ELECTRONIC SERVICING

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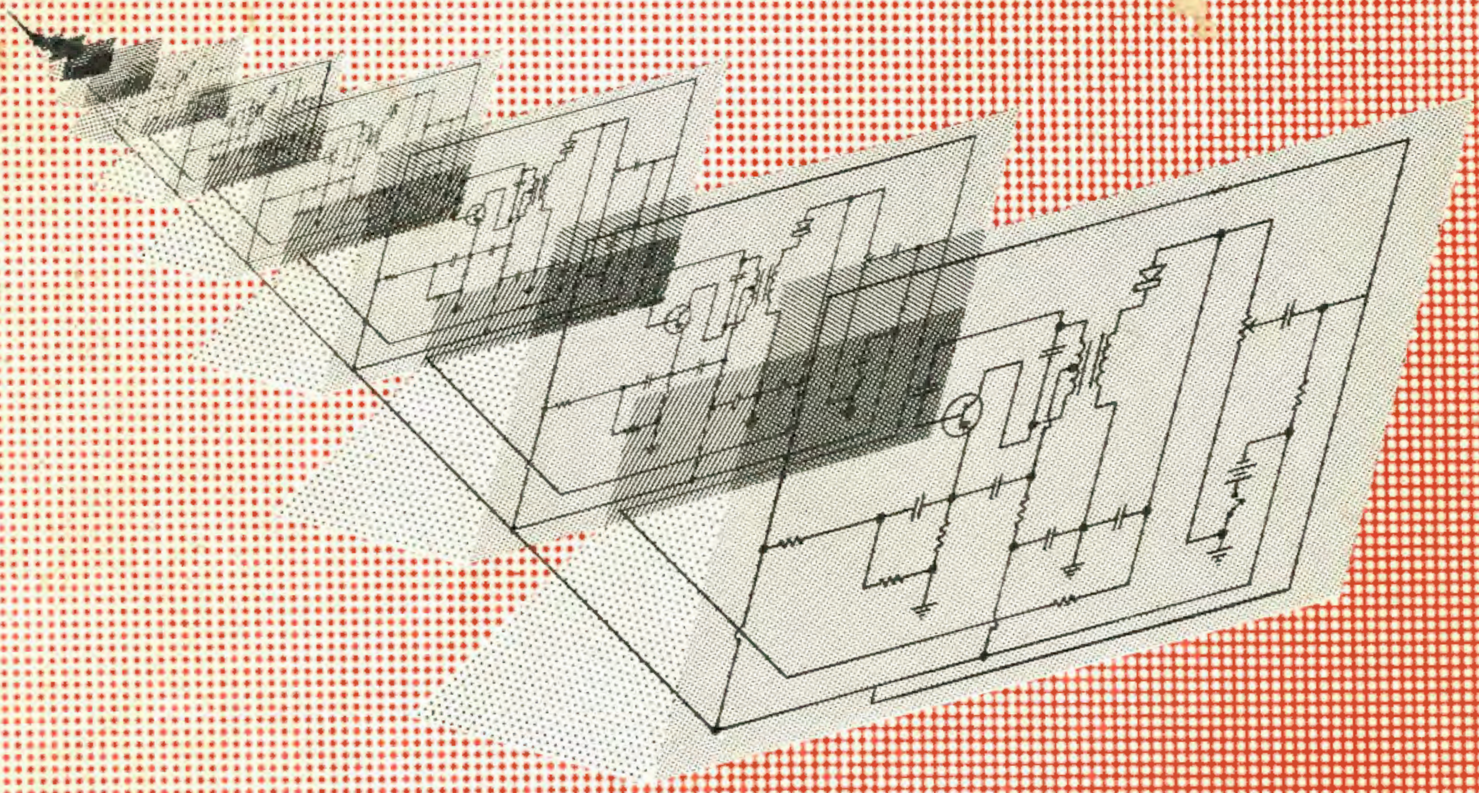

Solar Radio

Gassy Tubes

Transistor Theory

Multi-set Cou

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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 50¢. Second Class Mail privileges authorized at New York, N. Y. Copyright 1958 by Cowan Publishing Corp.

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

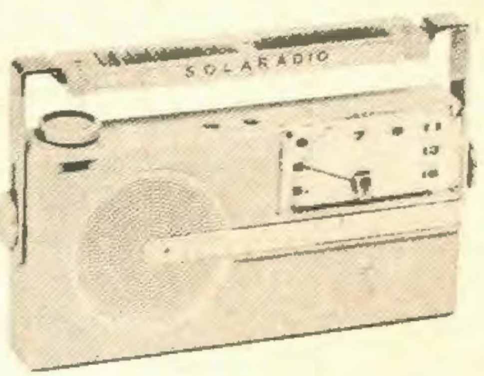
ELECTRONIC SERVICING

VOL. 19, NO. 3 — Member — MARCH, 1958

COWAN PUBLISHING CORP., 300 West 43rd Street, New York 36, N.Y.

The Hoffman Solar Radio

by W. F. Kaplar*



Transistorization of radio receivers has made practical the use of solar energy for the power supply. Here is a description of a radio receiver which makes use of this energy.

SINCE recent developments in the manufacture of semiconductors have made practical the use of solar power to operate electrical devices, it is fitting that the first consumer product incorporating solar power should be transistor type radios which are already using another form of semiconductor, the transistor. One instrument of this type which is receiving mention wherever the subject of solar power is discussed is the Hoffman Solaradio*. The Solaradio is a portable *am* radio using a six-transistor printed wiring circuit powered by a unique power supply which receives its energy from the sunlight. To better understand the operation of the Solaradio and its new power supply, we should first review some of the background relating to the devices which have made the Solaradio possible.

Solar Power

Scientists tell us that under direct sunlight, about 1000 watts of power fall on each square yard of the earth's surface. During the past couple of decades, a great deal of progress has been made in the storage of solar energy for heating purposes. The procedures for this use of solar energy did not however give the necessary capacity nor flexibility for general power needs. Until such time as a device could be developed which was capable of converting solar energy into mechanical or electrical power, there still was no practical method of utilizing solar energy to drive portable machines or moving vehicles.

Recent developments in the production of semiconductors have at last given us a practical device for capturing, storing, and using solar energy. This method of converting solar energy into usable power involves changing light energy into electrical energy. Since electrical energy is easily stored in batteries, can readily be transported to the point of use, and also provides an instant source of power, this form of conversion provides an ideal product of solar energy. Development of a material which could efficiently generate an electrical voltage through chemical action when exposed to sunlight has made this method of solar energy conversion a practical source of power. Materials having this characteristic are described as being photo-voltaic.

Photo Voltaic Materials

It has been found that highly refined silicon containing controlled minute quantities of arsenic and boron can be used to manufacture semiconductors with the photo-voltaic characteristic. Semiconductors with the photo-voltaic charteristic (Silicon Solar Cells) are the result of extensive research conducted by Bell Laboratories during recent years. The Silicon Solar Cells are now available in a considerable variety of sizes, shapes, and power ratings.

One of the first commercial products utilizing the Silicon Solar Cells is the Solaradio, a product of Hoffman Electronics Corporation, whose Solar Division is a manufacturer of Silicon Solar Cells.

Hoffman Radio Chassis 1109

The radio chassis used with the Solaradio is Hoffman *am* Radio Chassis 1109. Chassis 1109 has a six transistor, plus diode detector, radio circuit utilizing a printed wiring chassis board. The plug-in type socket is provided for all of the transistors, thereby simplifying service replacement and protecting the transistor against the hazards of soldering heat damage during installation. The miniature type tuning capacitor is sealed inside a plastic case to minimize any problem of noise due to dust or other foreign particles accumulating on the tuning gang plates.

An unusual feature of the Solaradio is the provision for plug-in of two extra speakers or earphones. (*J1* and *J2* in *Fig. 1.*) One receptacle switches off the radio speaker when the accessory is plugged in, while the other receptacle merely connects the accessory across the audio output leads. This arrangement allows for a variety of listening arrangements: a) Regular radio. b) Radio with two earphones. c) Radio with one earphone. d) Radio with speaker and earphone. e) A remote speaker or additional local speaker may also be added by use of the plug-in receptacles. Output impedance is 8 ohms.

Transistor Biasing

Examination of the schematic diagram discloses that the radio chassis has a transistor type circuit designed to operate on a 5 or 6 volt *dc* power supply. This feature allows for use of the chassis in other Hoffman radio models besides the Solaradio. All transistors used in chassis 1109 are the *n-p-n* type and are used in grounded emitter type circuits. Use of the same basic type of transistor in all stages of the circuit allows for simplicity in design, service, power supply requirements, and development of the required bias voltages. Each transistor has its own fixed positive base bias (forward bias) developed across a resistor type voltage divider connected to its base element. The push-pull audio output transistors share a common bias voltage. In their case, the fixed bias voltage is developed at the junction of *R20* (*4.7K*) and *R21* (*120*) which are connected directly across the *dc* power supply. The bias voltage is connected to the base element of each transistor in the push-pull stage via the secondary winding of *T4*, the audio driver transformer.

Self Biasing

In conjunction with the fixed bias voltage applied to the base, each transistor also has its emitter element connected above ground (B−) via a series resistor with capacitor by-pass which acts to establish a small positive voltage at the emitter element. The series used to couple the incoming signal to the oscillator circuit and to the base resistor is therefore, actually a part of the bias circuit and introduces a self-bias voltage to the fixed bias applied to each transistor base element. This type of combination biasing circuit is simple and easy to adapt to almost all uses of transistors. However, it has one disadvantage when used in an *if* amplifier circuit. Degenerative feedback is reduced, due to the shunting effect of the low value resistor in the voltage divider network and the emitter series resistor bypass, and therefore the circuit stability is not good at high frequencies. This disadvantage is easily overcome by resorting to a form of neutralization which has been proven in use with triode type vacuum tubes when used as *rf* amplifiers. Referring to the schematic diagram, we see that all *if* transformers have a tapped winding. In *T2* (*if* interstage) and *T3* (*if* output) the tapped winding is utilized to develop an out of phase signal which is fed back to the base element of the transistor, thereby stabilizing the operation of the stage and improving the gain characteristics.

Solaradio Circuit Operation

The Solaradio uses a ferrite rod type antenna coil (*L2*) which is located inside the cabinet and is part of the input circuit to the converter SC1 (2N212 transistor). Transistor SC1 performs three circuit functions: *rf* amplifier, Oscillator, and Mixer. The resonant tank coil portion of the oscillator coil (*L1*) is tapped and used as part of the collector circuit to provide the necessary feedback to sustain oscillation. The second winding of *L1* is of SC1 through a capacitor. The "beat" signal resulting from the mixing of these two signals is the *455 kc if* which is transferred to the first *if* amplifier via *T1* (*if* input). Transformer *T1* has a relatively high primary and low secondary impedance to match the transistor input impedances.

The 1st *if* stage SC2 (2N216) is biased by a combination of three source voltages: a) *R14* (*100K*), *R13* (*15K*), and *R15* (*5K*) form a voltage divider to supply positive voltage at the base of SC2. b) The voltage drop across *R6* (*470*) develops a self-bias voltage whose amplitude is dependent upon emitter current. c) An *avc* voltage is developed across the detector load (*R15*), with amplitude dependent upon incoming signal strength. The *avc* voltage is negative and when combined with the positive voltage already present at the base, the positive base bias is reduced and the gain of the stage is thereby reduced in proportion to the signal strength. The tapped winding of *T1* is utilized to provide a feedback voltage to the base of SC2 and thereby stabilize the circuit. The *455 kc if* signal is inductively coupled to the 2nd *if* stage through the low impedance secondary of *T2*, the *if* interstage transformer.

The second *if* stage is almost identical to the first *if* stage except for the absence of the *avc* voltage at the base of SC3.

Detector

The 455 *kc* output of the second *if* stage is inductively coupled to the crystal diode detector, SC4 (1N295). The detected signal is developed across

[Continued on page 47]

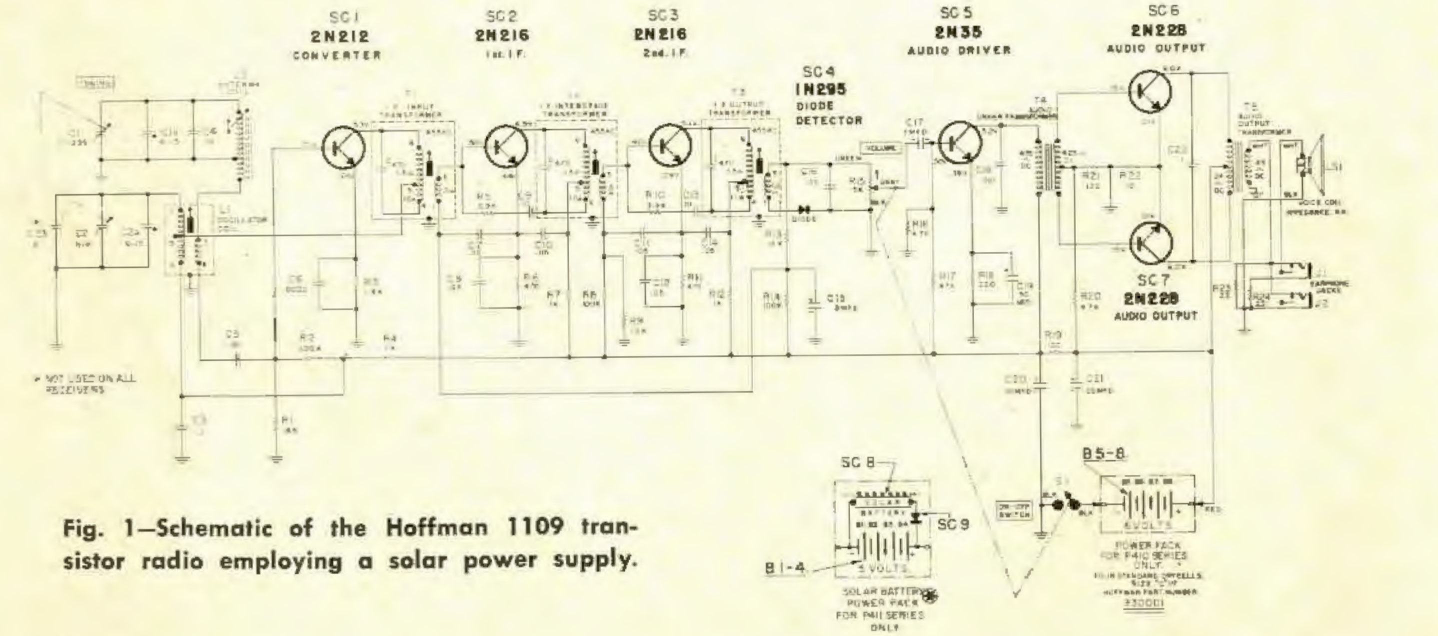


Fig. 1—Schematic of the Hoffman 1109 transistor radio employing a solar power supply.

*Field Engineer, Hoffman Electronics Corporation.

ANSWERMAN

Dear Mr. Answerman:

I have a condition which is quite unusual. It is an oscillation that appears in the picture on the left side. I have been unable to correct it with anything I've tried. I'm really lost now as to where to look further. The chassis is an Emerson 120258.

H. D.
New York City.

The interference in the picture is a result of radiation from some circuit into the picture signal path and a possible source of this interference is the damper and deflection system. Installation of an *rf* choke in the plate and cathode circuits of the 12AX4 horizontal damper tube as shown in *Fig. 1* should eliminate the trouble.

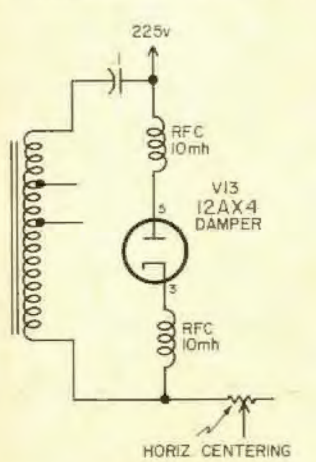


Fig. 1—Addition of chokes eliminates damper circuit radiation.

Dear Sir:

An Admiral 17L1 chassis has had three failures of the same condenser, *C431, .001 uf.* In the three instances the condenser shorted. I have been wondering if there is anything I can do to correct this condition so that it won't happen again. I doubt that the difficulty is the result of my using a poor quality condenser as I have always used the best obtainable. Perhaps you can advise me as to what can be done to prevent the condenser from failing again.

S. T.
Philadelphia, Pa.

The condenser you have found to be shorting should have a 5 Kilovolt rating. Undoubtedly the use of a condenser of a much lower rating is the cause of the repeated failures if such is the case.

On the other hand the shorting of the condensers may be the result of arcing in the picture tube electron gun. Resistor *R471* (120K ohms) should be added as shown in *Fig. 2*, in the focus anode circuit. The circuit of *Fig. 2* will prevent the shorting of *C431* if the arc-over should momentarily occur again.

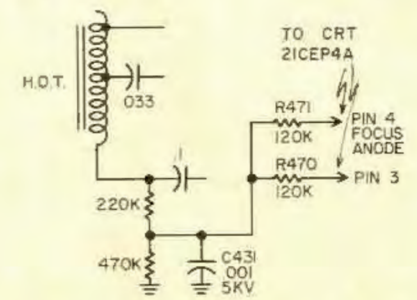


Fig. 2—R471 eliminates failure of C431 due to CRT flashover.

Answerman:

A Motorola chassis TS427 is giving us a little trouble with its width in that it is slightly narrow. I know there is a failure in the receiver because the set has worked well before with the same line voltage. Do you have any thoughts about this? I can increase the width but don't like to modify the receiver from its original design if I can help it. All tubes in the circuits that might cause this trouble as well as the rectifiers have been replaced.

T. F.
Washington, D. C.

One of the common causes of this problem is the cathode resistor, *R513* as shown in *Fig. 3*. The resistor should be 12 ohms and generally is of the ½ watt variety. Very likely the resistor which should be at least one watt in size has increased in resistance.

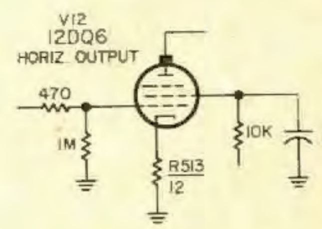


Fig. 3—Rise in value of R513 is frequent cause of lack of width.

Mr. Answerman:

A customer's TV receiver has strong diagonal lines in the picture for only channel 2. The interference is originating in the receiver because it performs the same on my shop bench. I have checked everything I can think of that might be causing the difficulty. Any suggestions?

B. T.
Albany, N. Y.

Although the trouble could be originating at several points in the receiver, a very likely circuit is the vertical oscillator as shown in *Fig. 4*. Most probably the blocking oscillator transformer *T5B* is developing oscillations in the secondary winding which are radiated and picked up in the *rf* circuitry. A *100K* ohm resistor should be shunted across the parallel tuned circuit to damp the circuit. This should not materially affect the operation of the blocking oscillator.

[Continued on page 43]

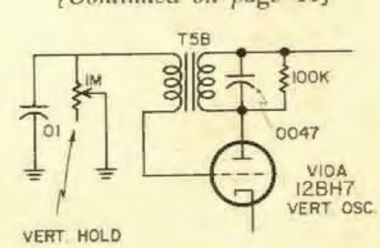
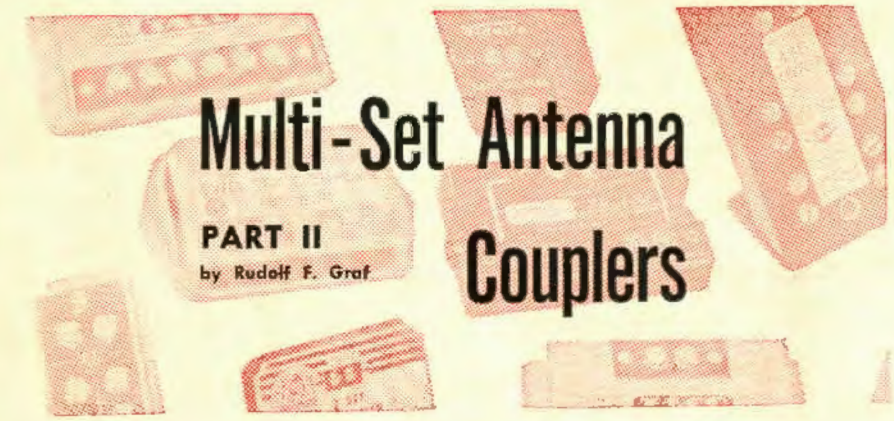


Fig. 4—RF interference caused by the vertical oscillator.



Multi-Set Antenna Couplers

PART II

by Rudolf F. Graf

In part one of this article bi-filar couplers were discussed. In this second installment other types of couplers are dealt with.

Resistive Type Couplers

In strong signal areas resistive couplers are quite satisfactory. One such coupler made by Superex contains a pi-type filter in addition to the resistors. A circuit diagram of this coupler together with a curve showing the characteristics of the high pass filter are shown in *Fig. 7*. The band pass characteristics of resistive type filters are good and their isolation is quite high. However the insertion loss is generally higher than that of a bi-filar coupler.

Other configurations are used in resistive couplers. Two of these are shown in *Fig. 8*. The simplest of these consists of two resistors, generally about 300 ohms each, connected from the transmission line to the second receiver as shown in *Fig. 8a*. The first receiver is directly connected to the line. In this case, the insertion loss as far as the second set is concerned is *9.5 db*. This type of coupler would be especially desirable in areas where one of the receivers is barely capable of delivering a suitable picture with the present antenna and could not do so if the insertion loss of some other coupler would be introduced. *Figure 8b* shows a resistive coupler having a *6db* insertion loss and *12db* of interset isolation. (*6db* in each direction.)

Since resistive couplers do not contain any reactances, they tend to be less frequency sensitive than the other types discussed. As a result they are quite suitable for *vhf* and *uhf* channels. They do, however introduce a loss which may be prohibitive in fringe areas unless the receivers are very sensitive and high gain antennas are employed.

Emergency Coupler Construction

A quickly assembled "emergency" two set coupler is shown in *Fig. 9*. This unit is suitable for a 300 ohm transmission line and two 300 ohm receivers. Three 900 ohm resistors are recommended (low reading 910 ohms resistors) but if these are not available 820 ohms may also be used quite satisfactorily.

There is a good match all around. Here's how. Three hundred ohms in parallel with 900 ohms gives an equivalent resistance of

$$\frac{300 \times 900}{300 + 900} = \frac{270{,}000}{1200} = 225 \text{ ohms.}$$

The two 300 ohm sets together with *R2* and *R3* thus represent 225 + 225 or 450 ohms. This in parallel with *R1* gives

$$\frac{900 \times 450}{900 + 450} = \frac{405{,}000}{1350} = 300 \text{ ohms,}$$

exactly what we need. By the same reasoning, the same conditions also exist for the other two resistors.

Inductive Couplers

An inductive or transformer type of coupler is shown in *Fig. 10*. This type of unit generally does not provide very much inter-set isolation due to the capacitive coupling between windings. The insertion loss and band width are frequency sensitive, sometimes tending to be inefficient at the higher channels. This may well be due to the unfavorable characteristics of some of the cores at higher frequencies. One of the manufacturers (Telematic), claims to have overcome this problem by using a special High Q high frequency core giving good performance over the entire TV band. An advantage of this type of coupler however, is the fact that it has relatively low losses and thus may be used in weak signal areas.

Multiset Operation

At times it may be required to connect *more* than two sets to one antenna. There may be several TV sets or *fm* tuners and TV receivers. Whether it is a home installation or a multiple dwelling or showroom installation, the types of couplers described so far may be used to do the job. Generally multiset couplers are

[Continued on page 40]

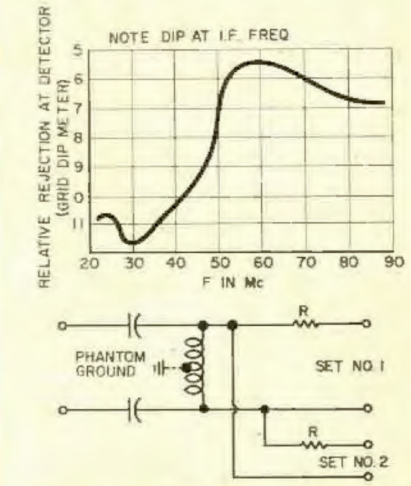


Fig. 7—Circuit diagram and filter response of Superex coupler.

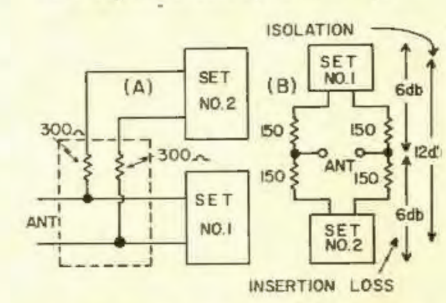


Fig. 8A—Circuit of the RCA 240 A1. B—The Vidaire C-1 circuit.

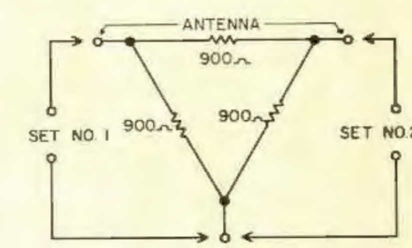


Fig. 9—Simple two set coupler for 300 ohm line and sets.

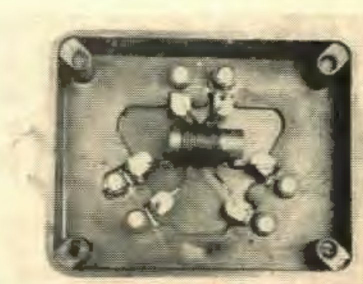


Fig. 10—The Telematic inductive or transformer type of coupler.

Ad Libs

by S. R. COWAN

As many of you know, I have been associated with or have published a radio serviceman's magazine since 1929, almost 30 years. Next month "Electronic Servicing" will enter its 19th year, and since launching it I have always maintained the firm belief that the servicemen who subscribe to it should help formulate and guide its editorial policies. To that end, for almost 20 years I have travelled constantly—or as my wife puts it, "much too much," visiting servicemen's groups in all parts of the country, getting first-hand information as to what's happening. Thus I have learned that, continuously, in every sector of the country problems of an entirely different nature face servicemen. For example, when *uhf* was giving Portland, Oregon and Norfolk, Va. servicemen much grief, New England servicemen had no such woes or interest in the matter. And more recently when color-TV came into the East and Mid-West, only a limited group of servicemen were affected, but not those who operate in the South or West.

I mention the above so you'll better understand what follows. Also, I might add, it has been our practice to send Questionnaires to a cross-section of our readership periodically so we can keep closely in touch with the servicemen situated in places where I have not been. *My findings* in the field and *your replies* to our questionnaires determine our editorial policies, with the wishes of the majority prevailing.

Last November our questionnaire form, (sent to every 10th subscriber, and replied to by the amazingly high ratio of 37%), was exceptionally comprehensive. The answers you gave are of such fundamental interest that we feel obligated to discourse on them in this, and subsequent editorials, just as your "directives" will be acted upon. In an aside I might say that some of your likes and dislikes rather surprised us. For example, before sending the questionnaire out I bet one of the Editors that in response to the question: "Do you want Ad Libs continued?" a negative vote would prevail. Instead I was rather flattered to learn that I lost the bet because 77% voted to continue it while only 12% voted to discontinue it and 11% did not vote either way.

One outstanding fact, or rather confirmation, brought to light by our survey, was not at all surprising to us because our own circulation records and recent reports from the U. S. Bureau of Census and Statistics had already forewarned us of the trend. I refer to the sharp drop in number of independent service firms now in business. Today there are less independent shops than there were in 1941, (22,500 today as compared to 42,000 in 1955 and 23,000 in 1941), but in contrast the average service shop today has on its payroll 4.8 men in addition to the owner as compared to 1.7 men (plus owner) as of 1953. Stated another way, the men have been separated from the boys in this highly competitive field.

Getting back to our readers' preferences, likes and dislikes, I'll now discuss the votes regarding tear-out TV schematic diagrams. Strangely enough when the *first* 100 replies had been tallied a majority (56) were in favor of discontinuing the schematics. Subsequently the voting-balance changed drastically and the final vote on this subject was quite surprising: 92% of our readers favored continued publication of TV schematics while only 8% favored dropping this department.

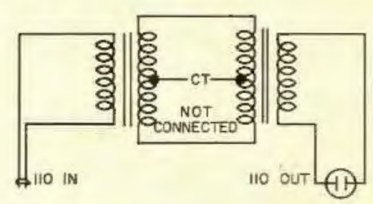
Also, in regard to our TV schematics, we were gratified to learn that our subscribers are overwhelmingly partial to *our* method of publishing them as quasi-complete schematics, one manufacturer's set to a sheet, rather than in the optional and unpopular form whereby one manufacturer's diagrams appear on one side of the sheet and another manufacturer's schematics on the reverse side.

One thing must be mentioned at this point in direct regard to what is stated in the paragraph immediately above. We here at "Electronic Servicing" do not control the design and development of new radio or TV circuitry. Thus it is that on occasion, and sometimes for a 1 to 2 month period, there

[Continued on page 15]

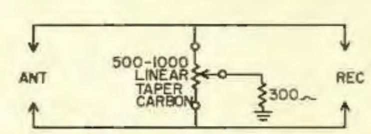
Shop Hints and Short Cuts

We would welcome hints and short cuts from our readers. ES will pay $5 for each hint used. Sorry, but we cannot be responsible for unaccepted material. In case of duplication, first received will be accepted.



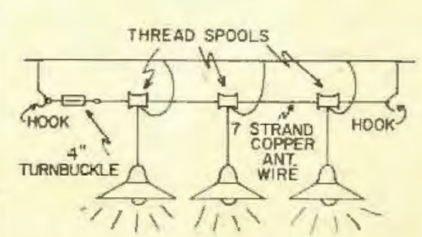
If an *ac* isolation transformer is needed in a hurry, connect two identical power or filament transformers back to back as illustrated. This may be required when aligning and hum develops or if you "borrow" the signal from one set to check another.

G. F.
Los Angeles, Cal.



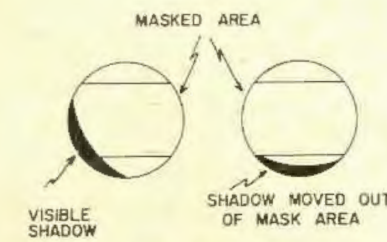
No matter how neat and "correct" an antenna installation may be a mismatch or unbalance condition may occur. This trouble may sometimes be cured very effectively by connecting a potentiometer (carbon *not* wire wound) across the transmission line at the receiver and grounding the arm through a resistor to the chassis or another ground. Adjusting the control loads either one side or the other so as to correct for the unbalanced condition.

R. G.
N.Y.C., N.Y.



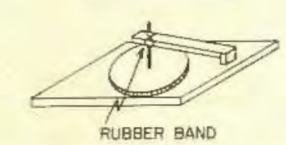
I do not like to use fluorescent lights on the bench because of interference so I use incandescent bulbs with cone shades. The light pattern is much narrower than the other type of light. To overcome this I mounted 3 drop lights on sliding thread spools I stole from my wife. This lets me concentrate a lot of light where I need it.

R. T.
Brooklyn, N. Y.



Neck shadow is sometimes tough to get rid of. It is possible that due to a slight misalignment of the electron gun any amount of ion trap, focusing coil and magnets or deflection yoke adjustment will not produce a 100% satisfactory picture. Here is a cure I've found effective in case of a round CRT. I simply turn the tube about 90 degrees or less from its position so that the shadow area will be on the top or bottom and thus be no longer visible. Of course, if necessary, the HV lead will have to be lengthened, since the anode connection may now be on the other side of the HV cage.

M. S.
Sacramento, Calif.



When taking in a record changer for repair, the arm should be secured in such a position that it may not accidentally drop or swing and thus damage the needle and cartridge. An easy way to avoid damage is to bring the arm near the top of the spindle and then hold it in place by wrapping a rubber band around the spindle and arm.

C. B.
Washington, D.C.

Anyone having difficulty in matching the color of grill cloth with speaker enclosures can do so by just spraying it with Krylon Spray Enamels. The result is a custom appearance that blends with any decor. After applying the quick drying spray to the enclo-

[Continued on page 45]

Introduction To Transistor Theory

Part 7 by George Browne

A qualitative discussion of some of the characteristics of transistors in common base, common emitter, and common collector circuits.

In the previous installments we discussed the basic physics of transistor action from the point of view of hole and electron flow in semiconductors. Understanding transistor circuit operation requires, in addition, an understanding of the manner in which transistors may be most efficiently used with other circuit elements to produce a desired effect. This effect might be to have the transistor act as an amplifier, an oscillator, a switching element, etc. In addition, the matter of coupling one transistor stage to another is a matter of importance, just as it is with vacuum tubes. Most of us, for example, are familiar with the problem of matching the impedance of the speaker voice coil to that of the audio output tube in order to accomplish maximum power transfer. A similar problem arises in coupling transistor stages to each other, as will be seen subsequently.

In this installment some of the basic information required to gain an understanding of these aspects of transistor circuitry will be treated. This will involve the study of certain important characteristics of transistors and a comparison between basic transistor configurations, and those of vacuum tubes.

In many cases certain relationships will be given as statements of fact. All this is in keeping with our intention to make the presentation as simple as possible. Those who are interested in more rigorous and more mathematical treatments are referred to any of the many engineering texts on the subject.

We begin our discussion by reference to *Fig. 1A*, the simplified diagram of a grounded or common base transistor amplifier circuit. In this illustration, and throughout our discussion, we shall arbitrarily use a *p-n-p* junction transistor. Wherever typical values are given, they too are for junction transistors. It should be understood than an *n-p-n* transistor could just as well be used with due regard given the direction of electron flow instead of hole flow. In the common-base circuit, or configuration, as it is often called, the signal enters the emitter and leaves the collector.

Notice that in accordance with transistor biasing principles previously discussed the emitter and base are biased in a forward direction and the collector and base biased in a reverse direction. This holds true in all of the subsequent configurations studied.

In making our comparisons between transistor and vacuum tube configurations we will make use of some of the familiar characteristics of vacuum tubes such as input resistance, output resistance, voltage gain, and phase change, if any, between output and input signals. With regard to input and output resistance it must be kept in mind that ratios of signal voltage to signal current are more accurately expressed in terms of impedance. For the present, however, we will assume that the frequencies used are low enough to permit the use of resistance instead of impedance with negligible error.

COMMON-BASE PARAMETERS

The characteristic values of a particular configuration are commonly referred to as the parameters of the configuration. These parameters may be in terms of resistance, conductance, impedance, admittance, voltage, current, power, or ratios of these terms. Thus, if the ratio is one of voltage to current, the parameter is in the nature of impedance or resistance. If the ratio is current to voltage, the parameter is one of conductance. If the voltage ratio is one voltage compared to another, the parameter is merely a number such as voltage gain.

Input Resistance Rib

The input resistance of a configuration may be defined as the resistance a signal sees looking into the input terminals of the amplifier.

Fig. 2 illustrates a commonly used equivalent circuit for a grounded base transistor. In this circuit r_e represents the emitter resistance, r_b the base resistance and r_c the collector resistance. The generator in the equivalent circuit $(i_e r_m)$ is not an actual generator, but must be included to provide for the transistor action taking place.

Reference to the equivalent circuit shows that to a first approximation at least, and neglecting the effect of transistor action, the input resistance would be the sum of r_e and r_b.

However, it is not quite as simple as all that, for a transistor is a complicated device in which the collector, emitter, and base, set up mutual effects upon each other. In a vacuum tube such effects are in the form of feedback within the tube. In a transistor, in addition to feedback, the carrier flow in any one section influences the carrier flow in other sections. The sum total of these effects results in complicated expressions for the various parameters. We shall call these mutual effects the "mutual resistive effect related to transistor action." In this particular case, its effect is to make the value of R_{ib} less than the sum of r_e and r_b.

In a common base circuit the emitter-base junction is forward biased so that in general the input resistance is fairly low as discussed in previous installments. This value is on the order of 100 ohms.

Common Base Output Resistance

The output resistance is that seen by a load as it looks into the output of a transistor circuit, in this case between collector and base (See *Fig. 2*).

Referring again to the equivalent circuit, notice that in this case, the output resistance includes r_c, r_b, and the mutual resistive effect related to transistor action.

Recalling that the collector is reverse biased, it might be expected that the output resistance, R_{ob}, would be high, and such is actually the case. A typical value of R_{ob} for junction transistors is about 500,000 ohms.

Current Gain

In general, the current gain of a transistor, is expressed by the ratio of the output current to the input current with the output short circuited. The symbol for this ratio is alpha (α). In a common base circuit alpha is specified by the symbol α_{ce}, the subscript referring to the ratio of currents in the collector and emitter circuits.

In previous installments it was shown that for a common-base circuit is equal to about 0.995.

Voltage Gain

The voltage gain in a transistor is defined as the signal voltage across the output load divided by the signal voltage at the input.

The order of maximum voltage gain in a common-base configuration is about 2,000. However, with a normal load the voltage gain reduces to about 150.

Power Gain

Inasmuch as the transistor is a current operated device, the gain usually associated with it is a power gain. In fact, in transistor charts one of the characteristics most always listed is power gain. The reason we discussed voltage gain is that it provides a comparable parameter in making analogies between transistor and tube configurations.

Power gain is defined as the ratio of output power to maximum available input power. This is generally given in characteristics charts as a number of *db*. A typical value is on the order of 26 *db*.

Phase

With regard to the relative phase of the output and input signals we observe, that if the signal e_g is instantaneously positive going at the emitter end of the generator the hole flow is increased. This results in an increased hole flow out of the collector circuit into the load R_L. Since holes flow down the load resistance the top end is positive. And since more holes flow as a result of the applied signal, the top end becomes more positive. Thus, the output and input signal phase are the same.

Summary

Summarizing the characteristics associated with a common-base configuration we obtain the following.

1—Low input resistance
2—High output resistance
3—Fair voltage gain
4—No phase change

Common-Base Vacuum Tube Analogy

An analogy might be made between a common-base transistor amplifier and a grounded-grid vacuum tube amplifier. Referring to *Fig. 1B* we might recall that in a grounded-grid amplifier the input resistance is low, the output resistance high, the voltage gain fair, and the output and input are in the same phase. These characteristics parallel the characteristics of the common base transistor amplifier.

COMMON-EMITTER CONFIGURATION

In addition to the common-base configuration there are two other types of configuration, the common-emitter and the common-collector. In this section we will discuss the common-emitter method of connection and observe how it is analogous to a grounded-cathode vacuum tube amplifier. Following this we will examine the grounded-collector circuit and observe how it is analogous to a grounded-plate vacuum tube or cathode follower.

Common-Emitter Input Resistance

The configuration corresponding to a common-emitter transistor circuit is shown in *Fig. 3A*. An equivalent circuit for this configuration is given in *Fig. 4*. Note that the equivalent circuit is almost identical to that of the common base arrangement, the only difference being that the positions of the emitter and base resistors are interchanged. This brings up an interesting point. Looking into the input side of the equivalent circuit, it might seem that the value of R_{ie}, the input resistance in the grounded emitter configuration should be close in value to R_{ib}, the input resistance for the grounded base configuration, since in each case the first approximation would be $r_e + r_b$. However, a typical value of R_{ie} is about 1500 ohms compared to about 100 ohms for R_{ib}.

This is explained by the fact that under normal operating conditions the effect of transistor action in the case of R_{ie} is to add to $r_e + r_b$, while the effect on R_{ib} is to subtract from $r_e + r_b$. In each case the value of the load resistance plays a part in determining the value of the input resistance.

Common Emitter Output Resistance

Referring once more to the equivalent circuit of *Fig. 4*, the output resistance R_{oe} is determined by $r_c + r_e$ and what we have been calling the mutual resistive effect related to transistor action. In this case, the transistor effect operates to reduce the value of R_{oe} below the sum of r_c and r_e.

Typical values of common emitter output resistance are on the order of 75,000 ohms.

[Continued on page 14]

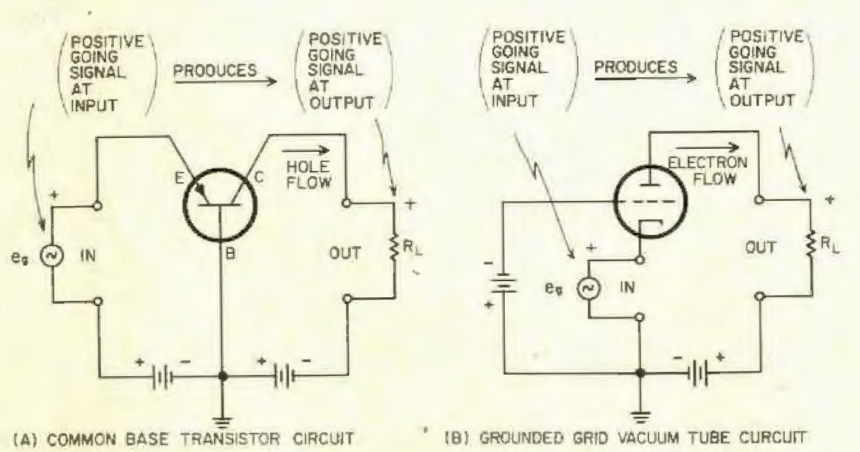


Fig. 1—The basic circuit for the transistor in the common base arrangement compared with a vacuum tube using a grounded grid.

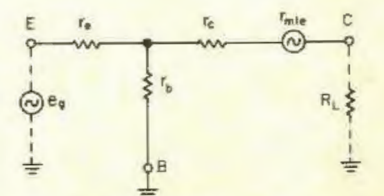


Fig. 2—Equivalent circuit for common base transistor circuit.

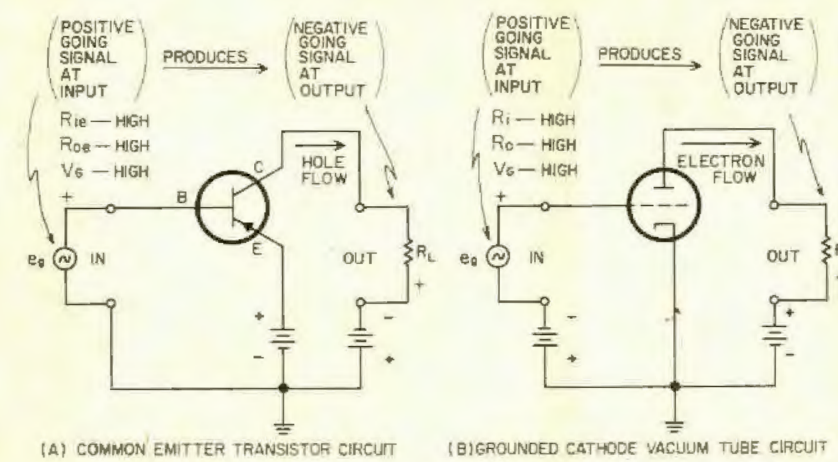


Fig. 3—Comparison of transistor in the common emitter configuration with a vacuum tube in a grounded cathode circuit.

Common Emitter Current Gain

In a common emitter circuit alpha, the current gain, is expressed by the symbol a_{eb} the subscript referring to the ratio of the collector and base currents.

Consideration of current gain in a common-emitter configuration should bring to mind that the input signal is fed into the base as shown in *Fig. 3A.* It thus modulates the hole flow from emitter to collector in much the same manner as a signal on the grid of a vacuum tube modulates the electron flow from cathode to plate. For this reason a small change in base current can produce a large change in hole flow from emitter to collector. Typical output to input current gain values in common-emitter configurations are on the order of 50.

Common Emitter Voltage Gain

The voltage gain in a common-emitter configuration is defined as the ratio of the signal across the output load to the signal across the input. The approximate value of the maximum voltage gain is about the same as in the case of the common-base configuration, namely, about 2000. However, the effect of the load resistance R_L in this case is much more favorable in producing larger voltage outputs than in a common-base circuit, and with a normal load the voltage gain of a common-emitter circuit is on the order of 500.

Power Gain

The increased current gain in a common-emitter circuit favors an increased power gain. As a result typical values of power gain are on the order of 40 *db.*

Phase Relations

With regard to the relative output to input signal phase, referring to *Fig. 3A* it will be observed that when the generator signal at the base is positive going, the emitter-base junction forward bias is reduced. This causes a decrease in hole current flow which reduces the voltage drop across the load resistor. Since the original polarity at the top of this resistor is plus, the reduced plus value is equivalent to a negative going signal. Thus, the output and input signals are 180° out of phase.

Summary of Common Emitter Configuration

Summarizing the characteristics associated with a common-emitter configuration we obtain the following:

1. High input impedance
2. High output impedance
3. High voltage gain
4. 180° phase change

These characteristics are the same as those of a grounded-cathode vacuum tube making the analogy between these circuits apparent.

COMMON COLLECTOR CONFIGURATION

The third type of configuration, the common-collector is shown in *Fig. 5A. Fig. 6* is a corresponding equivalent circuit.

Common Collector Input Resistance

Referring to *Fig. 6,* and following the pattern previously used, we may state that the input resistance in this case would be $r_b + r_c$ and in addition, whatever is contributed by the mutual resistive effect related to transistor action. In this case, the effect is to reduce R_{ic} to below $r_b + r_c$.

Typical values of R_{ic} are on the order of 750 K ohms.

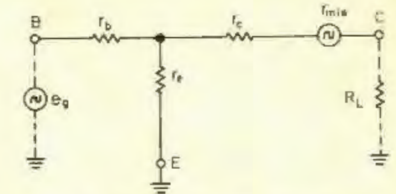


Fig. 4—Equivalent circuit for common emitter configuration.

Common Collector Output Resistance

The output resistance in the common collector configuration, consists of the sum of $r_e + r_c$ reduced, in this case, by the mutual resistive effect related to transistor action. This again may be partly seen, in a qualitative way, by reference to the equivalent circuit of *Fig. 6.*

The mutual resistive effect in this case is very much higher than that in the input resistance equation. As a result the output resistance is very low, on the order of 50 to 75 ohms. Thus, the common-collector configuration is effectively an impedance step-down circuit much like a cathode follower in a grounded-plate vacuum tube.

Common-Collector Current Gain

With regard to current gain it will be observed that the input signal is fed into the base. This signal modulates the hole flow from emitter to collector as in the case of the common-emitter. For this reason the current gain is high, on the order of 25.

Voltage Gain

Because of the very low value associated with the load resistance, R_L, the voltage gain is less than unity.

Power Gain

The power gain in this circuit is largely a function of the voltage gain and the load resistance. For this reason it also is very low, on the order of 0.02.

Phase Relations

The output to input phase relationship in a common-collector circuit may be obtained by assuming a positive going signal at the base as the input signal. This increases the forward bias, thereby increasing the hole flow from the emitter into the transistor. The emitter side of the load resistor being plus, an increased emitter current will make it more positive. Thus the input and output signals are in phase.

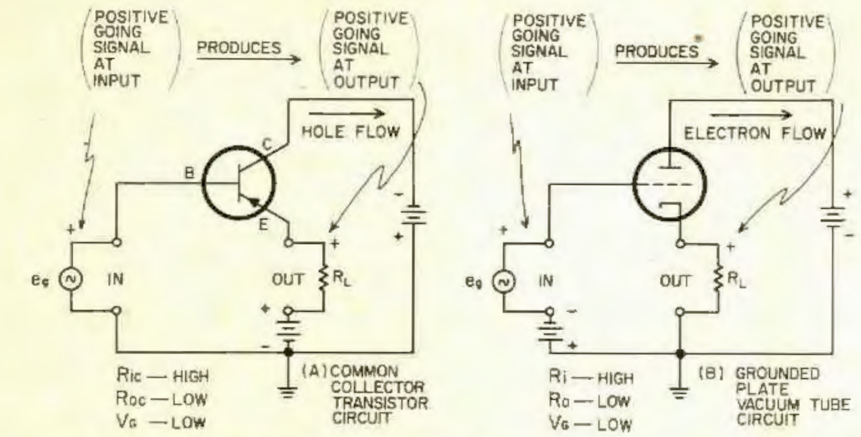


Fig. 5—Comparison of transistor in the common collector configuration with vacuum tube in a grounded plate circuit.

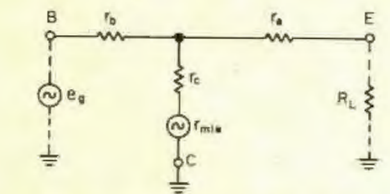


Fig. 6—Equivalent circuit for common collector configuration.

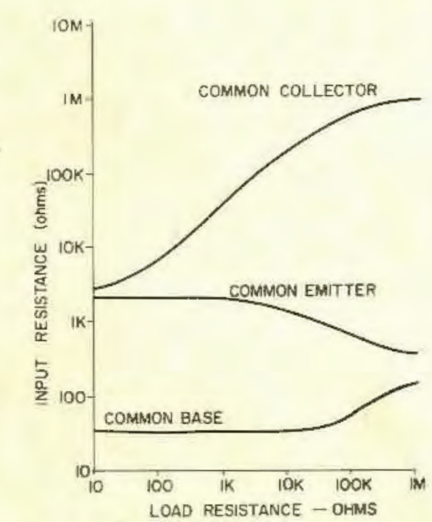


Fig. 7—Variation of input resistance with load resistance.

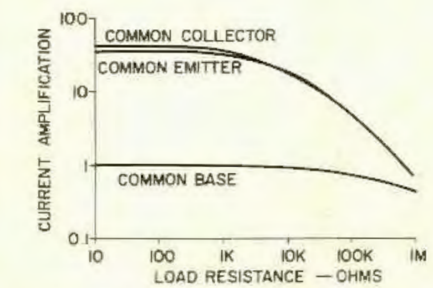


Fig. 8—Variation of current amplification with load resistance.

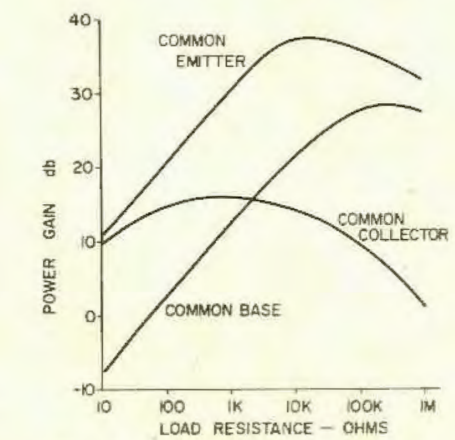


Fig. 9—Variation of power gain with changing load resistance.

From *Fig. 5B* it is apparent that these characteristics are analogous to the characteristics of a grounded-plate (cathode-follower) vacuum tube.

Although we have made analogies bringing out similarities between transistors and tubes it must be kept in mind that the transistor is primarily a current operated device, that is, its output is approximately linearly related to the current fed into its input (holes or electrons) rather than to the applied voltage. This is in contrast to a vacuum tube where the output depends more or less linearly on the voltage applied to its input and not on the current flow in the input circuit.

As an example of how transistor action causes mutual effects within the device we show how one of the circuit elements, R_L, affects the input resistance, current gain and power gain in the common-base, common-emitter and common-collector configurations. *Fig. 7* illustrates how the input resistance varies with the load resistance. *Fig. 8* shows how the current amplification varies with load resistance. *Fig. 9* shows how power gain varies with load resistance. This is but one of many variables which may affect the value of what we have called "the mutual resistive effect related to transistor action" and which, as we have seen, plays an important role in determining the value of the various parameters.

SUMMARY

Analogies may be made between transistor and vacuum tube configurations by comparing certain of their common characteristics such as input resistance, output resistance, voltage gain and phase relationships. However, a transistor is a much more complicated device than a tube because of the greater mutual effects that exist among the elements. Finally, a transistor is a current operated device; that is, the output signal follows current variations of the input in an approximate linear fashion rather than voltage variations as in a vacuum tube. For this reason power gain is a more valid figure of merit in transistor ratings than is the voltage gain.

[To be continued]

AD LIBS

[from page 9]

simply are no new circuits that are worthy of being published. We simply will not "fool" servicemen by publishing rehash or valueless schematics merely to "save face" or "fill space." In the past and in the future, if, as and when worthwhile material can be obtained, we'll publish it—first, accurately and completely. If, as sometimes happens, there's nothing new or worthwhile to publish—we'll just have a void and not publish schematics that issue. Finally—just to clear up one more point for those subscribers who have written that we only had four, or eight pages of schematics in any given issue, let me explain that a page (conforming to regulations of the U. S. Post Office) in our, or any other magazine, is *one-side* of a sheet of paper approximately 7" × 10" in size. When, as our schematics do, a diagram has an over-all sheet size of 14½" by 11¼"—the Post Office rules this must be called four pages—not one, or two, as many of you believed.

Finally, regarding our readers' wishes, next month we expect to give you an issue that will really warm the cockles of your heart.

I have touched upon just a few salient points regarding changing trends, our readers' views, and what's to be regarding schematics. In future Ad Libs—as Arthur Godfrey says, "Be The Good Lord Willin'," I'll cover many other subjects brought to light through your replies to our latest questionnaire. ■ ■

SERVICING TRANSISTOR RADIOS

CONCLUSION

by Sol Libes

Correction—In Part I of this article (Feb. 1958, p. 6) it was stated that "A battery eliminator is not recommended as a source of power for transistor radios (due to poor regulation and possible high *ac* ripple content).

In making this statement, the author had in mind the older type battery eliminator used for tube type auto radios. Many manufacturers of modern battery eliminators have taken special pains in the manufacture of their equipment to improve regulation and reduce ripple. These units were specifically made with the transistor radio in mind and as such make a very convenient addition to the bench.

PART III. MISCELLANEOUS CIRCUITS

The more popular type of audio output stage found in present transistor radios is the push-pull output circuit. One such circuit is shown in *Fig. 3*. The audio driver stage is also shown to illustrate another type of earphone connection jack. If this jack, located in the collector circuit, opens the stage will not function and no signal will be transferred to the output stage. This stage is otherwise checked in the same manner as the previous driver stage.

The audio output stage however, is quite different from the class "A" audio output amplifier shown in *Fig. 1*. Here the two transistors are operated class "B" and conduct on alternate half cycles. The driver transformer couples out-of-phase voltages to the base of each transistor.

The push-pull transistor audio circuit can have troubles similar to a class "A" stage. Namely, fused transistors, open transformer windings, etc. However, if only one transistor is fused, an unbalanced condition occurs and the audio will be weak and distorted. Likewise if the .1 mfd capacitor across the output transformer primary were shorted or leaky a weak distorted signal would result. If only one of the transistors is defective it will be necessary to replace both of the transistors with a matched pair.

When the transistors are not matched or an unbalance exists the audio peaks will be clipped unevenly with resultant distortion. To check a push-pull stage for unbalance, couple a signal into the receiver at the antenna. Connect the vertical input of an oscilloscope across the voice coil. Observe the signal on the scope as the volume control is varied. As the volume is increased, clipping of the sine wave should occur at equal amplitudes, above and below the zero reference, if the transistors are matched. If they are not matched one side of the sine wave signal will be clipped more than the other. Typical waveforms are shown in *Fig. 4*.

Transistorized detector stages are used frequently because they supply a small amount of audio gain (approximately 10*db*). One transistorized detector stage is shown in *Fig. 5*. The transistor is operated class "B" so that it clips the *if* signal. The *.05 mfd* capacitor in the collector filters any remaining *if* signal. *AVC* voltage

[Continued on page 46]

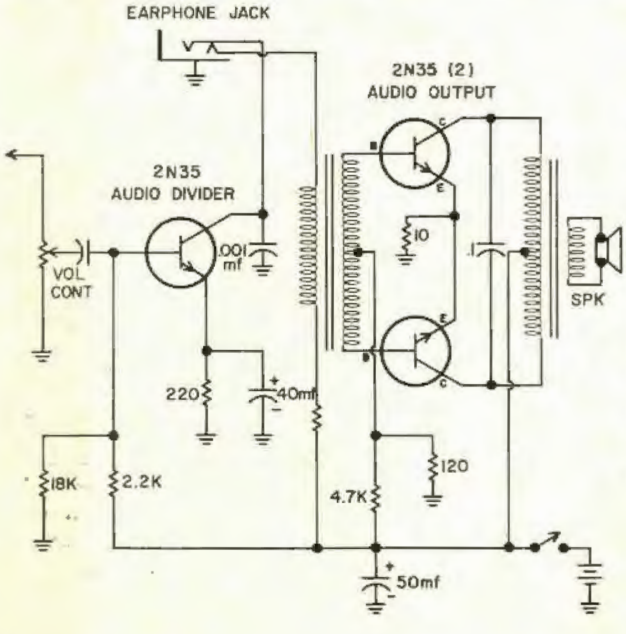
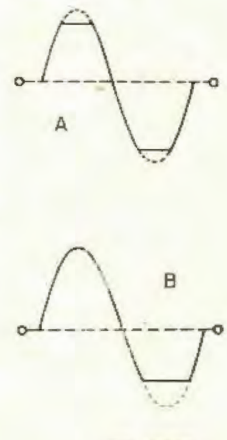


Fig. 3—A typical push-pull output stage in transistor receivers. Operation is Class B. Earphone jack in driver stage is another commonly used feature in these receivers.

Fig. 4 — Unequal clipping seen in lower waveform is an indication of unmatched transistors.



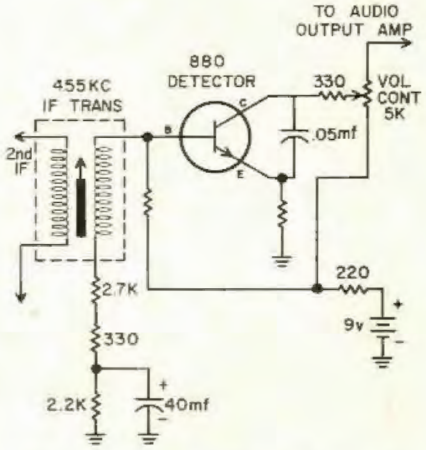


Fig. 5—Detector circuit used in Westinghouse Model H587P7.

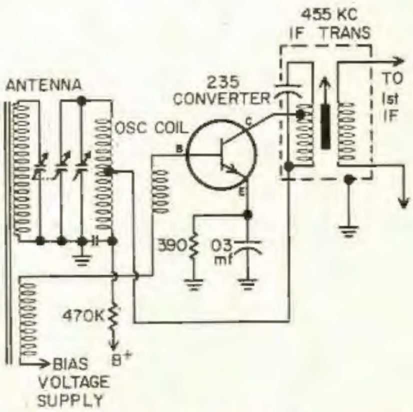
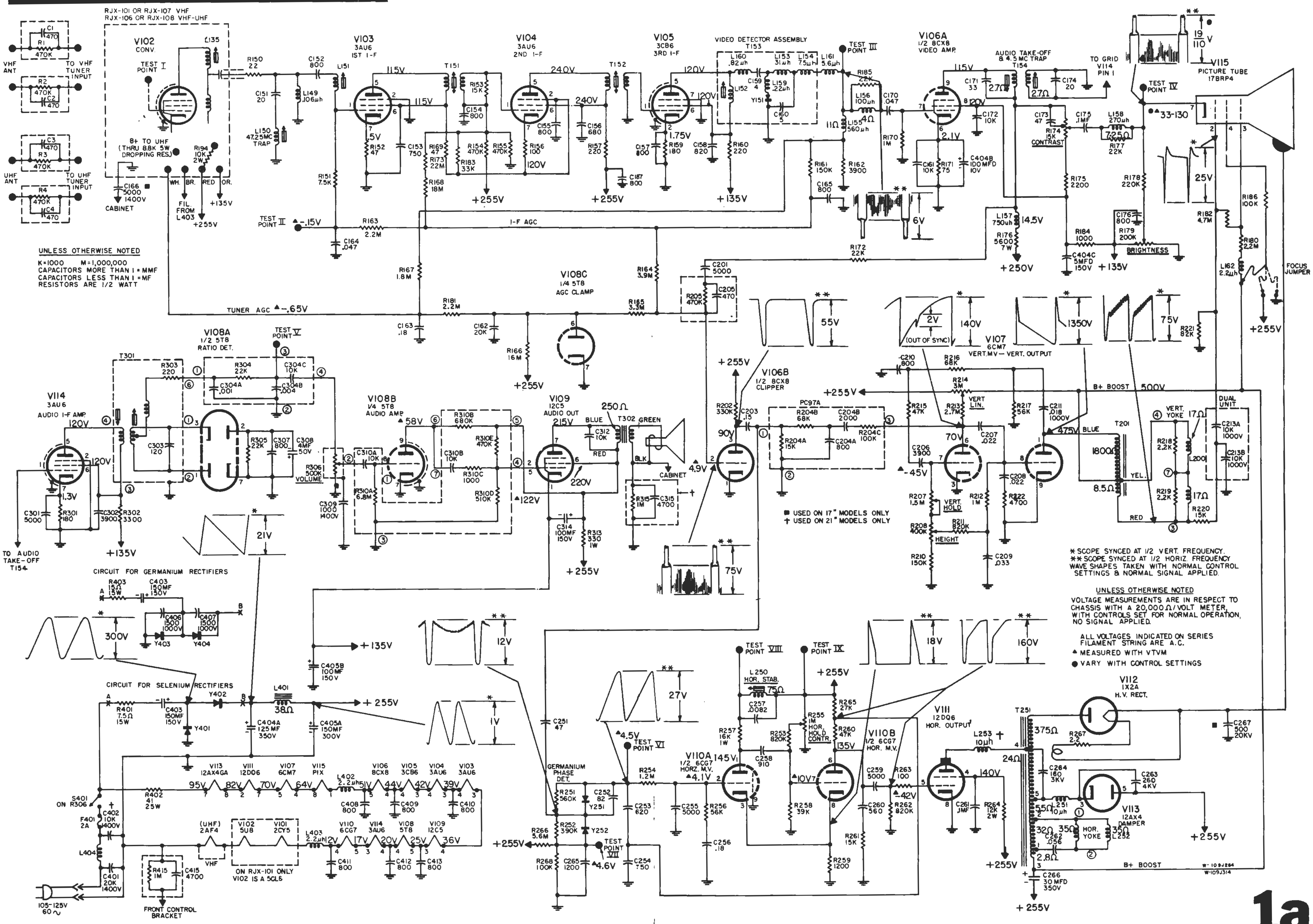


Fig. 6—RCA 7-BT-9J converter uses collector-base feedback.



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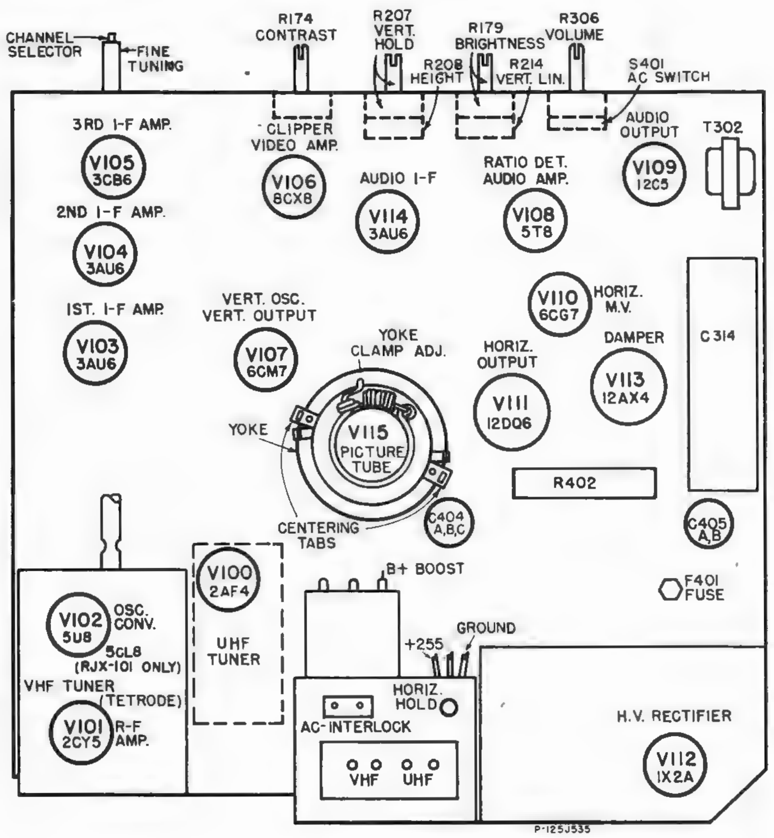
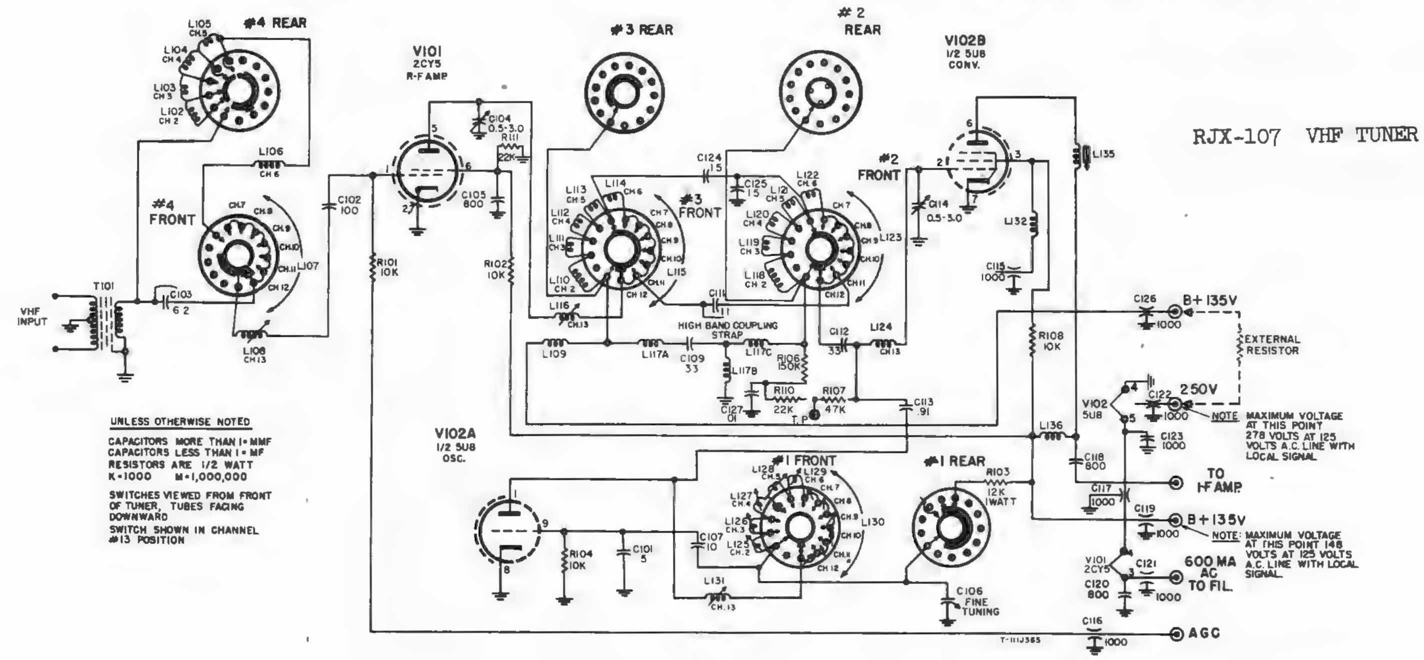
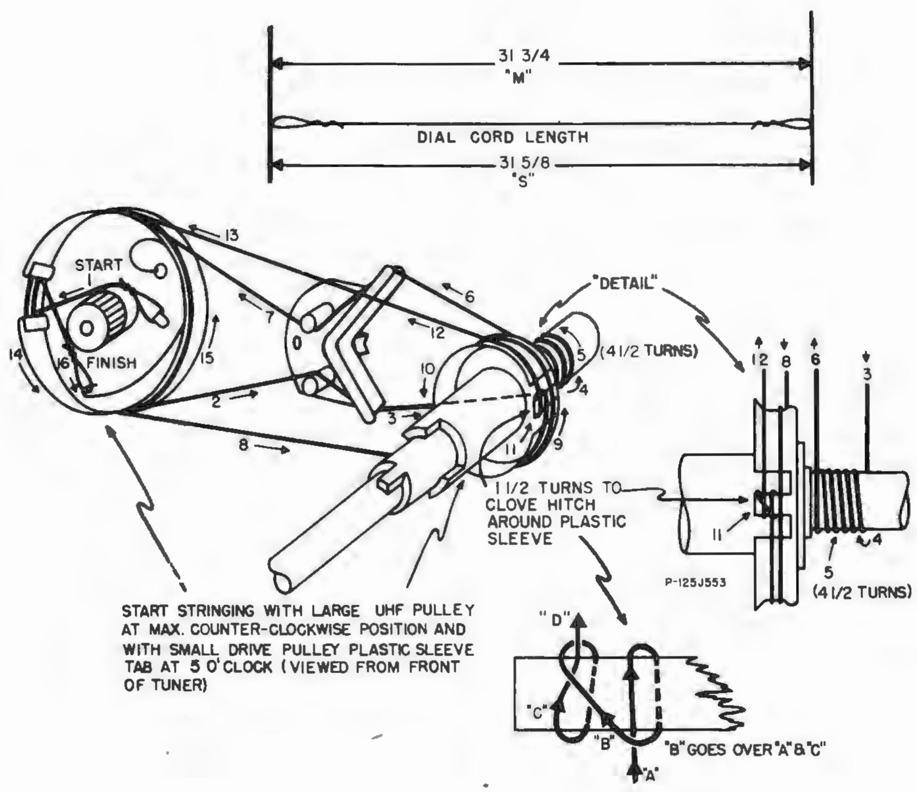
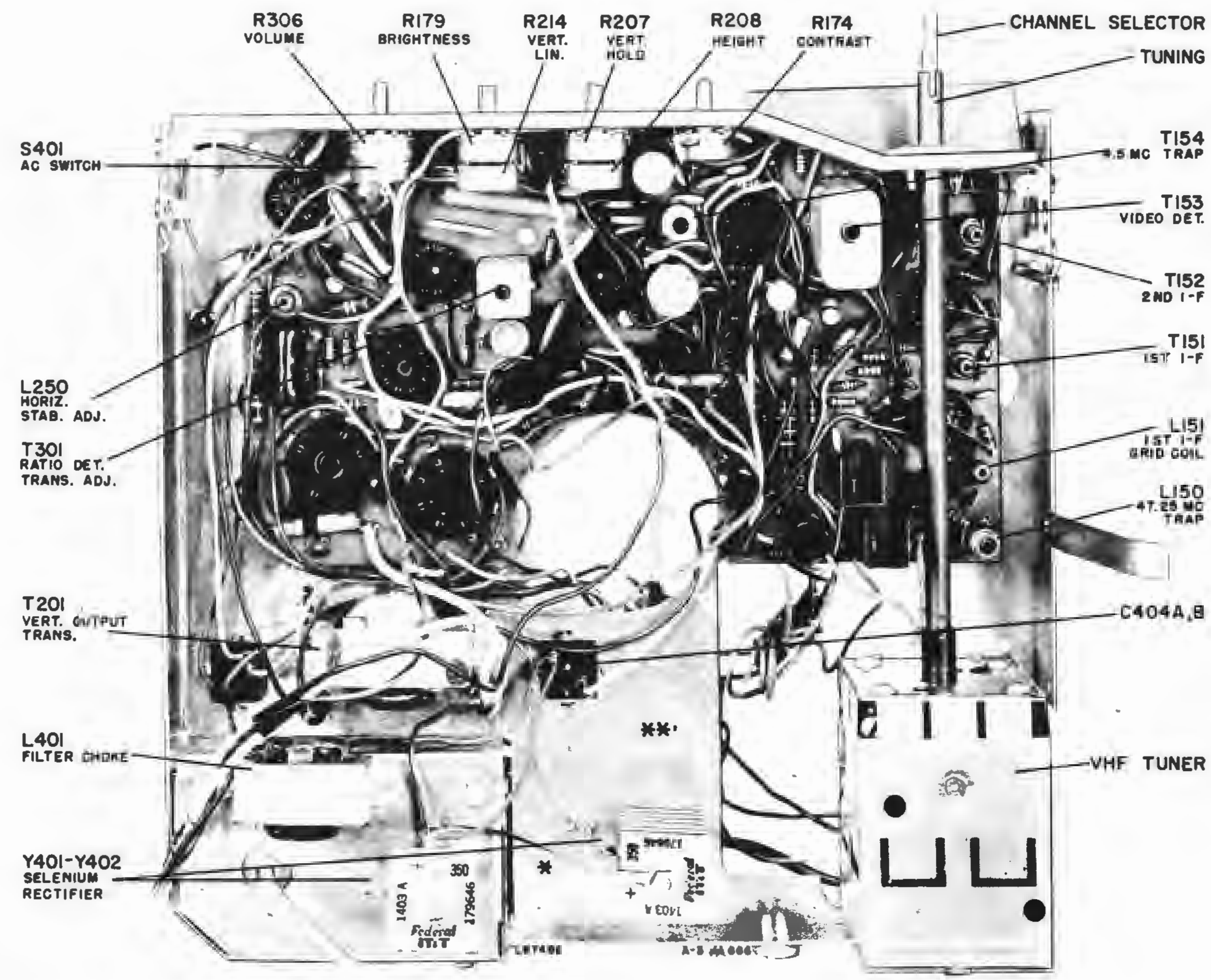


REAR OF CHASSIS







NOTE: PRODUCTION CHANGE -Selenium rectifier (Y401) moved to position indicated by *. C403 placed in position marked by **.

REAR VIEW OF CHASSIS - ALIGNMENT ADJUSTMENT LOCATION

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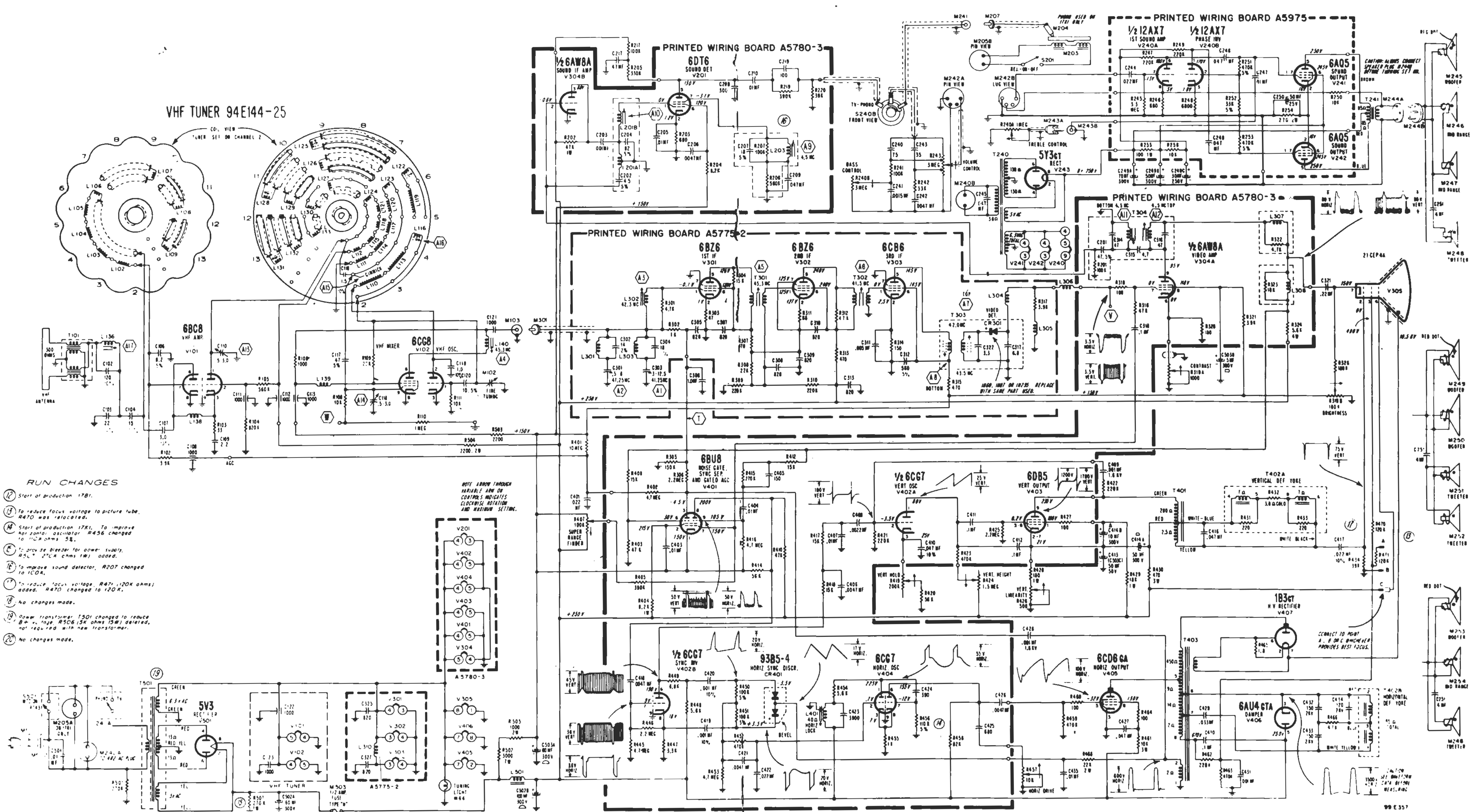
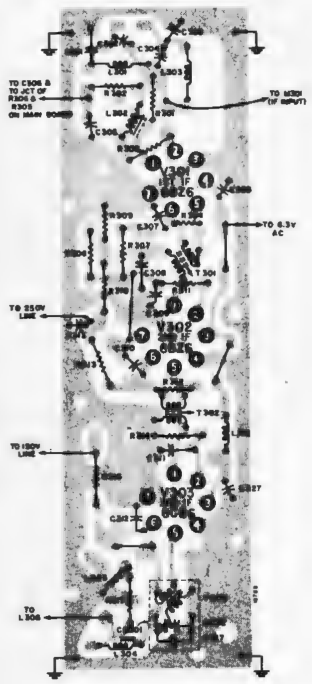
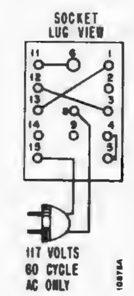

VHF TUNER 94E144-25
PRINTED WIRING BOARD A5780-3
PRINTED WIRING BOARD A5775-2
PRINTED WIRING BOARD A5975
PRINTED WIRING BOARD A5780-3
½ 6AW8A SOUND IF AMP V304B
6DT6 SOUND DET V201
½ 12AX7 1ST SOUND AMP V240A
½ 12AX7 PHASE INV V240B
6AQ5 SOUND OUTPUT V241
6AQ5 SOUND OUTPUT V242
5Y3GT RECT V243
6BC8 VHF AMP. V101
6CG8 V102
6BZ6 1ST IF
6BZ6 2ND IF V302
6CB6 3RD IF V303
½ 6AW8A VIDEO AMP V304A
21CEP4A V305
6BU8 NOISE GATE, SYNC SEP. AND GATED AGC V401
½ 6CG7 VERT OSC V402A
6DB5 VERT OUTPUT V403
1B3GT H.V. RECTIFIER V407
½ 6CG7 SYNC INV V402B
93B5-4 HORIZ SYNC DISCR. CR401
6CG7 HORIZ OSC V404
6CD6GA HORIZ OUTPUT V405
6AU4GTA DAMPER V406
5V3 RECTIFIER V501
RUN CHANGES
(12) Start of production 17B1.
(13) To reduce focus voltage to picture tube. R470 was relocated.
(14) Start of production 17K1. To improve horizontal oscillator R456 changed to 110K ohms 5%.
(15) To provide bleeder for power supply. R507 (270K ohms 1W) added.
(16) To improve sound detector, R207 changed to 100K.
(17) To reduce focus voltage, R471 (120K ohms) added. R470 changed to 120K.
(18) No changes made.
(19) Power transformer T501 changed to reduce B+ voltage. R506 (5K ohms 15W) deleted, not required with new transformer.
(20) No changes made.

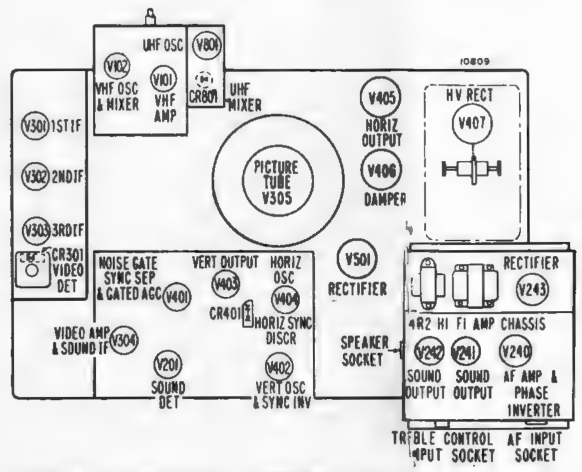


View of Printed Wiring Side of IF Board A5775-2. Used in All "17 Series" Chassis.



Adaptor Socket No. 700B122

TUBE LOCATIONS FOR 17AB1 AND 17AK1 CHASSIS



TUBE COMPLEMENT FOR 17AB1 AND 17AK1 CHASSIS

CR801—1N82A	V301—6BZ6	CR401—93B5-4
V801—6AF4A	V302—6BZ6	(Dual Selenium Diode)
V101—6BC8	V303—6CB6	V402—6CG7
V102—6CG8	CR301—1N87	V403—6DB5
V201—6DT6	(Crystal Diode)	V404—6CG7
V240—12AX7	V304—6AW8A	V405—6CD6GA
V241—6AQ5	V305—21CEP4A	V406—6AU4GTA
V242—6AQ5	V401—6BU8	V407—1B3GT
V243—5Y3GT		V501—5V3

CHASSIS REMOVAL

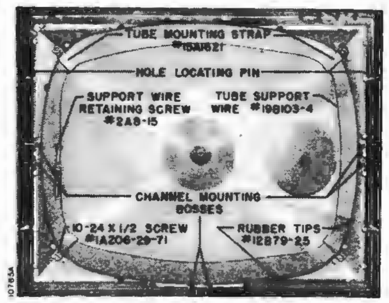
The chassis, picture tube and front escutcheon (molded mask) are removed as a UNIT FROM THE FRONT OF THE CABINET.

Remove chassis as follows:

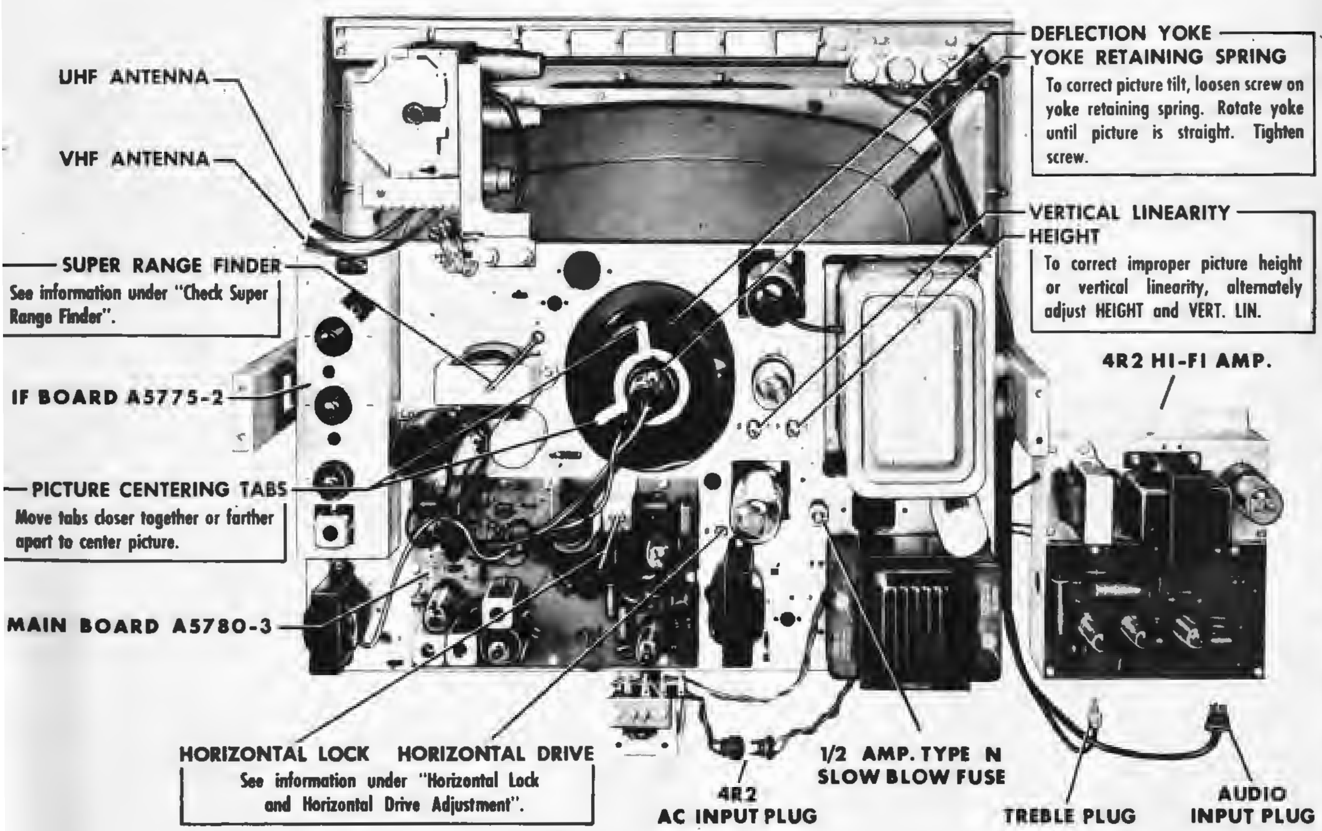
a. Remove antenna leads and cabinet back.

b. Remove the screws which mount the chassis support channels to the sides and bottom of cabinet.

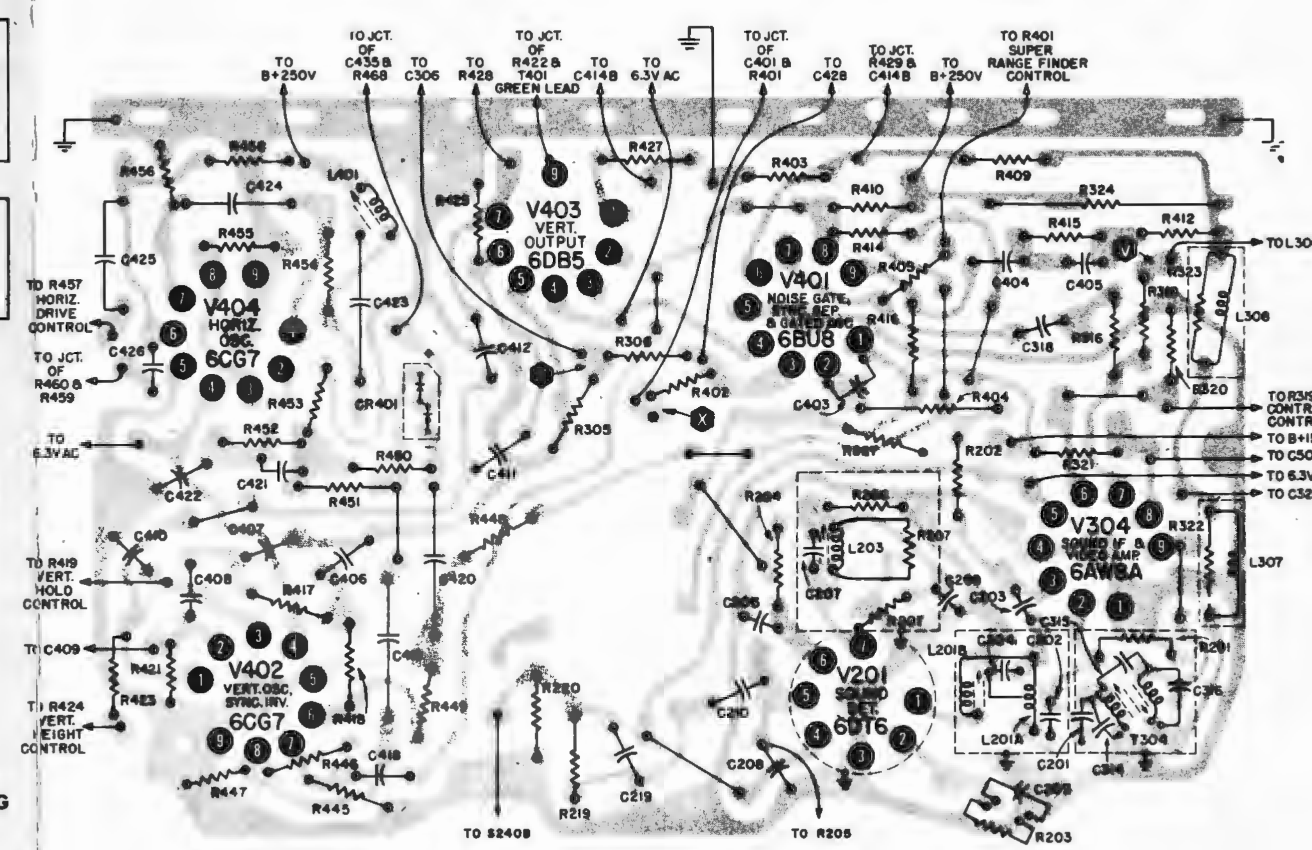
c. For models without a Hi-Fi amplifier, remove



Rear View of Escutcheon (Molded Front) With Picture Tube Mounted, Chassis Removed.



Rear View of 17B1, 17AB1, 17K1, 17AK1 Chassis Showing Adjustment Locations. Actual View is of VHF-UHF Chassis.

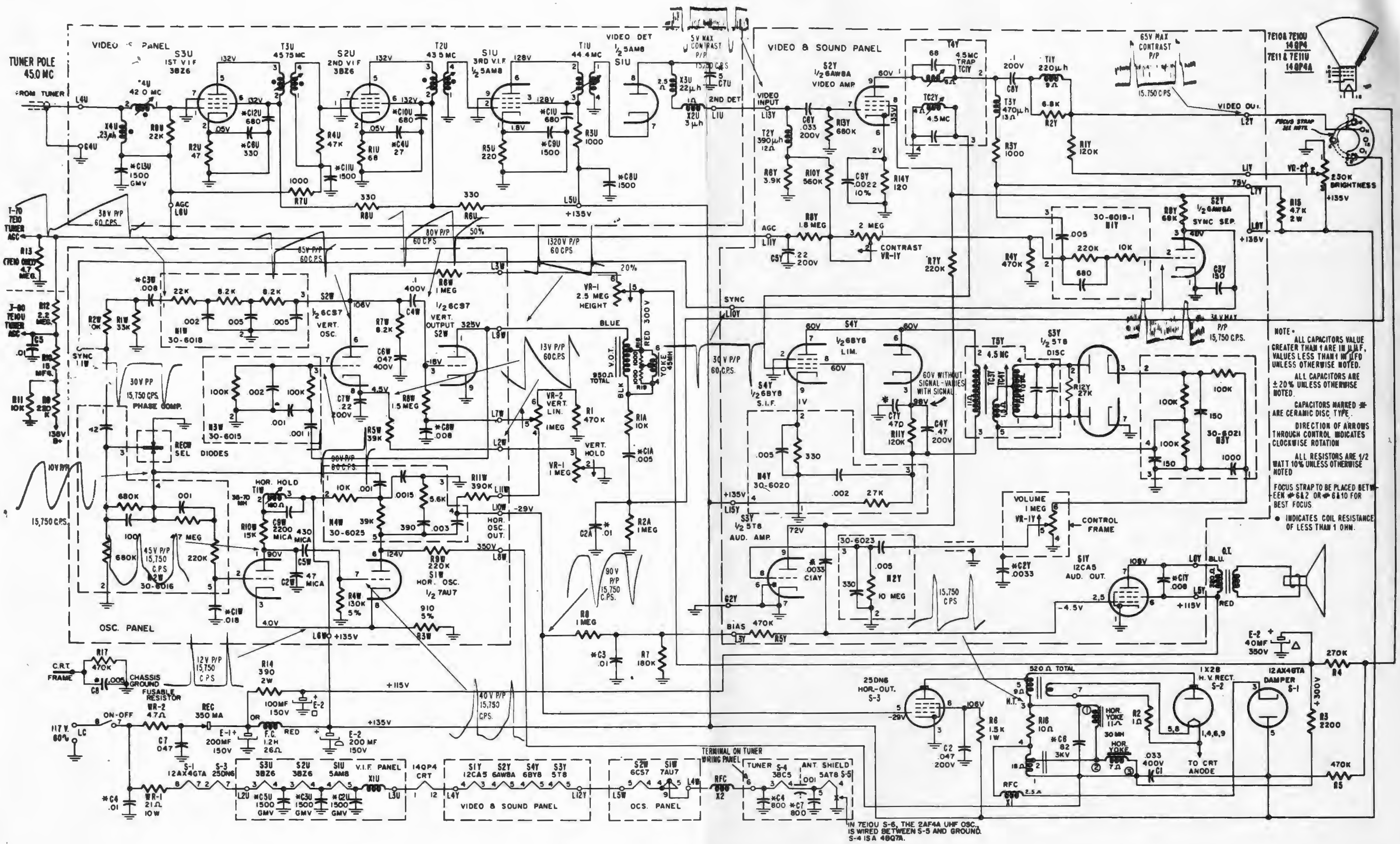


View of Printed Wiring Side of Main Board A5780-3 Used in 17B1, 17AB1, 17K1 and 17AK1 Chassis.

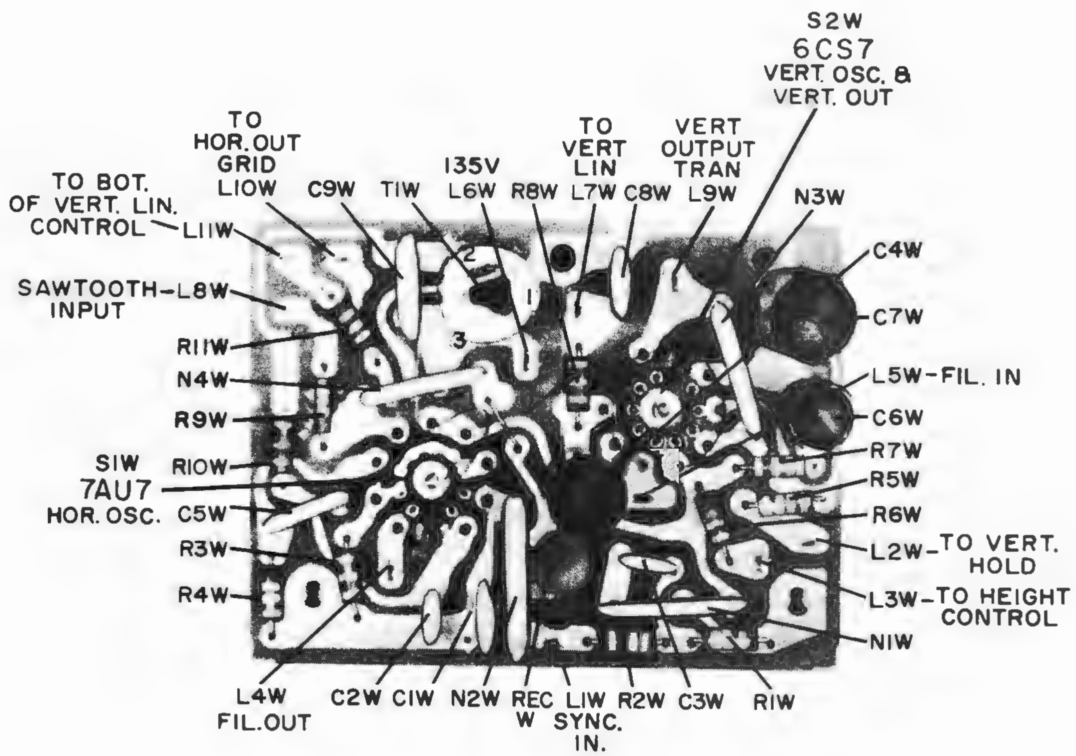
ELECTRONIC SERVICING / Manufacturer's Schematics

TV — 7E10

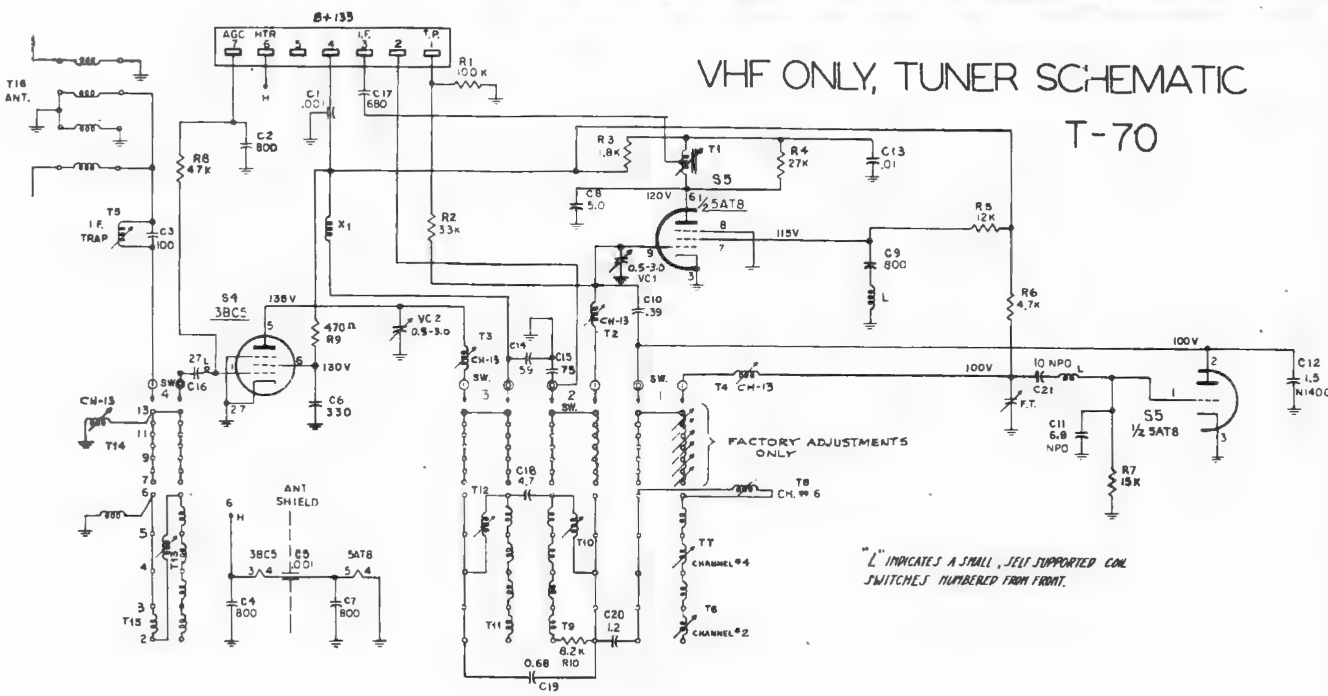
PHILCO

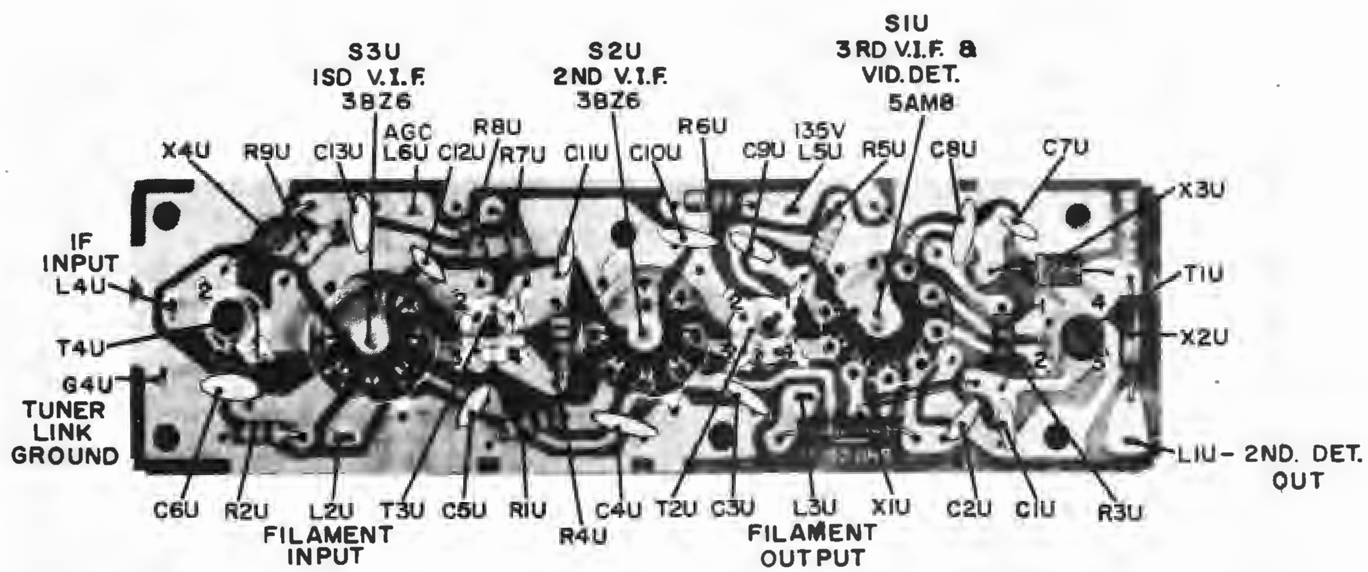


Schematic Diagram for Chassis 7E10, 7E10-U, 7E11 and 7E11-U

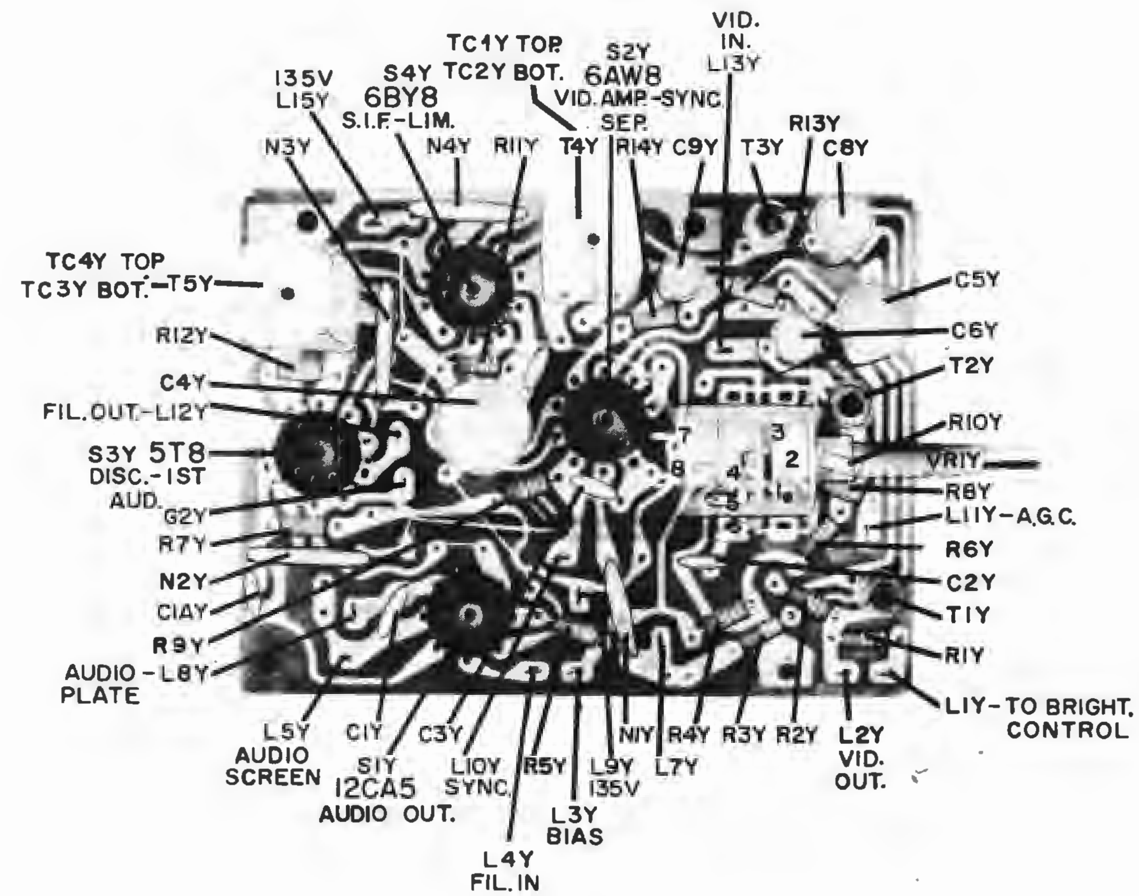


Component Layout — Printed Sweep Panel



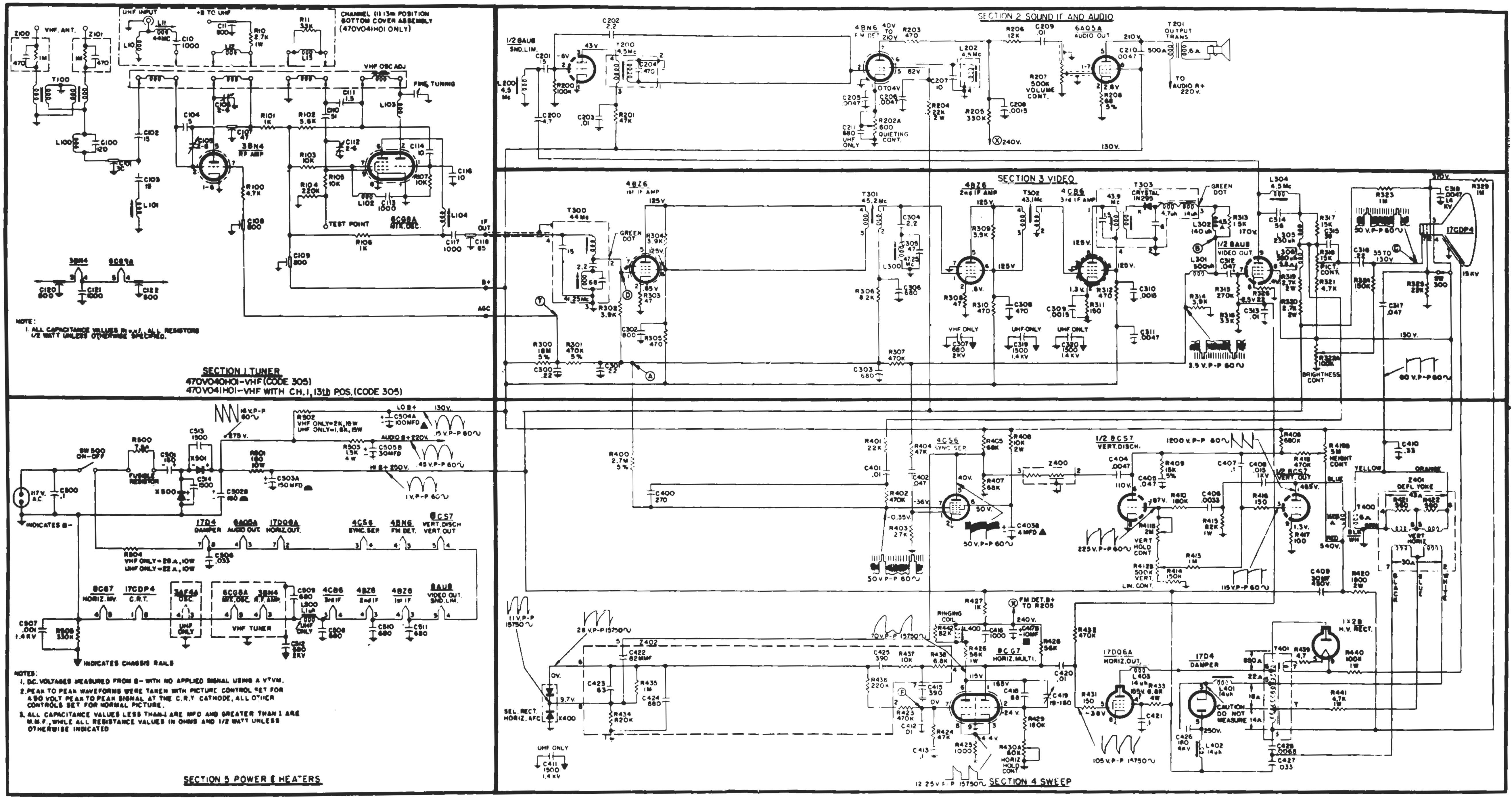


Component Layout — IF Panel



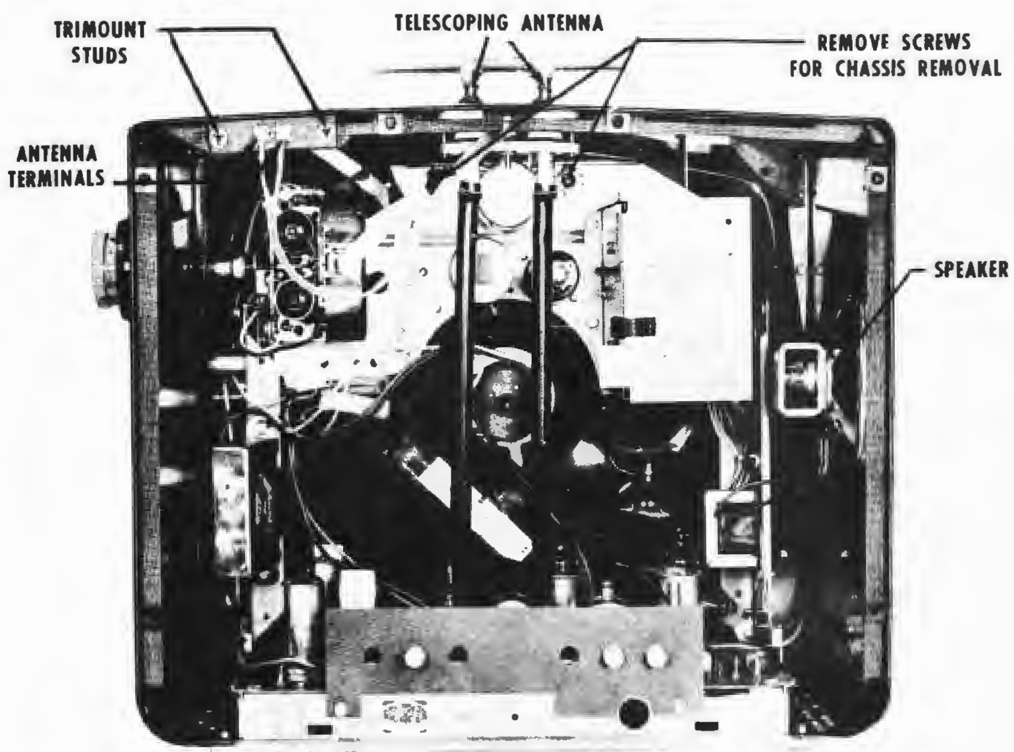
Component Layout — Printed Video and Sound Panel

ELECTRONIC SERVICING COMPLETE MANUFACTURERS SCHEMATICS. A service of Cowan Publishing Corp.

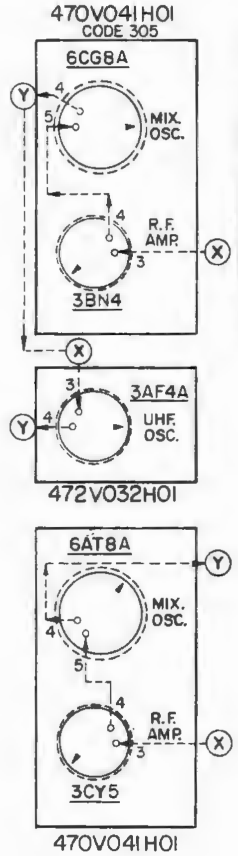

SECTION 1 TUNER
470V040H01-VHF (CODE 305)
470V041H01-VHF WITH CH. 1, 13 1b POS. (CODE 305)
NOTE:
1. ALL CAPACITANCE VALUES IN uuf. ALL RESISTORS 1/2 WATT UNLESS OTHERWISE SPECIFIED.
SECTION 2 SOUND IF AND AUDIO
SECTION 3 VIDEO
SECTION 4 SWEEP
SECTION 5 POWER & HEATERS
INDICATES CHASSIS RAILS
NOTES:
1. D.C. VOLTAGES MEASURED FROM B- WITH NO APPLIED SIGNAL USING A VTVM.
2. PEAK TO PEAK WAVEFORMS WERE TAKEN WITH PICTURE CONTROL SET FOR A 80 VOLT PEAK TO PEAK SIGNAL AT THE C.R.T. CATHODE, ALL OTHER CONTROLS SET FOR NORMAL PICTURE.
3. ALL CAPACITANCE VALUES LESS THAN 1 ARE MFD AND GREATER THAN 1 ARE M.M.F., WHILE ALL RESISTANCE VALUES IN OHMS AND 1/2 WATT UNLESS OTHERWISE INDICATED

WESTINGHOUSE

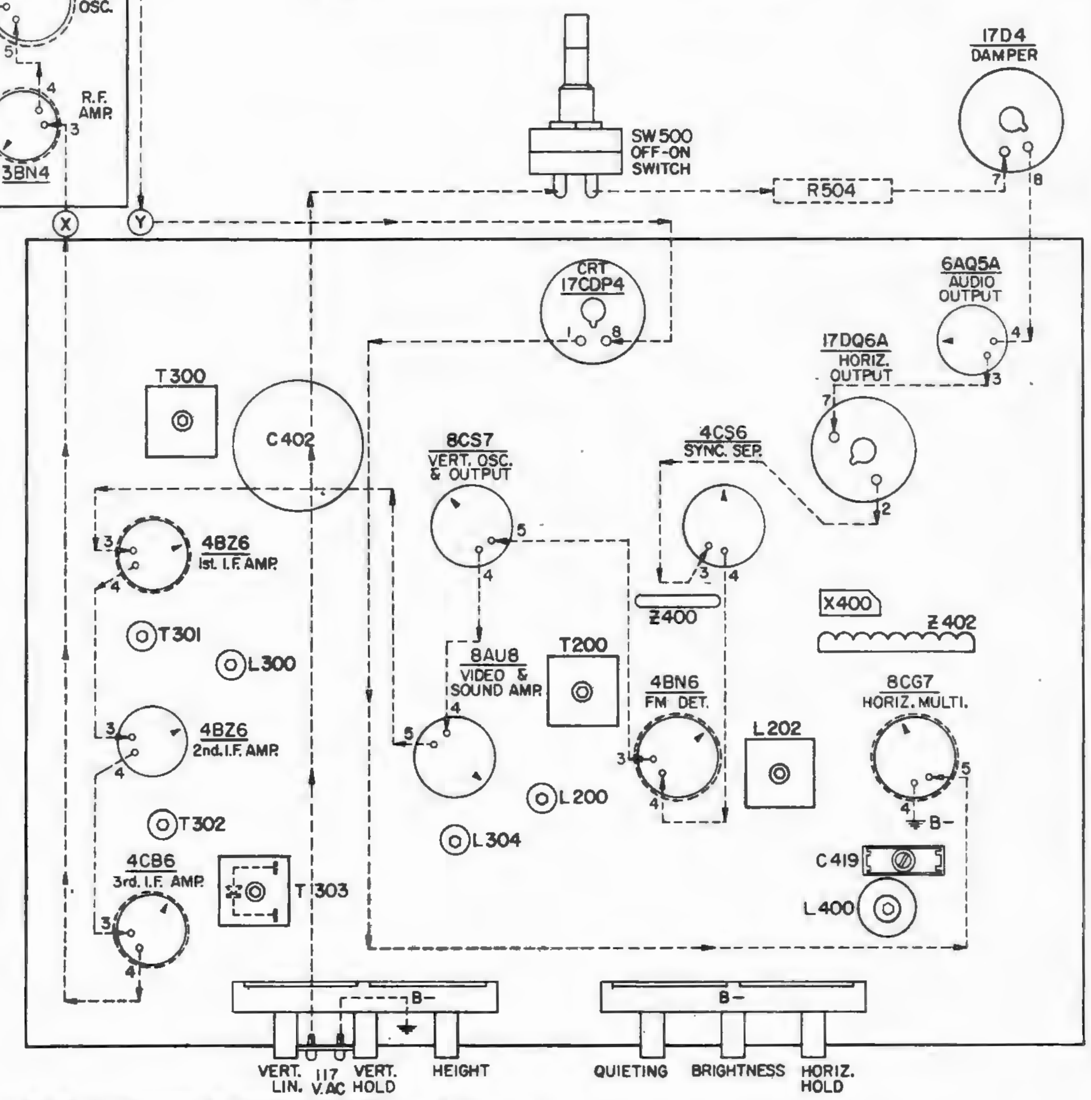
V–2373 & V–2383 Chassis, Schematic Diagram



Cabinet Rear, Back Cover Removed



Tube Location, Heater String and Adjustments



FUSIBLE RESISTOR IS LOCATED ON VERTICAL MEZZANINE.

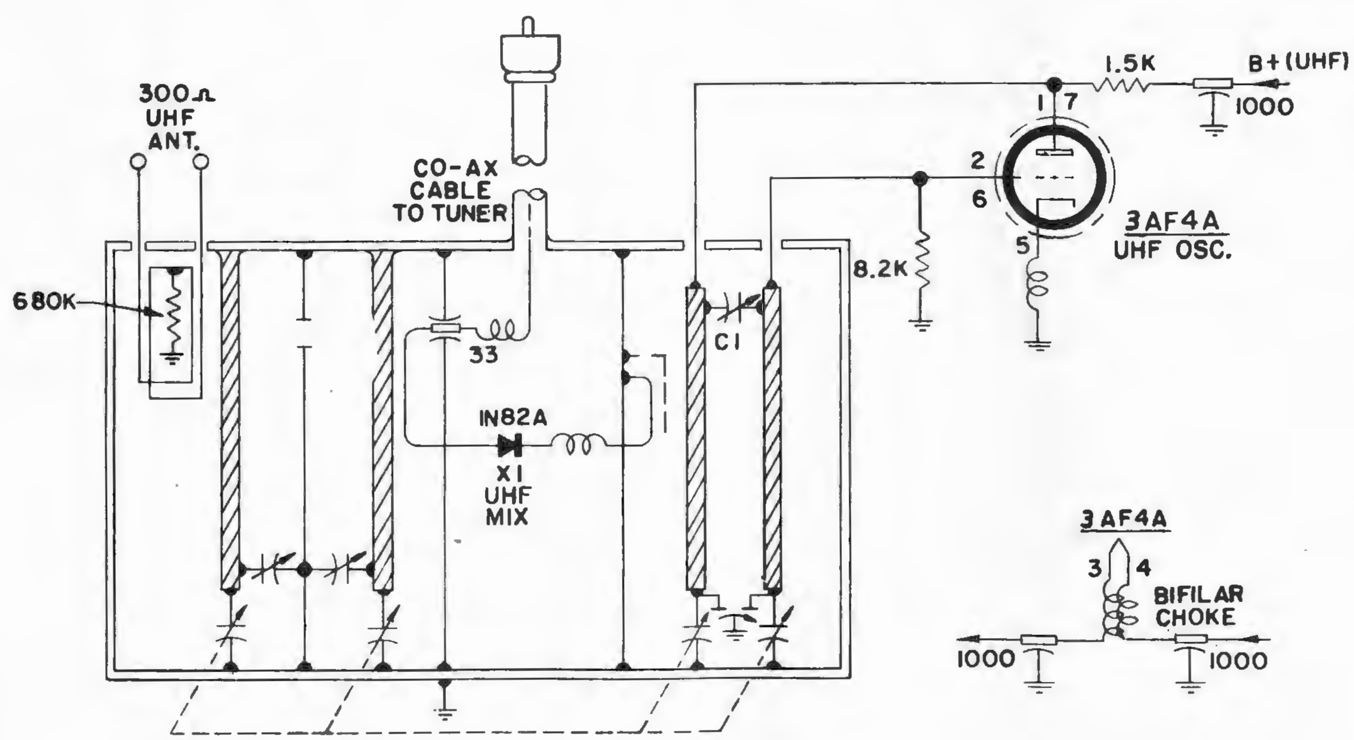
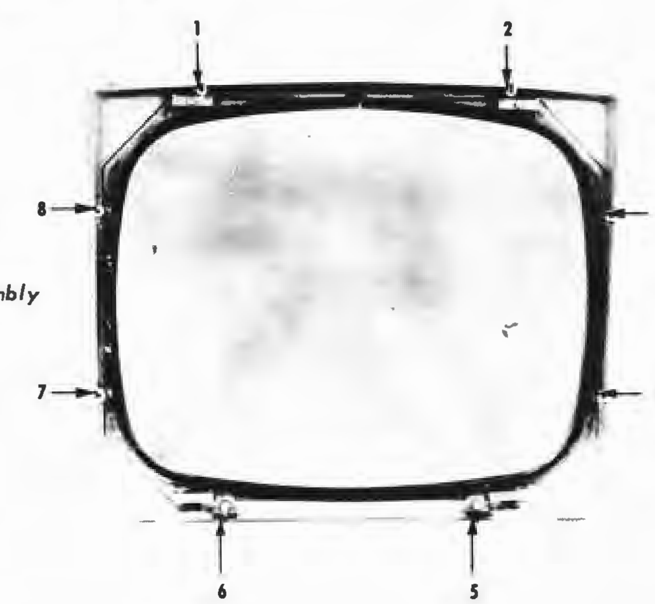


Figure 17 – 472V032H01 UHF Tuner, Schematic Diagram

Mask and Safety Shield Assembly



Mfr: General Electric **Chassis No.** S

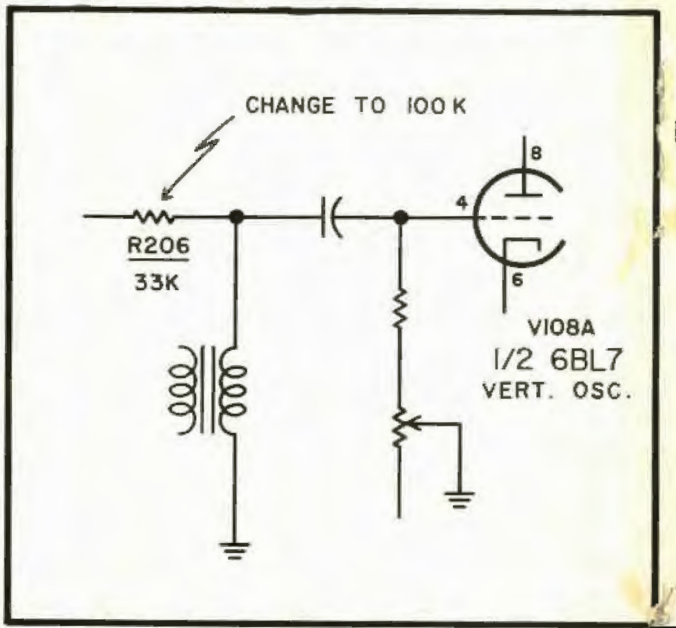
Card No: GE-S-1

Section Affected: Vertical oscillator.

Symptoms: Vertical roll after warm up—hold control at end of range.

Reason For Change: Hold control range limited on strong signals. Modification also improves noise immunity.

What To Do: Increase value of *R206* to *100k.*



Mfr: General Electric **Chassis No.** S

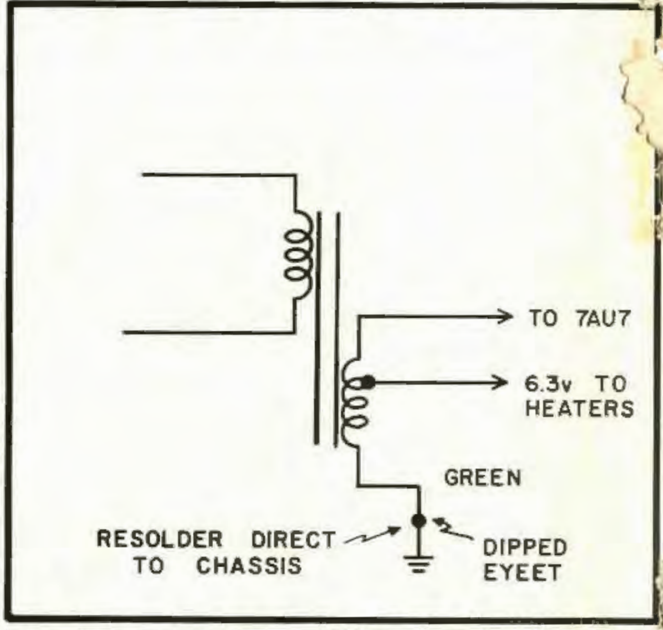
Card No: GE-S-2

Section Affected: Raster and video.

Symptoms: Insufficient sweep, weak contrast and low sensitivity.

Cause: Low filament voltage on all tubes.

What To Do: Resolder 6.3 filament line that is connected to the dip soldered eyelet alongside the 5U4G. Resolder it to the chassis with a heavy iron.



Mfr: General Electric **Chassis No.** S

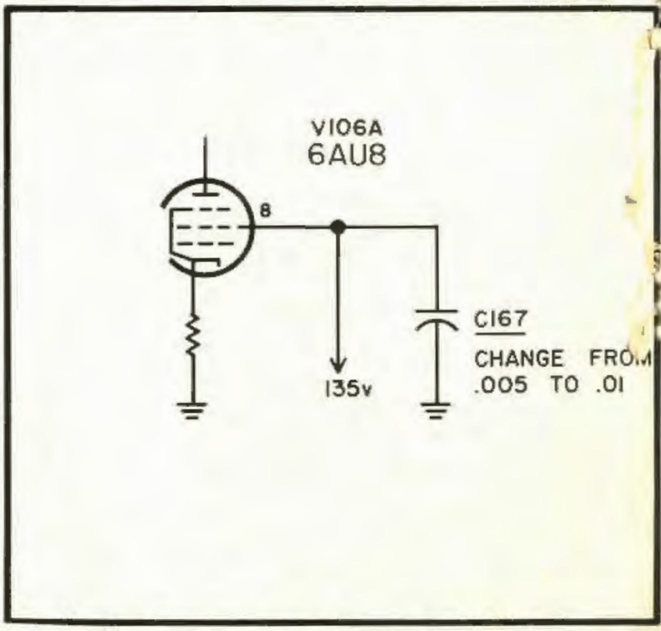
Card No: GE-S-3

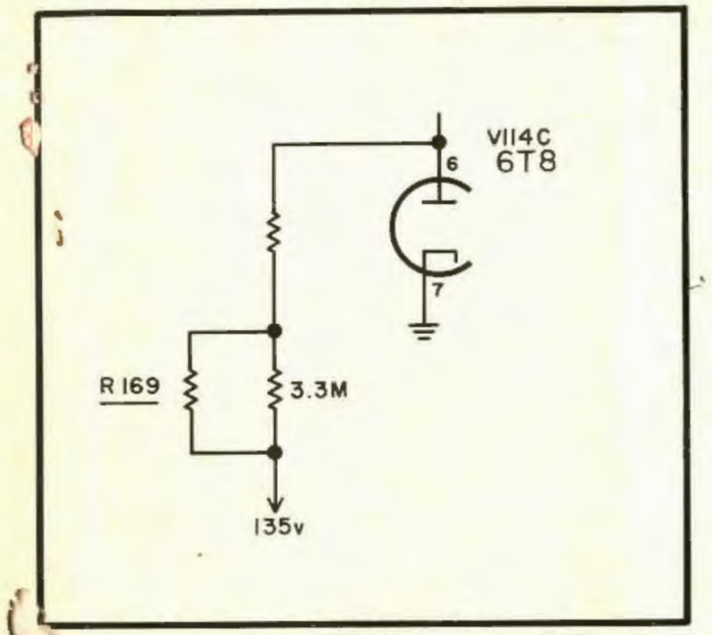
Section Affected: Pix

Symptoms: Picture ringing.

Reason For Change: To eliminate picture ringing.

What To Do: Increase *C167* from *.005 mfd.* to *.01 mfd.*





Mfr: General Electric **Chassis No.** S

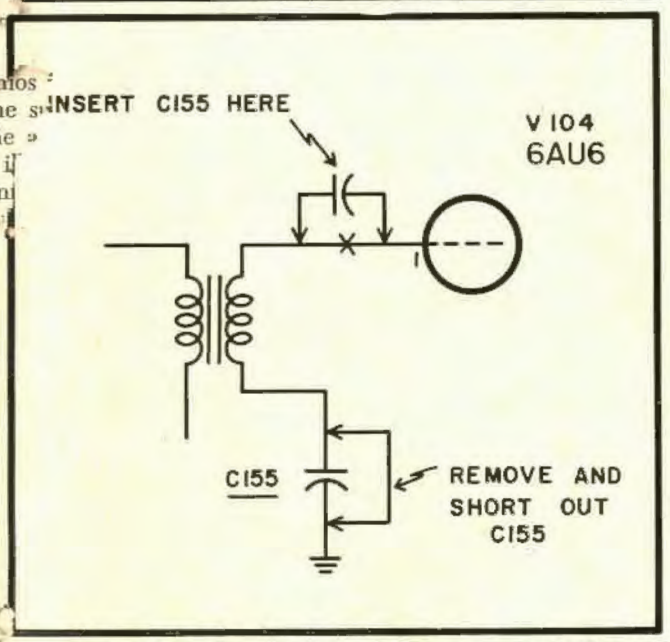
Card No: GE-S-4

Section Affected: Pix

Symptoms: Overload on strong signals.

Cause: Insufficient *agc* voltage.

What To Do: Remove *R169*, a *3.3* megohm resistor from the circuit.



Mfr: General Electric **Chassis No.** S

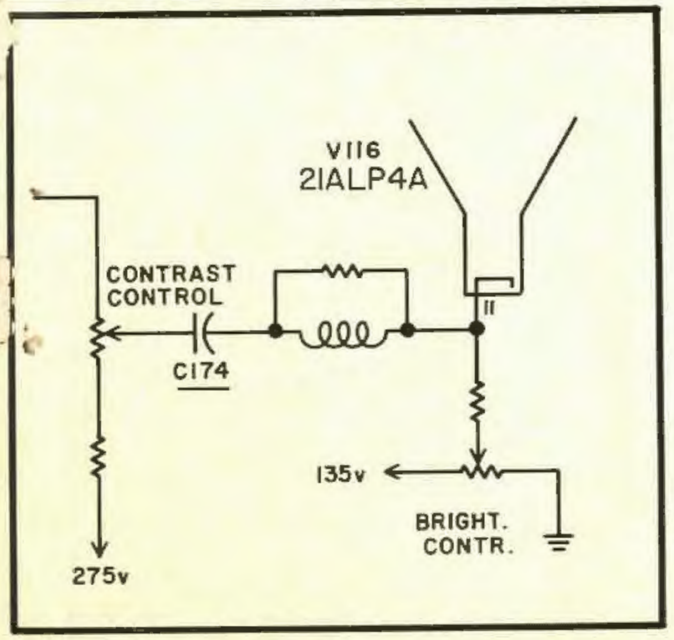
Card No: GE-S-5

Section Affected: Pix

Symptoms: Intermittent overload.

Cause: Leakage from primary to secondary of *T151.*

What To Do: Remove *C155, 800 mmf,* from the low side of the secondary winding and ground direct. Insert *C155* in series with the grid line.



Mfr: General Electric **Chassis No.** S

Card No: GE-S-6

Section Affected: Raster

Symptoms: Brightness control partially or completely inoperative.

Cause: Leaky or shorted *C174.*

What To Do: Replace *C174*, a *.15mfd.* 400V.

Mfr: Westinghouse **Chassis No.** V2372

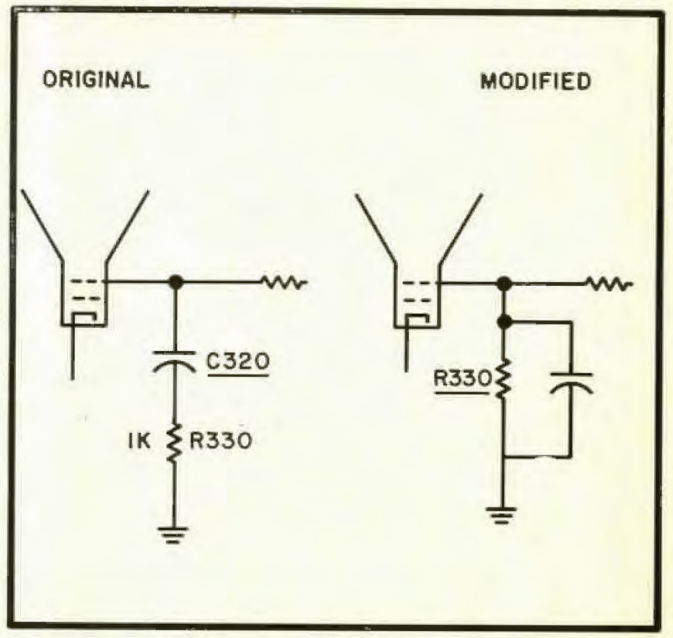
Card No: WE-2372-1

Section Affected: Picture

Symptoms: Reduced contrast.

Reason For Change: Lowered *crt* screen voltage increases contrast level.

What To Do: Remove *R330* and ground the free end of *C320.* Parallel *C320* with a 10 meg. 1 w. resistor.



Mfr: Westinghouse **Chassis No.** V2372

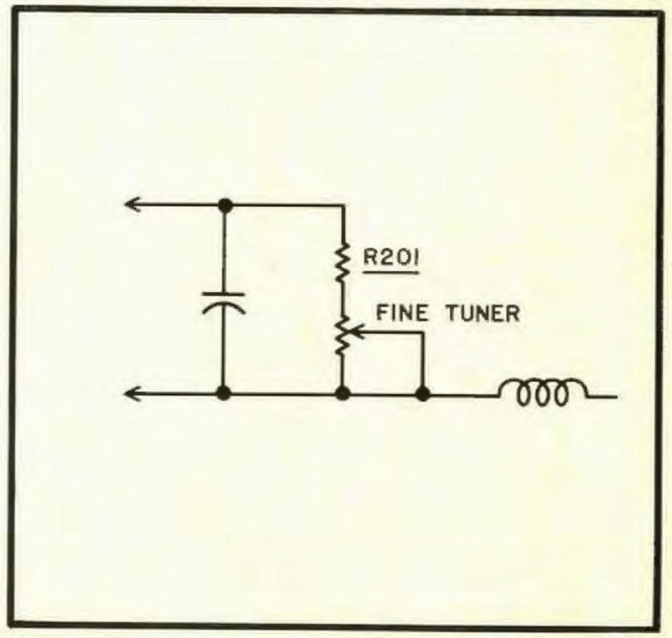
Card No: WE-2372-2

Section Affected: Fine tuner

Symptoms: Fine tuning range.

Reason For Change: To improve fine turning range.

What To Do: Change *R201* from 100 ohms to 330 ohms.



Mfr: Westinghouse **Chassis No.** V2372

Card No: WE-2372-3

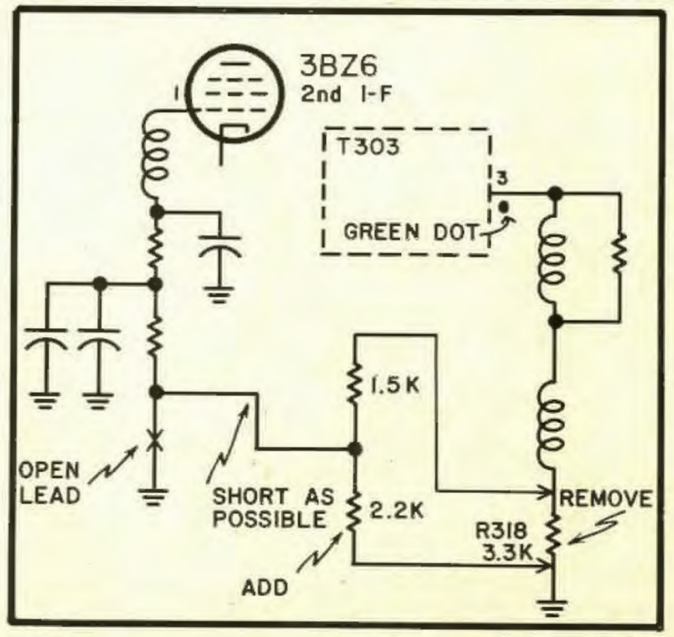
Section Affected: Automatic fine tuning.

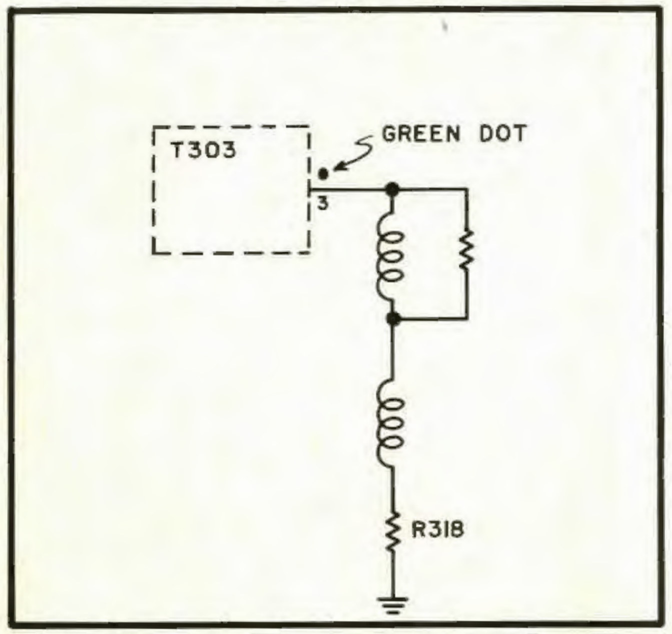
Symptoms: Poor lock in when set is cold.

Reason For Change: To improve lock in from cold start.

What To Do: Rewire *agc* circuit as follows:

1. Remove *R318* (*3.3k*).
2. Replace *R318* with a *1.5k* and *2.2k* in series as shown.
3. Lift ground end of *R309.*
4. Connect *R309* to new divider as shown (use shortest lead possible).





Mfr: Westinghouse **Chassis No.** V2372

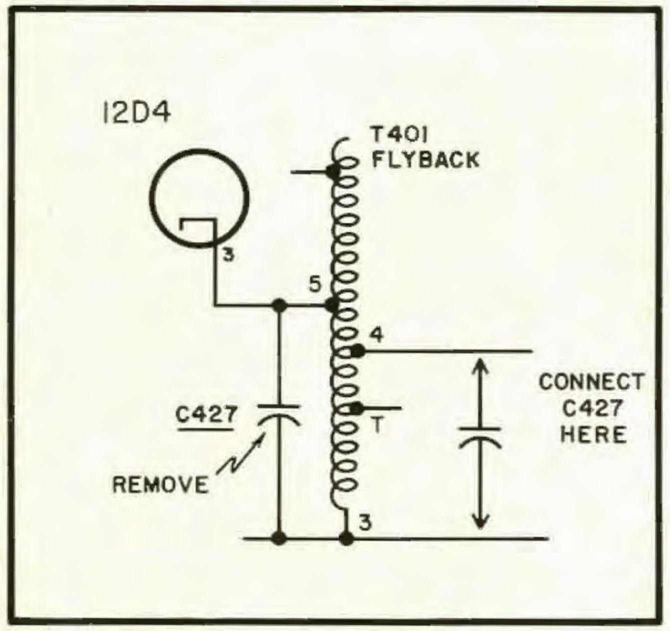
Card No: WE-2372-4

Section Affected: Pix

Symptoms: Reduced sensitivity.

Reason For Change: Improved sensitivity.

What To Do: Increase value of *R318* from *3.3* to *3.9k*.



Mfr: Westinghouse **Chassis No.** V2372

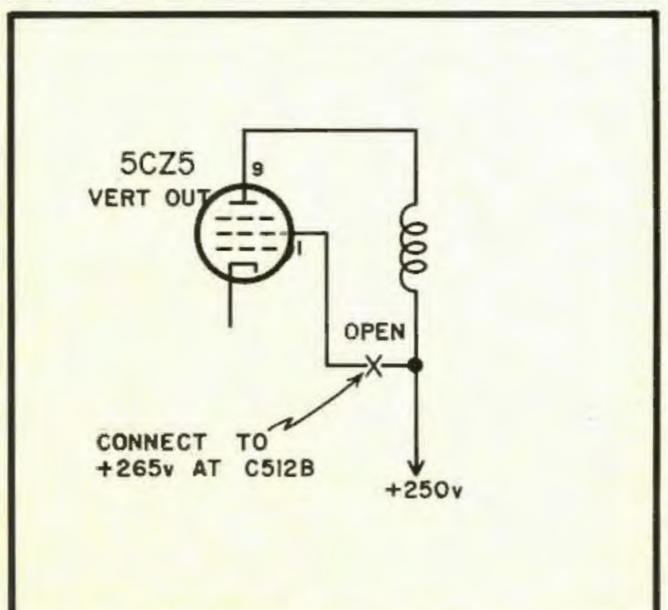
Card No: WE-2372-5

Section Affected: Raster

Symptoms: Insufficient width.

Reason For Change: Increased width.

What To Do: Remove *C429* connected between terminals 3 and 5 of *T401*. Reconnect between terminals 3 and 4 of *T401*.



Mfr: Westinghouse **Chassis No.** V2372

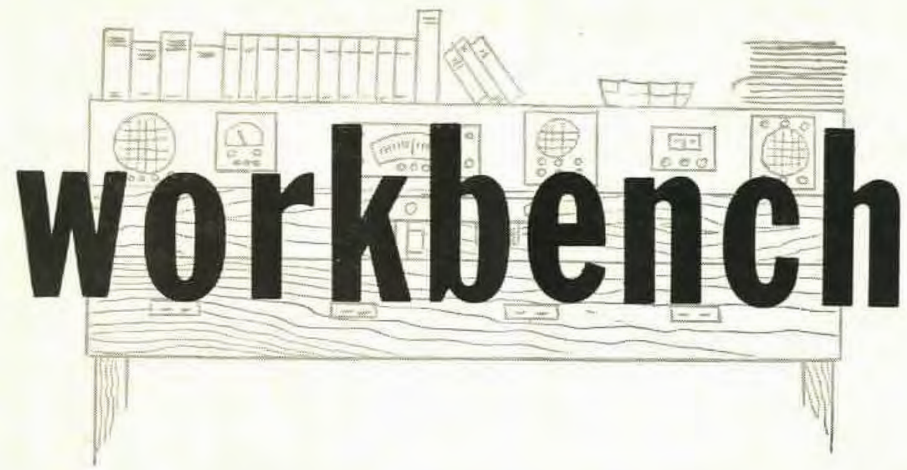
Card No: WE-2372-6

Section Affected: Vertical sweep.

Symptoms: Lack of height.

Reason For Change: To increase vertical output.

What To Do: Remove pin 1 of 5CZ5, vertical output, from the 250V line and reconnect to the 265V line.



workbench

THIS is the second in a series of Work Bench articles on color receivers. A thorough knowledge of fundamentals is helpful in solving these problems.

RCA Color Receiver 21-CD-8725

The receiver was turned on and it was observed that the black and white channels were operating properly, but the color channel also appeared in black and white. V701A and B, a 6U8A, color killer and 1st bandpass amplifier was replaced but had no effect. V702A and B, the 6AW8A, 2nd bandpass and burst amplifier was next replaced but also had no effect. V706A, B, and C, 6BN8, phase detector and color killer detector was then replaced with no effect on the trouble. V707A and B, a 6U8A, reactance control and 3.58 *mc* oscillator was replaced but had no effect.

Why were these tubes replaced? The 1st and 2nd bandpass amplifiers were replaced because they pass the chroma information. If either of these tubes is dead no chroma will reach the control grids of the picture tube. The color killer, killer detector, 3.58 *mc* oscillator, and burst amplifier tubes were replaced because each of these tubes is necessary in order that the killer tube function properly. If the killer tube is conducting during color transmission, it will supply cutoff bias to the 2nd bandpass amplifier control grid. Thus, no color.

Realizing this, the killer threshold control was varied from minimum to maximum, but could not cause the color to appear. With the channel selector set to the color channel, a voltage check was taken at the plate of V701A, the killer tube. The meter read about −24 volts. This voltage was enough to cut off V702A, the 2nd bandpass amplifier. As a positive check that the killer was supplying cutoff bias to V702A, a jumper was placed across *R706*, 100K, the grid leak resistor of V702A, grounding the cutoff bias. When this was done, the color came in properly.

The schematic was then studied. In this receiver on a color channel, the burst amplifier V702B conducts when the burst reaches its grid (gated by the horizontal retrace pulse). This burst is amplified and fed into the phase detector V706A and B. The 3.58 *mc* oscillator, V707B, also feeds a voltage through *C721*, to the phase detector. A resultant voltage is taken off the phase detector circuitry and fed to the killer detector cathode, pin 9, of V706C. This voltage causes the killer detector to conduct as the 3.58 *mc* oscillator supplies a voltage to the plate of V706C through *C720*. When the killer detector conducts it supplies cutoff bias to the grid of the color killer. With the killer cutoff no cutoff bias is supplied to the 2nd bandpass amplifier, which is thus enabled to pass the chroma information.

With these facts in mind, a voltage check was made at the grid of the color killer tube. The meter read zero volts. A resistance check was next made from the grid of V701A to ground. The meter read zero. Capacitor *C702* was next clipped out of the circuit and measured. It was found to be a dead short. Under normal conditions (black and white) the grid of

[*Continued on page* 42]

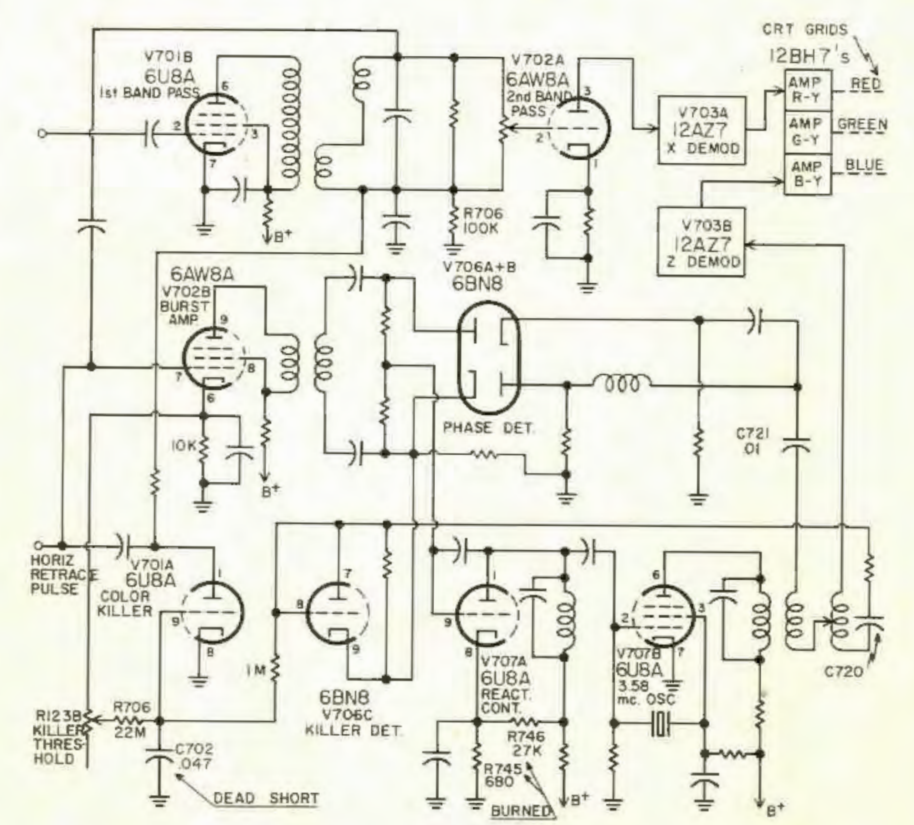
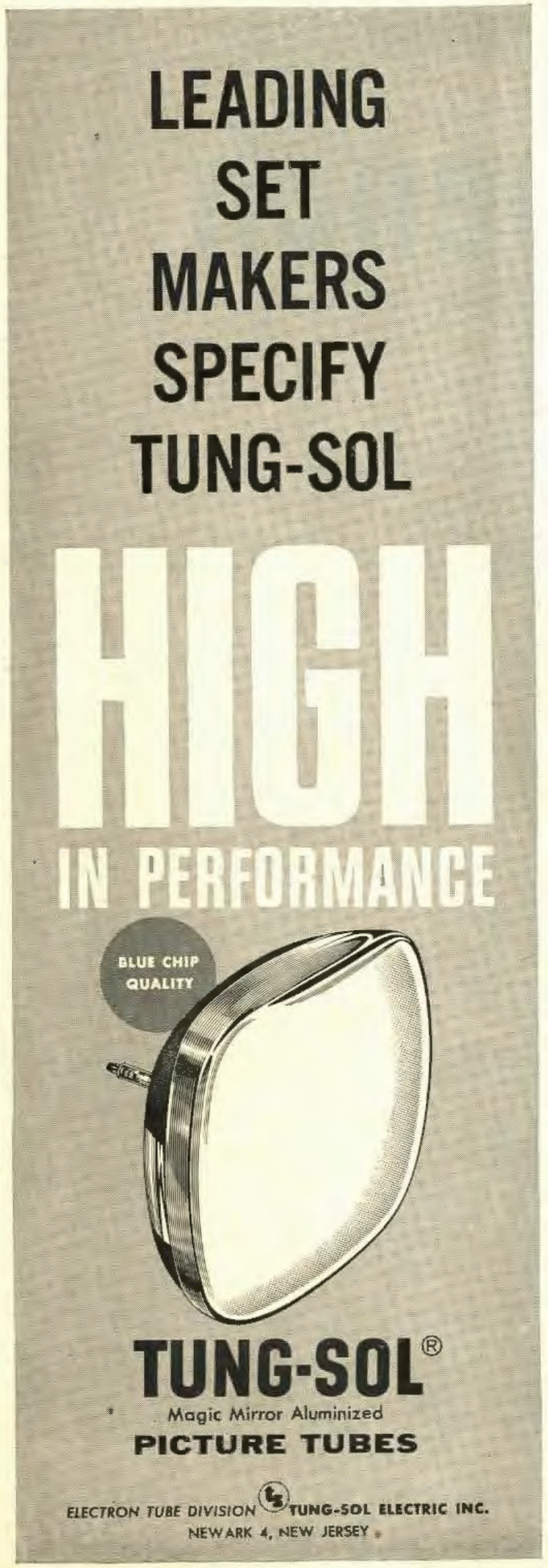


Fig. 1—Partial schematic of RCA color receiver 21-CD-8725.



TRADE FLASHES

Tape recorder fans will buy enough magnetic recording tape in 1958 to span the 230,000-mile distance between the earth and the moon ten times. "And there would be enough left over to circumscribe the globe (25,000 miles) six times," said J. Herbert Orr, president of ORRadio Industries, Inc., manufacturers of Irish brand tape. Mr. Orr sees 1958 as the year the tape recorder will come into its own. He estimates growing interest in tape recording will bring sales of 13 billion feet of tape to the more than 3½ million people who will have tape recorders by the end of 1958. He based his predictions on figures compiled by the Magnetic Recording Industry Association. These showed 500,000 tape recorders sold in 1957, including 300,000 new owners. "The estimate for tape recorder sales is 600,000 for 1958, 725,000 for 1959 and 850,000 for 1960," he said. "The industry expects tape sales to rise from 13 billion feet in 1958 to 17 billion in 1959 and 23 billion in 1960. "The emphasis on high fidelity plus the impact of stereophonic sound will bring the tape recorder into its own. Heretofore it has been an accessory to the *fm* tuner and the turntable. In 1958 we believe the tape recorder will become the center of the home music system," said Mr. Orr.

• • •

A 90-day parts and labor warranty on new RCA Victor "Flight-Line" portable television receivers is now being offered at no extra cost to the public by most retailers, it was announced today by J. P. Bannon, General Sales Manager, RCA Victor Television Division.

"This consumer protection against any service charges during the initial 90-day period is available because of the exceptionally high quality of our current line of portables," Mr. Bannon said. "While the plan is optional with dealers and distributors, practically all of them have decided to make this additional feature available to their customers." Any set needing service is to be taken by the customer to a service shop designated by the dealer. Use of the dealer's own facilities, an outside service organization or the RCA Service Company is optional under the plan.

All RCA Victor television receivers carry a 90-day factory warranty on all parts with the exception of the picture tube which has a one-year warranty. This warranty does not cover labor involved in replacing the parts.

Mr. Bannon stressed that the labor warranty on portables is being assumed by distributors and dealers due to the extremely low average rate of service currently required on the new RCA Victor portables.

• • •

Rugged radars that are at their best even when stormy seas and skies are at their worst soon will help the military merchant fleet supply the DEW line, Greenland and other strategic global bases with vital logistic and troop support. The Military Sea Transportation Service disclosed purchase of 40 new radars from Raytheon Manufacturing Company of Waltham, Mass. Because of the radars' frequency, they can "penetrate" a storm more deeply, and can pick out wanted objects from a maze of unwanted clutter. Choppy seas and irregular water spray which form false radar reflections have little effect on the MSTS's new radars. Likewise rain squalls and snowstorms, which often "knock out" other type radars, are handled in stride by the new units. The radar's 16 inch picture clearly reveals the smallest objects like buoys or small boats as close as 35 yards. It also detects targets up to 40 miles distant. The radar's six range scales: 1, 2, 4, 8, 20 and 40 miles, give the widest coverage to all possible navigational situations.

• • •

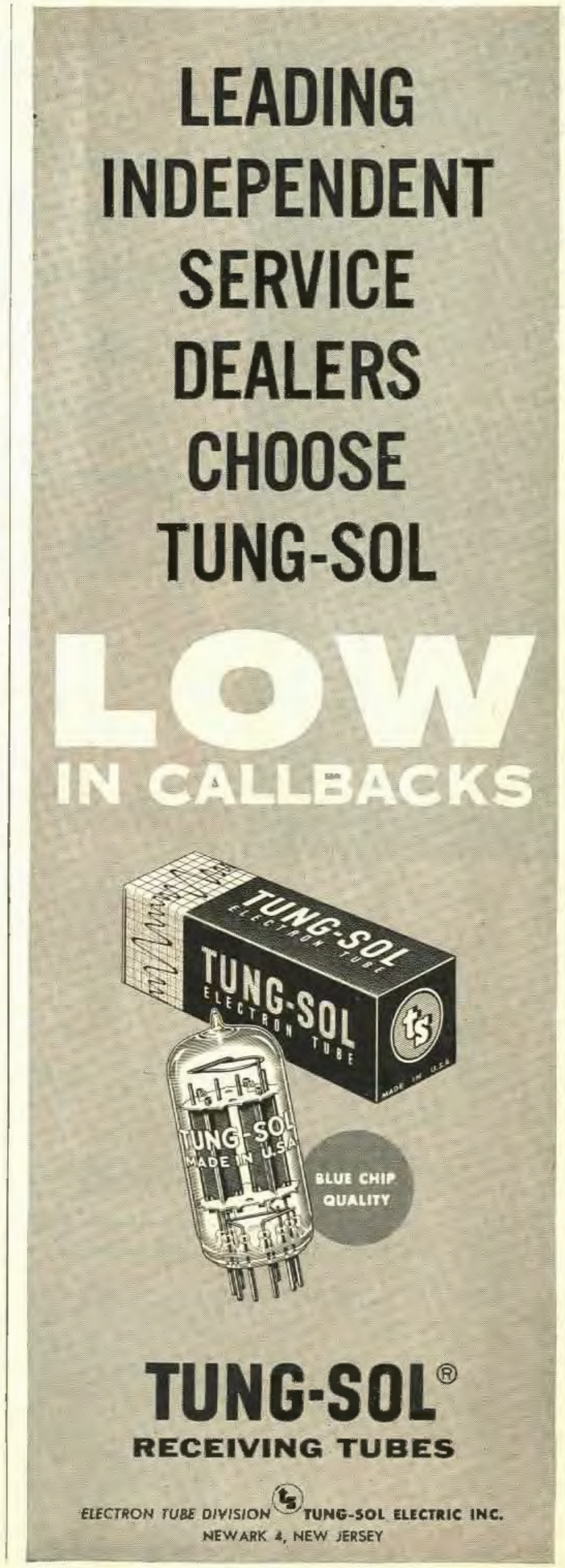
With an eye to the future, the Webster Electric Company, Racine, Wisconsin, announced today the production of a low-cost stereo-ceramic cartridge for the coming new stereo record market. The small, lightweight cartridge is designed to fit any standard record player or changer and can be installed in a matter of minutes, according to the manufacturer. Tests have proved complete compatibility on both regular (monaural) and stereophonic records. Howard Stacey, vice president of Webster, said that the company's sound engineers developed the cartridge in advance of the production of stereo discs cut by the new Westrex system (symmetrically cut at two 45 degree angles). "It has become apparent that the Westrex system of cutting stereo records will be the standard in the United States, so Webster engineers developed the ceramic cartridge well in advance of what we believe will be a booming market this spring or early summer," Stacey said.

• • •

Both radio and television receiver sales in November increased over October retail sales and were reported to be considerably over the sales level of November a year earlier, the Electronic Industries Association announced today. Cumulative sales of TV sets during the first 11 months of 1957 remained under the like 1956 period while radio set sales at retail climbed to one million units over the number sold during the like months of 1956, EIA said. Manufacturers' sales of both receiving and TV picture tubes in November and the first 11 months of 1957 declined from the number sold in October and the first 11 months of 1956, respectively.

• • •

Supported by an extensive promotion campaign, the fourth annual National Television Servicemen's Week intended as a tribute to the technicians who install and maintain the nation's 45 million TV receivers will be observed this year from March 24-29, Harold S. Stamm, Manager, Advertising and Sales Promotion, RCA Electron Tube Division, announced today. The Week, he said, is recognized and registered by the U. S. Chamber of Commerce. The 1958 campaign for National Television Servicemen's Week, the most extensive in the Division's history, will utilize magazine, television, radio and local newspaper advertising as well as special contests and sales promotion aids. The program is now underway and promotion materials already have been mailed to RCA Tube Distributors for use by independent TV service dealers across the nation. ■ ■



COUPLERS

[from page 7]

designed specifically for the purpose, however it is also possible to use some of the "two set" couplers already discussed.

A typical bifilar multiset couplers such as the Brach 300-72, each of which can accommodate up to four receivers, is shown in *Fig. 11.* This particular unit is designed to operate from a 300 ohm line into four 75 ohm receiver inputs. Reference to the schematic in *Fig. 12* shows that at the input end, the two bifilars are in series to match the 300 ohm downlead. The output of each of the bifilars is connected to two 75 ohm receivers in series so that here again we have a correct match. There are 75 ohm dummy load resistors built into each of the plugs and these are supplied with the coupler. This is done so that in the event there are only two or three sets to which we want to couple, the remaining connections can be terminated to maintain a proper load. If there is sufficient signal and more than four outlets are desired, couplers can be cascaded as shown in *Fig. 13.* In this particular case, up to 16 sets can be fed from one antenna.

The schematic of another coupler using bifilar coils is shown in *Fig. 14.* This coupler operates from a 300 ohm antenna to 300 ohm lines. The bi-filars are again in series to match the 300 ohm antenna lead and across each 150 ohm output there are two 300 ohm sets in parallel to again match at this end.

Resistive couplers such as the Vidaire model C-1 or the RCA-240A1 whose schematic is shown in *Fig. 8a,* may very easily be cascaded to supply any number of sets. It is however necessary to have one coupler for each set and the practical limit is usually no more than six sets that may be connected in this way before the loading of the line practically shorts the signal. *Figure 15* shows how to connect the RCA coupler. Each of the couplers has a 9.5 *db* insertion loss which will not be too serious in primary signal areas where the high (*19 db*) interset isolation between all receivers may be very desirable.

A resistive type tap-off which can be easily constructed and is recommended where many sets have to be connected to a 300 ohm line in a high signal area is shown in *Fig. 16.* Using the values shown there is a *16 db* insertion loss (*32 db* isolation) but very little load on the line. Hence a great number of sets may thus be connected.

Coupler Selection

The choice of couplers is dependent upon the signal strength and particular problems that may exist. It is generally true that a coupler with very high interset isolation also has high insertion loss. Thus in fringe areas such a coupler may not be the most desirable. On the other hand, a coupler with a low insertion loss may not provide sufficient isolation if one or both of the receivers radiate a strong interfering signal. This may be particularly true of older sets.

The problem of TV receiver radiation has been reduced on receivers produced as of this year, by an FCC ruling which sets a limit on the radiated signal of a TV receiver. The maximum direct chassis and antenna radiation measured at 100′ is 50 μv per meter on channels 2 to 6 and 150 μv per meter on channels 7 through 13.

When a TV receiver is turned off, the impedance at the antenna terminals increases. This change is generally more pronounced on channels 7 through 13 and the impedance may increase to anywhere from approximately 500 to 1200 ohms or more. If the circuits are well neutralized such as triode cascode circuits, this impedance change will be less pronounced than for a pentode circuit. Another factor affecting the input impedance of a receiver is the *agc* voltage. Receiver inputs will be closest to 300 ohms in fringe or semi-fringe areas. Furthermore, the best match, that is closest to 300 ohms is usually obtained near the picture carrier since it is not yet possible to design a front end with a constant input impedance over six megacycles.

It has been found, that in primary and secondary areas, the resultant mismatch due to one or the other set being turned off, does not cause any perceptible change in picture quality on the other set. As a matter of fact in many cases one of the receivers has been completely disconnected and the picture on the other has not been appreciably affected. In general a mismatch of up to 3:1 will not cause any serious difficulties in 90% of all installations.

When installing any type of coupler do not run the wires to the receivers in parallel since capacitive coupling will tend to negate the isolation provided by the coupler. The lengths of each transmission line to the sets should be about the same to ensure proper distribution of the signal. If they are of unequal length, the set with the longer line will generally be the one to suffer.

In addition to the usual application of any of these couplers, they may also be used to join two antennas to one transmission line. Thus the need for switching antennas is eliminated in areas where more than one antenna is used because of the geographical location of the receiver or because of co-channel or adjacent channel interference. This is accomplished by connecting the couplers backwards. That is to say where it says "Set 1" and "Set 2," connect the antennas, and where the "Antenna" terminals are, connect the line which goes to the set. In weak signal areas a higher gain antenna may have to be installed in order to compensate for the fact that each set receives only a fraction of the received signal.

Figure 17 pictures a powered type of multi-set coupler manufactured by the Blonder-Tongue Laboratories. This unit is capable of supplying an amplified signal to one, two, or three receivers. Amplification is accomplished by the inclusion of a broad band amplifier which covers all of the *vhf* channels. The unit is designed for continuous operation, and may be mounted at the rear of one of the receivers. It is claimed that there is no interaction between receivers. ■■

Fig. 11—A 4 set bi-filar coupler with 75 ohm output plugs.

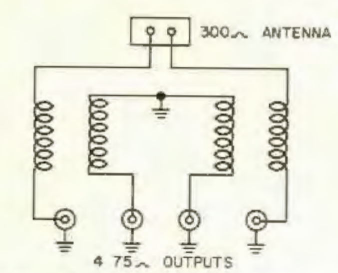


Fig. 12—Schematic of Brach 4 set coupler shown in Fig. 11.

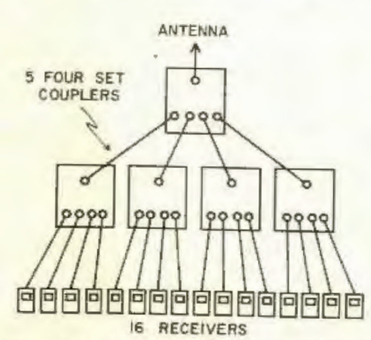


Fig. 13—Method of cascading to operate 16 sets on one antenna.

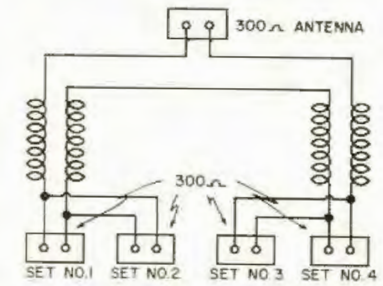


Fig. 14—Method of connecting 4 300 ohm sets to 300 ohm line.

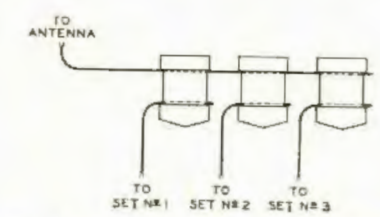


Fig. 15—RCA 240-A1 couplers accommodating three receivers.

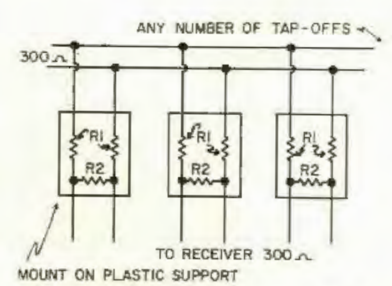


Fig. 16 — Resistive tap-off for isolation and minimum loading.

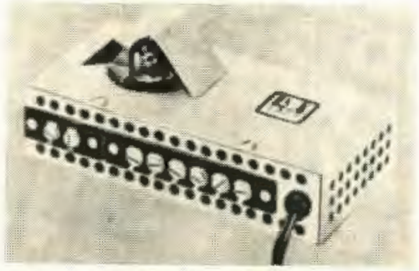


Fig. 17—Blonder-Tongue Lab's Model B-23 multi-set coupler.

WORK BENCH

[from page 37]

V701A should measure about –1 volt. This is because of the isolating resistor *R704* off the center arm of *R123B* is 22 meg. *C702* was replaced with a new .047 *mf* and the receiver was turned on. The channel selector was set to an inactive channel and the killer threshold control *R123B* was adjusted to just below the point at which colored snow appeared in the raster. The channel selector was next set to check the color channel. The color channel functioned properly. Observing no colored streaks in the black and white pictures we could state that the threshold adjustment was made properly. (The 2nd bandpass amplifier was not conducting during black and white transmission).

RCA Color Receiver 21-CD-8725

The receiver was turned on and it was noted that while black and white pictures were received properly, on the color channel there were different colored horizontal bars running vertically through the color picture. This is an example of the loss of color sync which is usually caused by trouble in the color sync burst circuits. In this receiver however, if the burst amplifier tube, V702B, does not function, there will be no color because its cathode voltage and output are essential to the operation of the color killer tube. Thus, in this receiver loss of color sync could not be caused by a dead burst amplifier tube. A dead burst amplifier would cause *no* color. If the 3.58 *mc* oscillator tube were dead there would also be no color, because this tube also is essential to the operation of the killer tube. (See *Fig. 1*). The color sync trouble could be caused by a misalignment in the burst and 3.58 *mc* oscillator circuits. Thus the following tubes were replaced: V702A and B, (to be sure there were no freak effects taking place), V706A, B, and C, V707A and B. Replacing these tubes had no effect.

In the light of the previous facts, we knew that the burst was getting through to the phase detector, but it was not synchronizing the 3.58 *mc* oscillator. We next studied the reactance control tube circuitry. The reactance control tube V707A receives the resultant *dc* voltage from the phase detector. The burst and the 3.58 *mc* oscillator voltages combine in the phase detector to produce this *dc* correction voltage. The correction voltage at the V707A control grid affects its plate current in such a way as to

[*Continued on page 44*]

GASSY TUBES*

***Reprinted from November 1957 Sylvania Service Digest**

MANY servicemen in daily routine service calls change tubes and then return them to the tube manufacturer, labeled "Gassy." Ninety-nine out of one hundred servicemen do not know what actually has happened to a tube to cause it to become gassy.

There are actually two conditions or symptoms that appear quite similar. One of these symptoms is the gassy tube, the other symptom is grid emission. The two will be dealt with separately.

A gassy tube is caused mainly by an accumulation of positive ions on the grid. These positive ions are some form of foreign gaseous material in the tube that have become positive charged. They are attracted to the grid as it is the most negative element in the tube. This accumulation on the grid places a positive charge there. This positive charge causes an increase in current through the tube. This increase in current will cause an increase in the cathode bias of the tube, but the grid will still be negative with respect to cathode. Due to the changing in bias and the positive voltage on the grid, the tube conduction becomes so great that the tube is usually damaged and associated components may be ruined. See *Fig. 1*.

The gas accumulation usually occurs after the tube is in operation, as all tubes are tested before they are shipped. Every effort is made to prevent this gas occurrence. All the elements inside of the envelope are baked in a hydrogen atmosphere. In other words they are brought to a red heat temperature to drive out any impurities that may be in the metal itself. They are then allowed to cool in an atmosphere of pure hydrogen. As the metals cool, they will pick up hydrogen gas. It has been found that hydrogen gas, of all gases, causes the least amount of increased current in the tube or in other words, is the least destructive of all gases.

Grid emission will show the same symptom as a gassy tube. Actually what has happened here is that the cathode material has been vaporized over to the grid. As the grid is heated by the cathode, it too will begin to emit electrons causing a current flow. This current flow through the grid resistor will cause a positive voltage to appear on the grid. This is exactly the same condition that happens to the cathode. See *Fig. 2*.

An easy way to distinguish between grid emision and a gassy tube is by a 10% change in filament voltage. This 10% change in filament voltage will reduce grid emission approximately 4 times, whereas it will cause only a slight change in the grid current of a tube that is gassy. ■■

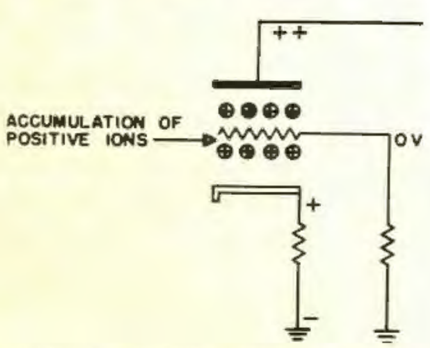


Fig. 1—Positive ions on grid causing a rise in plate current.

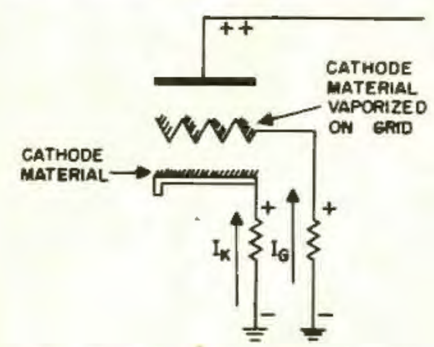


Fig. 2—Grid current caused by cathode material on the grid.

ANSWERMAN

[From page 6]

Dear Mr. Answerman:

I have an Emerson TV receiver chassis 120386 that exhibits a slight audio distortion. I have checked all possibilities such as tubes, alignment, etc., and measured components, at least those which are readily accessible. The trouble presents the appearance of a defective audio output tube. Replacing the tube does not correct it. Can you suggest some component that is likely to be causing this distortion?

H. B.
Chicago, Ill.

A most frequent cause of this trouble is the coupling condenser from the audio amplifier to the audio output stage. This condenser is shown in *Fig. 5* as *C7*. It is suggested that another condenser be substituted for this one. As can be noted in *Fig. 5*, the condenser is a component of a couplate. Components contained in couplates frequently are more difficult to reach and check and thus some condensers are overlooked. Generally, components such as this condenser can be replaced without replacing the whole couplate. In this case, terminal 7 is cut off the template. The elimination of this terminal removes the connection between *C7* and *R10*. A conventional *.022 mf* condenser is now connected from pin 2 of the 12C5 tube (V3) to couplate terminal 4. Resistor *R10* is added by connecting a *470K* resistor from pin 3 of V3 to chassis. By following the above described procedure the time required for the repair is shortened.

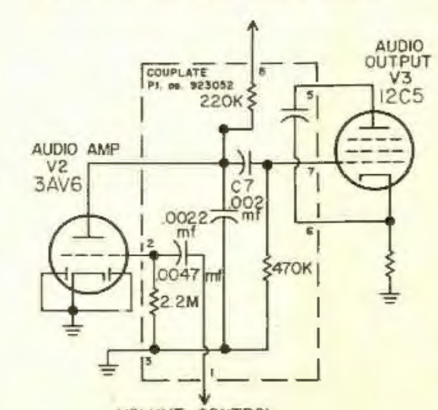


Fig. 5—Leaky C7 in couplate causes slight audio distortion.

WORKBENCH

[From page 42]

cause it to act as an inductive load on the 3.58 *mc* oscillator. This changes the oscillator frequency and thus forces the 3.58 mc oscillator to operate in phase with the burst signal.

A voltage check was taken at the plate of V707A. The plate voltage measured about +30 volts instead of +160 volts. The circuit was examined and it was noted that resistors *R746*, 27K and *R745*, 680 ohms were burned. The resistance of *R746* was measured and found to be 2K while *R745* measured about 250 ohms instead of 680 ohms. *R746* and *R745* were replaced. When the receiver was now turned on, the color picture was properly synchronized. The 6U8A was replaced as a precautionary measure.

RCA Color Receiver CTC5 (Fig. 3.)

The raster on this receiver had a definite yellow tint on both color and monochrome reception. This usually indicates that the blue is not getting through. Without the blue, the red and green mix to a yellow. This receiver does not utilize demodulator amplifiers. The demodulators V702 and V703, 12AT7's feed the three control grids (red, green, blue) of the picture tube directly. In this receiver a CW signal of correct phase is applied to the cathode of the + B − Y demodulator. The signal is inverted 180° and applied to the cathode of the − B − Y demodulator by means of a centertapped coil, T706, which is connected between the two cathodes. The CW signals for the − G − Y and the + G − Y demodulators are applied in the same manner. Because of the direct coupling between the plates of the demodulators and the grids of the picture tube, an increase or decrease in the demodulator plate voltage causes an increase or decrease in the corresponding picture tube grids and thus increases or decreases the Red, Green or Blue beam currents. Knowing these facts, the demodulators V702 and V703 were replaced individually but had no effect. The blue background control was next varied, (Red and Green mix to yellow) when the channel selector was set at a blank channel.

Adjusting this control *R117A* had very little effect. A voltage check was then made at the plate pin #6 of V702 which seemed to be correct at about 300v. Because very little effect was noted with variation of *R117A*, a resistance check was made of this potentiometer. It was found to be open

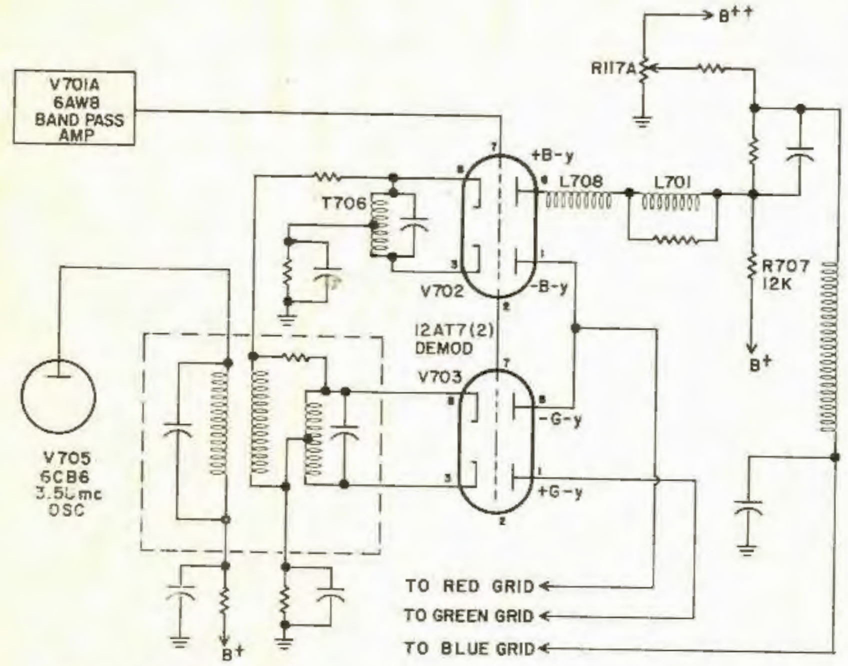


Fig. 2—Partial schematic of RCA color receiver model CTC5

from the center arm to B+. This potentiometer was replaced with a new one and the receiver was turned on. Had this potentiometer *R117A* been open from the center arm to ground, B+ would have been applied to the blue grid and a blue picture would have been the result.

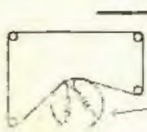
A black and white picture was tuned in and *R117A*, the blue background control was reset for the correct white, grey and black. The color channel was then tuned in and was found to be functioning properly. ■ ■

SHOP HINTS

[From page 11]

sure, spray the grill cloth with the same color or in a contrasting color. This decorative finish has no effect upon the sound quality of the grill cloth.

Krylon Inc.
Norristown, Pa.



Some hints for repairing dial cords are:

1—A very handy tool for stringing dial cords is a small crochet needle. When it comes to getting around tight places and pullies or when installing springs it can't be beat.

2—When the cord slips

a) Use a three cornered file or rasp to rough up the shaft

or

b) Put electricians tape around the shaft to increase the diameter and at the same time get better contact.

3—If the cord is a little too short or you want a little more tension, use another spring as illustrated.

W. L.
Denver, Colo.

TRANSISTOR RADIO SERVICING

[from page 16]

is developed by current flowing through the 2.2K resistor. This resistor, in series with the emitter of the first *if* amplifier (not shown), reverse biases the stage as the detector transistor conducts. This circuit should be checked in the same manner as an audio amplifier stage.

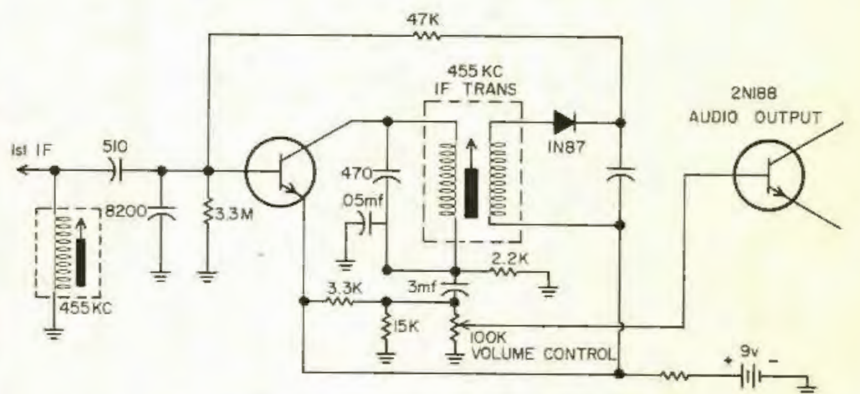


Fig. 7—Reflexed amplifier circuit used in GE Model P710A

The more popular form of converter-oscillator circuit was shown in PART II, *Fig. 1*. The oscillator circuit uses a feedback path from collector to emitter from a tap on the oscillator coil. Another type of oscillator circuit, which although less popular is still common, is the collector to base feedback circuit shown in *Fig. 6*. In this circuit the signal feedback to the base is obtained at the low end of the *if* transformer (for signal reversal). This circuit can be checked and serviced using the procedures given in the chart in PART II.

One circuit which is relatively new in transistor radios and which is becoming more popular because of its economy is the reflexed *if* amplifier. The circuit is shown in *Fig. 7*. Audio signals developed at the detector crystal are coupled back to the base of the second *if* transistor through a 47K resistor. The transistor amplifies *if* and audio energy simultaneously. No interaction between the two signals occurs. This is because the *if* signal is developed across the tuned inductive load of the *if* transformer, while the audio signal appears across the resistive load (volume control) in series with the *if* transformer. The *if* transformer offers practically no reactance at audio frequencies, while the *if* signal is returned to ground by a .05 mfd. capacitor to ground.

In most cases it can be assumed that if the reflexed stage is operating it is performing both its *if* and audio amplifying jobs equally well. To check the operation of the circuit first check it as an *if* amplifier and then as an audio amplifier as described in the chart in PART II.

CONCLUSION

This discussion has not attempted to discuss all the variations in transistor radio design used today. Rather it has touched only upon the circuits the servicing technician is most likely to encounter. The variations can, in almost every case, be serviced using the procedures described in the chart in PART II.

The transistor radio is only the prelude of things to come—namely the transistorized television receiver. Approach transistor radio servicing with eagerness and patience. Nothing is as hard as it first seems—this is particularly true of transistor radio servicing. Those who gain experience now will reap the profits later. ■■

"You and your big antenna!"

SOLAR RADIO

[from page 5]

a relatively low value load resistor which also doubles as the volume control for the Solaradio. While the volume control seems to have a very low resistance as compared to those used in a vacuum tube type radio or amplifier circuit, it does not load down the preceding stage since its resistance is many times greater than the impedance of the secondary winding of *T3*. The volume control provides another of the unusual features of the Solaradio. With the volume set at minimum, signals of average strength will still be reproduced at an audible level. This feature is used as an audible alarm to minimize the hazard of battery damage due to accidental failure to turn the Solaradio off when not in use for long periods of time.

Audio Stages

The audio driver stage consists of an *af* transistor amplifier stage (2N35) and an audio driver transformer (*T4*) with center-tapped secondary. The design of *T4* meets the requirements for driving the Class B push-pull output stage of the Solaradio. Just like their vacuum tube equivalent circuits, transistor push-pull circuits require a phase inverting device to supply a balanced signal input. Since a push-pull transistor circuit requires a balanced current signal, rather than the balanced voltage signal required by their vacuum tube counterpart, the center-tapped secondary windings of *T4* can provide a suitable phase inversion of current for this purpose. Resistors ***R21*** (120) and ***R20*** (4.7K) are a voltage divider and provide a forward base bias of correct value to keep each push-pull transistor from being alternately biased excessively in the reverse direction. Since reverse base bias could increase the input resistance of the transistor to a degree resulting in distortion of the output signal, a small amount of forward base bias is necessary to minimize this characteristic. The value of both *R21* and *R20* is critical because not only may distortion be introduced when forward base bias is not sufficient, but with excessive forward base bias a relatively high *dc* collector current would flow and the circuit would no longer operate as a Class B amplifier.

Solar Power Supply

The power supply for the Solaradio presents the really important point in which this instrument differs from conventional transistor portable radios. The low power requirements of this particular radio circuit (15 to 20 milliamperes for normal listening) make it a suitable instrument to be combined with the Hoffman Solar Battery Power Pack.

The solar battery power pack used in the Hoffman Solaradio consists of two sections. One section is made up of four rechargeable cells and is contained inside the Solaradio cabinet in the area normally used for the installation of the dry cell power supply common to most transistor type portable radios. The second section of the power pack is located inside of the Solaradio handle and is the heart of this unusual power supply. This second section is the solar power converting device and is encased behind a clear plastic window in the handle of the instrument, thereby allowing full exposure of the solar device to any available light.

The solar device consists of sixteen (16) type 120C Hoffman Silicon Solar Cells* connected in series. The metal ends of the Solaradio handle are utilized to make electrical connection between the Silicon Solar Cells and the *dc* power terminals inside the Solaradio. The Hoffman Silicon Solar Cell is essentially a silicon *p-n* junction which provides a photo-voltaic or self generating action. The cells are rectangular wafers of material 1 x 2 *cm* in size. (One *cm*—equals approximately 3/8 inch). The active area of each cell is 1.8 square *cm*. An interesting characteristic of the type 120C cell is that while the output voltage is essentially constant over large variations of light intensity and frequency, the current and power characteristics vary in direct proportion to any change in light intensity. For example: When exposed to 100-foot candles of sunlight, each type 120C cell is capable of delivering 4.2 milliamperes of current at .39 volts to a matched load. (1000-foot candles of light is equal to a 1000 candle power light at a distance of one foot.) When the supply of sunlight is increased to 10,000 foot candles, the same cell is capable of delivering 42 milliamperes at .4 volts to the same matched load.

Spectral Sensitivity

The Silicon Solar Cells have a very broad spectral sensitivity, being most sensitive to light in the infra red portion of the light spectrum and least sensitive to light in the ultra violet portion of the light spectrum. This characteristic of broad sensitivity allows the solar cells to generate electricity under almost any variation of daylight, even under the artificial light

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17G1-41MC	29U	39Q/R	54Q
18U	29Q-21MC	40U	55Q
20G1-41MC	30Q	40R	56Q
20U	30Q-21MC	42Q/R	57R-41MC
20Q/R	30G 41MC	42U	57R
21Q	31-41MC	43G1-41MC	58Q
21R	31Q	43Q	59U
22Q	32R	43R	59R-41MC
22QR	33U	45Q	59Q-21MC
23G1-41MC	33Q/R	46R	60Q
23Q/R	33R-41MC	46Q	60R
23U	33Q	47U	61Q
24U	33Q-G1-41MC	47Q	61Q-21MC
24G1	33Q-21MC	48R-41MC	62Q
24R	33Q	48Q	64G1-41MC
24Q	34Q/R	48G1-41MC	66U
25U	34U	48Q/R	67U
25Q-21MC	35Q/R	49U	67Q
25R-41MC	35U	49R	69Q
26Q/R	35R	50Q	71Q-21MC
27R	36Q-21MC	50R-41MC	73Q-21MC
27Q-21MC	36R	50G1-41MC	33R-91MC
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It is not necessary for the cells to be exposed to direct sunlight although direct sunlight produces most efficient operation. Reflected sunlight or outdoor daylight on a hazy or cloudy day is usually sufficient to activate the Silicon Solar Cells to the point necessary to operate the Solaradio without discharge of the rechargeable cells inside the cabinet. This combination of characteristics of the Silicon Solar Cells make them an ideal device for assembly into a battery charging device, which is one of their functions in the Solaradio.

The life of the Hoffman Silicon Solar Cells appears to be almost unlimited in normal use. They will operate under severe conditions of humidity and have an excellent temperature range of +175 degrees C. to −65 degrees C. (+100 degrees C. equals +212 degrees Fahrenheit.) Barring physical damage, they may be expected to outlast the useful life of most of the instruments in which they will be incorporated.

Rechargeable Cells

The four rechargeable 1.25 volt cells inside the Solaradio cabinet provide a standby source of power for use when no light, or insufficient light, falls upon the surface of the solar cells in the Solaradio handle. Since this section of the Solar Battery Power Pack is in parallel with the Silicon Solar Cells, it is possible for the Solaradio to operate on either, or both, sections of the Solar Battery Power Pack without any manual switching. The four rechargeable cells are connected in series to provide a 5 volt power supply to the transistor chassis of the Solaradio. Each cell has a nominal voltage of 1.25 volts and a capacity of .45 ampere hours at a 5 hour rate (.09 amperes). The average current requirements of the Solaradio are about 15 to 20 milliamperes with normal signal and volume. It is apparent that sufficient reserve power is always available for long periods of operation without solar power. However, the characteristics of the Hoffman Silicon Solar Cells are such that an almost constant trickle charge exists whenever the Solaradio is exposed to the bright daylight.

The rechargeable feature is automatic at all times, whether the Solaradio is turned on or off. The solar cells and rechargeable cells are connected in parallel across the Solaradio Power terminals. A silicon diode (SC9, Fig. 2) is utilized as an automatic switch to prevent discharge of the storage batteries through the solar cells when the solar cells are inactive. ■ ■

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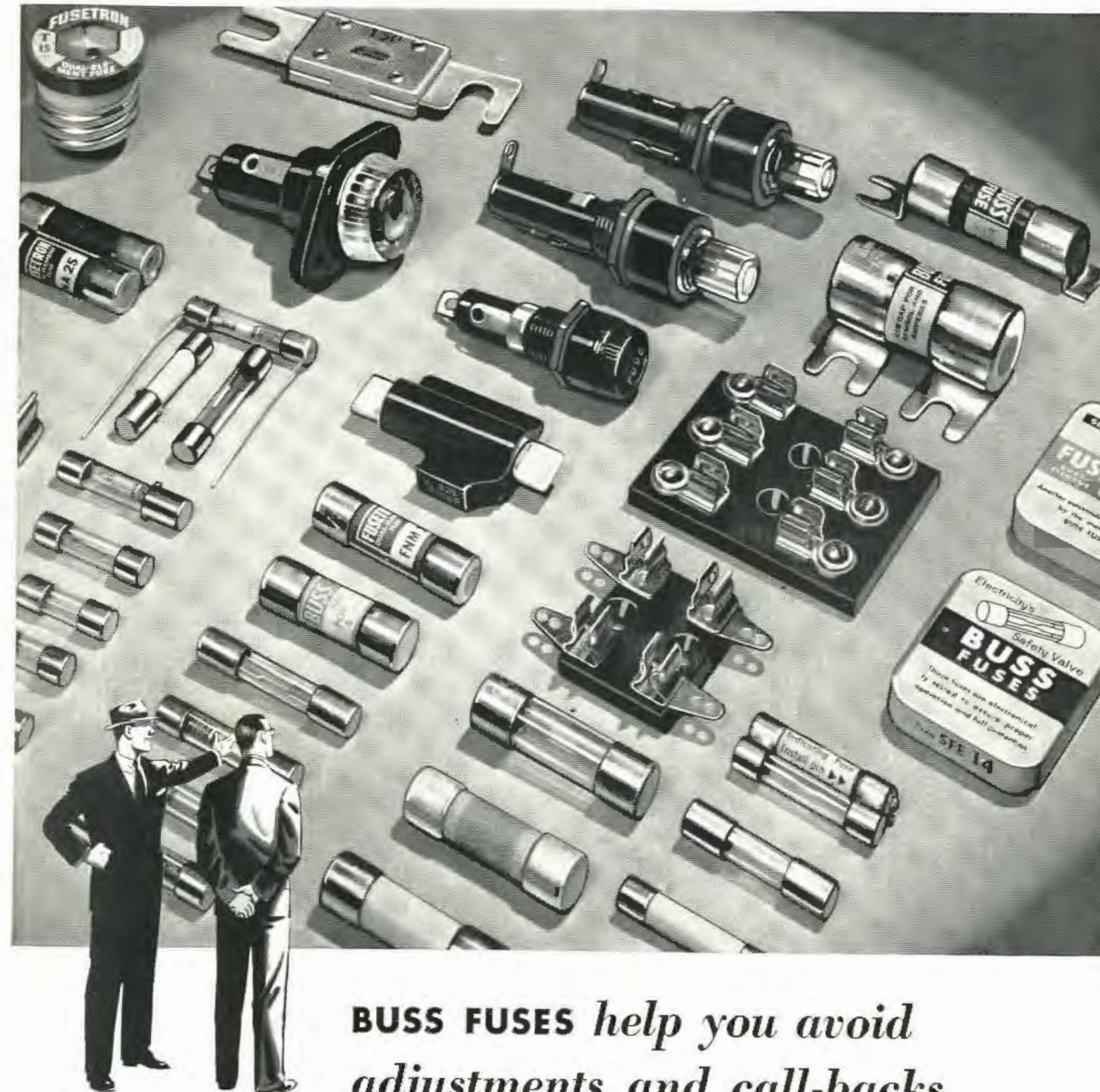

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