 0.9—always less than unity) it must be remembered that only *one* triode section is being used instead of two.

DC Coupled Phase Splitters

Typical of the phase splitter circuits so common in hi fi amplifiers is the circuit of the Fairchild Model 275 Power amplifier. A partial schematic of the phase splitter portion of the circuit is shown in Fig. 3 *R3* and *R4* in this diagram are immediately identified as the "matched pair" which comprise the cathode and plate load impedances. There is, however, one important difference between this circuit and the one discussed above. In the circuit of *Fig. 2,* the grid resistor is not returned to ground but rather to the junction of *R3* and *R4*. This was done to provide proper *dc* bias for the triode. The cathode voltage in the phase splitter shown in *Fig. 2* is about 100 volts positive with respect to ground, because of the high value of *R3* plus *R4*. If the grid were returned directly to ground the tube would tend to "cut itself off" with such high cathode voltage. By returning the grid to a point whose positive potential is just a few volts *lower* than the cathode, proper *dc* operating potentials are provided for normal triode conduction. Now consider the circuit of *Fig. 3*. The first half of the 12AV7 tube acts as a voltage amplifier, similar to those discussed in the previous installment of this series. *R1* and *C1* act as a phase correcting network, effectively rolling off supersonic response and preventing spurious oscillations. The main plate load resistance, *R2,* is arranged so that the actual plate voltage is 90 volts. The second half of the 12AV7 tube draws approximately 2.55 milliamperes of current, which causes a voltage drop of about 97 volts from ground to cathode, across the 43K resistor *R4*. Thus, the plate voltage of the first triode is 7 volts less positive than the second cathode voltage and there is no reason in the world why the first plate cannot be connected directly to the second grid, affording a net grid to cathode bias of about seven volts and, more important, eliminating a costly blocking coupling capacitor as well as two additional resistors. Then, too the

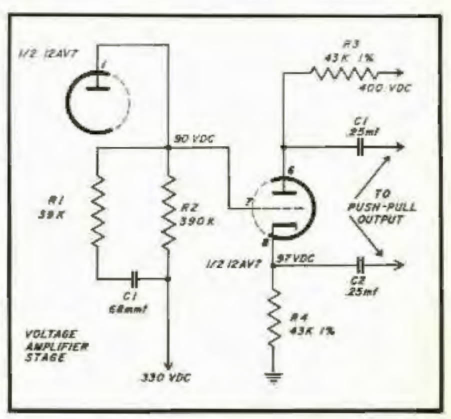


Fig. 3—Phase splitter circuit used in the Fairchild 275 Amp.

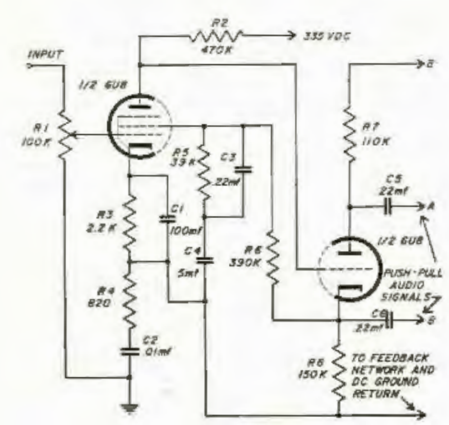


Fig. 4—Partial schematic of the Bogen DO-70 amplifier.

fewer coupling capacitors present in an amplifier having overall negative feedback, the less trouble will be encountered in connection with low frequency phase shift from ontpnt to input.

Another DC Coupled Phase Splitter

Still another variation on this theme is illustrated in the circuit of the Bogen Model DO-70 power amplifier. A partial schematic of the phase splitter circuit and voltage amplifying section is shown in *Fig. 4*. The phase splitter section consists of the triode section of a 6U8, in which the first pentode section serves as the voltage amplifier prior to phase inversion. *R7* and *R8* are immediately identifiable as the plate and cathode load impedances of the phase splitter, but one difference is also apparent between this circuit and the previous one. While the plate load is 100K, the apparent cathode resistance is 150K (*R8*). It would appear at first glance, then, that the signals developed across each could not be equal in amplitude, a condition which must be met in all

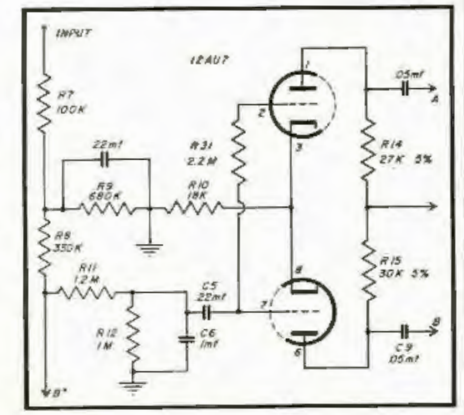


Fig. 5—Cathode coupled phase inverter used by McIntosh.

phase inverter circuits. Actually, there is a parallel load in the cathode circuit consisting of *R6* (390K), *C3* in parallel with *R5* (effectively a short circuit at all but the lowest frequencies, at which time this network acts as a phase correcting feedback path) and *C4*, which is also an equivalent short circuit at audio frequencies. Thus, the trne cathode load impedance is 390K in parallel with 150K or a little over 108K, which, within tolerance of components, is close enough to the plate load of 110K to be considered equal.

Cathode Coupled Phase Inverters

A seldom used but very excellent phase inverter circuit is the cathode coupled type, represented by the McIntosh Laboratory Model MC-30 power amplifier. A partial schematic is shown in *Fig. 5* and it can be seen that this circuit utilizes two triodes, with a common cathode resistor. The signal is fed to the first grid of the pair in the usual manner of triode hook-up, but the second grid is by-passed to ground. As a result, the second triode is effectively a grounded grid stage, with signal injected at the cathode. Such a configuration results in no phase reversal. Thus, the first triode inverts the phase, the second does not and both amplify equally. A further advantage of this circuit is the fact that the common cathode acts to automatically balance the two signals with respect to each other.

Checking Phase Inverter Circuits

By far the best technique for investigating the performance of phase inverters and/or phase splitters consists of signal tracing by means of an oscilloscope. While all but the most expensive 'scopes will not give a direct indication of phase (because the sync circuits will lock on either the positive or negative half cycle of a sine wave) they do provide an excellent means for comparing the amplitude of the two out-of-phase signals. Generally, a frequency of 1000 cycles or so is fed to the input of the power amplifier and the waveform is examined at the "cold" side of each of the two coupling capacitors which feed the stages following the phase inverter. (For example, in *Fig. 4* points A and B would be examined.) If the phase inverter circuit is functioning properly, the amplitude of the two signals will be equal within at least 5%. Distortion of either signal, such as clipping or asymmetrical appearance can often be attributed to a faulty coupling capacitor to the following driver or power output grids.

Hum

It can be seen in *Fig. 3* that, just as in the case of hi fi cathode follower circuits, the cathodes of phase splitter circuits are at relatively high B plus potentials. There exists, therefore, a great tendency for leakage between cathode and filament circuits. When such leakage occurs, hum voltages are often superimposed upon the desired audio voltages, with resultant hum induced into the entire system. Simple replacement of the tube is the answer here. One word of caution, however, if the trouble is not caused by defective tubes. Since phase inverters are often within the overall feedback loop of a power amplifier, the hum may seem to be present at every stage, because of the feedback system. Before it is possible to isolate this trouble to the phase splitter, it is a good idea to remove the feedback loop, to avoid confusion. ■ ■

CHECK YOUR OSCILLOSCOPE

[*from page 8*]

observed when the high-frequency response falls off objectionably.

Fig. 5A shows a rising mid-band response, which is caused by incorrect adjustment of peaking coils in the vertical amplifier. At *B* we see the result of unbalance in a push-pull stage—this is sometimes due to a weak section in a tube, but may also be caused by circuit faults in the vertical amplifier.

Frequency Marking

The frequency limit of the vertical amplifier response may be determined by the use of a marker. The output from an *am* generator can be mixed with the *fm* signal as illustrated in *Fig. 6C* to produce a marker on the display. Because this is an unmodulated type of display, the marker will appear as a small "break" in the *fm* pattern, as indicated in *Fig. 7*. As can be seen from this photograph, the marked frequency is rather indistinct. It is preferable therefore to use an absorption type marker. This may be done by using the arrangement illustrated in *Fig. 6A* or *6B*. The appearance of the marked point may be seen in the lower photograph of *Fig. 7*.

The same method can be used to check the frequency response of the horizontal amplifier, by interchanging

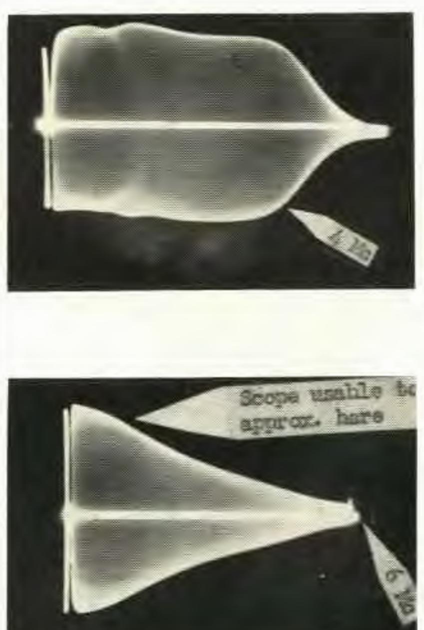


Fig. 4A (upper)—Fairly flat response. 4B (lower)—Poor above 1 mc.

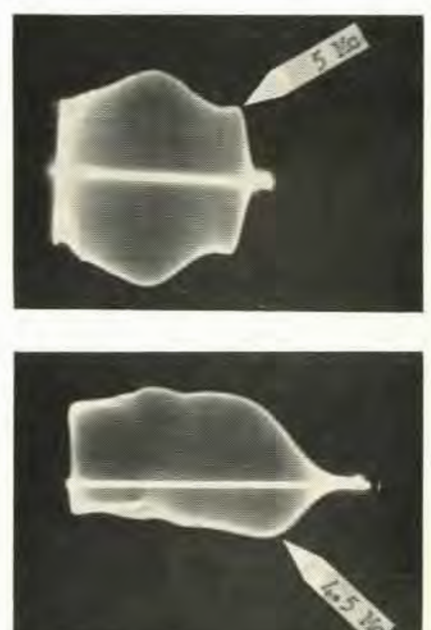


Fig. 5A (upper)—Rise at mid-band. 5B (lower)—Push-pull unbalance.

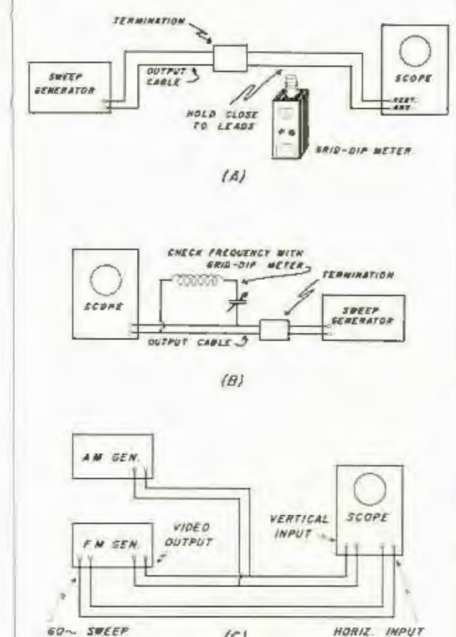


Fig. 6—Frequency marking methods.

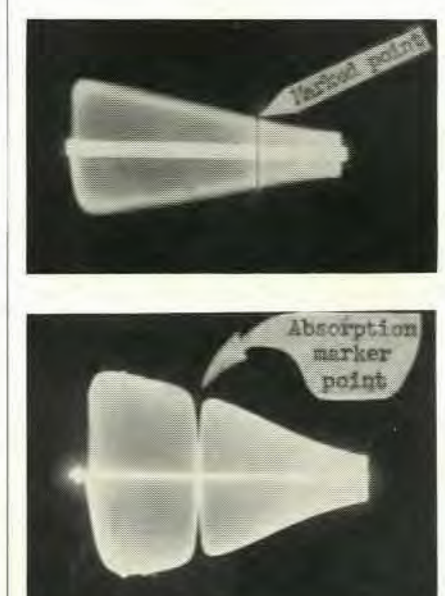


Fig. 7—Upper photo shows marker when Fig. 6C is used. Lower photo shows absorption marker.

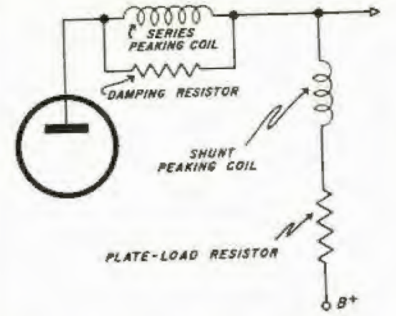


Fig. 8—Plate circuit components which affect frequency response.

the leads to the vertical and horizontal amplifiers shown in *Fig. 3*. However, if the frequency response of the horizontal amplifier is quite limited, you may find it more convenient to use an audio oscillator to check its response.

If you find faults in the frequency response of the vertical amplifier, these can be corrected by attention to the circuit factors pointed out in *Fig. 8*. Some scopes have adjustable peaking coils, while others do not. Faulty peaking coils of course, should be replaced with suitable values.

Why is good frequency response desirable? Let's take a look at *Fig. 9*. At A we see the appearance of the composite video signal (at the output of the picture detector) as displayed on the screen of a scope having a flat frequency response to 4 *mc*. Note the square corners on the sync and blanking pulses. However, at B we see how the waveform becomes distorted when the frequency response of the

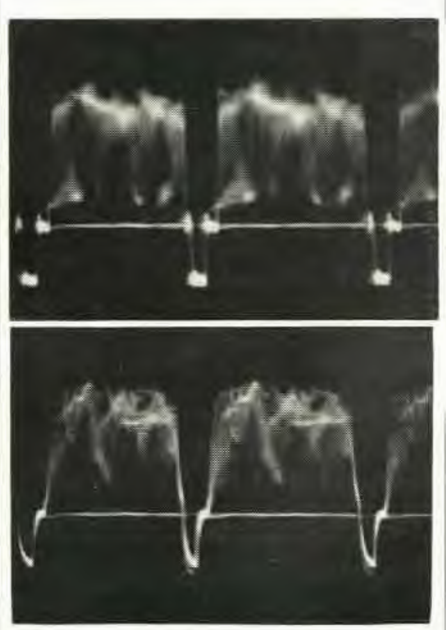


Fig. 9—Poor frequency response of scope produces rounded corners.

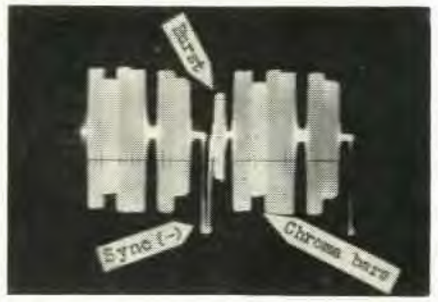


Fig. 10—Good wide band response is important in checking burst.

vertical amplifier falls off rapidly past 0.5 *mc*. We could come to the false conclusion in the latter instance that receiver alignment is poor, when actually the trouble is in the scope amplifier.

In color-TV test work, we are much concerned with the amplitude of the *burst*. (See *Fig. 10*). Color sync and color reproduction in general depend upon undistorted amplification and processing of the burst and the 3.58-*mc* chroma signal. You can easily understand that if a scope has high gain at 15,750 cycles, and low gain at 3.58 mc, we will be completely misled in checking the burst circuits, bandpass amplifier, etc.

Test of Deflection Linearity

To test vertical deflection linearity, apply the output voltage from a calibrator to the vertical input terminals of the scope. Set the calibrator for an output which produces one inch of deflection on the scope screen, and note the output voltage required. Then, double the output from the calibrator; the deflection obtained on the screen should be double. Again, triple the initial output from the calibrator; the screen deflection should be three times as great. Proceed in this manner to check full-screen deflection.

The linearity of vertical deflection should be within ± 10% over the entire screen excursion. The most common fault appears as a reduced rate of deflection as the input voltage is increased. Thus, we might find that 20 *mv* may produce 1 inch of deflection, 42 *mv* are required to produce two inches of deflection, 65 *mv* for three inches of deflection, 95 *mv* for four inches of deflection, etc.

When poor deflection linearity is observed, it is advisable to check the vertical-amplifier tubes for low emission. Scopes with single-ended amplifiers usually have less inherent linearity than scopes with push-pull amplifiers. Unbalance in push-pull amplifiers can cause deflection non-linearity.

The same method can be used to check horizontal deflection linearity, by applying the output from the scope calibrator to the horizontal-input terminals of the scope.

How to Check Amplifier Balance

Push-pull amplifiers should be biased so that balanced output is obtained over the entire range of screen deflection. To test for balance, apply the output from a calibrator to the vertical-input terminals of the scope. Start with zero output, and center the trace on the scope screen.

Then, advance the output from the calibrator for nearly full-screen deflection. The number of inches of deflection *above* the center of the screen should be equal to the number of inches of deflection *below* the center of the screen. Unless equal deflections are obtained (within 10%), check the bias voltages on the push-pull stages. If the scope amplifier is single-ended, the bias on single-ended stages should be adjusted to the best operating point, to obtain balanced deflection.

The horizontal amplifier can be tested in the same manner, by applying the output from the calibrator to the horizontal-input terminals of the scope.

Measurement of Attenuator Decading

Attenuator decading is checked by observation of the deflection obtained on the X1, X10, X100, and X1000 steps of the coarse attenuator. Set the attenuator to the X1 position, and apply the output from the calibrator to the vertical-input terminals of the scope. Adjust the output from the calibrator to obtain 1 inch of deflection on the screen and note the calibrator voltage.

Next, set the attenuator to the X10 position, and advance the output from the calibrator to again obtain 1 inch of deflection. The calibrator voltage should now be 10 times as great (within 10%). If more than 10% error is observed, check the values of the resistors in the decade attenuator.

Checks of the X100 and X1000 steps on the decade attenuator are made in the same manner. Of course, this is only a 60-cycle check of decading, but if the *frequency response* of the scope is satisfactory at each step, decading will also be satisfactory on higher frequencies of operation.

[*To be continued*]

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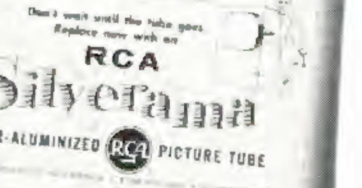

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